Earth Observation for an Indian Ocean Blue Economy - Consultation Workshop

Final Report

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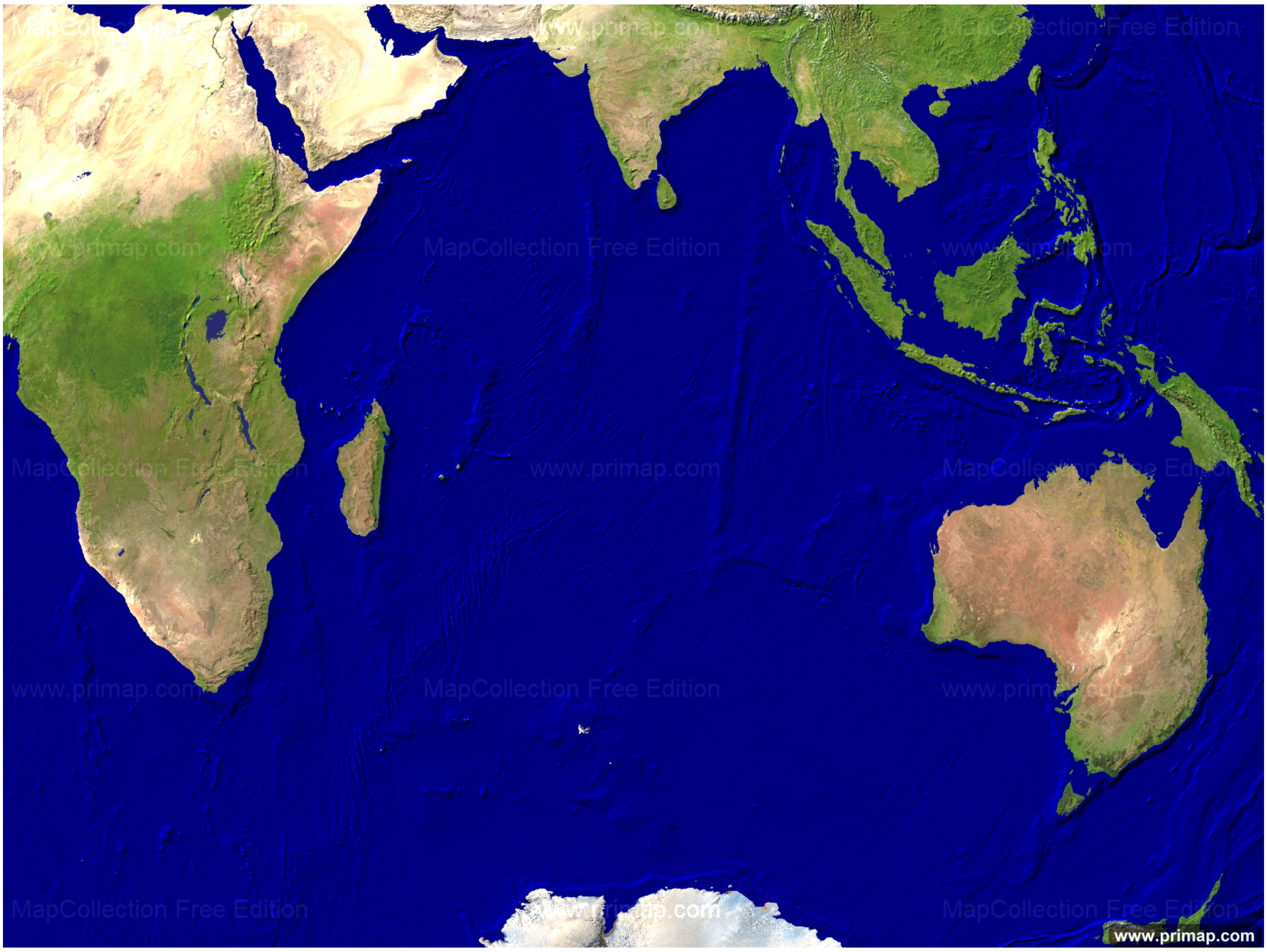

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IORA INDIAN OCEAN BLUE CARBON HUB

INDIAN OCEAN RIM ASSOCIATION

Australian Government
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Acronyms

ABNJ	Areas Beyond National Jurisdictions	IOC	Indian Ocean Commission
AIS	Automatic Information System	IOR	Indian Ocean Region
AOGEO	Asia Oceania Group of Earth Observations	IORA	Indian Ocean Rim Association
APEC	Asia-Pacific Economic Cooperation	IOTC	Indian Ocean Tuna Commission
ARD	Analysis Ready Data	IUU	Illegal, Unreported and Unregulated fishing
ASEAN	Association South East Asian Nations	LiDAR	Light Detection and Ranging
BIMSTEC		MDA	Maritime Domain Awareness
CEOS	Committee on Earth Observation Satellites	MOOC	Massive Online Open Course
DEA	Digital Earth Australia	NOAA	National Oceanic and Atmospheric Administration
CNES		POA	Plan of Action
CSIRO	The Commonwealth Scientific Industrial Research Organisation	RESAP	Regional Space Applications Programme for Sustainable Development
CSST	Centre for Space Science Technology	SAR	Synthetic Aperture Radar
CMEMS	Copernicus Marine Services	SCO	Space Climate Observatory
CMRE		SDG	Sustainable Development Goals
DFAT	Department of Foreign Affairs and Trade	SIBA	The Spatial Industries Business Association
DRR	Disaster Risk Reduction	SIDS	Small Island Developing States
EEZ	Exclusive Economic Zone	SLR	Sea Level Rise
EO	Earth Observation	SST	Sea Surface Temperature
ESA	European Space Agency	UAV	Unmanned Aerial Vehicle
EU	European Union	UN	United Nations
GA	Geoscience Australia	UNOSAT	United Nations Satellite Centre
GEO	Group on Earth Observation	UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ICRI	International Coral Reef Initiative	VMS	Vessel Monitoring System
INCOIS	Indian National Centre for Ocean Information Services		
INDOOS	Indian Ocean Observing System		

Executive Summary

Indian Ocean countries and territories require access to Earth Observation (EO) capabilities that could inform decision-making related to a range of environmental, climate, security (food and maritime) and disaster management issues. Fortunately, a range of new satellite capabilities including processing and analytical tools will make it increasingly possible to access EO products and services that are useful in informing the development of the Blue Economy, as well addressing several other areas of relevance to the Indian Ocean Rim Association (IORA).

This report summarises the key outcomes from a three-day consultation workshop that brought 87 representatives from 18 IORA Member States together with some of the world's leading providers in satellite EO data and data analysis to develop a shared understanding of the EO needs of Indian Ocean countries and territories and to how best to collectively cooperate to meet these needs in the future. The workshop was held virtually on 23-25 November 2021 and was hosted by the Commonwealth Scientific Industrial Research Organisation (CSIRO), with support from the Department of Foreign Affairs and Trade (DFAT), the French Republic and IORA.

This report provides: (1) a brief overview of the approach taken in the workshop, (2) summarises key findings that resulted from thematic discussion groups and (3) identifies agreed next steps to be implemented to build upon this initial dialogue and to establish a Plan of Action (PoA) for establishing and enhancing EO in the Indian Ocean Region to support blue economy activities.

Discussion was informed by brief presentations from IORA Member States and Dialogue Partners of needs and technical capabilities, which were framed around seven key blue economy themes:

- Marine Spatial Planning for a sustainable Blue Economy;
- Coastal and Marine Habitat Mapping and Monitoring;
- Coastal Vulnerability, Protection and Response;
- Sustainable and Equitable Fisheries;
- Combating Marine Litter and Pollution;
- Preparing and responding to Maritime Accidents, and
- Cooperation to address Areas Beyond National Jurisdictions.

All national representatives endorsed the utility of EO and a growing need for access to EO data, for performing their core business and recognised that overcoming technical, capability and capacity challenges were the key to implementing enhanced EO capabilities for the IOR. Based on discussions at the workshop it was identified that there is:

- Already a range of activities and EO-related infrastructure projects underway as well as good EO capability with some strong regional centres of expertise.
- Shared interest and potential synergy in thematic areas amongst Member States. Marine spatial planning and habitat mapping were the two themes accounting for the greatest interest amongst participants while enhanced EO and regional cooperation will be required preparing for and responding to natural and maritime disasters, to collectively address at source the pervasive spread of marine litter and in ensuring the sustainability and security of Areas Beyond National Jurisdiction. Helping decision makers better understand the full potential, limitations, and application of EO data will assist in developing and addressing these needs.
- Similar EO-related infrastructure needs of member states, as well as methods and guidance on how to translate EO data into decision making products.
- A need for regional communities of practice to share expertise as well as existing tools and awareness of available data sets and access to available data exploitation tools. Building enduring EO capacity building was highlighted as a need.

The workshop identified that there was a need for greater cooperation and collaboration to further develop EO capacity to addressing blue economy as well as other issues in the Indian Ocean region. Any developed regional EO framework and platform will need to be adaptive, flexible, and modular - rather than a 'one size fits all' solution, while offering a baseline level of best-practice, and access to infrastructure and resources, and encourages documentation and sharing of best practice information.

To move from concept to implementation the Workshop recommended that a Plan of Action (PoA) be developed that will engage users in further defining functional requirements for the development and implementation for a platform and should seek multi-lateral support from governments and non-governmental funding bodies. The PoA should identify the broad steps that could be taken to build the required EO infrastructure, capability, cooperation, and collaboration across IORA member states.

In the short-term recommendations focusing on building awareness, engagement and support for the outcomes of the workshop and the proposed PoA are to:

1. Present the results of the workshop to the IORA leadership and at regional forums within the IORA sphere of influence sharing the main conclusions, focusing on the areas of overlap and complementarity, and seeking support for the next steps.
2. Establish a small multi-disciplinary team to further develop the PoA starting with the scoping of the vision and objectives for an IORA cooperation and coordination framework and an inventory of current and planned EO activities which could be leveraged.
3. Undertake a review of existing EO training programs and refine training and capacity building needs for the IOR. Look to deliver a range of training for all aspects of EO through multiple platforms, including video and online resources.
4. Increase informal collaboration between member states by establishing a key contact point within each nation, convene an EO technical user's forum, and fostering opportunities for IORA member states with mature EO operational capacities in different blue economy sectors to assist those member states that are seeking to develop similar capabilities.

1 Introduction

1.1 About this Report

This report summarises the key outcomes from a three-day online consultation workshop that brought together 87 delegates from 18 IORA Member States and Dialogue Partners, to develop a shared understanding of the Earth observation (EO) needs in relation to the blue economy, as an information tool to support the development of blue economies of IORA MS, and for effective surveillance and management of areas beyond national jurisdictions (ABNJ) and discussed how to collectively cooperate to meet these needs.

The workshop was held online 23rd - 25th November 2021 and was facilitated by the Commonwealth Scientific Industrial Research Organisation (CSIRO) with support from the Australian Department of Foreign Affairs and Trade (DFAT), and the French Embassy. and Appendix 2 shows the agenda of the workshop and Appendix 4 provides a full list of participants.

This report provides: (1) a brief overview of the approach taken in the workshop, (2) summarises the key findings that resulted from thematic discussion groups and (3) identifies the recommended next steps to be implemented to build upon this initial dialogue to establish a proposed Plan of Action (PoA) for the Indian Ocean region (IOR) to better harness the capabilities of EO for building a sustainable Blue Economy (BE).

1.2 Background

The Indian Ocean is the third largest (68.56 million km2) ocean on Earth, and the 23 coastal and island member states of the Indian Ocean Rim Association (IORA) are home to nearly 2.7 billion people. The rich cultural and linguistic diversity of the region is woven together by centuries old trade routes that today are major sea-lanes essential to international trade, transporting half of the world's container ships, one third of the world's bulk cargo traffic and two thirds of the world's oil shipments. Beyond coastal and nearshore areas, the Indian Ocean Region (IOR) remains largely under-explored but holds huge potential and a wide range of natural resources and is positioned to play a key role in the evolving Blue Economy (BE).

While there are various definitions – internationally and across the IOR – of the Blue Economy (Text Box 1), common to all is to the need to ensure marine-based economic development leads to improved human well-being and social equity, while simultaneously reducing environmental risks and ecological scarcities (IORA, 2016; Mohanty, Dash, Gupta, & Gaur, 2015; Unit, 2019). The Blue Economy encompasses activities that explore, develop, and use the ocean's resources, that use the ocean's space and that protect the ocean's ecosystems. It incorporates traditional maritime industries (such as fisheries, coastal tourism, energy and mineral production, boat building, shipping, and ports) as well as new and developing industries such as blue carbon (the carbon stored in mangrove, seagrass, and saltmarsh ecosystems, which we will return to), new aquaculture products, marine renewable energy (which in turn includes wind, wave, and tidal energy), bio-products (pharmaceutical and agrichemicals), desalination and more.

Text Box 1: Terms and definitions used in the workshop

Blue Economy: The Blue Economy is sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health [World Bank 2017].

Earth Observation: the gathering of information about planet Earth's physical, chemical and biological systems. It involves monitoring and assessing the status of, and changes in, the natural and man-made environment [GEO].

As IOR nations pursue different approaches to realizing their own blue economies, science and technology plays a central role in the innovation of these industries, and in providing the tools to ensure that the other pillars of the blue economy – improved human well-being and social equity, reducing environmental risks and ecological scarcities – are met (Attri & Bohler-Mulleris, 2018; Mukhopadhyay, Loveson, Iyer, & Sudarsan, 2020; Roy, 2019; Steven, Vanderklift, & Bohler-Muller, 2019). The IOR faces considerable environmental threats resulting from both climate change and misuse of resources, including declining fishing stocks, recurrent coral bleaching, loss of coastal vegetation including mangroves and seagrass, and marine litter (Connan et al., 2021; Obura et al., 2021; Vanderklift, Gorman, & Steven, 2019). Climate change is also putting additional pressure on coastal communities and environments, and disaster risk management (DRM) is particularly urgent in the IOR because it is home to several small island nation states and developing littoral countries which with high population densities, and limited capacity are vulnerable to such calamities (Bennett et al., 2019; Cisneros-Montemayor et al., 2021).

With strong interest in sustaining and expanding the Blue Economy in the IOR, the IORA Secretariat has implemented a Blue Economy Working Group (BEWG) with the following six priority pillars: Fisheries and Aquaculture, Renewable Ocean Energy, Seaports and Shipping, Offshore Hydrocarbons and seabed Minerals, Marine Biotechnology, Research and Development and Tourism. It should be noted both the Blue Economy and the use of earth observation (EO) intersect with other IORA working groups including those for Maritime Safety and Security, Fisheries Management and Disaster Risk Management.

Data are needed to assess a nation's maritime wealth to better define a pathway to support the growth of a country's blue economy. Data are also needed to better assess the marine environment and ecosystem services to ensure future economic activity is sustainable and does not tip ecological processes beyond their limits, or place assets at risk from climate change and disasters (Paterson, 2018). Data – specifically data characterizing the status and trends of the environment of the ocean – which already much of the current economic activity around, on and under the ocean relies upon will become increasingly important to underpin safe, cost-effective and environmentally acceptable marine and maritime activity, and to address societal challenges and inspire their solutions (Rayner, Jolly, & Gouldman, 2019).

Earth observation (EO) encompasses a broad suite of remote sensing and in situ activities that gather observations to produce measurements and spatial data to monitor and examine our planet, its environments, human activities, and infrastructure.

Access to EO can help address a range of challenges related to the Blue Economy as well as including improved meteorological forecasting of potential ocean hazards and maritime security;

topics which aren't considered further in this report. A range of new and largely free satellite capabilities (e.g., increased spatial, temporal and spectral resolution) combined with modern data processing and big data analytic technologies such as cloud computing and regional EO Data hubs, offers unprecedented opportunities to utilise EO products and services to inform Blue Economy policy development and assessment and decision-making.

Reliable access to high quality, timely, authoritative, and comprehensive EO data is critical to enhancing how member states can collectively address and decide how best to manage surveillance of maritime activities, food security, sustainability of land and water resources and forecasting of conditions and hazards.

However, to realise the full potential, there is a need to increase the capacity of member states to better access and process the information. Small Island Developing States (SIDS) and Least Developed Countries (LDCs) also have unique challenges – particularly relating to infrastructure and capacity – and specific needs in relation to the access and use of Earth Observation data and products, all of which are quite variable across this large region.

With this background, this workshop was initiated to bring together representatives from IORA Member States and EO providers, along with IORA Dialogue Partners many of which have important EO capability, to listen to their needs directly, and to jointly progress a shared understanding of these EO needs and challenges. The outcomes of the workshop are intended to inform the development of a Plan of Action (PoA) that would seek consensus and resources to collaboratively develop improved national and regional-scale EO.

Further background information has been provided in the concept note incorporated in the appendices section 5.1 of this report.

1.3 Workshop Aims and Objectives

The workshop aim was to build a shared understanding of the EO needs for the IORA Member States by focusing discussion on the opportunities for, and challenges to, using EO in the IOR, both as an information tool to support the development of blue economies of IORA member states, and for effective surveillance and management of areas beyond national jurisdictions (ABNJ). Specifically, the workshop sought to:

- identify the EO data needs of IORA Member States;
- identify the actors who have significant EO capability to offer IORA Member States, especially among other Member States and Dialogue Partners;
- identify areas of common interest and expertise;
- identify key enabling actions based on common interest to IORA Member States and the capacities available.
- develop a Plan of Action (PoA) to implement the actions; and,
- communicate PoA to IORA and other high-level fora across the IORA regions.

Outcomes sought from the workshop were:

1. Improved awareness of the options available for EO in the Indian Ocean, including the data available, where to get it, and how to use it;

2. Enhanced understanding by policymakers and practitioners of how and when to use EO to help make decisions and develop indicators for reporting, and
3. Greater engagement from EO providers in IORA Member States and Dialogue Partners.

1.4 Workshop Organisation

The workshop was designed (within the constraints of online platforms) to be interactive and discussion-focused, whilst providing short talks that gave all participants a level of understanding on the contextual and technical issues that facilitated their participation.

The agenda (Appendix 5.2) was informed by a pre-workshop survey (Appendix 5.3) sent to participants that captured issues including: relevant policy drivers, prioritisation of issues and identification of constraints.

Seven key themes were identified for discussion in the workshop:

1. Marine Spatial Planning for a sustainable Blue Economy
2. Coastal and Marine Habitat Mapping and Monitoring
3. Coastal Vulnerability, Protection and Response
4. Sustainable and Equitable Fisheries
5. Combating Marine Litter and Pollution
6. Preparing and responding to Maritime Accidents
7. Cooperation to address Areas Beyond National Jurisdictions

1.4.1 Workshop Sessions

The workshop agenda was organised into three sessions to progress from developing a common understanding of EO needs through to informing the development of a Plan of Action that could be implemented.

A. Building a Common Understanding of EO Needs and Uses

Understanding what is possible with EO: there are a range of existing satellite EO capabilities that are already being used across the IORA Member States to greater and lesser extents, and across a number of application areas.

Understanding Indian Ocean EO needs: there are various services provided by the EO value chain such as data supply, data analysis platforms as well as services derived from data that have demonstrated success in unlocking value and information. Technical capacity building, expertise, and training resources are in demand for the Indian Ocean EO.

B. Exploring EO needs for BE Themes

Thematic application of EO to the Indian Ocean: the seven thematic areas listed above were each explored in greater detail through presentations from Member states and Dialogue Partners representatives and were followed up by plenary and break-out group discussion to further identify the needs opportunities and constraints facing implementation of EO.

Enhancing EO Capacity: three key EO Capacity topics– capacity building and training needs, infrastructure requirements for accessing EO data, research needs, and validation of data were discussed in Plenary.

C. Building a Plan of Action for enhanced EO

A brief Plan of Action (PoA) should be developed which identifies the purpose and initial steps that could be taken towards building cooperation and collaboration across IORA. This document should seek consensus within IORA Leadership based on the vision, objectives, information gathered, and steps identified to develop a strategy and implementation plan.

Presentations and other materials are available through at the following link.

1.4.2 Earth Observation Training

Two training sessions were also held alongside the main workshop to help give participants a sense for some of the capabilities that are currently available (Text box 2).

Text Box 2. Training Courses provided during the Workshop

Introduction to Digital Earth Africa (www.digitalearthafrica.org)

A two-hour workshop was organised to cover how the Digital Africa platform can support better decision-making in many areas, including: flood, drought, erosion of soils and coasts, agriculture, forest cover and use, land use change, water availability and quality, monitoring of urban dynamics and climate actions.

Digital Earth Africa exists to improve the lives of people across the African continent, including surrounding Indian Ocean Islands such as Madagascar, Comoros, Mauritius and Seychelles, by translating Earth observations into information that will support sustainable development. Digital Earth Africa's platform and services provide analytics-ready, free, open and accessible satellite data. The users, including governments, businesses, and policy makers, can use Maps and the Digital Earth Africa Sandbox to track changes across the continent in unprecedented detail. Access to online training is available at: https://training.digitalearthafrica.org/en/latest/

Coastal Vegetation Mapping with remap (https://remap-app.org)

The remote ecosystem monitoring and assessment Pipeline (remap) is an online mapping platform for people with little technical background in remote sensing. We developed remap to enable you to quickly map and report the status of ecosystems, contributing to a global effort to assess all ecosystems on Earth under the IUCN Red List of Ecosystems.

Remap uses the power of the Google Earth Engine, allowing users to directly access vast satellite data archives and state-of-the-art remote sensing methods to quickly map and report the status of ecosystems. Remap handles the technical details of remote sensing so that users can focus on training, classifying and improving the maps.

The short training provided by the remap developers was a methods-focused course, targeted at those who have little programming or data analysis experience but are interested in using remote sensing to map their local environments and how they change. Attendees were taught to use the remap application to make map classifications from freely available Landsat data, to identify the distributions of ecosystems, land cover, and quantify habitat loss and deforestation over a 20-year period. Access to online training is available at: https://remap-app.org/tutorials

2 Summary of Workshop Presentations and Discussion

This section summarises key points that emerged from presentations and discussion around the six thematic areas and the discussion of capability needs and commence with a summary of current EO use gleaned from Questionnaires circulated to participants before, and during, the workshop.

2.1 Indian Ocean User Needs and Capability

A pre-workshop survey was sent to workshop participants to build a better understanding of the thematic priorities and EO capabilities relating to current and future uses of EO data and constraints, and opportunities. The survey was completed by 21 respondents from 8 countries and the key results from the survey are shown in Appendix 5.4 and summarised in Table 1. During the workshop, live polling was also used to gather further insights from the participants. The responses largely mirrored the pre-workshop survey (Table 1), and a selection of comments is provided in Textbox 2.

Table 1. Summary of pre workshop questionnaire and polling of attendees at the Workshop.

Questions	Pre-Workshop Questionnaire	Live Polling in Workshop
Organisation use of EO	• More than 80% were users of EO. • 58% of respondents were from government agencies. • 50% were technical specialists; 12% were spatial analysts; and 19% managers or policy specialists.	• 83% were EO users and 17% were EO providers. •
Competence and Use of EO	• 27% would like to use EO data either daily and 18% would like to use weekly. • 36% of respondents either did not know or would never use EO.	• 28% were familiar with data analytics and services; 72% were only a bit familiar.
Expectations for EO:		• 21% want an easy to use interface and 16% wanted an easy to use system. • 18% want access to high resolution images. • 16% want the EO to be of low cost.
Top ranked use areas and themes	• Coasts & Coastline Change (30%) • Coastal and Marine planning (30%) • Coral Reef Monitoring (19%)	• Coastal and Marine planning (78%) • Coastal vegetation mapping (56%) • Coastal and coastline change (44%)

	• Maritime Accidents (19%)	
Main Global Reporting frameworks identified for EO applications	• 31% Sustainable Development Goals (SDGs) • 27% Blue Carbon Initiative.	• 83% SDGs; • 67% Blue Carbon Initiatives; and, • 44% Paris Agreement on Climate Change.
Potential constraints for access to EO		• 89% technical capacity to acquire or process EO data; • 67% access to data products or services; and, • 56% appropriate ICT infrastructure.
Main Services from EO providers	• fisheries and aquaculture (5); oceanographic condition (5); coastal and marine planning (4).	

In short, this feedback from participants highlighted:

1. The majority (> 80%) of attendees were users of EO who came mainly from government organizations with more than 60 % with technical roles and 19% from policy and management.
2. The majority of respondents would like to use EO more frequently, but many were only a little familiar with using EO.
3. Many respondents would like to see EO system and interfaces that were more user-friendly.
4. Lack of technical capacity to acquire or process EO data was seen as the principal constraint identified by most respondents.
5. The top three major uses of EO were Coastal and Marine planning, Coastal Mapping and Coastal and coastline change.

Textbox 3: Comments and other observations from the live survey process

Key constraints to greater EO uptake in the Indian Ocean Region could be resolved with the technical capacity building and development programmes, prioritising infrastructure.

"It's very new to us and we need help with technical capacity building and development."

"Institutional priority and funding for ICT infrastructure."

"Non-Uniform data structure design, different data sharing and usage policies, infrastructure and technical expertise are required to handle the data."

2.2 What is Possible with Earth Observation in the Indian Ocean?

Presenters
EO current and future capabilities of Earth Observation and their Application in the Indian Ocean David Antoine (Curtin University, Australia)
GEO Initiatives Relevant to the Indian Ocean Doug Cripe (GEO Secretariat)
CEOS Initiatives Relevant to the Indian Ocean Alex Held (CSIRO, Australia)
France - EO capabilities and applications Eric Brel (CNES, France)
India - EO capabilities and applications Srinivasa Kumar (INCOIS, India)

Australia - EO capabilities and applications Tim Malthus (CSIRO, Australia
South Africa - EO capabilities and applications Marjolaine Krug (DFFE, South Africa)

Six presentations were given that summarised the current and future capabilities of EO, the roles of several intergovernmental and organisations, and the capabilities of individual national agencies that provide EO data and imagery for downstream processing, products, and services.

Background information on the types of earth observation used in marine applications and the EO value chain are summarised in text boxes 4 and 5. The remainder of this section summarises key points which emerged from the workshop presentations and ensuing discussion.

