# CMEC Maritime Knowledge Lecture Series - 12th September 2025

## Marine Spatial Planning: Role of Remote Sensing, GIS & DEM in Development

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**Background**

Marine Spatial Planning (MSP) is increasingly recognized as a strategic tool for ensuring sustainable and integrated management of marine and coastal resources. With a coastline of over **11,098 km**, 12 major ports, more than 200 non-major ports, **20000+ km of 111 navigable national waterways** and 14 earmarked Coastal Economic Zones (CEZs), India is strategically placed for marine led growth.

India is also uniquely placed to become a global maritime hub, based on her geographical position and the large volumes of cargo which passes through these hubs. MSP has a vital role in boosting growth through port-led development, harnessing renewable energy potential, strengthening industries and facilitating cargo / passenger movement through inland channels, and contributing to the Blue Economy. At the same time, MSP aims to safeguard ecological balance and biodiversity.

The lecture examined the role of MSP and different tools such as Geographic Information System (GIS), Digital Elevation Models (DEM) & Remote Sensing (RS), their individual contributions, the significance of their integration, and the developmental related aspects of the emerging decision-making tools such as Artificial Intelligence (AI) and Multi-Criteria Decision Making (MCDM).

**Marine Spatial Planning and Its Relevance**

The speaker explained that MSP is defined as a systematic process that allocates spatial and temporal distribution of human activities in marine areas to achieve ecological, social, and economic objectives. It helps balance competing demands such as port operations, fisheries, tourism, energy generation, and conservation.

Marine Spatial Planning (MSP) follows a structured, iterative process starting with the definition of vision and objectives followed by initial assessment, planning process, implementation and final assessment and reporting. It involves legal frameworks, environmental and socio-economic assessments, stakeholder consultations, zoning, and management planning, The cyclical nature of MSP ensures adaptive and sustainable use of marine resources.

For India, MSP is especially relevant forexpansion of coastal and inland cargo movement, developing economic zones, harnessing renewable energy from offshore / onshore wind and even tidal energy, fishing zones and advisories, strengthen military defence, systems approach to aquaculture and topromote eco-tourism while conserving marine habitats.

**Leveraging the scientific tools such as RS, GIS, and DEM, MSP ensures evidence-based decisions that reduce conflicts, enhance synergies and guide sustainable development through a systems approach.**

**Remote Sensing in MSP**

Remote Sensing is the acquiring of information from a distance. It has four characteristics spatial resolution, spectral resolution, radiometric resolution, temporal resolution.RS provides synoptic and continuous monitoring of coastal and marine environments.

The speaker explained how**Spatial resolution** provides high-resolution satellite imagery from sensors such as MODIS, Landsat, IRS, and IKONOS enables mapping of land use/land cover (LULC), coastal morphology, and water quality.**Temporal Monitoring**is thetime-series data track dynamic events such as cyclones, floods, river meandering, and shoreline changes. For example, MODIS provides near-global coverage every 8–16 days. **Event Detection**like RS captures changes such as the course shifts of the Kosi River (1998–2008), which are critical for disaster preparedness. Role of **Altimetry**in MSP,satellite altimeters measure sea-surface height and wave conditions, supporting port operations, renewable energy assessments, and navigation safety.

The speaker referred to**Surface Water and Ocean Topography (SWOT)**satellite, for detailed mapping and monitoring of water bodies and ocean features using advanced satellite technologies. It is a joint mission by NASA and CNES, and it uses **KaRIn radar interferometer.** It focuses on measuring water levels, flow, storage, and movement in rivers, lakes, reservoirs, and oceans. By providing high-resolution spatial and temporal data, SWOT helps in understanding hydrological cycles, climate change impacts, flood forecasting, sediment transport, and ocean circulation patterns. This information is critical for sustainable water management, disaster preparedness, and advancing Marine Spatial Planning (MSP) by linking inland hydrology with coastal and marine systems.IIRS (Indian Institute of Remote Sensing) and other Indian organisations are using the SWOT data. Recently, IIRS published a study using SWOT data to measure continuous water heights and elevation changes along the Ganga River.

**Geographic Information Systems (GIS) in MSP**

A Geographic Information System (GIS) is a computer system that analyses and displays geographically referenced information. It uses data that is attached to a unique location. Strength of GIS comes from its ability to analyze data representing a particular point, line, or polygon. GIS complements RS by enabling the integration, storage, analysis, and visualization of spatial data. Its applications include data integration, spatial analysis, marine zoning,& decision-making. The strength of GIS lies in its ability to transform raw data into actionable insights, making it indispensable for MSP.

