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Ecomondo, Rimini

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CMCC - Advanced Training and Education Center: The case of FERS School on Sea Level Rise and Coastal Adaptation

Giulia Galluccio,

Director of the Information Systems for Climate Science and Decision-Making
Director of the Advanced Training and Education Center and FERS School
Euro-Mediterranean Center on Climate Change (CMCC)

CMCC Advanced Training and Education Center

The Euro-Mediterranean Center on Climate Change (CMCC) is an international, independent, multi-disciplinary research center that studies the interaction between climate change and society. We produce advanced climate research developing cross-cutting and multidisciplinary analyses and data that combine first-class climate modeling with climate change impact modeling and environmental economics.

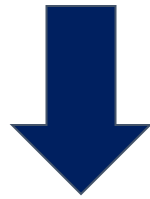
We deliver the crucial scientific insight needed for a successful transition to a sustainable future by providing **foresight and quantitative analysis on our future planet and society**.

Among its institutes and centers of excellence, CMCC established the Advanced Training and Education Center (ATEC) in 2024. It is within the framework of the Center that the FERS School is offered. The Center operates with a fourfold mission:

- **Educating the next generation**
- **Building a Global Knowledge Hub**
- **Training for Policy and Governance**
- **Accelerating innovation in the Global South**

Climate Change Education

Sustainability-related degree programmes have proliferated rapidly among higher education institutions and sustainability literacy is therefore quickly emerging as a trend in Europe, with a marked geographic concentration in the North and Western Europe.



There is still a **gap in current Education programmes** focused on our themes:

UNESCO data from 100 countries shows that **only 53%** of the world's national education curricula **make any reference to climate change** and when the subject is mentioned, it is **almost always given very low priority**. (*UNESCO, Getting every school climate-ready: how countries are integrating climate change issues in education 2023*)



Distribution of the number of dedicated sustainability-related MSc degree programmes in Europe, per country, in 2024.



Distribution of the number of dedicated sustainability-related PhD degree programmes, in Europe, per country, in 2024.

Source: *MAGICA Deliverable 4.8 "Report on Strategic Mapping of current available higher education programmes and products on climate change issues" (July 2024)*

Future Earth Research School in a Nutshell

FERS is a **CMCC** initiative, organized within the **Advanced Training and Education Center**, funded by the **Emilia-Romagna Region**.

The School aims to become a **reference point** in research on sustainability by providing high-level scientific courses that give **young researchers and early-career professionals** the tools to **understand and anticipate future global environmental challenges**.

The school offers a unique opportunity for researchers and international experts to **collaborate and share experiences** on different multidisciplinary aspects of research, building a fertile ground for innovation and new research pathways.