Textbox 4: A short primer on the Earth Observation Value Chain
EO can provide access to current and historical information that can be used to assess and respond tactically to changes over time and can be used to inform assessments of existing and future risks that can be used for strategic planning. For example, in Blue Economy applications *products* developed from satellite data can be used to map quantities of interest, or to integrate with results other studies, quantify stock and fluxes of parameters of interest, and assess changes at time scales from days to decades. When combined with in situ observations the accuracy and utility of these satellite products is increased. Information services based on satellite and in situ data for marine fisheries, weather, oil spills, coral bleaching, water quality, harmful algal blooms (HABs), and others are increasingly common in providing actionable information to a growing number of *end-users*.

Thus, the EO value chain extends from data providers to value added services to end-users (Figure 1). Access to these satellite data and derived information products services are available from national – usually public good – EO providers and an increasing number of commercial providers who can provide niche and customised services.

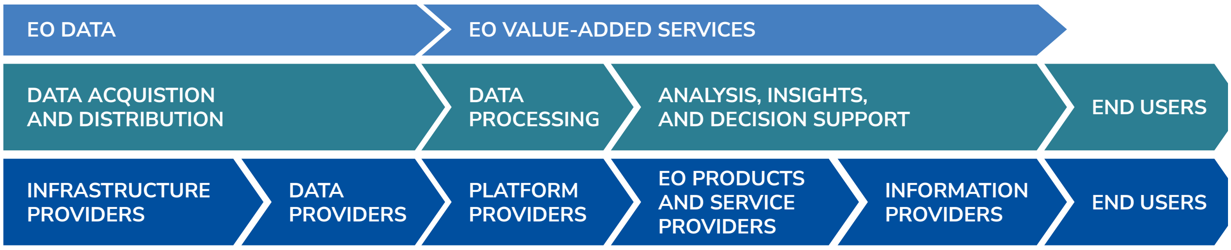


Figure 1 Earth Observation Value Chain.

Providers include *data providers* of unprocessed or pre-processed EO data including satellite and ground station operators and *platform providers* of online platforms and/or digital services, through which users can utilise tools and capabilities to analyse EO data. *EO products and service providers* produce products or services that make full use of EO data and processing capabilities offered by data and platform providers and ***Information providers*** supply sector-specific information that incorporates EO data along with non-EO data. There are growing number of these commercial, often small to medium enterprises (SME) intermediaries that (re)-use satellite data as an input to the production of information products and services underpinning specific sectors or societal benefits that are then on-sold to end users.

End-users are those actors whose activities or businesses derive benefit from EO data and information products and services. The can further be differentiated into: *science end-users* who undertake research activities; *operational end-users* who make use of ocean data and information to support operational needs related to safety, economic efficiency, and protection of the environment, *policy end-users* who require EO information to support policy formulation, monitoring compliance, and assessment of policy effectiveness, and *public end-users* who have a general interest in the ocean or make use of ocean data and information in support of their leisure activities or recreational pursuits.

The EO market is rapidly changing with the growing diversification of users and a wider range of user needs as EO is increasingly integrated into many sectors of our economy and society, including agriculture, banking, insurance and infrastructure sectors. Rapid growth in global EO market revenues is expected over the coming decade with an evolution of the technology and business models have expanded the types of data available with a rapid increase in niche services The number of commercial EO missions being launched is increasing exponentially and the proportion of public missions within the total of active EO satellites is decreasing accordingly. Cloud Computing is enabling new, easier ways to access data, and facilitating large-volume storage.

Full, Free and Open (FFO) data policies of the man public good EO providers result in data and value-added products e made available free-of- charge to users and service providers.

Textbox 5. Satellites Uses in Blue Economy Applications

There are four main satellite EO techniques enabling ocean and coastal measurements: radar altimetry for ocean surface topography, circulation, and mesoscale activity; thermal and microwave radiometry for sea surface temperature; active microwave imaging (e.g., Synthetic Aperture Radar); and visible and near-infrared imagery for ocean colour and ecosystem mapping.

The resolution of these satellite sensors varies in resolution with respect to:

Spatial resolution that defines the size of the pixels analysed by the sensors and are typically. categorised as Low and medium resolution (), High resolution, and Very-High Resolution.

Temporal resolution defines the frequency at which the data is acquired for a defined area. The needs can vary substantially for this parameter, with applications requiring images every day or every few hours, whilst others require updates only every few weeks.

Spectral resolution for optical sensor is defined by the width of the spectrum bands that can be distinguished with some applications require measurements of specific wavelengths and are often classified as either panchromatic (1-2 bands) multispectral (4-36 bands) or hyperspectral (>37 bands).

The most commonly available medium resolution satellites used in marine have been those developed and operated by the USA including Landsat series (30m 1985) MODIS and IIRS the Sentinel series operated by the USA since 2014 provide a range of better spatial and spectral resolution for Optical and radar. Commercial satellite providers, most notably MAXAR, Planet and Spot as well as a growing number of microsatellites providers generally provide much higher resolution imagery, typically less than 5 m, and provide a manage of niche products and services. Civil satellite EO data sources can be explored at database.eohandbook.com, and information on CEOS ARD can be found at ceos.org/ard.

The availability of extended EO time series from these satellites and the enhanced capabilities of recent and upcoming sensors/platforms combined with ability to access them with cloud computing infrastructure and analysis ready data (ARD) is transforming the use and utility of EO. Many agencies are transitioning from limited research and development modes into routine, sustained and widespread operational usage where customised products can be accessed.

2.2.1 EO Needs in the Indian Ocean

In the Workshop discussion the following points were made:

- High-resolution images with superfine pixels are not always required to monitor the coastline changes, and archives with deep temporal coverage can be quite useful.
- There is a need for foundational and integrated remote sensing and in situ datasets in the coastal zone as well as the analytics and workflows to support them to easily incorporate in situ data and model output.
- The importance of providing access to real-time data for applications was highlighted for several applications particularly those related to disaster response.
- EO data can aid in modelling and forecasting systems including baseline assessments, assessment of carbon reservoirs and carbon fluxes, assessment of blue carbon stocks and health, fisheries (potential fishing zones, long-term sustainable management), state of marine ecosystems, hazards (sediment plumes, HABs), and the impact of infrastructure projects.

- Support from related space domains such as telecoms and positioning, navigation, and timing are essential in many applications across the IORA regions.

2.2.2 Data Analytic Hubs, Products and Services

One of the most significant advances in recent years have been the development of regional data infrastructures that enable digital access to multi-satellite data and make redundant the need for individual agencies to retain satellite receiving hubs. For example, the Copernicus Australasia Regional Data Hub provides a localised complement to data from the European-based Sentinel Hub and Copernicus Science Hub enabling free and open access to Sentinel-1, Sentinel-2, and Sentinel-3 datasets on cloud computing infrastructure.

The advent of data hubs has enabled the development of an ever-increasing number of data products that can be accessed as a service by end users with varying EO requirements and capabilities. For examples Operational oil spill detection using radar imagery from Sentinel-1, NovaSAR-1, and commercial data providers has proven useful, and greater access is being enabled via cloud computing infrastructure.

Access to data and range of products is supported by Analysis Ready Data (ARD), which helps ensure harmonisation and interoperability of datasets across the supply chain, platforms, and infrastructure. The utilisation of open-source tools and software libraries such as Python libraries and J*upyterLab* greatly facilitates the consistent and repeatable processing and analysis of data.

There are already several data analytic hubs and various products and services available direct from EO providers that can be freely accessed by Indian Ocean EO users. Table 2 summarises a number of these initiatives and the products and services that can accessed. Other examples relevant to the IOR that are either operating of under development are summarised in Table 2 and 3). Presentations were made on several regional data hubs and are summarised below.

South-East Asian EO for Climate Smart Innovation Platform (EOCSI) is powered by CSIRO's Earth Analytics Science and Innovation Hub (EASI Hub) and the Open Data Cube (ODC) and is hosted by AWS Singapore. It engages local government, business, and education institutions to take advantage of EO for the development of climate-smart applications. **Link to presentation**

Digital Earth Africa is a fully operational platform that provides free and open access to African continental-scale data and processing. Using time series to derive insights and value from the data stack. **Link to presentation.**

Copernicus Marine Services is a user and policy driven operational and open service that provides global and regional scale ocean data and forecasts that range from ocean circulation and wave sea to biogeochemistry. Via a cloud-based infrastructure users can access, search, view, and download the ocean products and ocean monitoring indicators. Copernicus and Copernicus Marine products (*in situ* and satellite observation) and products are highly relevant to the Indian Ocean blue economy and applications. For example, Marine and Coastal Operations for Southern Africa (MarCOSouth),   one of four marine projects under the within the Global Monitoring for Environment and Security (GMES) and Africa programme, aims to promote the sustainable management of marine resources, improve marine governance, and stimulate the growth of the blue economy in the South and East African regions. The project has produced several co-designed and user-focused decision-making services based on locally optimised satellite observations, in situ observations, and model-based forecasts including for coral bleaching.

Table 2. Summary of major data analytics hubs and services relevant to the Indian Ocean Region

Data Analytics Hub	Geographic Coverage	Satellite Imagery Available	Available Marine Products
Copernicus Australasia **www.copernicus.gov.au**	Australasia, South-East Asia, South Pacific, Indian Ocean and Australian Antarctic Territory	Sentinel-1 Sentinel-2 Sentinel-3 Sentinel-5P	• Oil spill monitoring (S1) • Coral monitoring (S2). • Sea surface skin temperature (S3) • Algal pigment concentration (S3)
Copernicus Marine Environmental Service https://marine.copernicus.eu	Global	Sentinel-1 Sentinel-2 Sentinel-3 Sentinel-5P	Free, regular and systematic information on the state of the ocean, on global and regional scales o boost the Blue Economy across all maritime sectors by providing free-of-charge state-of-the-art ocean data and information.
DE Africa **www.digitalearthafrica.org**	African Continent	Landsat Sentinel-2 Sentinel-1 SRTM DEM ALOS Annual Mosiac	Information through DE Africa Sandbox, DE Africa Map, Africa GeoPortal, Online training) includes: • Water Observations from Space (WOfS) • Sentinel-2 & Landsat Annual GeoMAD • Chlorophyll-a in water bodies. • Long- term changes in water extent • Monitoring mangrove extent. • Shoreline contours for coastal erosion.
DE Australia www.dea.ga.gov.au	Australia	Landsat Sentinel-2	Monitoring and tracking coastal change Mangroves, Saltmarsh. Water innnunatipons Products link
SE EASI https://explorer.sg-dev.easi-eo.solutions/products	South-East Asia,	Landsat NovaSar Himawari MODIS GEDI	Development in progress
Allen Coral Atla allencoralatlas.org	Global 30 N to 30S	Planet Dove (3.5m)	• Geomorphic map • Benthic Map • Quarterly turbidity maps • Bathymetry
BIMSTEC **https://bimstec.org**	South Asia and Southeast Asia		Application prototype development in progress
VEDAS: Visualization of Earth Observation Data and Archival System https://vedas.sac.gov.in	India	Various optical radar and microwave imagery	Maps of : • Wetlands, • Reefs, • Shoreline change • Wave atlas
Indian National Centre for Ocean Information Services (INCOIS) https://incois.gov.in		Oceansat-2 (OCM) NOAA-18 & 19 (AVHRR)	• Potential Fishing Zone • Coral Bleaching Alert • Harmful Algal Bloom

		METOP A &B (AVHRR) Terra (MODIS) Aqua (MODIS) NPP (VIIRS)	• Coastal Water Quality • Ocean State Forecast • Marine Search and Rescue • Oil Spill Trajectory • Marine safety services for swell surge forecast, tsunami and coastal multi-hazard warning services,

2.2.3 Intergovernmental EO Agencies and Broader Coordination Opportunities

International EO coordination bodies such as the Committee for Earth Observation Satellites (CEOS) and the Group for Earth Observations (GEO) and United Nation organisations play important roles in linking national efforts to the global agenda and fostering regional cooperation to address a number of topics relevant to IORA. **Link to presentation.**

The CEOS The Open Data Cube (ODC) initiative) provides a data architecture solution that increases the impact of satellite data by providing an open and freely accessible exploitation tool, that minimizes the time and specialised knowledge required to access and prepare satellite data and provides free and open EO satellite data and application algorithms. CEOS-COAST is a current initiative co-led by ISRO and NOAA that aims to improve accuracy of coastal data on the basis of satellite and land-based observations. Key themes include disaster risk reduction & coastal resilience among continental shorelines and small island nations.

Under GEO regional cooperation relevant to the IOR is coordinated through the Asia Oceania GEO (AGEO and the African GEO AfriGEO. Thematically the GEO Blue Planet and GEO Aquawatch initiatives provide opportunities for IORA to highlight and promote its efforts, and potentially to partner on implementation.

UNOSAT is the United Nations Satellite Centre, hosted at the United Nations Institute for Training and Research (UNITAR), and its mission is to promote evidence-based decision making for peace, security and resilience using geo-spatial information technologies. UNOSAT supports Member States with satellite imagery analysis over their respective territories and provides training and capacity development in the use of geospatial information technologies. UNESCAP's Regional Space Applications Programme for Sustainable Development (RESAP) connects space agencies and ASEAN end-users seeking benefits from geospatial information applications. RESAP supports member States through building capacity in using space science, technology and their applications for disaster management and sustainable development. This work contributes to implementing the Asia–Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030), a regionally-coordinated, blueprint that harnesses space and geospatial applications, as well as digital innovations to support countries, to achieve the goals of the 2030 Agenda addressing six priority: (1) social development; (2) disaster risk reduction and resilience; (3) climate change; (4) management of natural resources; (5) connectivity; and (6) energy.

The UN Decade of the Ocean (2021-2030) provides another framework for foster regional coordination in the IOR. It seeks to create a paradigm shift in the generation of priority qualitative and quantitative ocean knowledge to inform the development of solutions to contribute to the 2030 Agenda for Sustainable Development. The Ocean Decade Action Framework contains ten

Ocean Decade Challenges that represent the most immediate and pressing needs of the Decade, as well as three objectives that represent three critical steps in the ocean science value chain: the identification of knowledge needs, the generation of knowledge and the use of that knowledge, all supported by extensive capacity development.

Discussion Points

- A number of individual agency activities were highlighted, including ISRO, CSIRO, and CNES. **Key missions:** Himawari-8 (and next-generation geostationary), OceanSat (ISRO), and Connect by CNES. Australia (CSIRO) is developing the AquaWatch mission concept for inland water quality monitoring, and extension to coastal areas has been discussed.
- The **2nd International Indian Ocean Expedition is** an example of how EO could help build an Indian Ocean scale activity.
- The **Lucinda Jetty Coastal Observatory** initiated by CSIRO represents an important capability to support EO for water observation, and similar efforts in Malaysia show the potential to expand the approach across the IORA regions.
- The International Methane Emissions Observatory (IMEO) project is looking at fugitive emissions using satellites. CEOS has started discussions with the IMEO regarding the land-based facilities and oceans may also be in the scope.

2.3 Thematic Applications of Earth Observation for a Blue Economy

The following section summarises for the seven thematic areas addressed by this workshop, the key points and future needs drawn from presentations and the ensuing discussion.

2.3.1 Marine Spatial Planning for a Sustainable Blue Economy

Marine spatial planning (MSP) is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process (Ehler & Douvere, 2009).. Several countries have implemented marine protected areas and fisheries protection zones. MSP is required not only for use within national boundaries, i.e., exclusive economic zones, but also for areas beyond national jurisdiction (Ardron et al. 2008). Nine large marine ecosystems (LMEs) have been designated across the Indian Ocean and the IUCN has recently announced the Great Blue Wall Initiative a regionally connected network of seascapes for the Western Indian Ocean (WIO) to develop a regenerative blue economy.

Presenters:
MSP in India - Dr Tune Usha (NCCR, India)
MSP in the Seychelles - Helena Sims (TNC, Seychelles)
MSP in the Indian Ocean Region -Dr Piers Dunstan (CSIRO, Australia)

MSP was one of the highest priorities identified in the workshop surveys and is fundamental to achieving a sustainable and equitable Blue economy. The main application areas are summarised in figure 5 and includes climate, law enforcement, administrative, ecological and environmental, societal and economic.

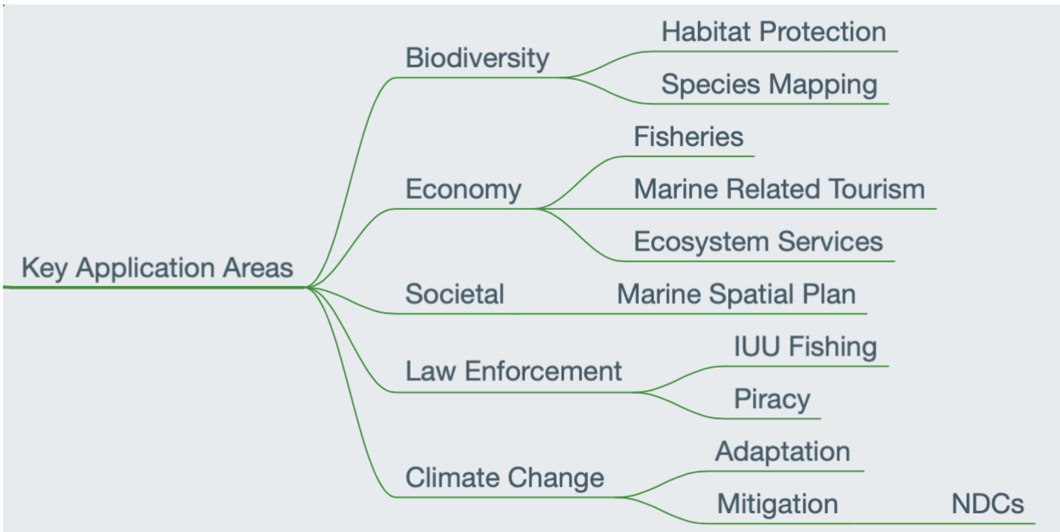


Figure 2. Key Application Areas of marine spatial planning.

Effective MSP relies upon access to good EO for providing insights valuable in understanding coastal processes, shoreline management, coastal hazards, marine pollution, ecosystem-based services, human impact, and capacity building. Observations from ships are also key in producing multiple layer products, for example bathymetry and mapping.

The following key points raised and future needs were discussed:

Marine spatial planning (MSP) relies on a variety of mapping and management tools, including GIS, remote sensing, numerical modelling, and extensive field measurement tools are used for monitoring. This is complemented by Land Use Planning, and Integrated Coastal Zone Management (ICZM). These efforts help to produce key economic benefits from the efficient use of resources and space. IOC-UNESCO maintains a summary of global MSP activities and reports at least 70 countries have implemented MSP in some form.

Habitat protection and species mapping of ecologically sensitive areas such as mangroves, tidal flats, coral reefs, wildlife sanctuaries, turtle breeding grounds, and salt lakes across exclusive economic zones (EEZs) are keys to protecting biodiversity. Across the region, there are several species on the *IUCN Red List of Threatened Species*, which is a key driver, with the Convention on Biodiversity calling for marine protection by 2030.

Fisheries and tourism are two of the key economic drivers across the region. These are underpinned by a healthy environment and biodiversity and are put at risk by ongoing threats like piracy, illegal, unregulated, unreported (IUU) fisheries and impacts of climate change. Policies and marine spatial plans are being put in place to mitigate these threats, and EO can provide important transparency and visibility for law enforcement and tracking of policy impact.

Future Needs

- High resolution bathymetry and elevation data are needed for near shore areas, and coastal habitat mapping. Currently CartoSat is used, and if the area is small LIDAR is collected, though this is costly.
- High resolution Bathymetry and Biogeochemical data for model inputs for nearshore ecosystem modelling.
- Operationally there needs to be more research on algorithm development for new and upcoming sensors. Few available algorithms are based on MODIS sensors and Sentinel

- Getting water quality remote sensing data for detecting the pollution level of coastal water quality through satellite data.
- It would be helpful to work on how to use the EO data sets to predict future shoreline inundation changes based on seal level.
- Using available information to anticipate changes of sea level rise on the coast can be mapped on remote sensing and their modelling.
- Integration of sources of information to come up with a map of biodiversity (coarse level). First step in the process to map areas, including seagrass beds, hard substrate on sea floor, slowly building through time and into the database.
- There is no MSP for the Bay of Bengal (e.g., biodiversity, habitat, shipping, etc.); data is scattered. Database is mostly land-based and does not cover oceans well.
- EO to map other uses of the ocean, for example through lights on ships

2.3.2 Coastal and Marine Habitat Mapping and Monitoring

The Indian Ocean has some of the most extensive corals reefs (~30%) mangrove (~50%) and seagrass (~18%) in the world that support numerous livelihoods and integrity is fundamental to the BE (Vanderklift et al., 2019). However, changes in these ecosystems are occurring rapidly often in response to a combination of shifting climate conditions and extremes as well as human development activities. Other areas beyond EEZs such as the Mascarene Plateau are largely under-explored and understood. Mapping the way for the sustainable use of these resources is crucial, particularly for coastal communities dependent on marine resources.

During this session, we heard from three presenters who gave overviews of the approaches and applications that can be used to effectively map these habitats.

Presenters:
Indonesia's coastal and marine mapping - Syrarif Budhiman (LAPAN, Indonesia)
Coral Mapping with the Allen Coral Atlas – Dr Mitch Lyons (UNSW, Australia)
Coastal and Intertidal Wetland Mapping – Dr Nick Murray (JCU, Australia)

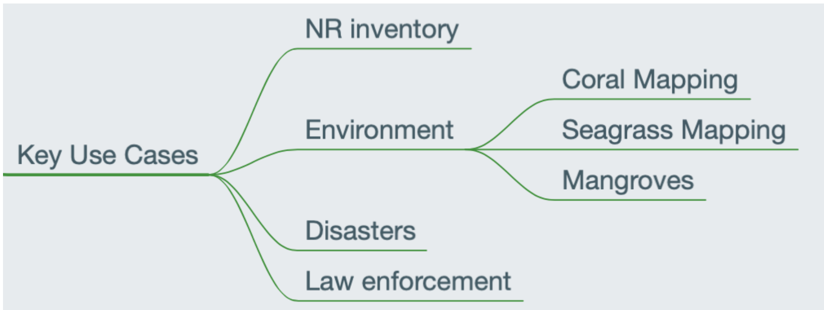


Figure 3. Key Application Areas of Marine Habitat Mapping and Monitoring.

The following highlights can be summarised from the discussion.

- Key applications in this area include maintaining an inventory of natural resources, environment and disasters, and law enforcement.
- Examples of operational inventories include Indonesia which has a 'One Map Policy' by Presidential Decree. This national EO System (SPBN) is a key national facility for sharing

geospatial information across Indonesian government and agencies and enables interoperability across departments. This has helped enable not just mapping, but also national policies to move applications from R&D to economic driven activities. Indonesia is conducting marine surface accounts using the classification of UN SEEA and depending on special data sets to establish their base year. Using coastal habitat in 1990 mapping, one can see the change overtime. Indonesia is also working with Machine Learning on a Marine Ecosystem service. Link to Presentation.

- The Allen Coral Atlas has released its first version and provides a valuable tool for policy makers, outreach, and communications. The backbone of the service is Planet Dove imagery with more than 480 datasets, and 2.25 million satellite images used. There were three classifications in the Allen Coral Atlas, and these products need to be sub-classified by countries to be applied optimally. The Allen Coral Atlas and mangrove mapping in Sri Lanka has not been completed. This task needs to be progressed first by the country and then regionally. Link to Presentation
- Intertidal.app is a Google Earth Engine-based tool that uses a supervised classification workflow applied to datasets from tidal flats, mangroves, and tidal wetlands across the world. This offering is packaged in a similar way to Global Forest Watch (GFW) using similar data structures and supporting multiple analysis languages and tools. It has been useful in tracking dynamics of coastal ecosystems, Link to Presentation
- Mobile application-based solutions for the collection of *in situ* information has also become much more common and is important in the validation of EO products.
- Africa's Oceans Accounting community has initiated activities on Marine Ecosystem accounts using EO. One of their sites is the Archipelago region of Central Mozambique where they have interest in mangroves, seagrass and coral reefs.

2.3.3 Coastal Vulnerability, Protection and Response

The Indian Ocean is often referred to as the climate hazard belt as it is prone to disasters, both natural and man-made. Many IOR countries have developing or emerging economies, or are island states, and are vulnerable to extreme weather events, to changes in monsoon cycles, and to climate variations and climate change. In coming years, climate change is likely to act as an impact multiplier, increasing vulnerabilities caused by natural hazards. It may exacerbate existing threats to human security. The high population density of several countries in the eastern Indian Ocean (for example, India, Bangladesh and Indonesia) and the location of many large and densely populated cities on the coast might be expected to further magnify the impact of such maritime-related disruptions in this region. There are two key scopes for disasters: operational response to extreme events; and preparation for future scenarios (e.g., climate change adaptation).

Addressing this theme 3 presenters provided an overview of approaches that were being taken to DRM in a coastal (Bangladesh and Island state (Maldives) and regionally in the Western Indian Ocean.

Presenters:
Bangladesh - Disaster Risk Response - Dr Zahirul Haque Khan, (IWMN, Bangladesh)
Maldives - Small Island States challenges– Ms Mizna Waheed (MOFA, Maldives)
Indian Ocean Climate Risk and Early Warning Systems – Mr Jean-Baptiste Migraine (WMO, France)

The main application areas are summarised in the following figure, and included disasters, forestry, environment and economy.

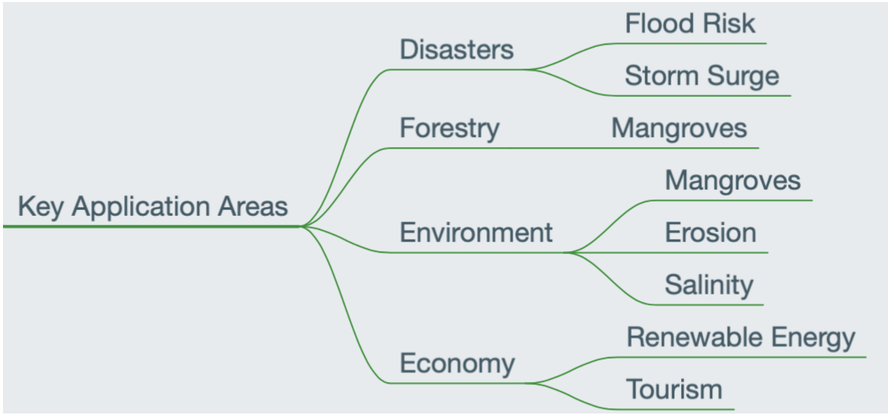


Figure 4. Key Application Areas of Coastal Vulnerability, Protection and Response

The following summary points emerged from the presentations and discussion.