**Digital Elevation Models (DEM) in MSP**

The speaker explained the Digital Elevation Model (DEM) as a representation of the bare ground (bare earth) topographic surface of the Earth excluding trees, buildings, and any other surface objects. DEM represents land and seabed elevation in a digital format and is essential for terrain and hydrological analysis. Some terrain attributes are Flow direction, flow pathways, flow accumulation, stream network, catchment area, upstream contributing area for each grid cell, slope/ aspect. Its applications in MSP includesediment studies - modelling sediment transport and deposition, vital for dredging and port operations, indices calculation - Generation of wetness and topographic indices to assess ecological conditions, SRTM data - Shuttle Radar Topographic Mission data (30–90 m resolution) provide accurate elevation models, critical for coastal drainage and flood mapping.DEM adds value to MSP by simulating terrain processes and hydrodynamic conditions that shape coastal and marine systems.

**Integration of RS, GIS, and DEM in MSP**

The speaker explained that integration of these three technologies offers a holistic framework for MSP:

- **Port Planning:** Identifying optimal sites for jetties, terminals, and berthing facilities.
- **Renewable Energy:** Locating offshore wind, tidal, and solar projects.
- **Fisheries Management:** Establishing fishing zones and preventing juvenile fish exploitation.
- **Sedimentation Profiling:**Modelling sediment dynamics for navigation and dredging. MSP can even help prevent sedimentation in the riverine channels.
- **Defence Applications:** Planning coastal security installations in non-major ports.
- **Tourism and Conservation:** Creating eco-tourism zones while protecting sensitive ecosystems.

Such integration ensures that MSP decisions are scientifically robust, spatially optimized, and environmentally sustainable.

**Emerging Tools for MSP**

Advances in computational and analytical methods are further enhancing MSP effectiveness:

**Multi-Criteria Decision Making (MCDM):**defined as the process of making decisions that involve multiple, often conflicting objectives, requiring a decision-maker to choose among various quantifiable or non-quantifiable criteria while seeking a compromise based on their preferences.

**Artificial Intelligence and Machine Learning (AI/ML):**Artificial Intelligence (AI) is the broad concept of machines performing tasks that typically require human intelligence & Machine learning (ML) is the field of study of programs or systems that trains models to make predictions from input data.

These tools make MSP more adaptive, dynamic, and participatory, strengthening its role in the Blue Economy.

**Conclusions**

Remote Sensing, GIS, and DEM together form the technological backbone of Marine Spatial Planning. Their integration allows for accurate mapping, efficient analysis, and informed decision-making, which are essential for balancing economic growth with ecological sustainability.

For India, the application of these tools in MSP will be central to unlocking the potential of non-major ports, advancing renewable energy, managing fisheries, and safeguarding marine biodiversity.

Looking ahead, the adoption of advanced tools such as MCDM, AI, and ML will further refine MSP processes, enabling dynamic, data-driven, and inclusive management of marine spaces. Thus, MSP supported by RS, GIS, and DEM provides a scientific pathway for achieving sustainable maritime development and realizing the vision of a thriving Blue Economy.

**Key take-aways and Q&A session**

Experts from Ministry of Earth Sciences, Ministry of Jal Shakti, NIDM, IIT Delhi, Delhi University and large number of researchers attended the session. The key take-aways and Q&A covered, are as follows:-

- A PhD scholar highlighted reliance on SRTM for DEM. Prof. Kumar noted its limitations in capturing bathymetry and pointed to technologies like the SWOT satellite, sonar, and shipborne surveys that improve depth data for sediment monitoring, dredging, and port planning.
- A DU Professor asked about the economic link to MSP. Prof. Kumar explained that RS, GIS, and DEM can quantify benefits of alternatives, e.g., shifting fish transport from trucks to ships can cut costs and improve sustainability.
- The Ministry of Earth Sciences representative shared initiatives under the Blue Economy, including MSP pilots, ecosystem valuation, and bathymetric mapping. Prof. Kumar stressed the need for data integration, better Environment Impact Assessment (EIA), and centres of excellence to support national geo-spatial policy.
- Discussions also covered **drone-based DEM** for coastal vulnerability. Prof. Kumar noted drones give high-resolution data but need interferometers for bathymetry. Participants emphasized creating centres of excellence and integrating datasets for climate adaptation.
- Questions on Krishna and Cauvery basins raised navigation issues. Prof. Kumar said dams and diversions reduce discharge, affecting sediment flow, nutrients, and navigability, requiring engineered channels and careful marine spatial planning.
- Students also asked about emerging career opportunities. Prof. Kumar highlighted roles in transport, aquaculture, fisheries, sediment management, and renewable energy, stressing data analysis, innovation, and start-ups, with scope across major as well as 200+ non-major ports and 111 waterways.

- Industry representatives called for **a national Blue Economy playbook**. Prof. Kumar pointed to rising R&D funding and said large, well-structured proposals could attract major support. He stressed **joint solutions from academia, industry, and government**.