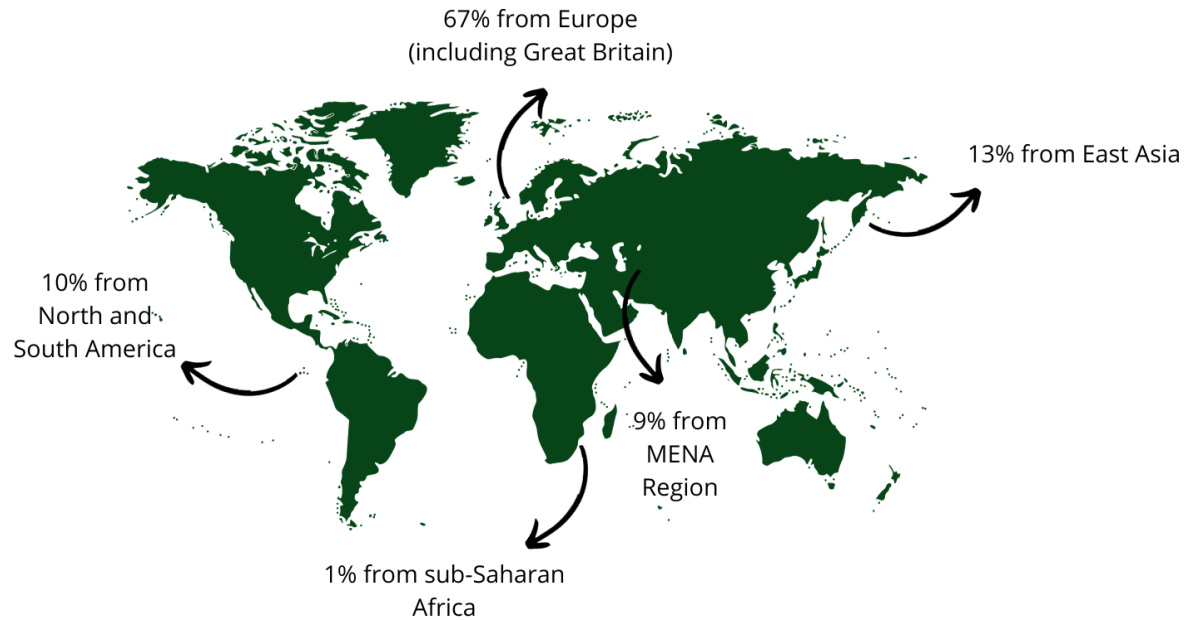


Future Earth Research School

The school offers its courses in the beautiful, historic setting of the Fortress in Bertinoro, at CEUB, near Forlì-Cesena.



Future Earth Research School – Highlights



6 Courses completed
528 Hours of high-level scientific contents
+50 faculty members

120 Students
24 Countries
28.5 average age
51% Female

WATER RESOURCES, LAND-USE AND FORESTRY

20/6/2022 – 2/7/2022

Bologna, (BO)



ADAPTATION AND SUSTAINABLE RISK MANAGEMENT

3/10/2022 – 15/10/2022

Bertinoro, (FC)



Future Earth Research School – Highlights

DATA SCIENCE AND MACHINE LEARNING

5/6/2023 - 16/6/2023

Bertinoro, (FC)



LAW, FINANCE, AND LITIGATION: addressing climate change risks in Europe

7/10/2024 - 18/10/2024

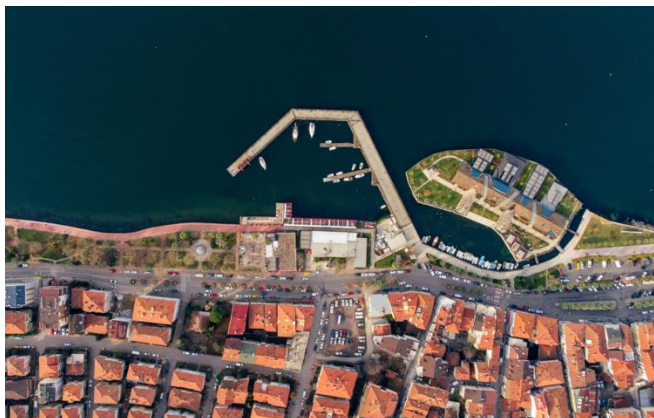
Bertinoro, (FC)



SEA LEVEL RISE AND COASTAL ADAPTATION

9/10/2023 - 20/10/2023

Bertinoro, (FC)



DATA DRIVEN MODELING AND PREDICTIONS OF THE EARTH SYSTEM

9/12/2024 - 20/12/2024

Bertinoro, (FC)



Course on Sea Level Rise and Coastal Adaptation

The course took place from October 9 to 20, 2023.

It involved **21 attendants** from **11 different countries** and with **different multidisciplinary backgrounds**.

The participants had the opportunity to

- Meet and participate in **lectures** delivered by a **high-level faculty** specialized on the course topics.
- **Network and interact with the faculty.**
- Meaningfully **interact** with each other and **develop experience** on the course main topics.
- Have direct experience through guided tour a **guided tour visit**, together with members of the faculty, to the **Po Delta Park**, one of the most important wetlands in Europe and the largest in Italy.



Sea Level Rise and Coastal Adaptation - The Structure



Course structure

Week 1: Understanding Sea Level Rise

- The science behind sea level changes
- Sea level measurement techniques
- Sea level modelling
- Factors influencing sea level variability
- Climate change and sea level rise

Week 2: Impacts and Adaptation

- Coastal processes affected by sea level rise
- Analysis of case studies showcasing the environmental, economic, and social impacts of sea level rise on coastal regions
- Overview of different adaptation strategies and approaches to addressing sea level rise impacts
- Integrating Science into Coastal Adaptation

Sea Level Rise and Coastal Adaptation - The Faculty



Begoña Pérez Gómez
Director of the Course
Physical Oceanographer
Head of the Harbour Oceanography
Department at Ports of Spain



Gianandrea Mannarini
Physicist
Institute for Earth System Predictions
Global Coastal Ocean Division at CMCC
Foundation



Simona Masina
Physical Oceanographer
Director of the Ocean Modelling and Data
Assimilation (OMDA) Division at CMCC Foundation