- Coastal areas have huge potential for development of ecotourism. However, there are many potential vulnerabilities that bear a significant risk to the economy. Such vulnerabilities are cyclonic storm surge, salinity intrusion, tidal flooding, riverbank/coastal erosion, land subsidence, water logging, water and soil salinity, scarcity of drinking water, climate change and sea level rise.
- In Bangladesh An Interactive Geo-Database for Coastal Zone (IGDCZ) is being developed that covers the land area, ocean areas and other biophysical features for monitoring the potential vulnerabilities. A special plan for Bay of Bengal is being prepared to derive social, economic and economic benefits. Knowledge sharing will help in gaining access to more information. It is also important to have mangrove afforestation to protect the island and to exhilarate land acquisition. Link to presentation.
- The CREWS initiative supports LDCs and SIDS to increase the capacity to generate and communicate effective, impact based, multi hazard, gender-informed early warnings to protect lives, livelihoods, and assets. The project targets the southwest Indian Ocean to strengthen capacity in four countries: Seychelles, Madagascar, Mauritius, and Reunion have been initiated. WMO provides technical advice based on coordination of multiple EO networks. Monitoring and forecasting of tropical cyclones and analysis of their environment are done through the satellites. In situ calibration is key to enabling interoperability between networks and observations. Link to presentation.
- Key needs identified were multi-hazard coastal hazard mapping and better bathymetry is a key data need.

2.3.4 Sustainable and Equitable Fisheries

The Indian Ocean is rich in seafood resources, both in coastal areas and offshore areas and supports over 800 million people that rely on seafood as a major source of protein. Artisanal (small scale) fisheries exist throughout the region and involve coastal communities accessing the ocean and resources for local livelihoods and subsistence. Commercial fisheries in the region are largely operated by distant water, foreign fishing vessels from Europe and Asia and focus on tuna or tuna-like species, accounting for more than 20% of the world's tuna catch. The Indian Ocean region is plagued by Illegal, unreported, and unregulated (IUU) fishing resulting in multi-million-dollar losses of revenue to members states, destroying marine habitats, distorting competition and weakening coastal communities.

> **Presenters:**
> Tanzania Fisheries needs - Dr. Ismael Kimirei, (TFRI, Tanzania)
> Indonesia: Combating IUU– Dr Nyoman Radiarta (IMRO, Indonesia)
> India's EO use for fishing – Dr R.S Mahendra (INCOIS, India)

This theme encompassed a range of EO relation services that covered how the fish more sustainably and efficiently to better surveillance of illegal unregulated and unreported fisheries operations encompassed. Presenters from Indonesia, India and Tanzania presented how their agencies were using EO to fish more sustainably and to protect their fisheries from IUU activities. Applications that emerged from the session included identification of areas where there is potential to increase fish catches (potential fishing zones), and monitoring and surveillance of existing fishing areas (for example monitoring compliance or identifying illegal use). These require different but complementary types of EO data.

The main application areas are summarised in the following figure, and included climate, environment, food security, disasters, and weather.

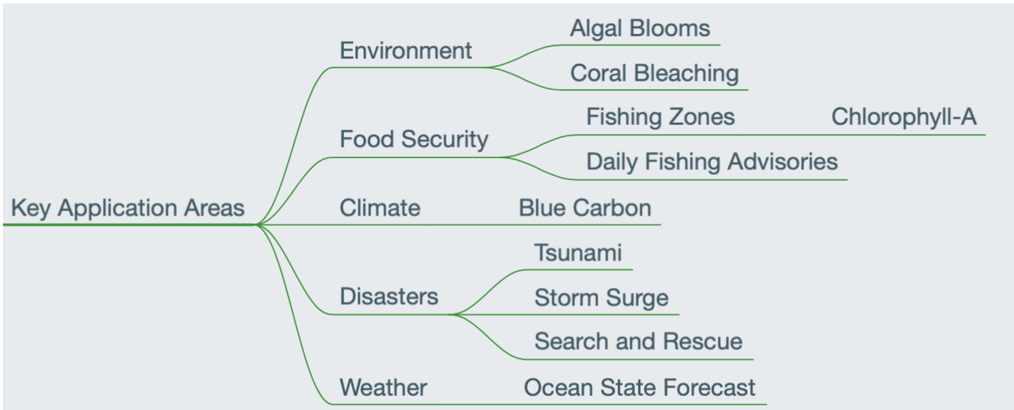


Figure 5. Key Application Areas of Sustainable and Equitable Fisheries.

The following points were highlighted in the presentations and the discussion.

- Tanzania is a beneficiary of EO infrastructure provided to TAFIRI from AMESD, MESA, GMES and AFRICA. Satellite products received at TAFIRI can be used for monitoring and forecasting of oceanographic variables and to detect and derive potential fishing zones (PFZs) empowering the small and medium scale fishermen to access the information by mobile application). It has more than 55,000 users covering 29 areas. Commercial radar data (RADARSAT-2, COSMO-SKYMED, Sentinel-1) and ground stations are used to compile near real time information. A data centre is being developed to produce reliable information on fishing, oil spill, oceanographic characteristics, coastal ecosystems including marine aquaculture, mangroves, coral reefs, coastline change detection. TAFIRI would like assistance to further operationalise it PFZ services. Link to Presentation.
- For India INCOIS provides a variety of fisheries services that are delivered by mobile app and SMS. Data is shared from a number of satellites, and Indian ground stations - Oceansat, NOVA series, MODIS Terra and Aqua, and VIIRS. Digital display boards have been set on all the

harbours for information viewing, information is also shared via phone, SMS, website, direct calling and broadcasting at some places. Weather forecasts, highway alerts, storm search alerts are also provided to increase the livelihood and economies of the fishermen. Calibration and validation is key for interoperability and to this end sites have been established to develop regional algorithms to provide more accurate chlorophyll-A estimates. Link to Presentation.

2.3.5 Combating Marine Litter and Pollution

it is estimated that there are about 60,000 tonnes of plastic floating in the Indian Ocean –second only to the North Pacific – that are entrained in gyres and visible from space. Of an estimated 8 million tonnes of plastic that enters the worlds ocean each year, about 90% of this debris comes from just ten rivers, eight of which are in Asia and two in Africa. A confluence of factors contributes to the high volume of plastic from Indian Ocean Rim countries including a lack of basic waste collection and recycling, illegal dumping, financial disincentives and excessive use of single-use plastic. Addressing marine litter in Indian Ocean is now a key issue affecting all Indian Ocean Rim countries, requiring cooperation as well as addressing issues at source. A range of satellite, UAV and ML learning technologies are being actively developed for tracking and combating marine litter (Connan et al., 2021; IOCCG, 2021). and under the UN Decade of the Ocean and a global integrated marine debris observing system (IMDOS) to provide long-term and support operational activities to mitigate impacts on the ecosystem and on the safety of maritime activity been outlined (Maximenko et al., 2019).

Presenters:
Indian Ocean trends and actions in litter - Dr Denise Hardesty (CSIRO, Australia)
Marine Litter survey and Modelling in Indonesia - Dr Gede Hendrawan (University of Udayana, Indonesia)
UNESCAP Programs to address Litter - Janet Salem (UNESCAP)

Three presenters addressing aspects of addressing issue of marine litter from understanding national to regional trends in marine litter using a range of observations and modelling technologies to initiatives that aimed to better addressed the cause of marine litter.

The main application areas are summarised in the following figure, and included baseline assessment, monitoring, seasonal variability, model validation and ocean current monitoring.

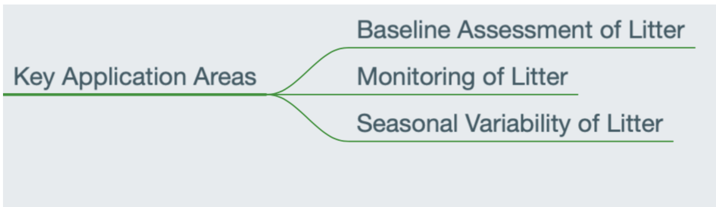


Figure 6. Key Application Areas in Combating Marine Litter and Pollution.

The following summary points capture the presentations and the discussion.

- Statistically robust sampling approaches are being developed and undertaken in many countries in many IORA countries across land, coast and ocean sites to help build a global picture of marine litter. Marine debris loads are driven by urbanisation, land use, and socio-economic variables. New policies can drive substantial change quickly. AI and machine learning on SAR data being used that are focused on larger objects. These are in the early phases. Capacity building and understanding the drivers are the key. Link to presentation.

- In Indonesia baseline data on marine plastics is being collected for Bali province with the support of the Bali Government, International Solid Waste Association, Norwegian Ministry of Foreign Affairs, Systemiq, University of Leeds and ISWA. PISCES is a newly initiated project with consortiums from different countries and will be implemented from 2021 until 2024. Link to presentation.
- The UNESCAP-led *Closing the Loop: program* **is** supporting ASEAN Cities to Reduce Marine Plastic Pollution through a measure-monitor-manage approach that standardises baseline assessments, provides a digital mapping tool and assists in developing city actions plans. marine litter is being measured through the baseline assessment and complement baseline with a digital monitoring tool to help track progress and support management and action plans. ISWA Plastic Pollution Calculator is also being used. A digital mapping tool has been developed to support the stakeholders to track the progress. Different AI algorithms have been developed and a variety of remote sensing techniques – phones, satellites, mobile apps–are being used to identify the plastics Link to presentation.

2.3.6 Preparing and responding to Maritime Accidents

Just under a third of the world's offshore oil and gas rigs are located in the Indian Ocean, and around 80% of the world's seaborne trade in oil is carried over the Indian Ocean. A considerable portion of this maritime traffic is clustered in relatively narrow sea lanes across the northern Indian Ocean, particularly in and around so-called 'maritime choke-points' for entry to and exit from to the Indian Ocean. Accidents involving shipping can represent a significant threat to marine life and livelihoods. However, the Indian Ocean is also one of the world's least regulated regions for shipping and although many states in the Indian Ocean are members of the *Indian Ocean Memorandum of Understanding on Port State Control* (Indian Ocean MOU-PSC), this arrangement is seen as less effective than other regional arrangements in the Atlantic and Pacific oceans.

In 2021 Mauritius and Sri Lanka were both subject to major oils spills from foreign vessels (*Wakashio and the X-press Pear*l) that caused irreparable damage to their marine habitats and biodiversity and highlighted how vulnerable the IOR was to such impacts.

Presenters:
Sri Lanka Oil Spill - Terney Pradeep Kumara (Sri Lanka)
Detecting oil spills with SAR - David Blondeau-Patissier (CSIRO, Australia)

During this session, two presenters examined firstly the consequences of the Sri Lankan Oil spill and the use of EO technologies while another showcased the development of operation oil spill detection system in Australia that use synthetic aperture radar (SAR) and could be applied more broadly across the Indo-Pacific.

The main application areas are summarised in the following figure, and included oil spill, detection of oil like features and monitoring the environment.

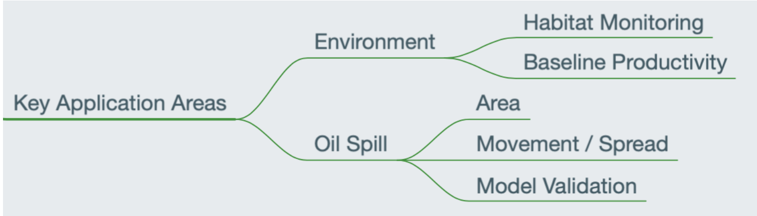


Figure 7. Key Application Areas in Preparing and responding to Maritime Accidents.

The following points summarise the presentations and discussion.

- The *X-press Pearl* oil spill that occurred in Sri Lankan waters in 2020, caused a significant loss of marine life and the technical assessment team is working to understand the damage to the ocean bed, seagrass, coral reefs, and the sea floor. Visual, analytical, model based, and research-based actions were taken to control the oil spill and a huge clean-up operation is still ongoing. Thermal imaging was used to support these assessments. Sri Lanka is interested in cooperation through IORA to develop better Oil spill preparedness and response capabilities for the region and consider EO data availability, real time monitoring of oil spills a marine spatial planning, marine habitat atlas and sensitive area index mapping, as key components that will require development and regional operationalisation. Link to Presentation.
- **An automated oil spills detection system based on Copernicus Sentinel-1 SAR imagery** has been developed for the Great Barrier Reef that applies deep learning approaches to detect oil features and trained with ship samples. The system can be relocated to any part of the world, particularly the Indian ocean and CSIRO is willing to extend this more broadly within IORA Member States. Link to Presentation.

2.3.7 Cooperation to address Areas Beyond National Jurisdictions (ABNJ)

Marine Areas Beyond National Jurisdiction (ABNJ), commonly called the high seas, are those areas of ocean for which no one nation has sole responsibility for management. In all, these make up 64 percent of the world's ocean surface As marine ecosystems are interconnected by ocean currents and the movement of migratory species that happens in ABNJ can therefore cause impacts in territorial waters. The sustainable management of pelagic fisheries has been an ongoing issue in ABNJ waters, while renewed interest in deep sea mining in the Indian Ocean, which has been identified as one of the hotspots for polymetallic nodules and sulphides, has raised a great number of environmental concerns and highlighted how little we understand about these benthic environments. In 2021 a new international legally binding instrument (ILBI) under the United Nations Convention on the Law of the Sea (UNCLOS), aimed at the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction.

During this session, we heard from three presenters who addressed various issues of how EO can be used to address ABNJ issues including deep sea mining, IUU, and a broader understanding of the dynamics of the Indian Ocean.

Presenters:
India and ABNJ - Dr Anil Kumar Vijayan, CMRE, India
EO in ABNJ, and examples of why it matters to the Commonwealth Blue Charter- Jeff Ardron (The Commonwealth)
Infrastructure and finance approach - Torsten Thiele, Global Ocean Trust

The main application areas are summarised in the following figure, and included monitoring the high seas, fisheries, biologically and ecologically significant marine areas and infrastructure.

Figure 8. Key Application Areas in Cooperation to address Areas Beyond National Jurisdictions

The following points summarise the presentations and discussion.

- The High seas cannot be governed effectively without EO to address issues such as monitoring fisheries activities and addressing IUU, meteorological forecasting, responding to natural and maritime disasters, and spatial and conservation planning of the high seas.
- Five perspectives where cooperation in ABNJ will be required include: Regional ecosystems and resilience, Ocean governance for ABNJ region, Knowledge and science, Remote sensing and data infrastructure and Ocean finance and the sustainable blue economy. Innovative financing, that is the development of new funding sources and mechanisms including from the private sector, can be used to deliver promising ocean conservation opportunities in ABNJ(T. Thiele & Gerber, 2017). Applying these financing approaches to the development of nature-based Blue Infrastructure, for coastal and high seas resilience and is receiving a great deal of attention from the investment community (T. Thiele, Alleng, G., Biermann, A., Corwin, E., Crooks, S., Fieldhouse, P., Herr, D., Matthews, & N., 2020). Link to Presentation.
- The Commonwealth Blue Charter is a global alliance partner of the earth shot prize. Commonwealth portal for the Allen Coral Atlas helps the countries within national jurisdiction to monitor the health of the corals and plan their restoration and protection activities. The Nekton mission to protect the ocean will also collect information on the high seas. The desired outcomes of the blue economy are investment, security, knowledge and ocean health. Each desired outcome needs EO and ocean observations to plan, manage and enforce including the high seas beyond national jurisdiction. Not all EO data are equally available and until human use data, oceanographic, physical, and biological data are shared together, sustainable blue economies will be out of reach. Link to Presentation.
- ABNJ research conducted by India's CMLRE Marine Living Resources surveys use ship-based surveys, satellite-based monitoring, modern approaches to marine and technology development. They have undertaken significant campaigns in the Eastern Arabian Sea, and recently conducted a first expedition to Antarctica and the Southern Ocean cruises. Most data are stored in the data repository of the International Centre for Ocean Information Services. Link
- Global Fishing Watch is a trusted example that has a complex algorithm to look at AIS and VMS data to identify suspicious fishing-like behaviour in places where fishing is not supposed to occur. Their algorithm is proprietary, but their tools are available for free to all the countries. Planet does a lot of philanthropic work by donating the satellite data they have acquired to the organisations. Many of the sensitive data are more useful to plan the policies, laws, and enforcement.
- iAtlantic, a regional cooperative program for the North and South Atlantic, was suggested as a successful cooperation framework for ANBJ that could be assessed as to its applicability to the Indian Ocean.

- A lot is happening in making the data available and the conceptual component is worth considering as it works well with other spaces. Raw data should be open, available, and clearly offered. Algorithms and mechanisms to analyse data need to be targeted and sold to address the different use cases. Should draw from other spaces where there is a lot of activity. Data that are least contentious are most available. More sensitive data like fishing data, or data related to maritime security are not generally available.

2.3.8 Summary

The thematic sessions provide a useful overview of the challenges and approaches taken. To addressing seven key aspects of the Indian Ocean Blue Economy. Examples and activities from these thematic areas are summarised in Table 3 and Figure 9.

Table 3. Summary of application and products in the seven thematic areas. Addressed in the workshop.

Thematic Area	**Disasters**	**Ecological and Environment**	**Economy**	**Climate**	**Law Enforcement**	**Administrative and Societal**	**Oceanography**	**Fisheries**
Marine Spatial Planning for a sustainable Blue Economy		✓	✓	✓	✓	✓		
Coastal and Marine Habitat Mapping and Monitoring	✓	*Habitat Mapping, Coral Mapping*			✓			
Coastal Vulnerability, Protection and Response	✓	✓	✓					
Sustainable and Equitable Fisheries	✓	✓		*Climate and weather*				*Food Security*
Combating Marine Litter and Pollution		*Baseline Assessment, Monitoring, Seasonal Variability, Model Validation*					*Ocean Currents*	
Preparing and responding to Maritime Accidents	*Oil Spills*	✓						
Cooperation to address Areas Beyond National Jurisdictions		*Ecologically Significant Marine Areas*	*Infrastructur e*			*Monitoring of the High Seas*		✓

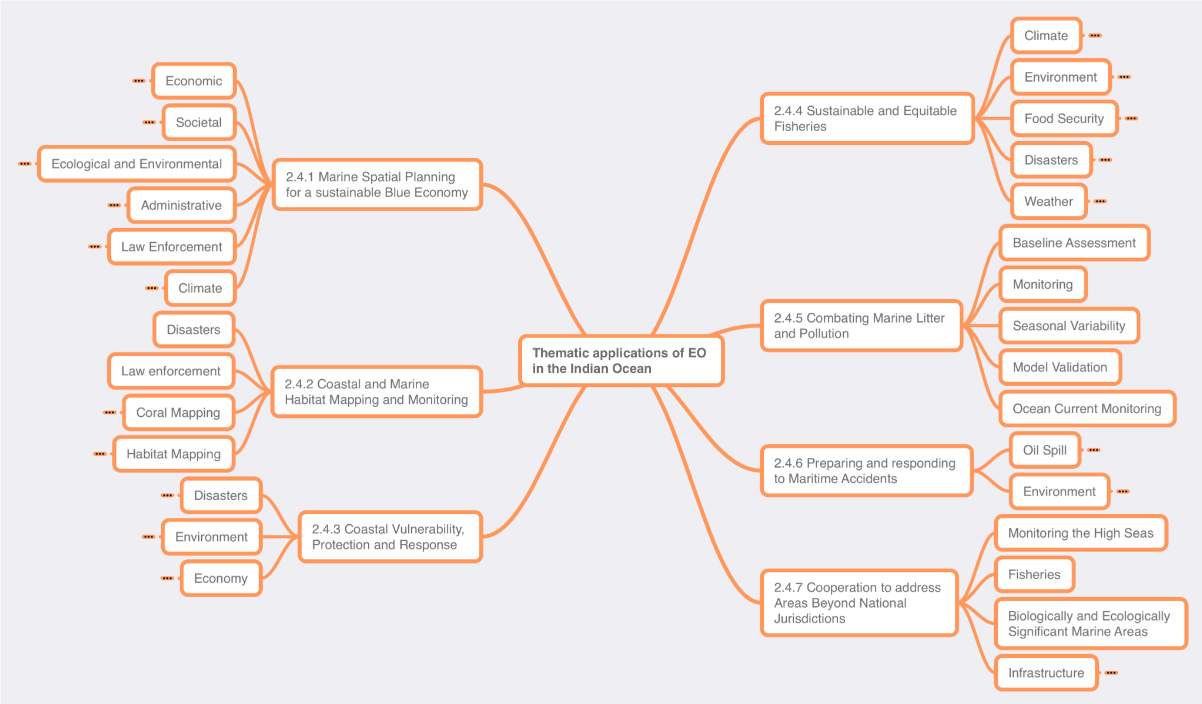


Figure 9. Schematic of key thematic applications discussed in the Workshop

2.4 Earth Observation Challenges and Opportunities in the IOR

To improve EO literacy and uptake across the IOR the challenges and opportunities relating to three cross- cutting areas were discussed in plenary.

1. **EO Capability Building and Training Needs:** what are the capacities needed across IORA Members States? What is the current distribution of capacities, what are the existing ways of boosting capacity where needed, and what new methods, guidance, and resources would be required?
2. **Infrastructure Requirements for accessing EO data:** what is the current infrastructure needs across IORA Members States? Which Member States remain underserved, and which have capacities which could be expanded or scaled up to help address gaps. Is a common or shared infrastructure needed?
3. **Research Needs and Validation of EO Data:** what are the key research questions which are required to be answered to address the needs of IORA Member States? And how can IORA support developing answers to these questions, including via the identification and sharing of validation data for EO.

Facilitated Plenary Discussions were held for each of the above topics and the main discussion points raised for each of these areas of action are summarised below.

2.4.1 EO Capability Building and Training Needs

Capability and Training emerged strongly from the questionnaires and in thematic discussion as a key priority for many participants. The training needs have evolved somewhat as digital access to ARD EO products and services that have occurred in last 3-5 years, places greater emphasis on having the skills to use applications such as Google Earth Engine, and ODC technologies and obviates the need to have a strong remote sensing background – though of course is still fundamental to interpreting the data. The following summary points emerged from the discussion.

- The need to raise awareness of the IORA Blue Economy work plan activities could be promoted through the development of fact sheets, tutorials, and virtual training programs. Ideas suggested included a Massive Open Online Course (MOOC) focused on Blue Economy, as well as a training course offered by the University of the UN. In addition, a repository of information, including guidance around data and methods would be a valuable tool in supporting the development of further awareness.
- The identification of target audiences for training materials was identified as a key topic, including the development of appropriately targeted materials. Examples of training audiences that should be considered included management and decision makers, training for trainers, EO analytical staff, and computer infrastructure and cloud computing staff.
- There is a need for dialogue with decision and policy makers end-users to understand their information needs and expectations for geospatial solutions. These may not always be map products and tools and may need to be more finely tuned to decision-making processes.
- The recruiting of staff and human resources was identified as a common issue across several the IORA Member States. Developing training resources and materials could help in onboarding and developing talent, and the possibility of Fellowships through the Blue Carbon Hub were identified as a possible route to attract talent.
- Training in best practice for validation was seen as key, in enabling the adaptation of systematically produced global products such as the *Allen Coral Atlas*. The role of systematic in situ measurements is key here. It may also be possible to leverage international efforts here, via the CEOS Working Group on Calibration and Validation as well as the CEOS Working Group on Capacity Development and Data Democracy.
- Technical capacity building, expertise, and training resources are important. The example of Digital Earth Australia Coastlines was discussed, including methods and processing steps used.
- Google Earth Engine (GEE) and the Open Data Cube were both identified as key tools for accessing where additional training and support would be helpful and enabling. Similarly, the use of Python and JUPYTER notebooks.
- Training in emerging technologies and methods. These included the increased use of SAR for monitoring IUU fisheries and oil spills. Machine Learning was also identified as a key emerging area for future training and capacity development.
- There are a number of very good training module already being delivered and are freely available. All of the services such as DE Africa provide both self-paced online and virtually taught courses.
- The OceanTeacher Global Academy provides a comprehensive web-based training platform that covers a range of topics related to the IOC programmes, including MSP, marine and coastal ecosystem, and Disaster Risk reduction. Several IORA countries host regional and specialise training centres including Indonesia, Malaysia, India Kenya and Mozambique.

2.4.2 Infrastructure Requirements for Accessing EO Data

With the increase in the availability of EO data analytical hubs infrastructure needs have also shifted such that it no longer necessary to have a ground receiving stations in every country or institution. Rather, telecom and internet and more powerful compute resources for processing and storage of data are emerging as the key infrastructure constraints. The following summary points emerged from the discussion.

- EO infrastructure includes satellites, ground receiving stations, cyber infrastructure (computers, telecommunications, storage, cables, connectivity), in situ instrumentation (in water, atmosphere) to validate EO information, and for radiometric calibration.
- People need better infrastructure to access the regional hubs with analytics information. Many analytics hubs are being developed such as the Sentinel hub, DE Australia, DE Africa. Google Earth Engine and products for oceanographic data can be accessed from anywhere as they are only depends on the internet capability and performance of the computer.
- A key gap across nearly all countries and thematic application is the need to collect better in situ data for validation of EO products. While some form of monitoring occurs in many member states, they are seldom collected specifically for EO validation and so there is a reliance on vicarious measurements. Investment in in situ validation will lead to more accurate products which will in turn increase trust in the products. There are significant opportunities to leverage existing monitoring programs and engage local communities in data that would be very valuable for validation
- There is significant ongoing investment in underground telecommunication cables across the Indian Ocean as well as improvements nationally to internet communications. However, there remain significant challenges in remote areas. For example, Indonesia, a very geographically dispersed archipelago does not have the equal quality of internet communication and infrastructure. There is a state provider of internet service which has nationwide stations but still has not covered the whole archipelago. Some potential solutions are being developed including Google experimenting with a flying connecting internet service.

2.4.3 Research Needs and Validation of EO Data

To ensure confidence in the accuracy of EO products local calibration and validation is required. This requires both infrastructures, as discussed above, and ongoing research to further develop algorithms that are tuned to local conditions. The following summary points emerged from the discussion.

- A 'must have' is the access to the sufficient data for calibration and validation. Capacity building is necessary to ensure in situ instrumentation is calibrated and well maintained.
- Various algorithms, detection of change, trends and AI/ML methods are being developed for the improvement of the products.
- Questions such as do individual nation states have sufficient coverage of the coastal zones, EEZ's and ABNJ, bathymetry data need to be addressed.
- SAR (oil spills, ship detection, IUU) do not have sufficient SAR coverage that covers entire zones of Australia, and it is the same for other nations.

- For data fusion, there is opportunity for greater integration of observations from geostationary satellites. The best way to integrate the data from multiple optical observations should be identified to eliminate the problems like cloud cover.
- Development of joint projects, common protocols, algorithms and sharing of practice to harmonise the methods from one nation state to another is necessary. BIMSTEC and DE Africa are open-source examples that are highly relevant.
- Use of aerial and underwater drones can also build a platform to collect high resolution data. Some countries are more advanced in terms of modelling. The combination of EO and modelling will make a reliable solution.

3 A Plan of Action for developing an Indian Ocean Earth Observation Platform

3.1 Take-outs from the Workshop

This workshop started a conversation between IORA Member States and EO providers on how to collectively harness the capabilities of satellite-derived information to provide relevant and timely information that assists policymakers, practitioners, and scientists working towards a sustainable Blue Economy.

The workshop endorsed the utility of EO and noted that continued development of satellite coverage and capability were providing greater access to imagery and data – often at substantially lower, or at no cost. There was limited awareness of some of the newer satellite capabilities or missions or technologies and initiatives such that will enable more efficient processing and access to analysis ready data (ARD). New technologies such as SAR are s potential gamechanger in being able to provide a number of new capabilities essential to the blue economy for coastal habitat mapping, coastal and ocean infrastructure surveillance, maritime disasters and surveillance of shipping and fishing fleets.

Many national representatives expressed a growing need for access to EO data, for performing their core business. It was noted that for some applications the spatial resolution of publicly accessible imagery was still too coarse, and while commercial imagery has the necessary resolution, the cost of acquisition can be prohibitive. What has significantly changed in the last few years is the advent of regional EO data analytic hubs that are significantly changing the infrastructure, training, and capacity needs in the IOR. No longer is it necessary for countries or organisations to have satellite receiving stations; rather access to satellite data over a range of levels can be accessed from data hubs and this opening access to EO products and services and lower the entry level such that they are no longer the domains of specialists.

The workshop developed a richer understanding of the needs and products for each of the 7 thematic area addressed by the workshop (see section 2) and identified priorities and actions to address the challenges identified. Based on these discussions it is clear there are already a range of activities and EO-related infrastructure projects underway in the IOR and that there is a considerable overlap in priority thematic areas of interest for Member States. MSP and habitat mapping were the two themes accounting for the greatest regional interest amongst participants.

To address ABNJ issues, preparing for and responding to natural and maritime disasters, and to collectively address the pervasive spread of marine litter into and across the Indian Ocean at the source, greater regional cooperation will be required.

Overcoming technical, capability and capacity challenges is the key to implementing enhanced EO capabilities for the IOR.

- To fully benefit from EO important telecommunications infrastructure challenges (internet speed and reliability) need to be addressed. While there will be a significant improvement in telecommunications infrastructure over coming years, sharing data across their more remote geographies, will be remain an issue.
- While there is a wide range of mapping and GIS tools and products, there is a lack of standardization, and as a result, there are significant issues of interoperability
- Training and capacity needs are changing with more focus on training a greater number of users with different levels of expertise to access and use the available products and services. Capacity needs will increasingly be in areas of expertise relevant to using cloud-computing resources and analysis ready data – such as skills in software and computing.
- A key challenge is the need for regional and local validation of these products and services to provide confidence in their accuracy but here there is potential for strong partnerships to be formed (with the right training).

Commonalties in the needs of member states for EO-related infrastructure, as well as methods and guidance on how to translate EO data into decision making products also suggest benefits could be realised from further cooperation and collaboration through IORA.

There are strong opportunities for member states to share and to learn from each other. A salient example was Tanzania seeking to operationalise potential fishing zone forecasts for its small-scale community and for surveilling IUU activities. The experiences of both India and Indonesia in developing such operational systems could be assist Tanzania and could be achieved through a variety of mechanisms including exchanges, training provided access to established workflows and protocols.

The need for enduring capacity building was highlighted by several participants. While there is a great desire amongst the global community – and countries with a strategic interest in the region – to assist in the provision of EO data, infrastructure, and capacity, it should also be recognized that there is good capability amongst IORA members with strong regional centres of expertise.

It should also be recognised that the needs, capacities and capabilities across IORA Member States are diverse, and not evenly distributed. In particular, Small Island States will have different needs from coastal member states and regionally the western, northern, and eastern Indian Ocean also have different priorities, needs and capacities.

In summary, the benefits of using EO technology as an operational support tool for planning, implementation, and monitoring of BE in the IOR are clear. However, effective use requires both training and capacity building enable by cooperation amongst IORA partners and the broader EO provider community. Going forward, better communication channels that inform member states of relevant EO developments, and how to access EO data and expertise are required to build government capacity to understand and apply the technology top address their specific needs. Other capacity issues raised at the meeting include how to improve career paths in EO in the region so ensure retention of staff, the potential to maintain a regional cadre of EO experts – as not all states can afford to engage full time with an EO expert.

3.2 Developing an EO Plan of Action for the Indian Ocean

Consideration of the above suggests that any cooperation or collaboration framework will need to be adaptive, flexible, and modular - rather than a 'one size fits all' solution. Activities that emerged as priorities at the workshop include the need for training and capacity building, developing specific products to support different aspect of the blue economy and making them available to IORA member states, and in country validation to ensure accuracy of the satellite products.

Given these needs, and the fact that are several regional data-hubs that already cover much of the IOR, it is recommended a 'lighter touch' approach focusing on coordination and building and cooperation amongst member states and training and capacity development is adopted. that seeking to implement a singular EO platform. Such a coordination framework which offers a baseline level of best practice, as well as access to infrastructure and resources based on need, and encourages the documentation and open sharing of best practice could be of great benefit to the IOR and member states.

To effectively move beyond the strong support expressed at the workshop for greater access to current and emerging EO products and services it is recommended that a Plan of Action (PoA) should be developed which identifies the broad steps that could be taken that would build the required EO infrastructure, capability, cooperation and collaboration across IORA member states.

While the workshop focused on several blue economy themes, a broader consideration of IORA's EO needs in other priority areas (e.g., fisheries, DRM) might also be considered. The IORA Working Group on Science, Technology, and Innovation (WGSTI) might be the best placed to lead this process, with the IORA Secretariat playing a key role in ensuring a robust, outcome-oriented process is followed.

In developing a PoA the following elements should be developed ideally by a cross sectional group of EO experts and end-users and based on foundational principles that are based on equitable access to trusted and actionable information.

1. **Present a Vision** for what cooperation and coordination across IORA Member States might look like. This should invoke a shared and inspirational vision of an idealistic outcome for the region for IORA to aspire to.
2. **Identify Objectives** for that cooperation and coordination, including addressing how to support the adoption and implementation of best practice via a common baseline knowledge, methods, guidance, infrastructure, capacity, and resources to support optimal outcomes across IORA Member States and the Indian Ocean as a whole.
3. **Gather Information** including from comparable efforts globally (even if these are not oceans-related) as well as from across IORA Member States. This 'inventory of activities' should seek to identify best practice, and potential resources which could help enable the next steps. This information gathering should include a set of suggested next steps for IORA Leadership to consider.

4. **Seek Consensus within IORA Leadership** based on the vision, objectives, information gathered, and first steps identified, and based on that consensus develop a Strategy and Implementation Plan to take forward.

5. **Consultation and Engagement:** Potential partners include: the French government and CNES, who have indicated a strong interest in working in the region, particularly under their Space Climate Observatory (SCO) initiative and offer support through existing capabilities in French territories and institutions.

6. **Undertake a functional EO needs analysis:** While this workshop has broadly identified some of the needs for a blue economy a formal needs analysis, that builds from engagement with technical and policy users across the region a functional specification for EO products, training and infrastructure is needed.

7. **Review and Analysis of Needs:** As table 3 summarises there are several current or proposed initiatives being proposed for the Indian Ocean Region. A thorough review of these initiatives and in consultation with their proponents will be required to identify synergies.

8. **Demonstration Project**: A 'Phase-0' demonstration project has been suggested to showcase what can be undertaken, learn about user needs and specific functionalities. This will also build collaborations between stakeholders and gain valuable practical experience. Agreement on the nature and scope of the demonstration will need to be brokered and modest levels of resourcing secured.

The PoA should be also look at opportunities to developing supportive policy frameworks across the IOR that embed legislation, funding, and activities to harness EO applications. The PoA should be informed at the policy level by various UN initiatives including, the *2030 Agenda for Sustainable Development*, the *Sendai Framework for Disaster Risk Reduction*, *the Paris Agreement*, and the *Convention for Biological Diversity* and the *End Plastic Waste, which* collectively constitute a new integrated global development agenda, and will play a key role in shaping the world well beyond 2030. The *UN Oceans Decade* is as a catalyst for further dialogue engagement and implementation.

In developing a PoA for the IOR there are several regional examples (summarised in Table 4) of other EO platforms that could be reviewed, and discussions held with key personnel to glean lesson learnt of approaches that have been implemented. The Global Forest Observation Initiative (GFOI), explained in more detailed in textbox 6, provides a comparable analogue of what an IORA EO Platform might seek to achieve.

Barriers to effective data sharing, management, storage, and usage in the region are complex. Understanding issues around data sensitivities as well as current limitations for effective use of data can help provide solutions and enhance applications. To improve metadata quality and, hence, increase dataset usage, open source standards such as the FAIR principles, which emphasize the importance of including information on the provenance of the datasets and their quality in the metadata, using standard vocabularies (Textbox 7). Longer term a data sharing policy and data standardisation protocols for how data are collected and received may need to be developed for the region.

Table 4. Examples of relevant Regional EO initiatives.

iAtlantic (iatlantic.eu)

iAtlantic aims to deliver knowledge that is critical for responsible and sustainable management of Atlantic Ocean resources in an era of unprecedented global change. IiAtlantic is undertaking an ocean-wide approach to understanding the factors that control the distribution, stability and vulnerability of deep-sea ecosystems including the resilience of deep-sea animals – and their habitats – to threats such as temperature rise, pollution and human activities. Work spans the full scale of the Atlantic basin, from Argentina in the south to Iceland in the north, and from the east coasts of USA and Brazil to the western margins of Europe and Africa. Central to the project's success is the international collaboration between scientists throughout the Atlantic region, with sharing of expertise, equipment, infrastructure, data and personnel at the forefront of iAtlantic's approach. The spatial extent, and cultural diversity across the Atlantic Ocean is comparable to the Indian Ocean, and so the suggestion is that their approach to collaboration might offer lessons for the development of a similar international collaboration for the IORA regions and Member States.

Digital Earth Pacific (www.spc.int/DigitalEarthPacific)

DE Pacific is planned to be a regional, public good, operational data infrastructure that enable access to current and historical, analysis-ready satellite data for the Western Pacific nations. DE Pacific uses Open Data Cube technology to turn raw data into decision-ready products to inform policy and drive action at community, national and regional levels. The first phase of DE Pacific commenced in 2021 and included (1) an outreach campaign to understand needs and priorities of Pacific Island Countries and Territories on the use of EO data to address national development priorities and sustainable development ; (2) the preparation of a business case articulating the broader needs for developing a DE Pacific programme and (c) a prototype to develop a minimum viable product (MVP) demonstrates the core functionality and data of an operational DE Pacific infrastructure. Phase II commenced in 2022 and focuses on building the ongoing sustainable infrastructure for the Open Data Cube, while also establishing the institutional governance to properly host the program. The phases and steps undertaken by DE Pacific provide guidance on implementing and Indian Ocean Earth Observation Plan of Action.

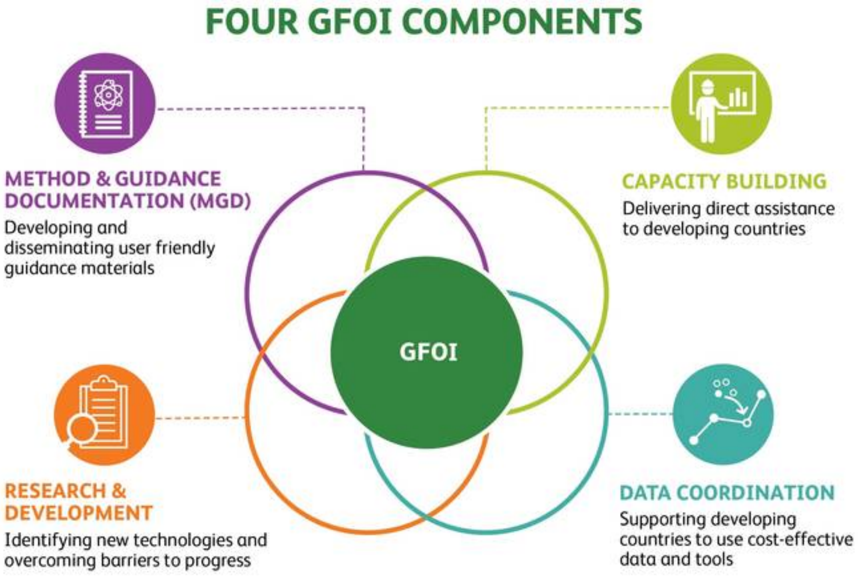
Digital Earth Africa (digitalearthafrica.org)

DE Africa – presented during the workshop – is a good example of a fully operational platform providing free and open access to continental scale data and processing to deliver decision-ready products enabling policy makers, scientists, the private sector and civil society to address social, environmental and economic changes on the continent and develop an ecosystem for innovation across sectors. In addition to being directly relevant for African IORA Member States, its model of the provision of a basic and shared level of common infrastructure, coupled with an investment in fostering end user ownership of the platform and the sharing of capacity and methods all represent opportunities to inform and enable an IORA cooperation and coordination framework.

Textbox 6. The Global Forest Observation Initiative (GFOI, fao.org/gfoi/en)

GFOI is *an informal partnership to help coordinate international support to developing countries on forest monitoring and greenhouse gas (GHG) accounting for REDD+ and related activities.*

GFOI is organised around four key components each of which could be mapped to the needs articulated during this workshop. In particular, GFOI's Methods and Guidance component has developed the REDD Compass (reddcompass.org/home) to provide a set of best practices for monitoring, looking at the institutional, technical, data sources and processing, integration, and reporting and verification. Comparable sets of guidance could be valuable across a number of the topics discussed at the workshop, with one example discussed being the ISWA Plastic Pollution Calculator (plasticpollution.leeds.ac.uk/toolkits/calculator).



Textbox 7. Principles underpinning an EO PoA for IORA

Accessible: provides open access to satellite imagery and data, raw and pre-processed or and customized products tailored to identified needs.

Equitable: Provide a level playing field that enables spatial literacy as well as access to data, imagery and information for all, and in forms that support relevant and national, regional global policy contexts and priorities.

Trusted: To ensure the accuracy of data and products validation with in situ data will be required; again there are a number of extant initiatives and capacity to provide this data. Quicker analysis through simpler analysis through predictable and standardised access to EO data and faster (lower latency) data analysis.

Actionable: provides information in formats that inform evidence-based decision-making.

Inclusiveness: To ensure the long-term sustainability and use, IORA representatives should be involved from the start of the design, capacity development and establishment phases of the platform, as well as decision making on the functionality and day-to-day operation of the platform once established.

3.3 Recommendations and Short-term Actions from Workshop

Short term actions which IORA could consider following this workshop to build engagement and consensus around the next steps include:

Raising Awareness of EO in the IOR with Partners

1. Present the results of the workshop to IORA Member States sharing the main conclusions, and focusing on the areas of overlap and complementarity, to build support for the next steps.
2. Present the results of the workshop at regional forums within the IOR and its sub-regions, and to other international coordination and funding forums.
3. Establish a small team to further develop the PoA starting with the scoping of the vision and objectives for an IORA EO cooperation and coordination framework, as well an inventory of current and planned activities across IORA Member States which could be leveraged as the basis of such a framework.

Training, Capacity Building and Data sharing

4. Undertake a review of existing EO training programs and refine training and capacity building needs for the IOR. Look to deliver a range of training for all aspects of EO through multiple platforms, including video and online resources.
5. Increase formal and informal collaboration between member states by establishing a key contact point within each nation and convene an EO technical user's forum.
6. Fostering opportunities for IORA member states with mature EO operational capacities in different blue economy sectors to assist those member states that are seeking to develop similar capabilities.
7. Conduct a data mapping exercise, identifying data relevant to research priorities in the IOR including location, ownership and quality.

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5 Appendices

5.1 Concept note: IORA Indian Ocean Blue Carbon Hub Earth Observation for an Indian Ocean Blue Economy

Background

IORA Member States (MS) have a strong interest in developing their blue economies. Other state actors (including IORA Dialogue Partners) are also seeking to exploit the resources that the Indian Ocean contains, both on the High Seas and in Exclusive Economic Zones. The Indian Ocean is vast (~70.6 million km^2), and infrastructure is relatively limited, so Earth Observation (EO) will be an essential tool to develop solutions to the multiple challenges. Among these challenges include food security, climate change and sustainable use of coastal ecosystems, all of which are faced by IORA Member States. EO is in many instances the only way to obtain information across the spatial extents needed for informed and improved decision-making to address these challenges.

To develop their blue economies, IORA MS would benefit from access to high-quality, up-to-date and comprehensive EO capabilities. Such access provides the information for a range of national environmental planning, mapping and assessment needs (e.g. blue carbon stocks, coral reef condition), as well as reporting obligations, such as on progress towards Paris Agreement and Sustainable Development Goal targets. It would also enhance operational surveillance (e.g. illegal unreported and unregulated fishing, piracy) and forecasting of conditions and hazards (e.g. sea level rise, extreme events, coral bleaching).

Combining EO with modern data processing and big-data analytic technologies, such as cloud-computing, offers unprecedented opportunities to assist with rapid evidence-based decision-making and policy development. Emerging 'remote', cloud-based data archive and processing approaches would significantly reduce the need for very high band-width internet access, which would be a significant benefit for the multiple IORA MS where this is not yet possible. While an increasing amount of EO data is becoming freely available, there remain challenges related to coverage of ocean areas, adequacy of spatial and temporal resolution, different needs of continental and island states, and delivery of data to nations with limited telecommunications infrastructure.

Much EO data available is free but it is often not in a form that can be used by non-experts. In other cases, free EO data may not be of a high enough resolution to be useful, particularly for low-lying small island states. A range of new satellite capabilities (which have increased the spatial, temporal and spectral resolution of EO data), as well as processing and analytical tools (e.g. Data Cubes) and access (free access to archived EO data through bilateral and multilateral arrangements) improve the potential to deliver EO products and services that are useful to IORA Member States.

Australia and France are active in the Indian Ocean on EO data, and each have the capacity to provide access to, and processing and interpretation of, EO data. They and the European Union have previously cooperated in 2018 to host an EO workshop for Pacific Island Nations. In addition, India also has considerable EO capabilities, and improving access to these aligns well with the Indo-Pacific Oceans Initiative, announced in November 2019 by the Indian Prime Minister. The proposed activity is relevant to IORA priority areas of Disaster Risk Management, Blue Economy, Fisheries and Academic, Science and Technology Cooperation, which India leads.

The IORA Indian Ocean Blue Carbon Hub aims to build knowledge and capacity relevant to protecting and restoring blue carbon ecosystems throughout the Indian Ocean, in a way that enhances livelihoods, reduces risks from coastal hazards, and helps mitigate climate change. It supports Australia's involvement in IORA and links it to other initiatives that Australia is fostering, such as the International Partnership for Blue Carbon and the Commonwealth Climate Finance Access Hub. The Hub also complements Australia's leadership in Blue Economy dialogue, especially in IORA. It anticipates that the greatest improvements can be made through improved leadership and development of evidence-based policy.

Proposal

We propose a multi-day virtual workshop to convene representatives from IORA MS and Dialogue Partners to consider the EO data needs in the context of a blue economy. The workshop would focus on how assistance including access, training and development of useful products could be cooperatively delivered. France would be a central partner in delivery of the workshop.

Objectives

The Objectives of the IORA Blue Carbon Hub workshop on 'Earth observation for an Indian Ocean Blue Economy' are:

- Identify the EO data needs of IORA MS
- Identify the actors who have significant EO capability to offer IORA MS
- Identify areas of common interest and expertise between Australia, France and India (as well as Dialogue Partners with significant EO capacity, such as Japan, Korea and the European Union)
- Identify key enabling actions based on common interests of IORA MS and the capacities available
- Develop a roadmap and/or proposals for joint projects to implement the actions (including actions identified in the Blue Economy Working Group Plan)
- Communicate this action plan to high-level fora.

The workshop will deliver an implementation pathway that would include future project collaborations, funding sources for potential partners, country programs and resources that can be leveraged.

Outputs and outcomes

The workshop would focus discussion on the current challenges and impediments with using EO in the Indian Ocean.

The workshop would also take note of the offers to be made by the Dialogue Partners regarding their support on the potential research, training, workshops, seminars, capacity building, technology transfer, funding or by any other means.

The primary outputs would be:

- a set of presentation materials,
- a brief workshop report, and
- a roadmap and/or proposals for actions that can be implemented.

The workshop report would be made freely available through the Hub website.

The outcomes sought are:

- improved awareness of the options available for EO in the Indian Ocean, including the data available, where to get it, and how to use it
- improved capacity in EO in IORA Member States
- enhanced understanding by policymakers and practitioners of how and when to use EO to help make decisions and develop indicators for reporting greater engagement from EO providers in IORA Member States and Dialogue Partners.

These outcomes would be communicated to a number of upcoming high-level meetings, including: the Group of Earth Observation (GEO), the Committee of Earth Observations (CEOS) and the High Level Panel on a Sustainable Ocean Economy.

Milestones

The workshop would fix the deadlines to complete the tasks as decided by the Member States in collaboration with the dialogue partners. An agreed method would be developed to follow up the action plans and trigger the tasks.

Workshop format

We envisage an opening Track 1.5 session for technical and policy representatives from IORA MS and DP, followed by Track 2 sessions for representatives from EO providers (including national space agencies and industry) and other interested end users from IORA MS and multilateral development organisations, regional EO coordination groups (e.g. CEOS, GEO) and other relevant regional organisations (IOTC, IOC, Commonwealth) and industry sectors.

The meeting will:

- Provide information through invited expert speakers
- Provide training modules in the key underlying concepts and approaches
- Convene discussions about potential partners and approaches for local-scale collaboration to undertake following the meeting.

The meeting is proposed to be held online over three (3) days for five (5) hours per day (including breaks) with the following draft headline agenda:

Day 1

1. Plenary openings: (a) Opening Remarks from IORA, Australia, France, and India senior representatives; (b) Invited expert EO opportunities and challenges for EO in the IOR.

2. User Needs for EO: (a) Results of questionnaire; (b) Thematic presentations based on questionnaires and MS nominations

3. Overview of EO Capabilities. Overview of capabilities and services form major providers

Day 2

Thematic breakout sessions. (a) Breakout sessions to review needs, opportunities and challenges relating to the following nominal themes, the final list to be shaped by the questionnaire: Marine spatial planning, Coastal land use and vegetation, Fisheries (including stock management, IUU, and PFZ services), Disaster Risk Reduction, Marine pollution and litter, Environmental and Climate Change.

Reconvene in Plenary: (a) summary presentations of theme discussion results. (b) General Discussion (c) Road Forward (d) Closing ceremony.

Day 3

Bespoke EO Training sessions: inter alia; using Google Earth Engine, Accessing Copernicus data, using datacubes, Mapping Mangroves, Radar for IUU applications.

Further workshop details, including registration instructions, will be provided in a subsequent Administrative Note. Member States and Dialogue Partners are requested to nominate a policy and a technical expert, through their respective National Focal Point, to join the meeting. Because the meeting is online, additional representatives can be accommodated on request.

Host

We propose this meeting to be co-hosted by IORA Blue Carbon Hub (Australia) and the French Embassy in collaboration with the IORA Secretariat.