Nadia Pinardi
Physical Oceanographer
Director of the UN Decade Collaborative
Centre for Coastal Resilience hosted by the
University of Bologna

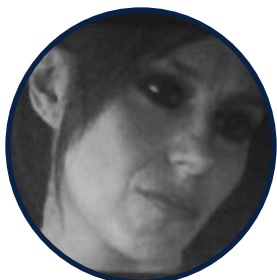


Ivan Federico
Scientist in Ocean Modelling
Ocean Predictions and Applications (OPA)
Division at CMCC Foundation



Agustín Sánchez-Arcilla
Civil Engineer
Full professor at the Department of Civil
and Environmental Engineering (DECA) of
the Polytechnic University of Catalonia

Sea Level Rise and Coastal Adaptation - The Faculty



Sara Morucci

Physicist

National Centre for Environmental Characterization, Coastal Protection and Maritime Climatology, Operational Oceanography; ISPRA



Francesco Trotta

Ocean Modeler

Ocean Predictions and Applications (OPA) Division at CMCC Foundation



Giorgia Verri

Physicist and Environmental scientist

Ocean Predictions and Applications (OPA) Division at CMCC Foundation



Javier López Lara

Civil Engineer

Head of the Climate Risks, Adaptation and Resilience Group of IHCantabria



Vittoria Mencarini

Architect

Municipality of Ravenna



Johannes Pein

Marine Environmental Scientist

Institute of Coastal Systems, Analysis and Modelling, Hereon Research Center, Geesthacht



Claudia Romagnoli

Geologist

Associate Professor, University of Bologna, Department of Biological Sciences, Geology and Environment (BiGeA)

Group Works: Coastal Cities - Case Study

Besides a more traditional learning approach, FERS courses include active learning activities, to engage with the faculty and fostering interaction among participants.

Participants in the course on Sea Level Rise and Coastal Adaptation were divided into 5 small groups to put into practice and exchange knowledge.



Group Works: Coastal Cities - Case Study

The groups analyzed **5 different case studies** (i.e., **coastal cities**), delving into and evaluating different type solutions and responses, including

- *Current & Future Conditions*
- *Risk & Impact Analysis*
- *Existing adaptation solutions assessment*
- *New proposal development*

During the activities, while gaining concrete insight into coastal adaptation to sea level rise, the groups received **recommendations from the faculty.**

Jakarta, Indonesia

2.1 Land subsidence and sea level rise

Jakarta Is Sinking
 More than 2 inches per year
 Less than 2 inches per year

3.1 Engineering measures

"We're trying to build a seawall city. That's completely new"
 V. Coenen, project manager for the Jakarta seawall project

2.3 Economic impacts

Effects of Sea Level Change in Aquaculture Sector

Risks to aquaculture sectors due to sea level rise:

- Aquaculture farm become connected to the sea at higher sea levels
- Invasive fishes may disperse during high water levels
- Fish population subject to die
- Groundwater may inundate cesspools

3.2 Nature-based Solutions

Artificial mangrove embankments

- Vertical aquaponic system in mangrove planting
- Horizontal aquaponic system in mangrove planting

2.5 Overview of the complexity of Jakarta

RISK			
HAZARD	EXPOSURE	VULNERABILITY	LACK OF COPING CAPACITY
SUBSIDENCE	LOW LYING COASTAL AREA	LOW-CLASS COMMUNITIES	GOVERNANCE
COASTAL FLOODING	RAPID URBANIZATION	FOOD SECURITY	DRRM
TYPHOONS	OVER-EXTRACTION OF GROUNDWATER	SOCIAL INEQUALITIES	COMMUNITY OWNERSHIP
SALTWATER INTRUSION	INFORMAL SETTLEMENTS	LIVELIHOOD	PREPAREDNESS & RESPONSE
SOIL EROSION	INFRASTRUCTURES	POLITICAL ISSUES	ACCESS TO BASIC NEEDS
EARTHQUAKE		ENVIRONMENTAL DEGRADATION	LACK OF WORKING EWS
CLIMATE CHANGE (SEA LEVEL RISE)			

4.1 Assessment of the existing adaptation measures

ADAPTATION MEASURES	IMPACTS OF COASTAL FLOODING			
	ECONOMIC			
	Maintenance cost of infrastructure	Land property values	Maintenance of buildings and facilities	Economic activities
ENGINEERING	Sea wall/dikes	••••	••••	••••
	Pumping flood waters	•	••	•••
NATURE	Dredging and "normalizing"	•	••	•••
	Mangrove planting and aquaponic system	••••	••	••
	Wetland parks	••••	••	••
SOCIAL	Inhibition of groundwater extraction	••••	••	••
	Resettlement	•	••••	••••
	Amphibious houses	••	••••	••
	Early warning system	•	•	•