Contact

For further information please contact the following persons:

IORA Secretariat
Dr Shamimtaz B. Sadally Roomaldawo
Email: shamimtaz.sadally@iora.int
IORA Blue Carbon Hub
Lauren Hardiman
Email: lauren.hardiman@csiro.au

5.2 Workshop Agenda

DAY 3 – 25th November 0500 - 0900 UTC		
04:45	*Training Session opens*	
05.00 – 7.00	Workshop 2: Coastal Vegetation Mapping with GEE REMAP	Nick Murray & Mitch Lyons
06:45	*Plenary session opens*	
07:00	Overview of Day 3 and Recap of Day 2 Housekeeping	Andy Steven
Session 5: From data to decision-making products		*Moderator: Andy Steven*
07.10	EO Capability Building and Training Needs Infrastructure Requirements for accessing EO data Research Needs and Validation of EO Data	Mat Vanderklift (CSIRO, Australia) Sabine Schmidt (EPOC, France) Tim Malthus (CSIRO, Australia)
Session 6: Developing a Plan of Action for better harnessing the potential of EO for IORA		*Moderator: Andy Steven*
08:20	Outline and Discussion of Synthesis Report and Roadmap	Andy Steven & George Dyke
08:45	Discussion, Conclusions, Takeaways and Actions	Discussion (all)
08:55	Final remarks from hosts	Andy Steven
9:00	Close of workshop	

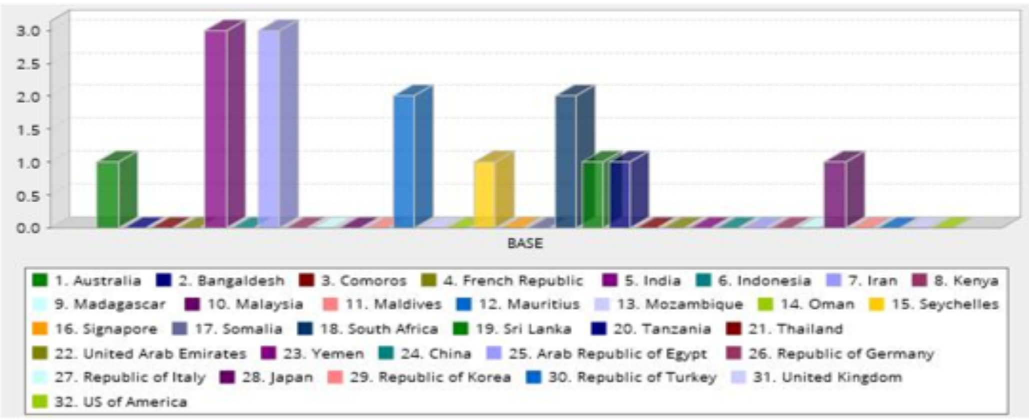
5.3 List of Participants

Organisation	Full Name	Organisation	Full Name
CCCRM (Sri Lanka)	Dammith Rupasinghe	Ministry of Environment (Maldives)	Mahid Abdul Rahman
CMIRE (India)	Anil Kumar Vijayan	Ministry of Environment (Maldives)	Manoharan Sarathanjali
CNES (France)	Eric Brel	Ministry Of Environment, Climate Change and Technology (Maldives)	Ilham Mohamed
CNRS EPOC (France)	Sabine Schmidt	Ministry Of Livestock And Fisheries (Fisheries Division)	Stephen Augustine Lukanga
CPUT (South Africa)	Ken Findlay	MMAF (Indonesia)	Nyoman Radiarta
CPUT (South Africa)	Tainã Loureiro	MMAF (Indonesia)	Novi Adi
CSIRO (Australia)	Paul Branson	MOI (Mauritius)	Eric Martial
CSIRO (Australia)	Joey Crosswell	MOW (Tanzania)	Zaid Tofiki
CSIRO (Australia)	Daniel Gorman	NCCR (India)	Umasankar Panda
CSIRO (Australia)	Britta Denise Hardesty	NCCR (India)	Tune Usha
CSIRO (Australia)	Lauren Hardiman	NMDIS (China)	Yuxi Liu
CSIRO (Australia)	Alex Held	NPARKS (Singapore)	Jeffrey Low
CSIRO (Australia)	Tim Malthus	NPARKS (Singapore)	Rochelle Chan
CSIRO (Australia)	Amy Parker	PMO (Iran)	Reza Bagheri
CSIRO (Australia)	Andy Steven	PMO (Iran)	Roya Emam
CSIRO (Australia)	George Dyke	PMO (Iran)	Sahar Mokhtari
CSIRO (Australia)	Riza Singh	PMO (Iran)	Rasoul Ghanbari Maman
CSIRO O&A (Australia)	David Blondeau-Patissier	President's Office (Zanzibar)	Chiengere Mkama
CSMZAE (Mauritius)	Arshad Rawat	President's Office (Zanzibar)	Erasto Mtai
Curtin University (Australia)	David Antoine	President's Office (Zanzibar)	Mahfoudh Soud

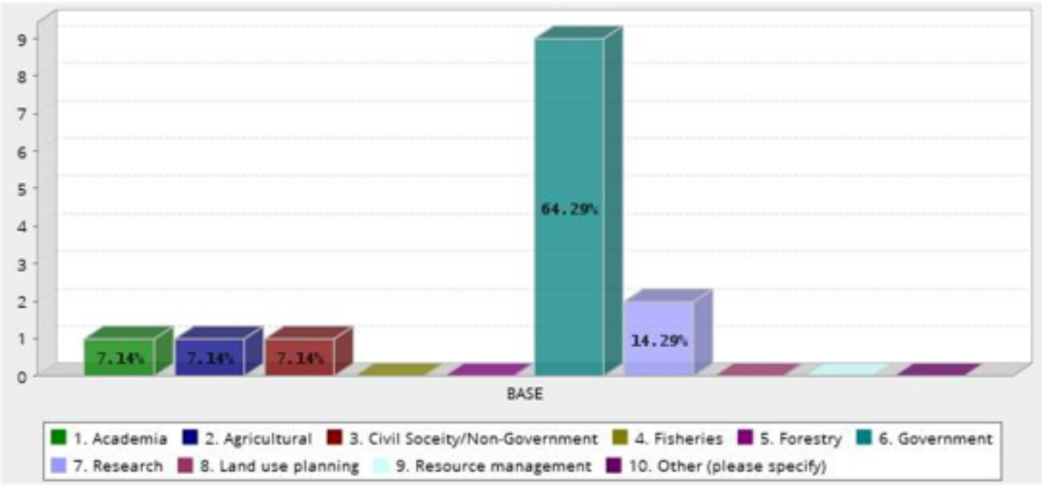
DE Africa (Australia)	Cedric Jorand	SAEON (Zanzibar)	Nicole Du Plessis
DE Africa (Australia)	Adam Lewis	SAMSA (South Africa)	Malibongwe Ndlozi
Department Of Blue Economy (Seychelles)	Elna Etienne	TAFIRI (Tanzania)	Ismael Kimirei
Department of Oceanography and Marine Geology, Sri Lanka	Terney Pradeep	Tanzania Navy (Tanzania)	Adam Richard
Department Of Science And Innovation, (South Africa)	Fhumulani Ramukhwatho	Tarbiat Modares University (Iran)	Habibollah Younesi
DFAT (Australia)	Dalin Hamilton	Tarbiat Modares University (Iran)	Mehdi Ghodrati Shojaei
DFFE (South Africa)	Marjolaine Krug	The Commonwealth Secretariat (UK)	Jeff Ardron
DOM (Sri Lanka)	Sachith Wickramasuriya	The Department of Blue Economy (Seychelles)	Kim Samy
ESCAP (Thailand)	Janet Salem	The Nature Conservancy (Australia)	Helena Sims
GEO (Switzerland)	Douglas Cripe	TPDF (Tanzania)	Justine Killenga
INCOIS (India)	Srinivasa Rao Neerukattu	Udayana University (Indonesia)	I Gede Hendrawan
INCOIS (India)	Srinivasa Kumar Tummala	University of Queensland (Australia)	Mitchell Lyons
INCOIS (India)	Alakes Samanta	WMO (Switzerland)	Jean-baptiste Migraine
INCOIS (India)	Mahendra Rs		Piers Dunstan
IORA (Mauritius)	Gatot Gunawan		Andreas A. Hutahaean
IWM (Bangladesh)	Md. Zahirul Haque Khan		Em Muirhead
JCU (Australia)	Nicholas Murray		Ramchurn Seenauth
LAPAN-BRIN (Indonesia)	Syarif Budhiman		Torsten Thiele
MFAEAC (South Africa)	Miriam Ntuah		Joseph Tuyishimire
MFAEAC (South Africa)	Hamida Juma		Mat Vanderklift
MFARIIT (Mauritius)	Krishnaveni Nagen		Mizna Waheed
Ministry Of Agricultural & Fisheries and Water Resources	Ali Al Shehhi		Mark Wilson
Ministry Of Blue Economy, Marine Resources, Fisheries And Shipping (Mauritius)	Degambur Dharmendra		Pierre Yves LaTraon
Ministry of Defence (Sri Lanka)	Mayuri Perera		

5.4 Results of Pre-Workshop Survey Questionnaire

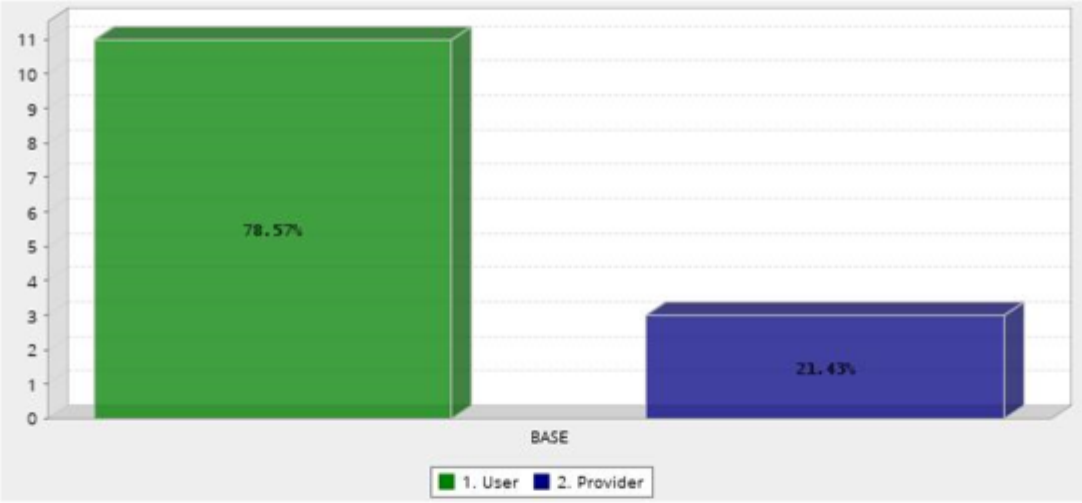
Which country, state or nation do you represent?



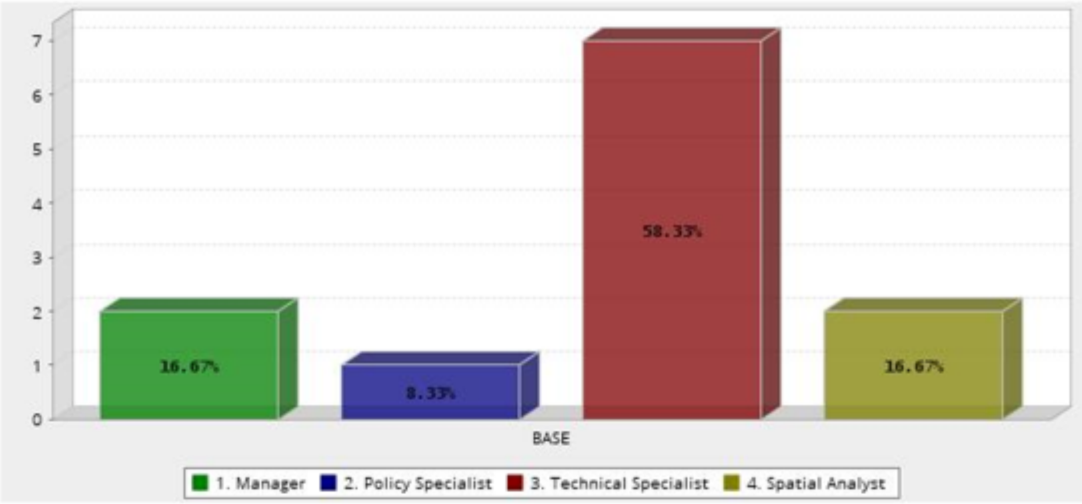
What is your industry sector?



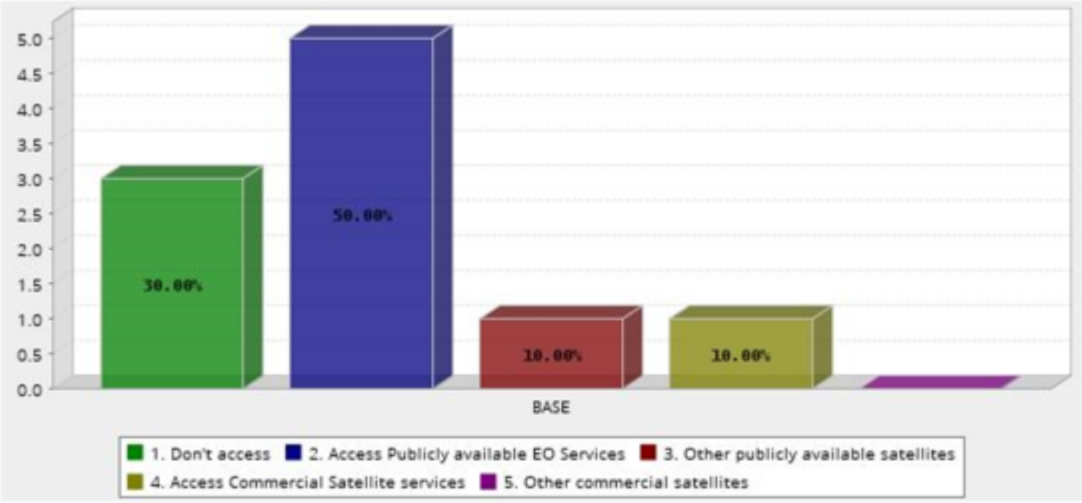
Is your organisation a provider or user of Earth Observation data, technologies or services?



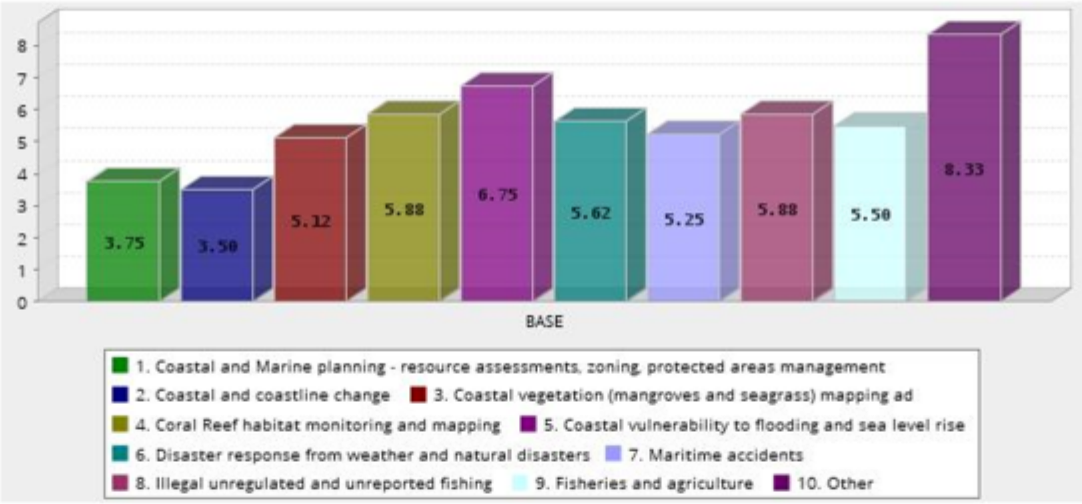
What is your role in your organisation?



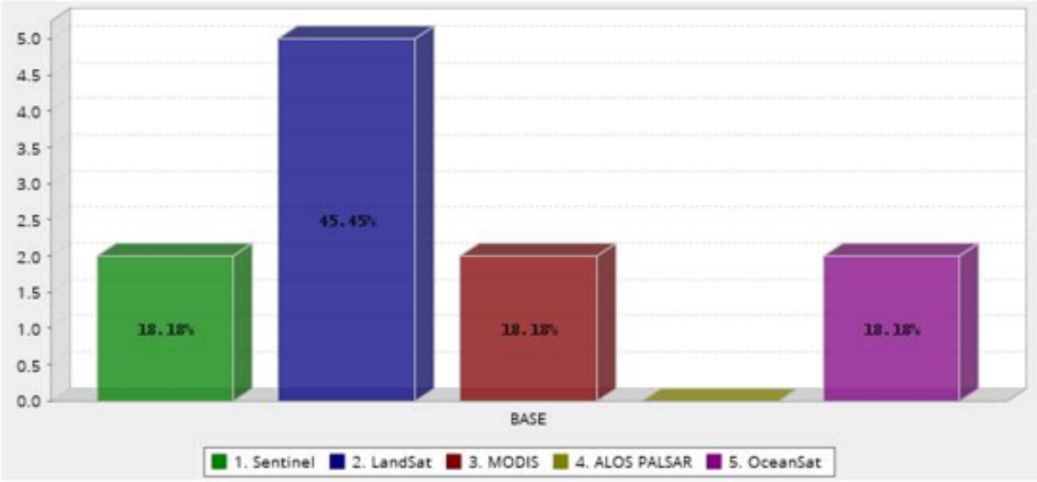
Does your country access EO data, products and services in relation to these themes below? If so which ones?



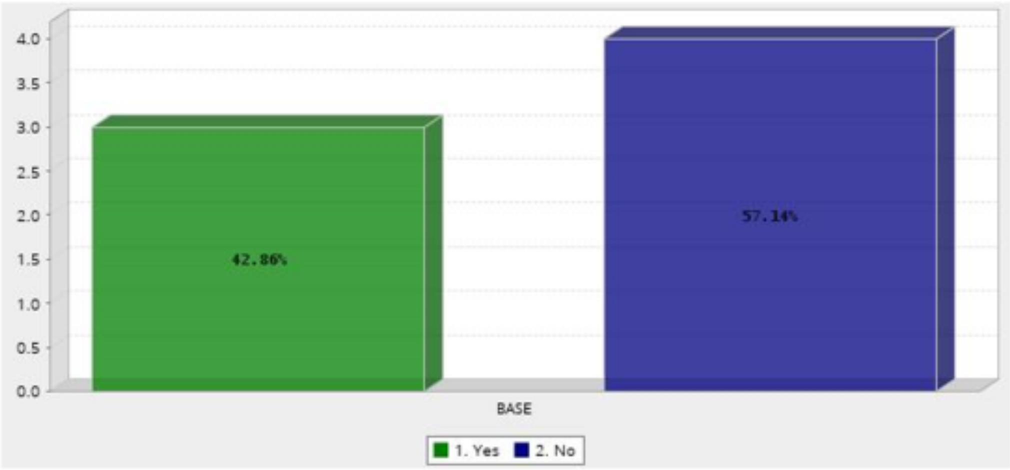
Rank the following Coastal and Marine Earth Observation use themes on their importance to you (1 being the most important)



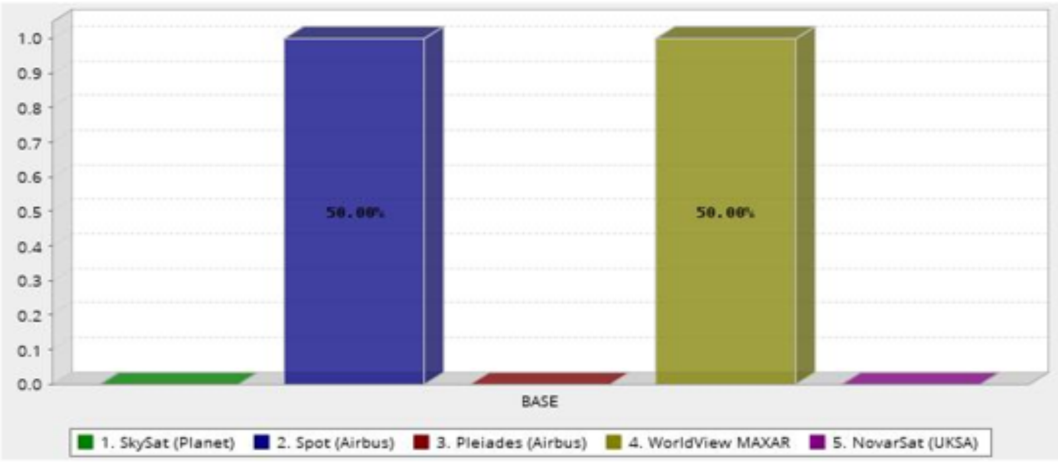
If you selected Access Publicly available EO Services, please tick the following you access



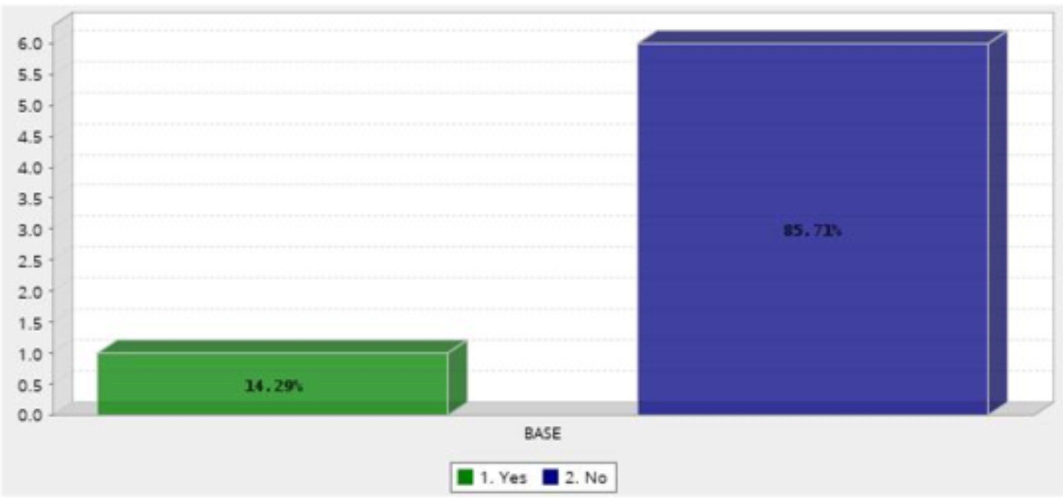
Does your workplace employ EO specialists?



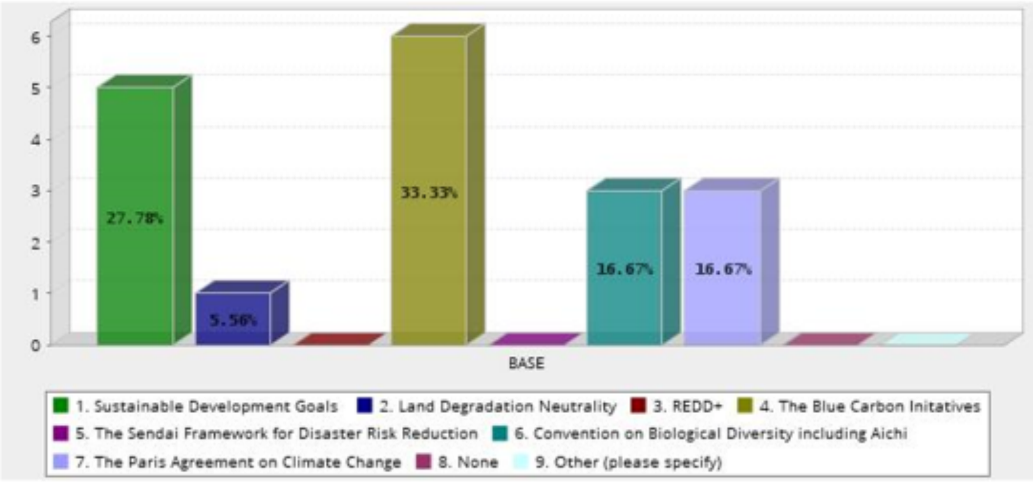
If you selected Access Commercial Satellite services, please tick the following you access



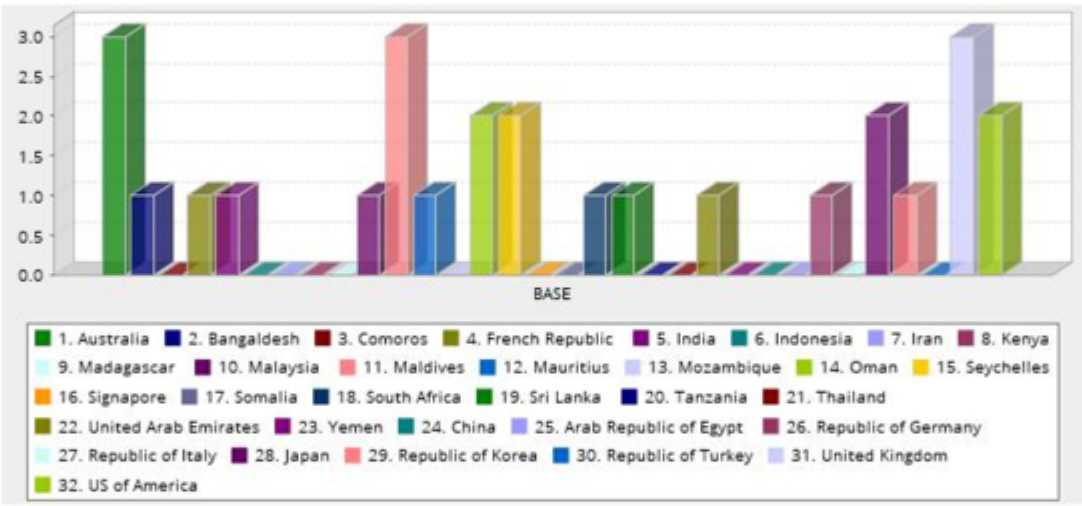
Does your workplace provide training in the interpretation of EO data?



For which global initiatives will you use, or do you want to use Earth Observation technologies?



Which other countries, states or nations do you think most close shares your environmental concerns and Earth Observation needs?



Rate your current capacity to use Earth Observation data, technologies or services in relation to the following:

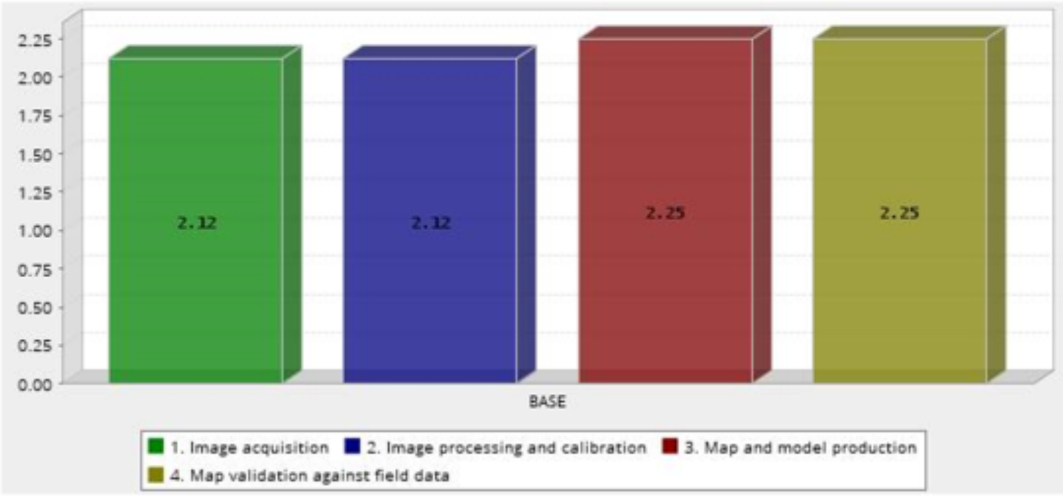


Image acquisition

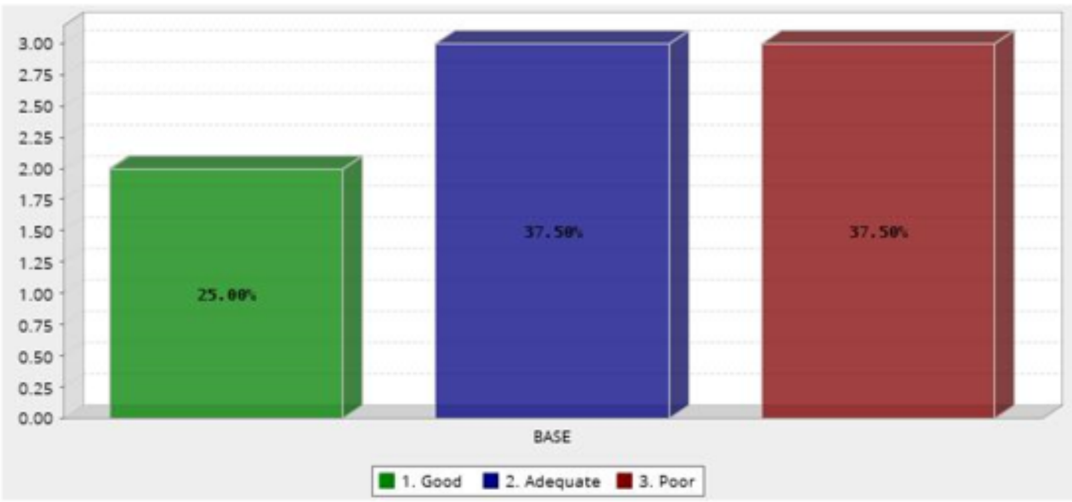
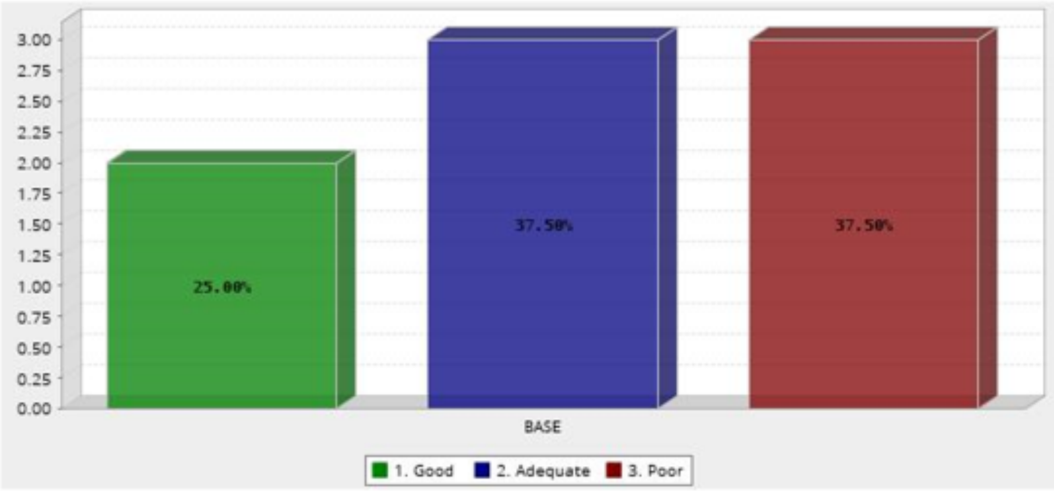
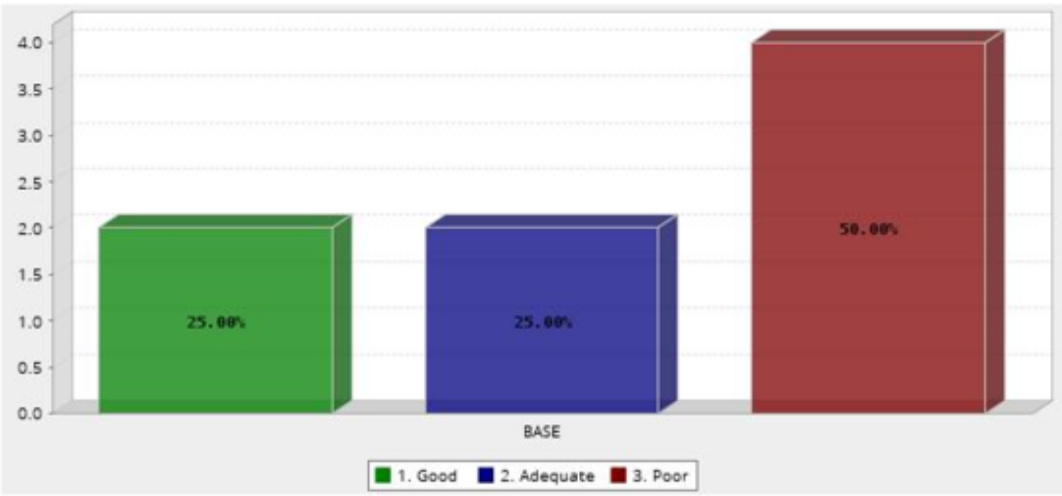


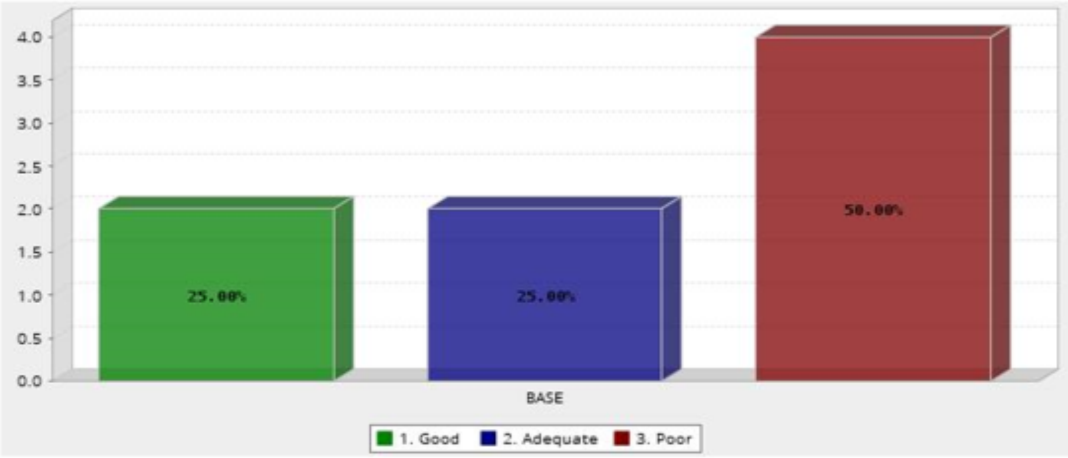
Image processing and calibration



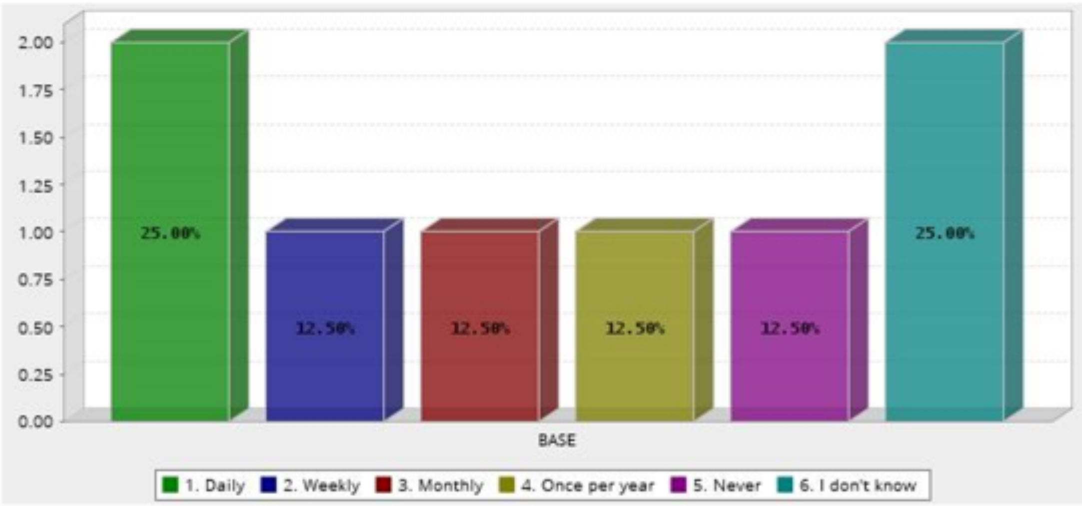
Map and model production



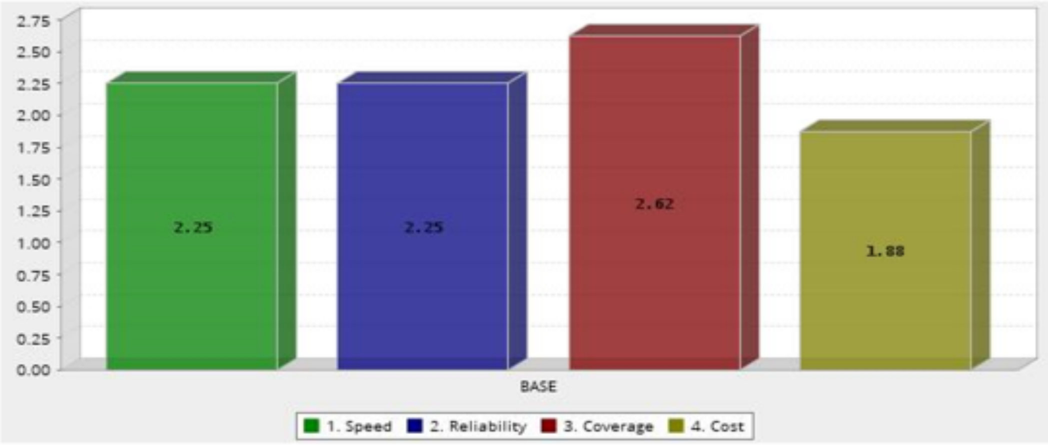
Map validation against field data



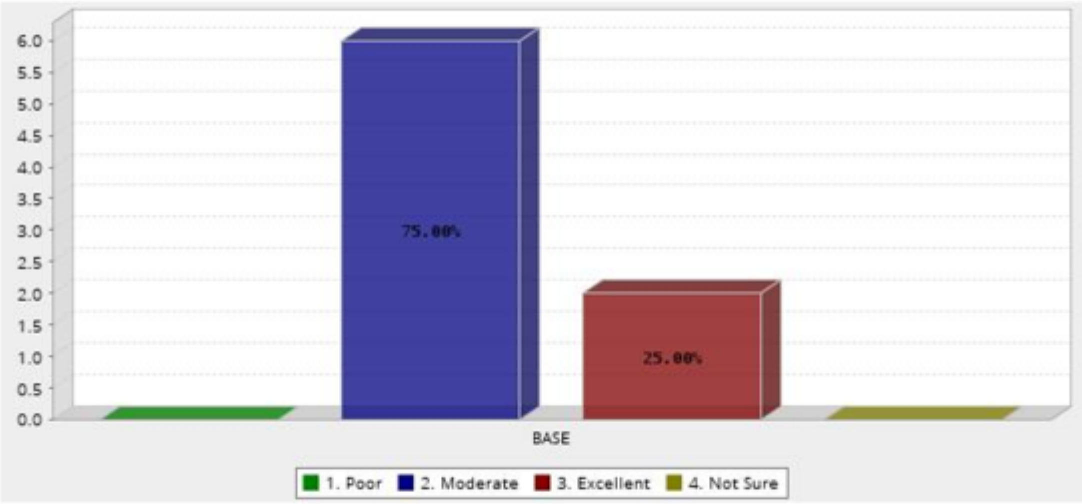
How often do you use or intend to use the EO data?



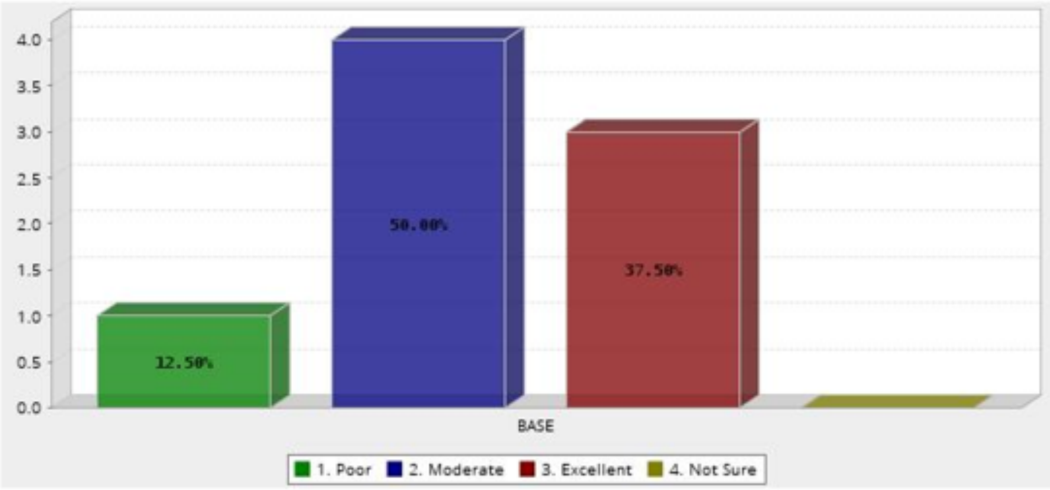
How good is the internet access in your country, state or nation?



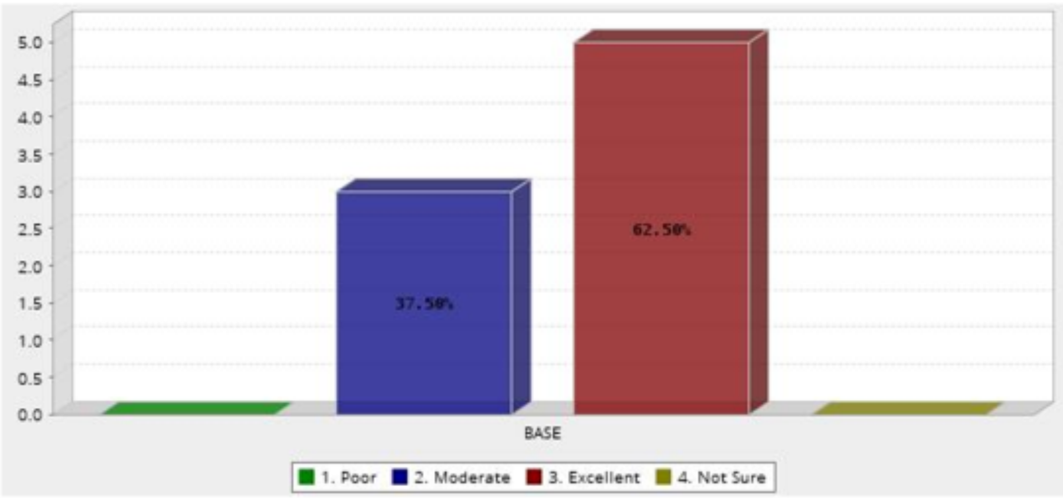
Speed



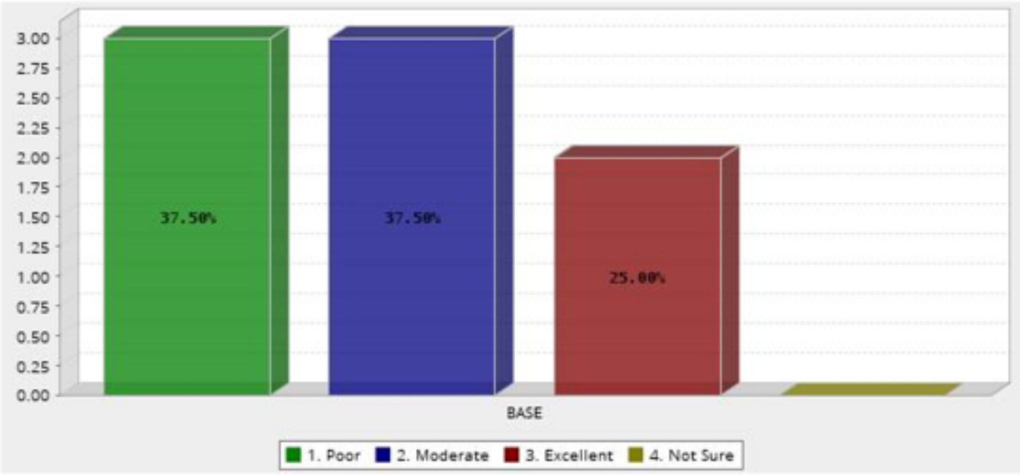
Reliability



Coverage



Cost



Rate your current costs to access to Earth Observation data, technologies or services

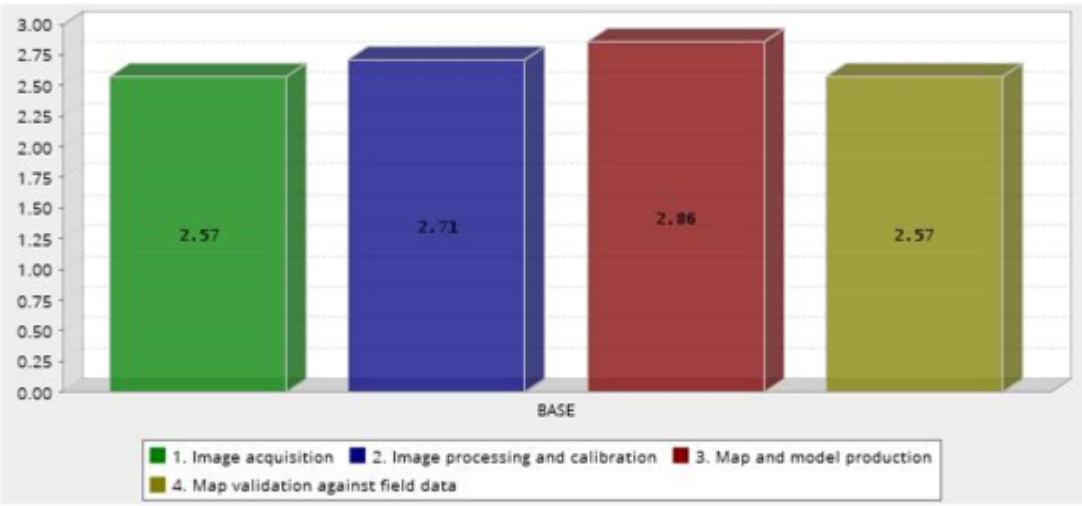


Image acquisition

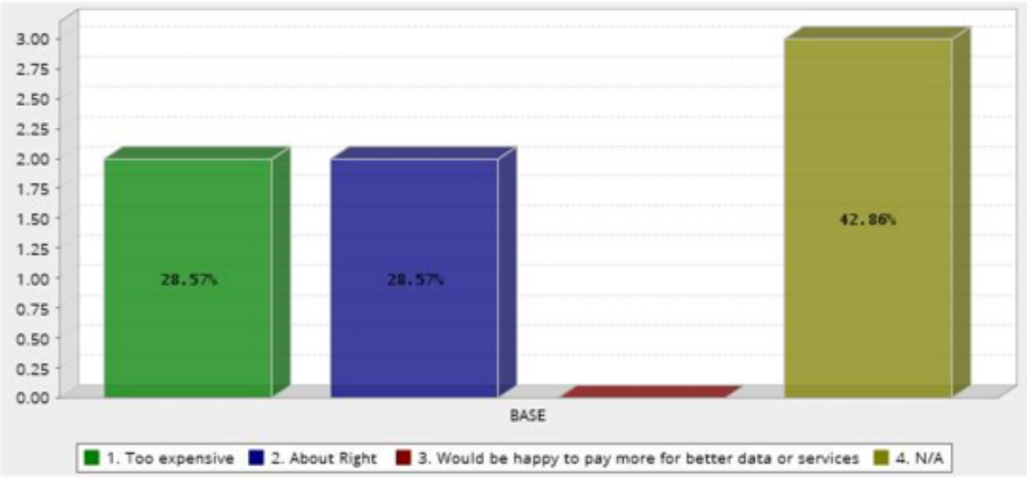
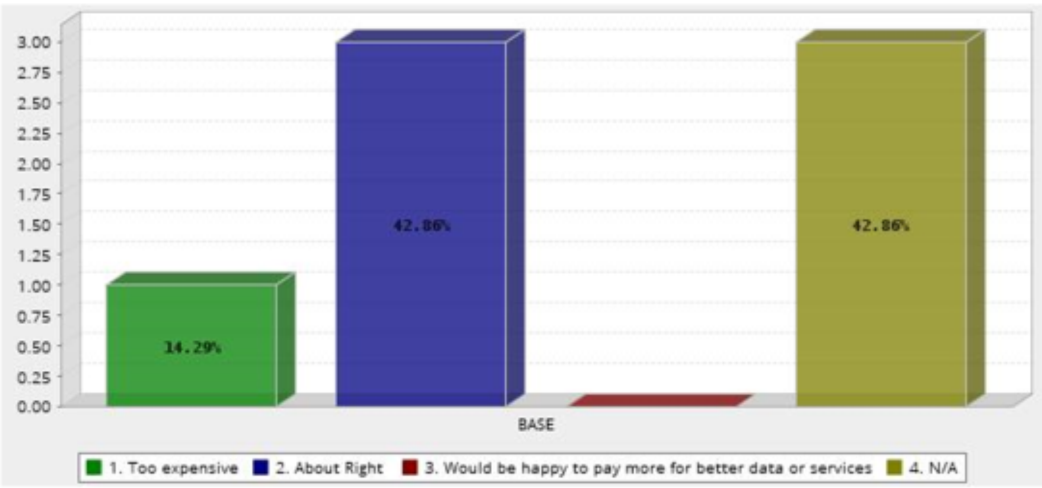
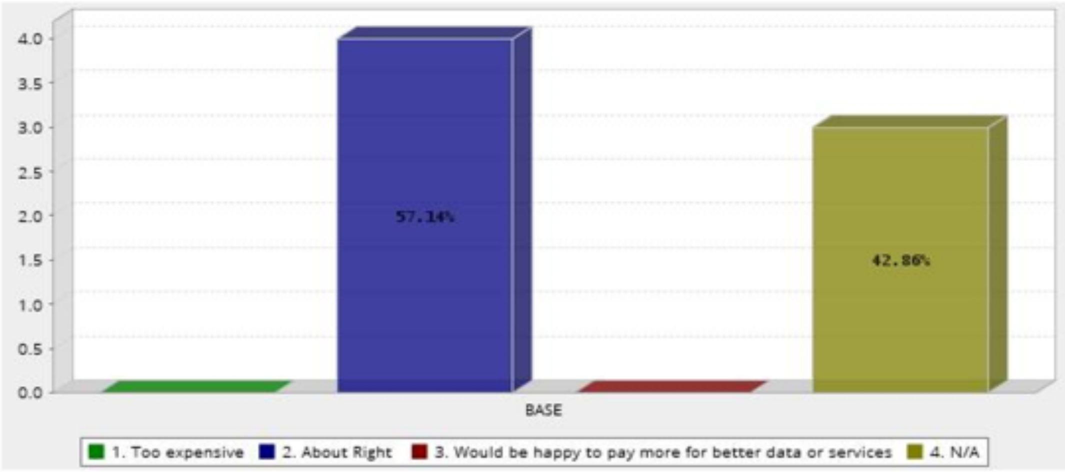