Group Works: Coastal Cities - Case Study

Miami, USA

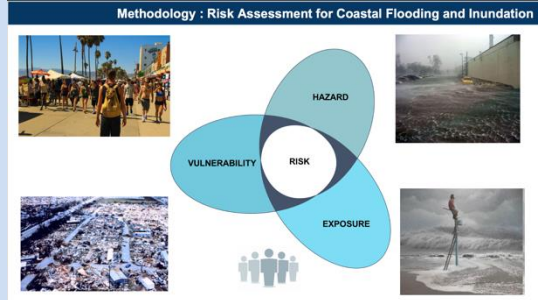


25.76° N, 80.19° W

SEA LEVEL RISE AND COASTAL ADAPTATION IN MIAMI BEACH, FLORIDA

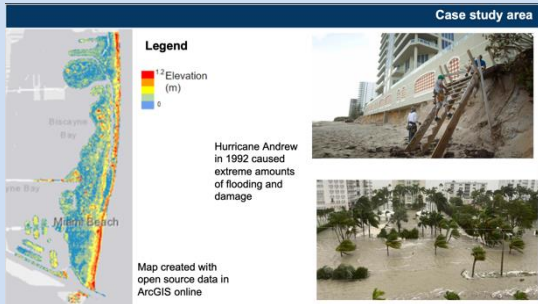
CMCC FERS
Future Earth Research School

Methodology : Risk Assessment for Coastal Flooding and Inundation



HAZARD
VULNERABILITY
RISK
EXPOSURE

Case study area



Legend
12 Elevation (m)
0

Hurricane Andrew in 1992 caused extreme amounts of flooding and damage

Map created with open source data in ArcGIS online

Preparedness: **BE PREPARED FOR A FLOOD**

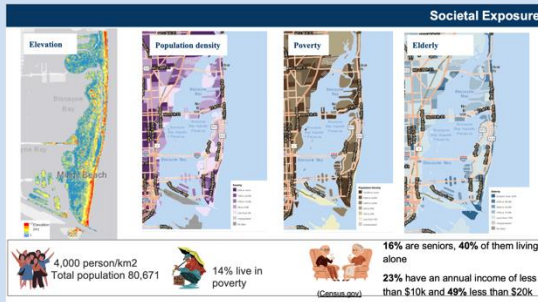
Prepare NOW

Also for children... Social Preparedness with Kids

Social Adaptation Measures



Societal Exposure

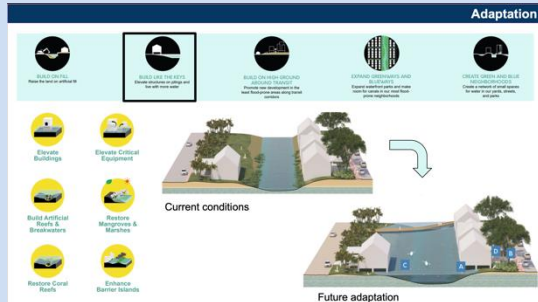


4,000 person/km²
Total population 80,671

14% live in poverty

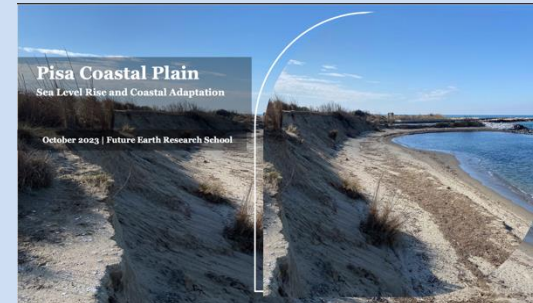
16% are seniors, 40% of them living alone
23% have an annual income of less than \$10k and 49% less than \$20k