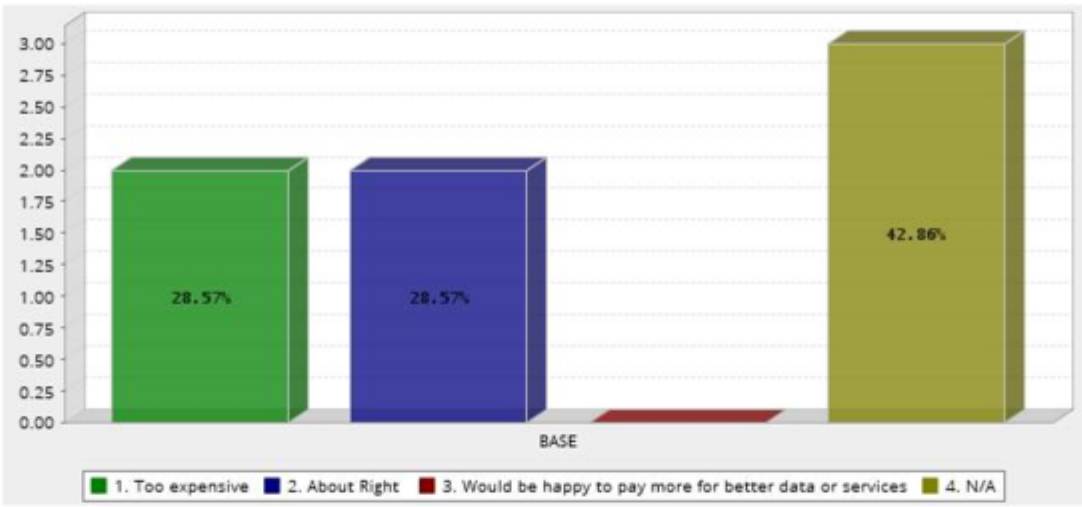
Image processing and calibration



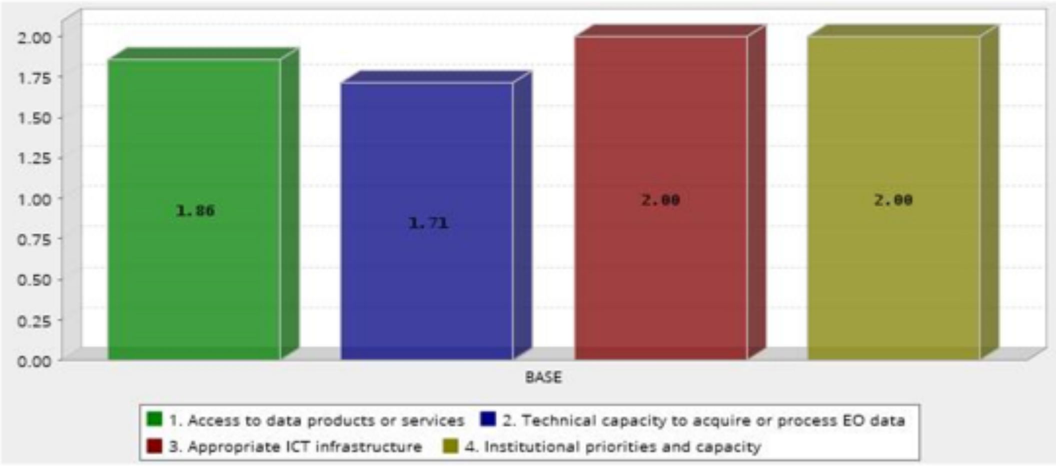
Map and model production



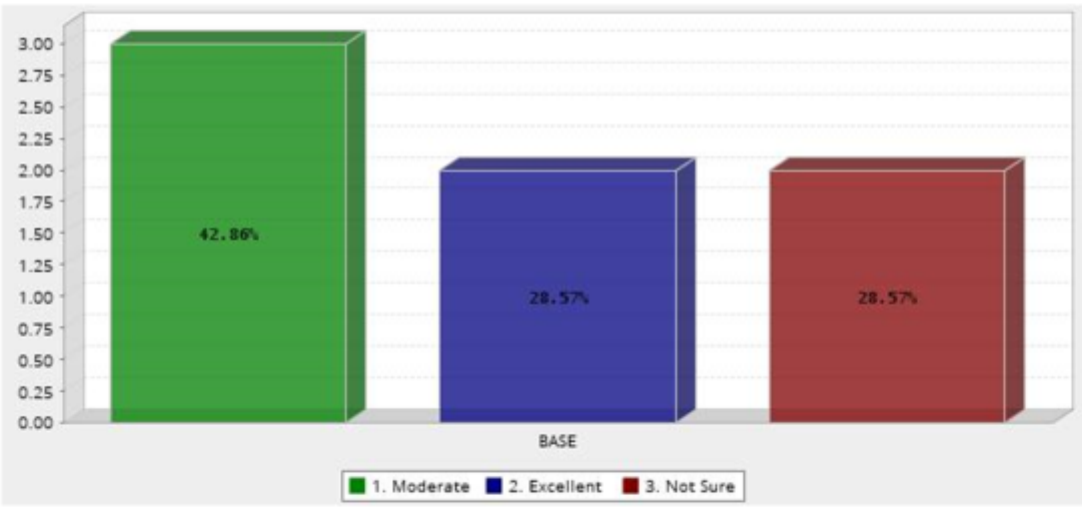
Map validation against field data



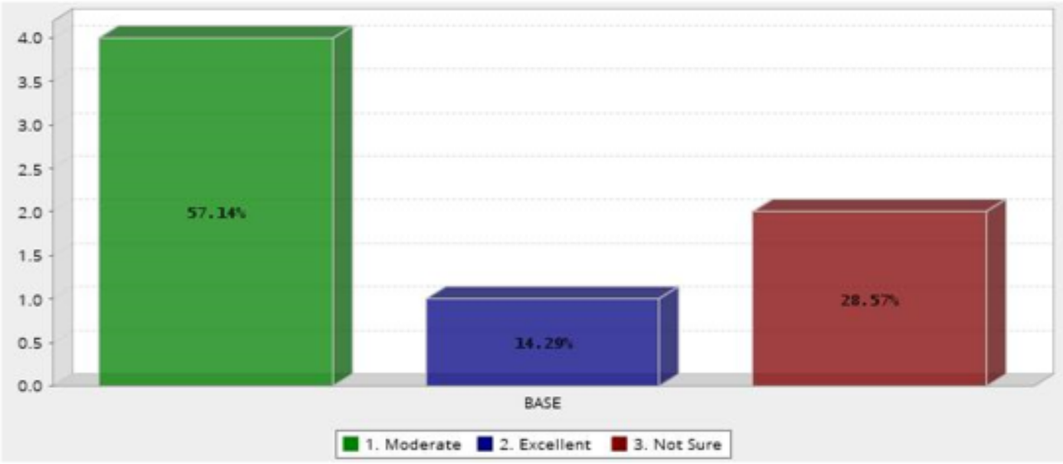
Rank the following potential constraints to your use of access Earth Observations data and services in your organisation or country



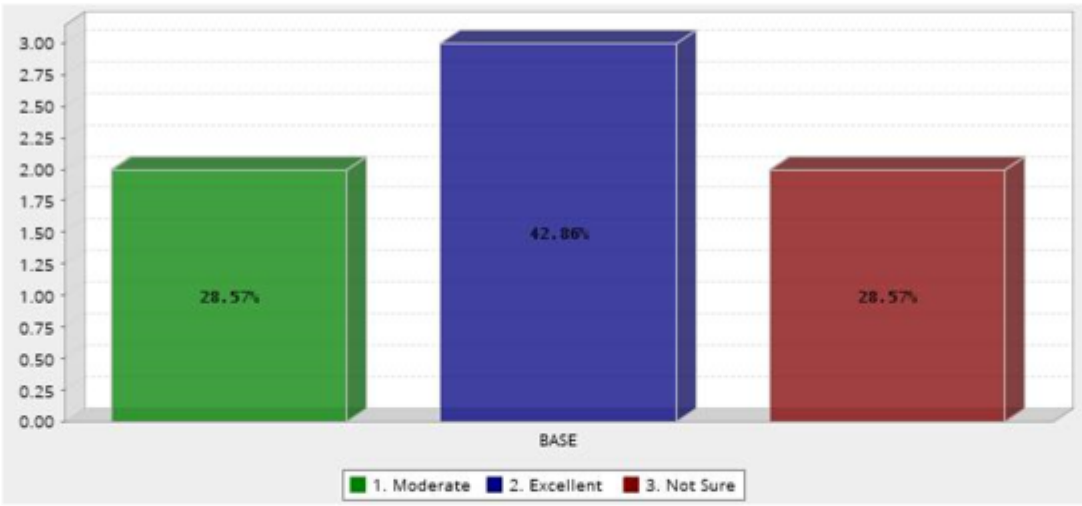
Access to data products or services



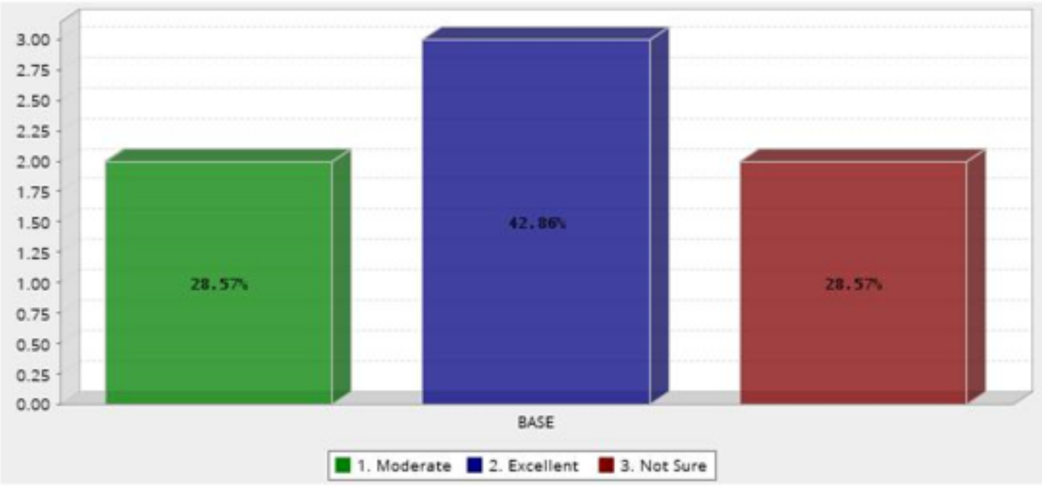
Technical capacity to acquire or process EO data



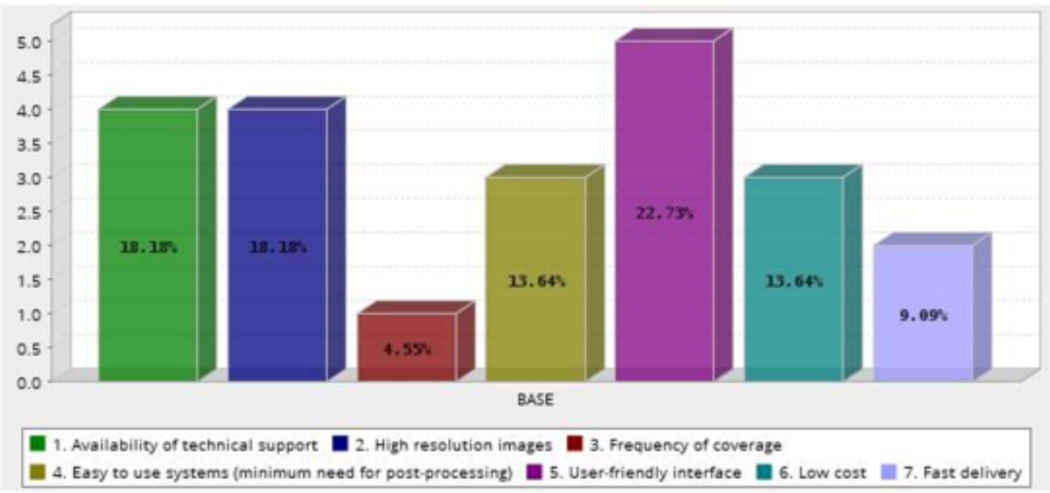
Appropriate ICT infrastructure



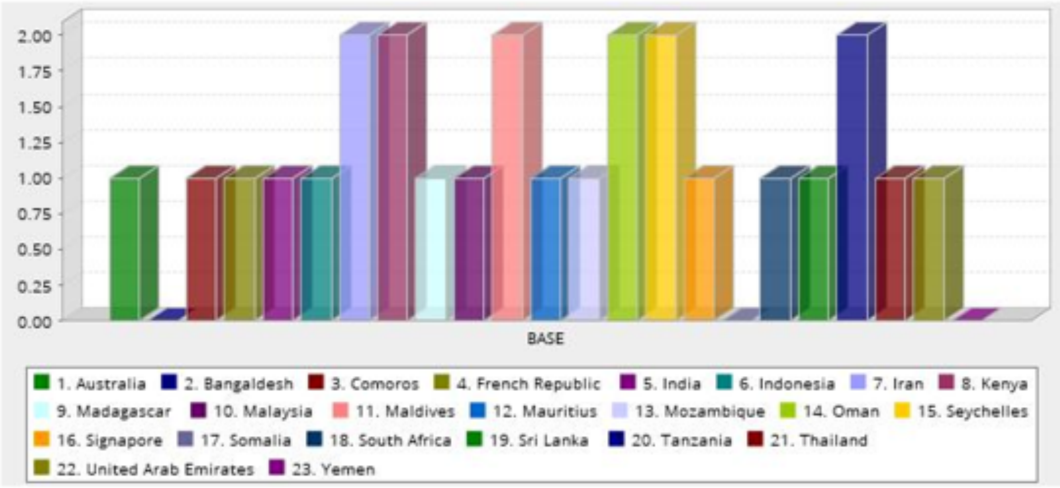
Institutional priorities and capacity



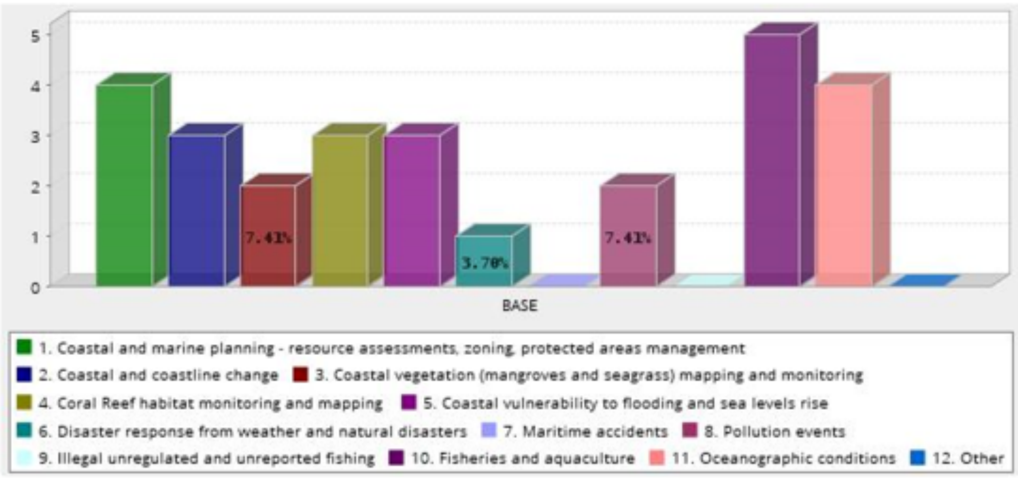
What are your user needs/expectations from EO data providers?



Which IORA countries do you currently provide EO data or services for?

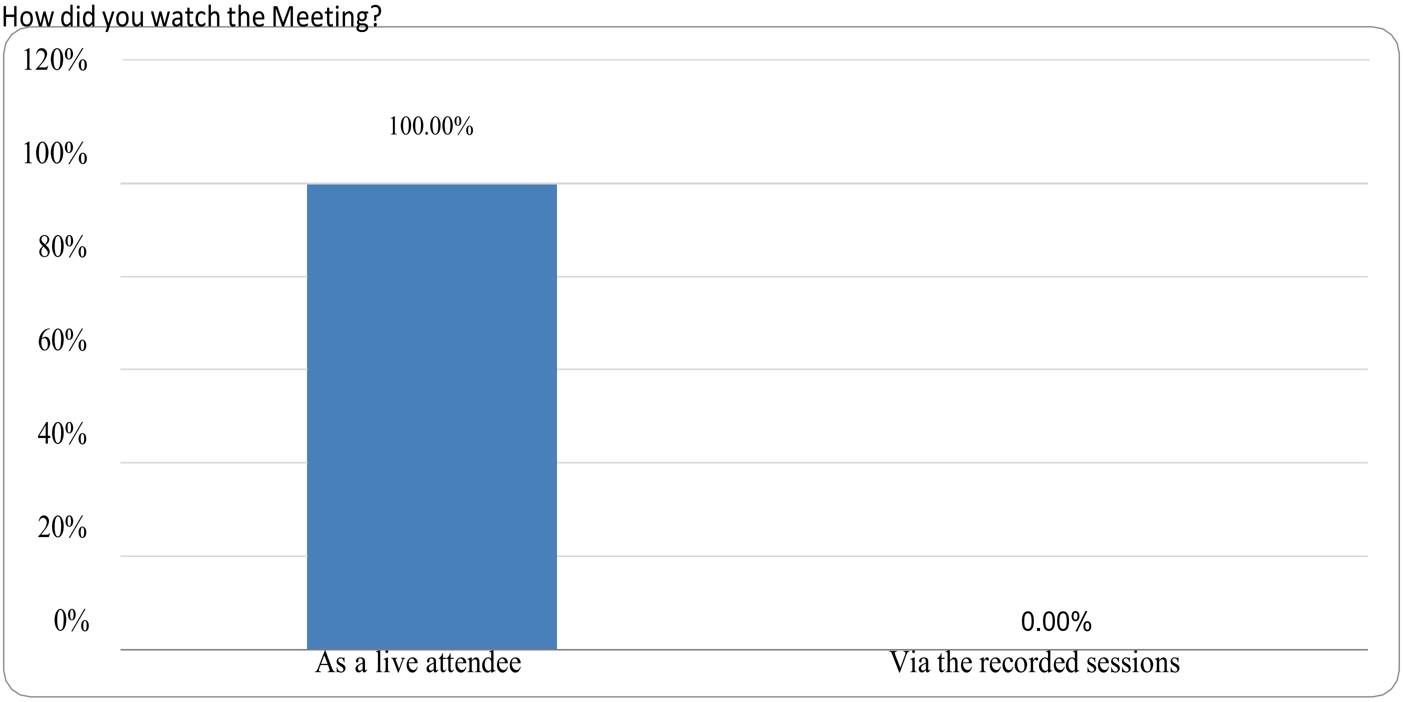


Which of the following coastal and marine themes does your organisation provide products or services for?

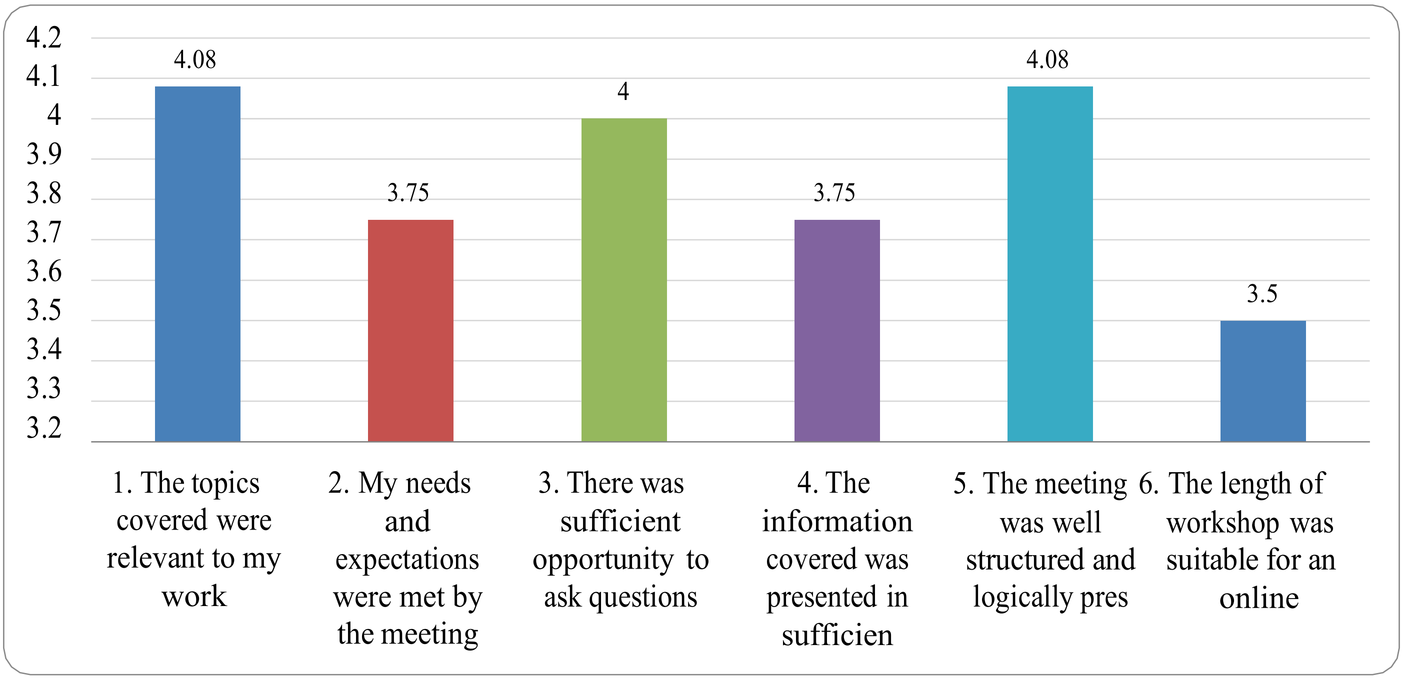


5.5 Post Workshop Survey Results

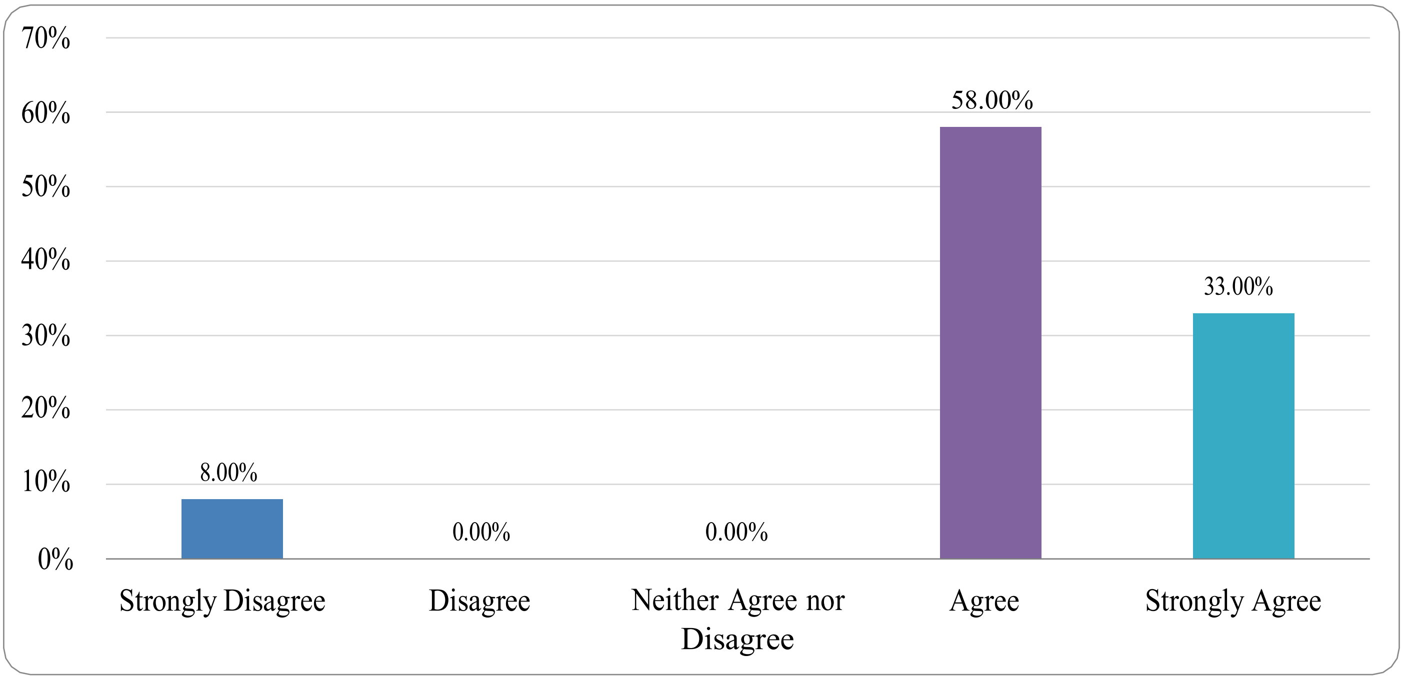
How did you watch the Meeting?



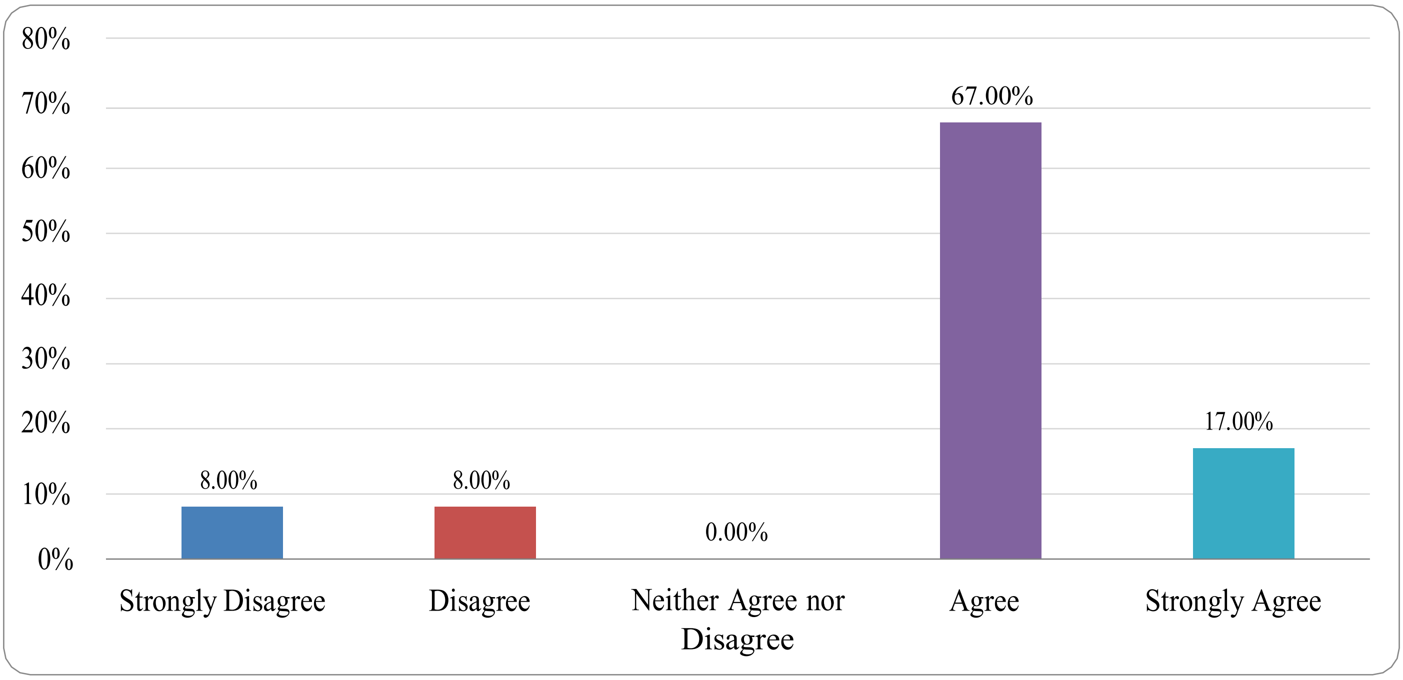
My needs and expectations were met by the meeting



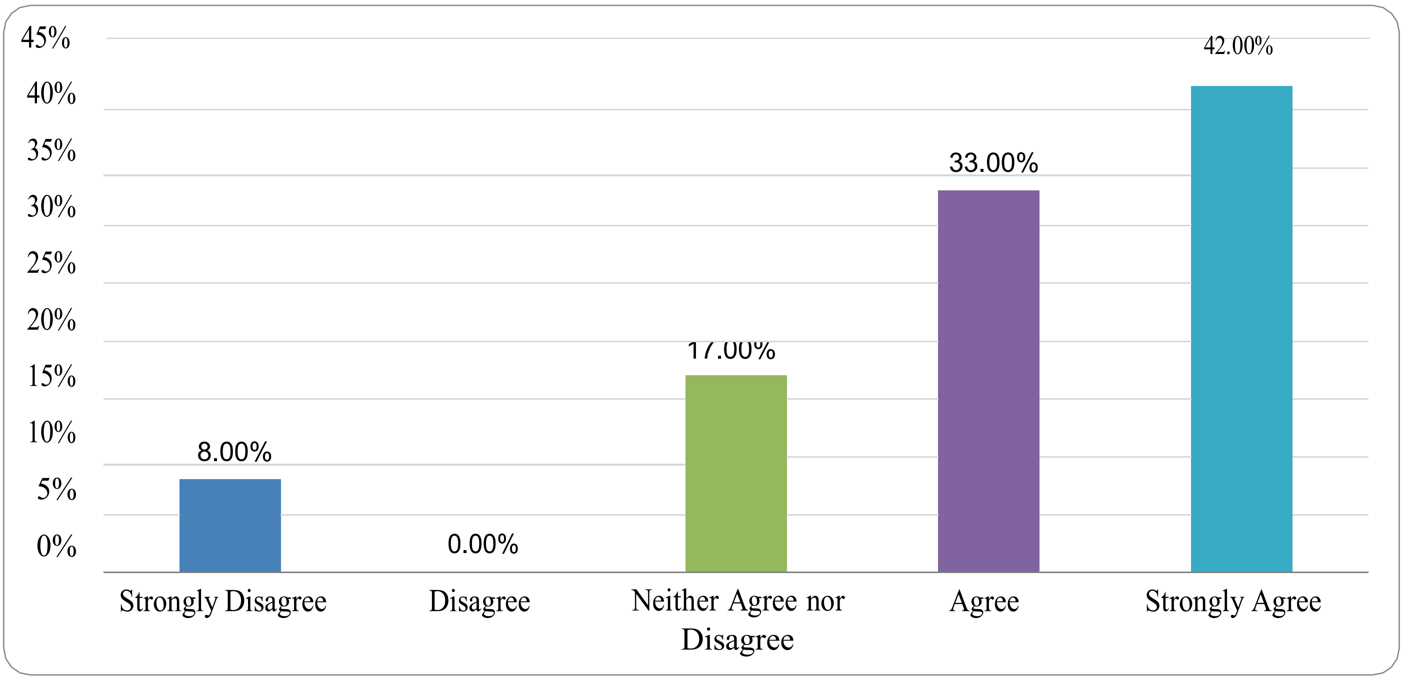
The topics covered were relevant to my work



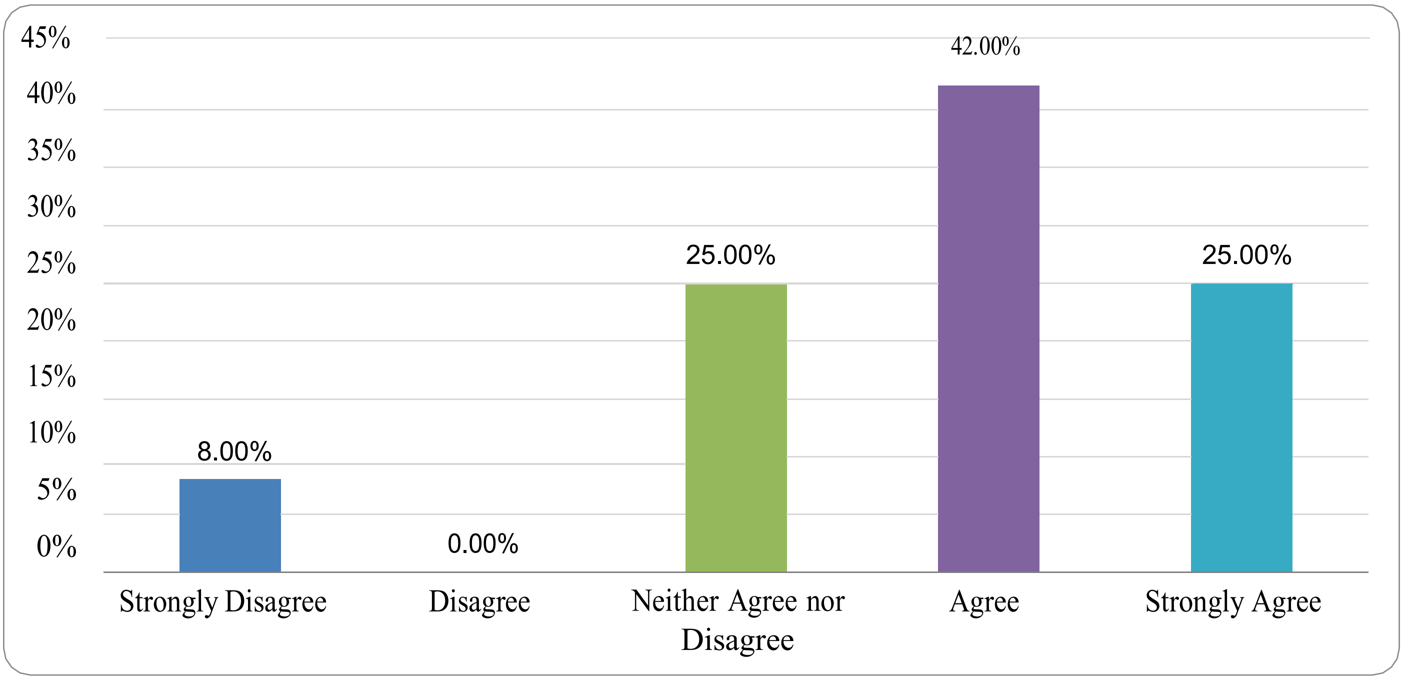
My needs and expectations were met by the meeting



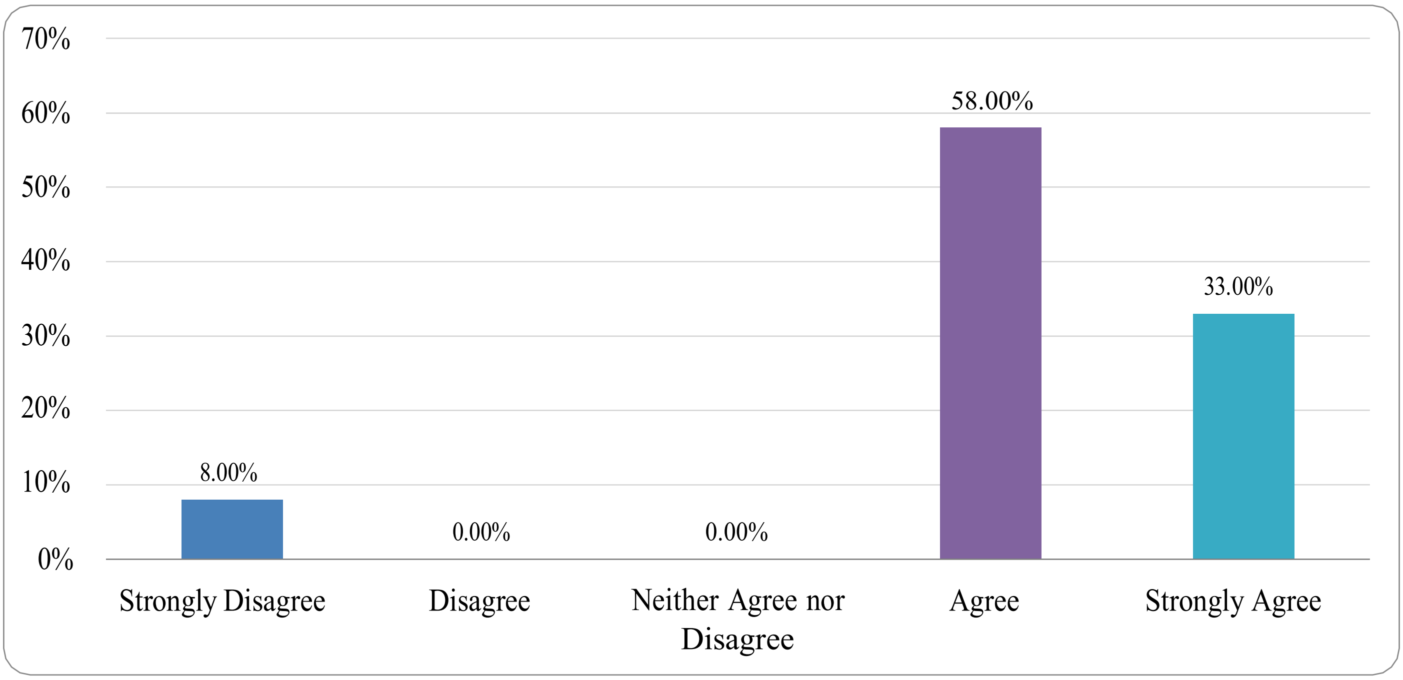
There was sufficient opportunity to ask questions



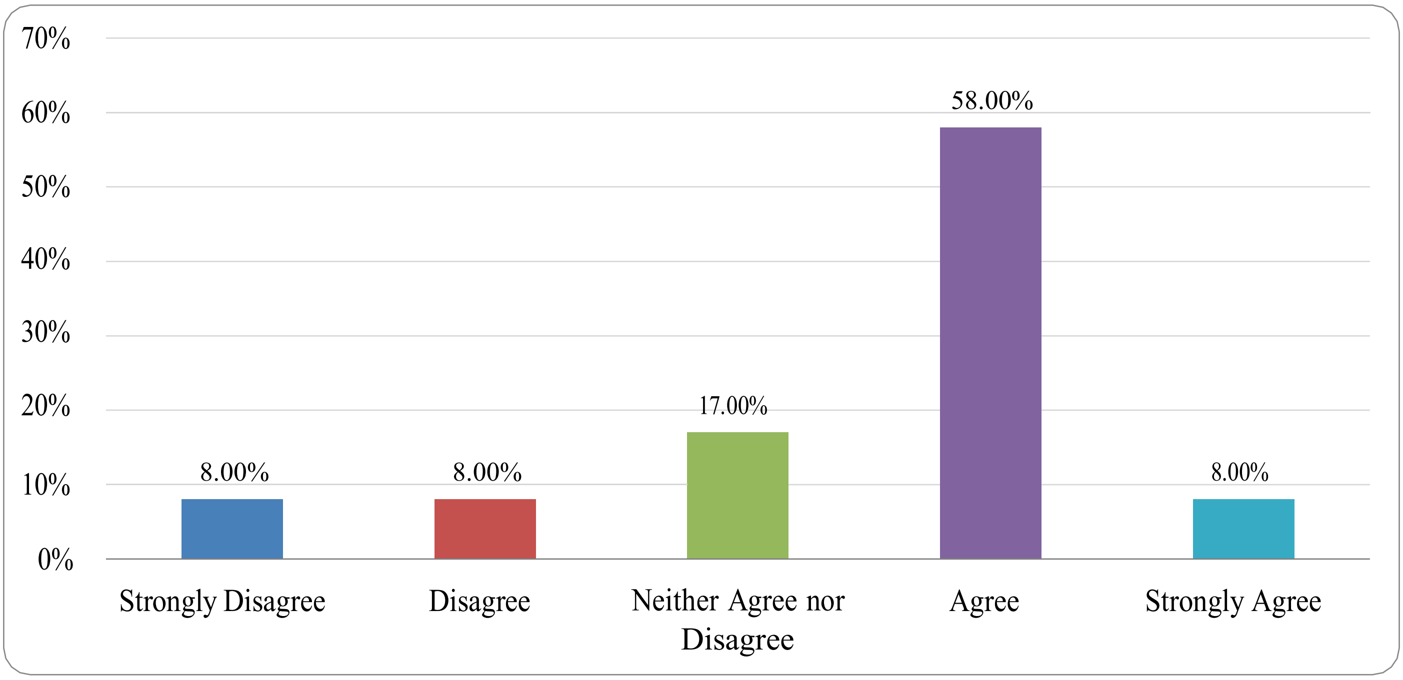
The information covered was presented in sufficient detail



The meeting was well structured and logically presented



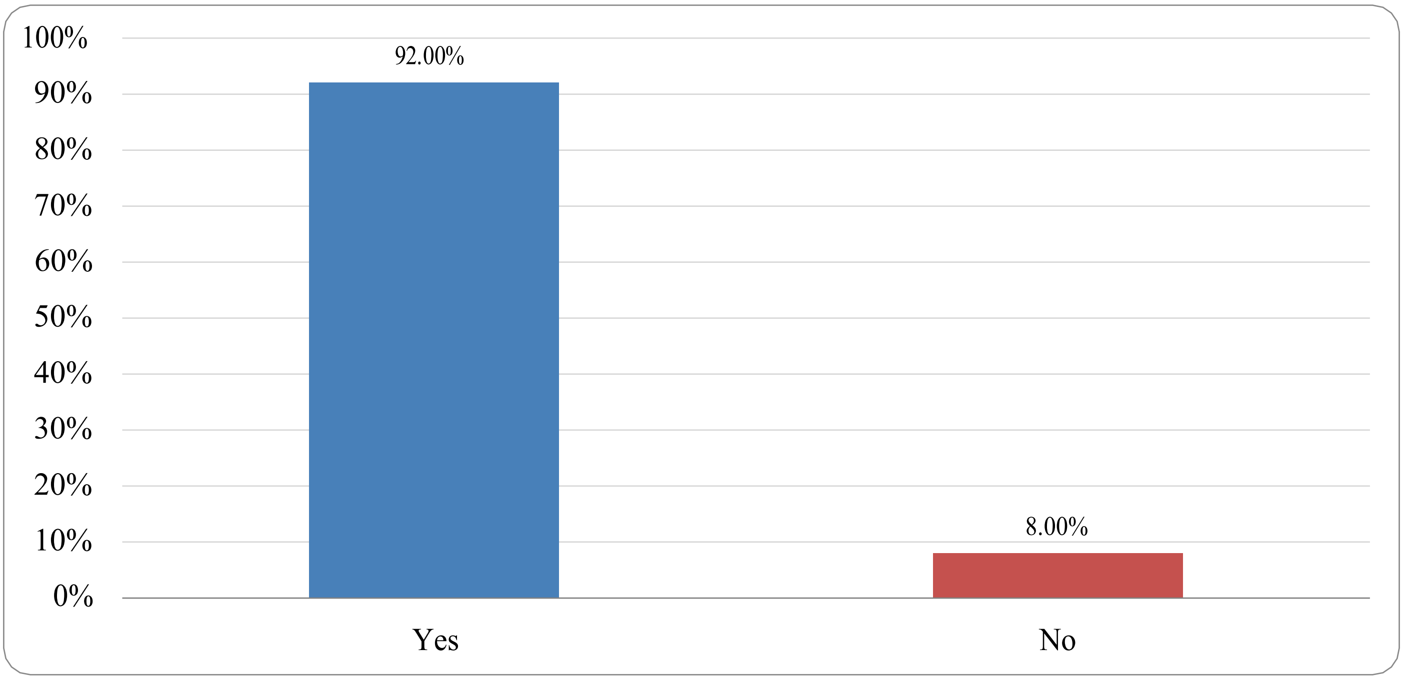
The length of workshop was suitable for an online event



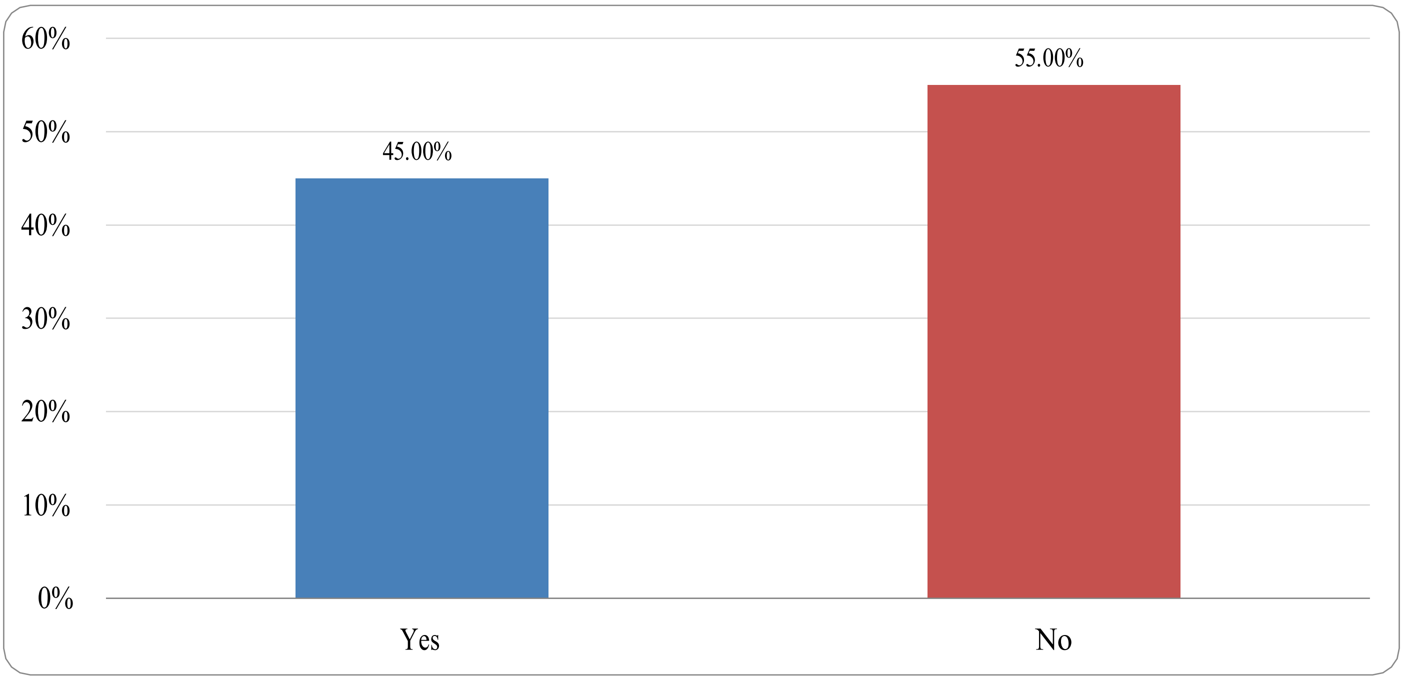
Do you have any comments about the content covered in the IORA 'Earth Observation foran Indian Ocean Blue Economy' workshop?

Response ID	Response
28840664	no comments
28836178	No
28835117	None as I only attended on behalf of DE Africa workshop. This was very relevant. However, I could not comment on other sessions I did not attend
28828403	Content on the potential area for collaboration may need more discussion and elaboration for further follow-ups
28826363	NO
28826322	I really enjoyed the workshop! Congratulations.

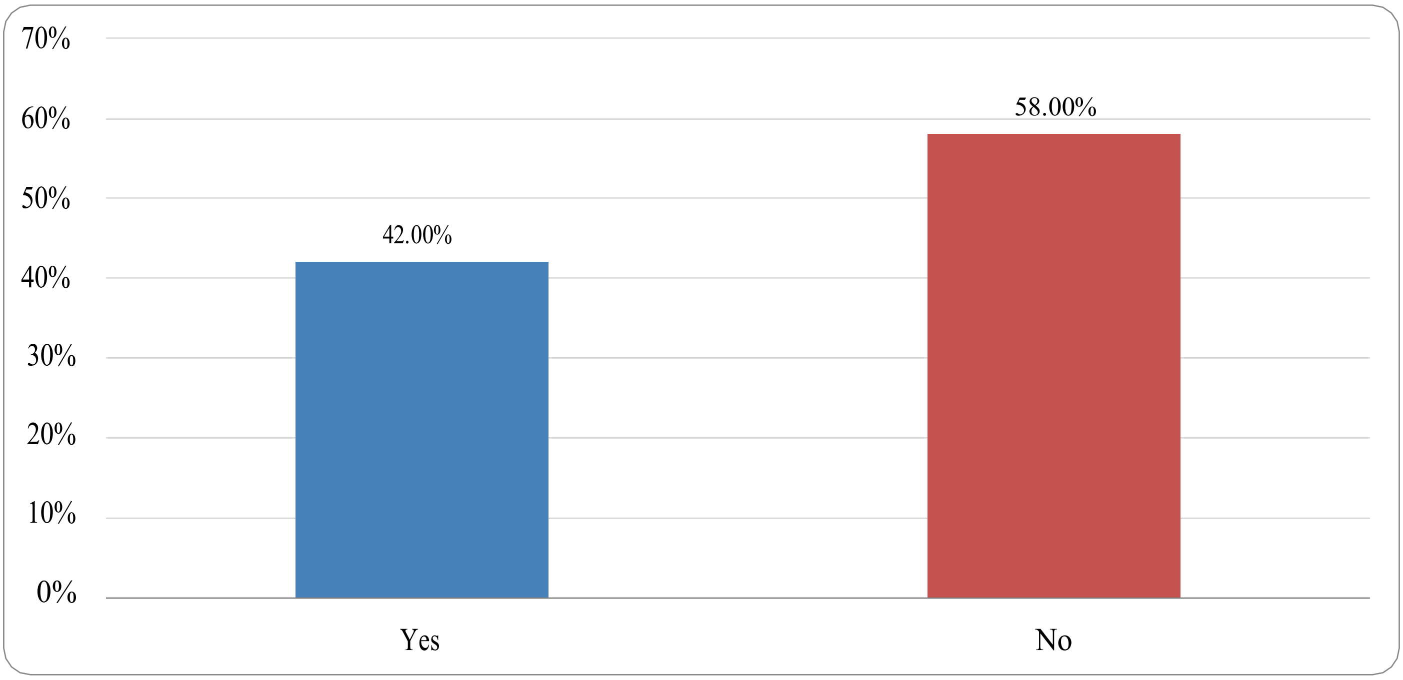
Were you able to interact and engage with the speakers/participants during the workshop?



Did you use the breakout sessions to connect with anyone?



Did you connect with any participant after the workshop?



Which topic(s) of the meeting were most relevant to you?

Response ID	Response
28840664	Session 2b: EO Services for the Indian Ocean Session 3: Understanding IORA Earth Observation needs
28836178	Blue economy
28835117	EO for Water and Mangrove monitoring
28828403	1. Marine spatial planning 2. the use of EOS and geospatial service (e.g. Google Earth Engine) to manage coastal-marine ecosystems
28826363	ABNJ
28826350	All topics highly relevant
28826322	The practical training.

Will the skills and knowledge gained at the meeting be useful for your work/organisation?

Response ID	Response
28840664	yes
28836178	yes
28835117	Yes
28828403	Yes as I work in the area of technical and management side on coastal-marine environment
28826363	Yes
28826350	Definitely
28826322	Certainly!

What aspects of the workshop could be improved for future virtual meetings?

Response ID	Response
28840664	more Q&A time
28835117	Not sure as I attended one workshop which was fine
28828403	1. shorten the duration of the workshops, i.e. 2 days. 2. provide more time to technical aspects of blue economy (e.g. the hands on training, study case of infrastructure development for EOS)
28826363	Advance planning and finalization and circulation of final agenda
28826350	First group of breakout sessions did not seem to work so well. Some greater preparation of what was expected might have been useful. It would have helped.
28826322	It was great.

Do you have any comments about the Virtual Event Platform - OnAIR?

Response ID	Response
28840664	Quite handy, actually
28835117	Nice platform with several options. I liked it
28828403	There were difficulties, at least for me, to use the web-based platform, particularly function for background picture and share-screen menu, so I always changed to the stand-alone zoom application.
28827012	Sometimes it became hard to close the settings or chat when it is clicked which is very annoying.
28826363	It was not working well for me. So used ZOOM
28826350	Sometimes the sound quality was not so great. No problem with video. But I had to go out and come back in several times on day two to overcome sound quality issues. Only that meant I would lose the chat history...
28826322	No

Please indicate which session/speaker was of most value to you and why?

Response ID	Response
28840664	unsure
28835117	I only attended DE Africa session and by default, this would be the most relevant to me given my academic and professional background in EO
28828403	1. Session on marine spatial planning 2. Session on the use of EOS to map, model and manage coastal-marine habitat and environment because I work in this area and these are aspects that need to be enhanced in my country
28826363	Session 2
28826322	Remap training

Do you have any comments about any of the presentations including feedback forindividual presenters?

Response ID	Response
28840664	no
28835117	No
28828403	It would be good if presenters can adjust the content of their presentation to the allocated time into a brief but rich information (there were cases where the slides were so many and the presenters presented them hastily)
28826363	No
28826350	All very informative.
28826322	The plenary with countries experience was a bit too fast. Too much information in a short time, and the session was too long for that kind of presentation.

Which topics do you think IORA should address?

Response ID	Response
28840664	Long-term sustainability of EO programs focused on the Indian Ocean
28835117	Am not sure
28828403	Blue economy is the right direction with various components of it, e.g. technology, economy, sustainable use of resources, capacity building, technology & knowledge exchange + transfer.
28826363	EO services
28826322	Practical training, a showcase of tools, ocean accounts.

What are your recommendations for future IORA projects?

Response ID	Response
28840664	none
28835117	Great job. Keep it up. Put much emphasis on communications especially through social media
28828403	Projects that focus on blue economy which can address common needs of IORA country members and at the same time contributing to global commitments (e.g. SDGs, climate change, biodiversity)
28826363	NA

Do you have any further comments about the IORA Blue Carbon Hub 'Earth Observationfor an Indian Ocean Blue Economy' workshop?

Response ID	Response
28840664	That was an excellent initiative and maybe it should be followed by some more focused workshops.
28835117	No
28828403	looking forward to potential collaboration and capacity building related to blue economy initiated by IORA
28826363	NA
28826322	Congratulations on the extraordinary and well-organised event.

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