Adaptation

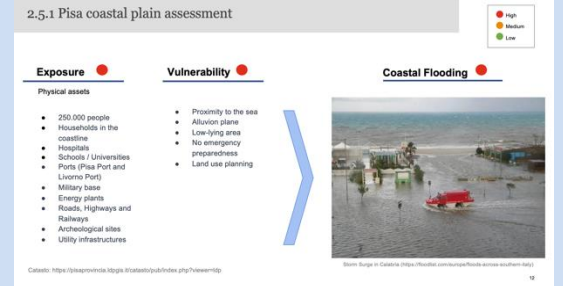


Current conditions
Future adaptation

Pisa, Italy



2.5.1 Pisa coastal plain assessment



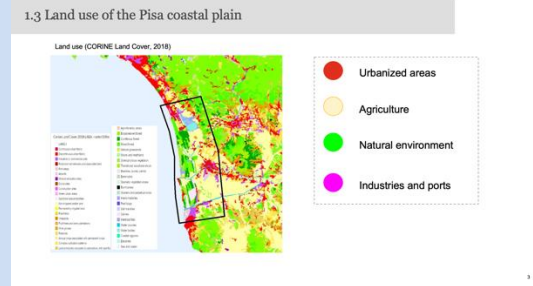
Exposure
Vulnerability
Coastal Flooding

Physical assets

- 350,000 people
- Households in the coastline
- Hospitals
- Schools / Universities
- Ports (Pisa Port and Livorno Port)
- Military base
- Energy plants
- Roads, Highways and Railways
- Archaeological sites
- Utility infrastructures

- Proximity to the sea
- Alluvion plans
- Low-lying area
- No emergency preparedness
- Land use planning

1.3 Land use of the Pisa coastal plain



Land use (CORINE Land Cover, 2018)

- Urbanized areas
- Agriculture
- Natural environment
- Industries and ports

3.3 Proposed Adaptation Measures - Natural Park (North of Arno River)



Yucca (alien species)
Ammophila arenaria (native species)

3.6 Proposed Adaptation Measures - Urban Adaptation (Green areas, SUDS) Hybrid

Applications for coastal areas



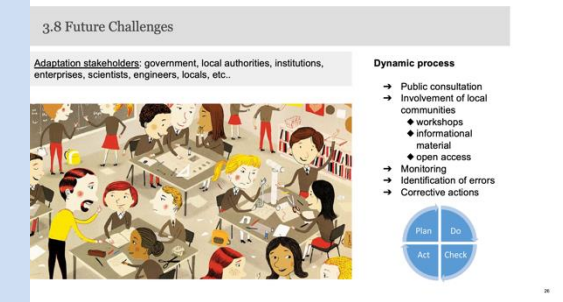
In Flow With Nature

3.8 Future Challenges

Adaptation stakeholders: government, local authorities, institutions, enterprises, scientists, engineers, locals, etc.

Dynamic process

- Public consultation
- Involvement of local communities
- workshops
- informational material
- open access
- Monitoring
- Identification of errors
- Corrective actions



Group Works: Coastal Cities - Case Study

Lisbon, Portugal

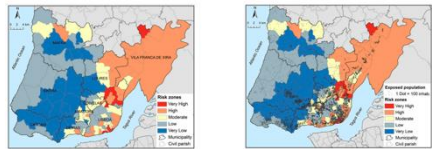


Lisbon Resilience Action Plan



Spatial Distribution of Exposed Population

Lisbon and its region are vulnerable to several natural disasters. Being the capital and the largest city of Portugal, many **buildings, infrastructures, and economic activities** are concentrated in Lisbon and its region, where about **two million** people live.



Gulland-Gonçalves, Clémence, et al (2015)

Lisbon Drainage Master Plan: NbS for Flood Control (1)

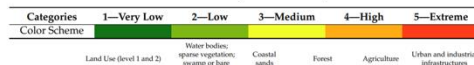
The **Lisbon Drainage Master Plan 2016–2030** was approved by the city Council in 2015 and proposes several interventions to control flooding problems and to adapt the city's drainage system to new challenges. These challenges arise, mainly, from land use and climate change; namely, the already confirmed sea water level rise and the increased risk of extreme rainfall events. In fact, these situations aggravate the risk of flooding in particular in **low-lying areas** located downstream of large river basins, close to the Tagus estuary and with significant impermeabilization, as is the case of Alcântara and Chelas. (Cui et al 2021)



Flooding in Praça de Espanha on 22 September 2014 (left) and in Alcântara on 13 October 2014 (right).

Physical Vulnerability Index by Land Cover Classes

- Urban and Industrial structure is the more vulnerable area
- followed by Agricultural land
- which is gonna impact economy
- potentially could contribute to Malnutrition problem



Monitoring and control

The environmental and ecological effects on the structures and on the neighbouring marine and coastal environments should be monitored for **years** by teams of expert ecologists, geologists, topographers, and engineers, using appropriate scientific methods and state-of-the-art technologies, including **acoustic Doppler, drones, underwater techniques, and data loggers**.

Hydrodynamic and coastline could be analysed using data collected by topographic survey using:

- Global Navigation Satellite Systems (GNSS) observations in Network Real Time Kinematic (NRTK) mode
- digital photogrammetry by UAVs (Unmanned Aerial Vehicles).

Short wave measurements campaigns could be performed at the study site to validate the numerical models. For example an acoustic Doppler current profiler (ADCP) equipped with a pressure gauge could be installed in shallow water to better estimate the transmitted waves (Lamberti et al., 2005).

Reef habitats, communities and biodiversity could be analysed in the field by collecting **underwater photographic samples** to be processed with image analysis software (e.g., **photoQuad**, freely available from the University of Agropoli) applying collecting **direct samples** of the substrates and the benthic assemblages to be analysed a benthic lab.



Bangkok, Thailand

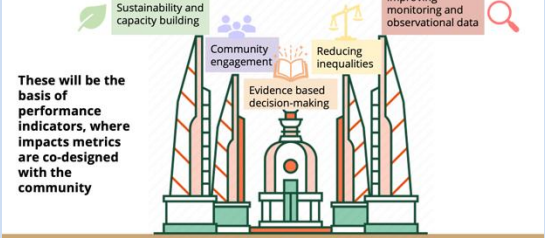
Flood misery for much of Thailand's Bangkok metropolitan area



Woman electrocuted as she waded through floodwater in Bangkok



Adaptation Pillars



Sediment loss and coastal erosion

Winterwerp et al., 2005
Bidorn et al., 2021

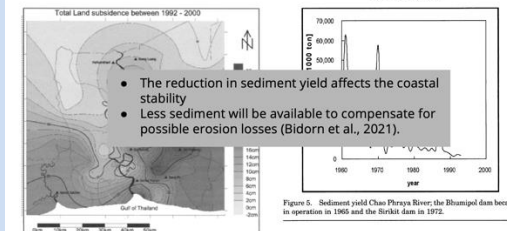
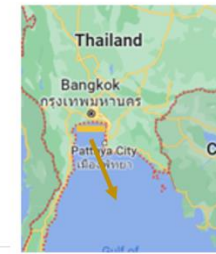


Figure 5. Sediment yield Chao Phraya River, the Bhumipol dam became in operation in 1960 and the Birkel dam in 1972.

Figure 4. Measured land subsidence in the period 1992–2000.

Land reclamation

- Cost ~9 billion euros
- Advance and 'buy more time' to address land subsidence and inequalities
- Deter saltwater intrusion
- Preservation of local historic and cultural communities, and jobs



The Gulf of Thailand Lake

Cost ~350 billion euros based on North Sea Lake estimate (Gronkamp and Kjelson, 2020)



SciFi City

Cost ~700 billion euros based on Saudi Arabia futuristic desert city (Thapa, 2023)

- Reinforcing buildings to be flood resilient, including raising infrastructure
- Building urban parks with elevated walkways for recreation



Site visit: Po Delta Park

The course included a site visit to provide participants with a **first-hand experience of sea-level rise challenges in Italy.**

The activity included a visit to the Delta Po Park, near Ravenna, included in UNESCO **Man And Biosphere (MAB) Reserves list**, and an example of **Ecosystem-Based Adaptation measure.**

As a **sea-level rise hotspot in Italy**, the group was guided by the expertise of **local practitioners**, exploring the sandy coastline and historical managed pine forests around the **Lamone River mouth.**



Participants' feedback and future perspectives

FERS School considers it essential to **collect feedback** from participants in order to further establish itself as a **reference point**, while continuously adapting to the **evolving needs of new generations and trends**.

The course on Sea Level Rise and Coastal Adaptation was structured to enable participants to get a **comprehensive understanding** of the science, measurement and modelling techniques, impacts and adaptive measures related to sea level, to **access and interpret relevant data** sources and visualization tools, and to be well-equipped to **contribute to the development** of sustainable and resilient coastal communities based on existing and ongoing initiatives.

What the participants appreciated:

- **Networking** with professors and students with different backgrounds
- **New ideas and methodologies**
- **Group works, site visit, practical sessions**

The School aims for future courses to keep the **interdisciplinary and holistic approach**, exploring ways to further **expand the blend of more traditional and practical activities**, which are often the most challenging yet valuable opportunities for younger generations of researchers and professionals.



**Thank you for your
attention!**

Any questions?



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