GMES and Africa: Marine and Coastal Areas

Justification and need

With more than 35,000 km of coastline, coastal and marine environments play a vital role in the socio-economy of many African countries, contributing significantly to national Gross Domestic Products (GDPs), to food security, and supporting a wide range of coastal livelihoods. According to NEPAD (2005), the coastal and marine fishery sector provides vital contributions to the protein needs of 200 million people in Africa. Biodiversity and natural assets of African coasts are important attractors for tourism. In some countries, tourism represents not only the largest employment sector but accounts for significant contributions to national GDPs, for example up to 60% in the Seychelles (WTTC 2005). According to the Intergovernmental Panel for Climate Change (IPCC), "Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by the interaction of multiple stresses, occurring at various levels, and low adaptive capacity" (Boko *et al.* 2007). IPCC-projected sea level rise will increase the number and severity of coastal flooding events causing further severe damage to the coastal and marine environments and the resources and services they provide, and ultimately endangering even more coastal populations and economies. On top of that, expanding catches on the continental shelf (whether illegal or through excessive international trade agreements) over the last 4 decades have contributed to an important decline in fish stocks, particularly off West Africa (OECD 2007). The sustainable management of coastal and marine resources and environmental services for continued development in Africa requires the establishment of a pan-African Earth Observation (EO) monitoring and data management and analysis system to understand long term environmental trends, and develop appropriate management responses fully respecting the ecosystem-based approach.

Existing initiatives

The implementation of a GMES and Africa Programme in Marine and Coastal Areas will build upon existing EO programmes, components and facilities, taking into account the current situation as well as current programming in international and bilateral development cooperation.

Several agencies have expended considerable investment in EO activities to date, and would be important co-funders, data providers, or co-implementers or users of GMES and Africa services.

With the success of the African Monitoring of the Environment for Sustainable Development Project (AMESD), the European and African Union have extended the development and application of EO services in Africa through the 2013-18 **Monitoring of Environment and Security Project (MESA)** implemented by AUC and dedicated African regional centres at the Mauritius Oceanography Institute and the University of Ghana.

The **Europe-Africa Marine EO Network (EAMNet)** has developed networks linking Earth Observation (EO) information providers, user networks and centres of excellence in Europe and Africa in the area of coastal and marine observations towards sustainable development in Africa.

The **DevCoCast** programme, funded through European Union International Cooperation, provided infrastructure support for satellite transmission of EO products, extending GEOSS **GEONETCast** across the countries of Africa .

The **African Large Marine Ecosystem (LME) Projects and Commissions** have been instrumental in planning and implementing long term monitoring programmes for coastal and marine ecosystems of the region. LME Projects have supported in-situ data collection, earth observation, as well as the development of spatial and model products for coastal and marine management.

OceanSAfrica is an integrated network for ocean observation and modelling in southern Africa, made up of i) in-situ ocean observation, ii) remote sensing, iii) Data description and management, and iv) modelling. Having established platforms for components of EO in the southern African region (associated with the LMEs), OceanSAfrica is well placed to support GMES & Africa Services.

The **African Marine and Coastal Atlas Project**, developed by 16 African states with support from the ODINAFRICA Project of the IOC/UNESCO, has developed an online resource of delayed-mode spatial data products derived from in-situ and EO data sources. The atlas has established nodes at continental, LME and national scales, and has an active capacity building and training component.

Other important partners include Adaptation to Climate and Coastal Change in West Africa (ACCC-Africa), Programme régional de Gestion de la Biodiversité (EDF-COI), Réseau des aires protégées d'Afrique Centrale (RAPAC), Coastal Oceans Research and Development in the Indian Ocean (CORDIO), the Data Buoy Cooperation Panel of JCOMM.

Gaps

Despite the considerable investment in observing systems, there is still a clear need for a more robust, operational, Africa-wide programme for earth observation. There is a critical need for improving capacity

and infrastructure for delivering EO products to marine and coastal stakeholders. Elements that need strengthening include:

- Improved acquisition of relevant EO data at appropriate temporal and spatial scales
- In situ measurements in their own right, and for validation of EO data to support interpretation and the development of model products
- Effective dissemination of value added products, in near-real time and delayed mode, taking advantage of new and developing broadband links in Africa
- A strong capacity building and maintenance programme to support the GMES & Africa process, building on existing capacities and training facilities

Priority products

Operational programmes in the marine and coastal sector need to routinely bring information and products of value to users (managers, scientists, policy makers and the general public). To enable this, Africa needs a **GMES and Africa Service for Marine and Coastal Areas** that should be Pan African: reaching to all the coastal countries of Africa; Operational: utilising Earth Observation from space agencies; Comprehensive: an end-to-end service from observations, through analysis and forecasts, to the dissemination of value-added products; Built on existing research projects and pilot programmes; Maintained and operated by Africans, developing and utilizing African capacity in African Centres of Excellence; Demonstrably useful for marine and coastal managers and policy makers to maintain sustainability of marine living resources; Feed into local and national governance schemes that ensure effective consultation with all stakeholders; and Equipped with a continuous funding processes and sustainable budgeting so as to maintain long-term sustainability of the Service.

The following products have been identified as high priority for the Marine and Coastal sector:

1. Operational coastal sea level, coastal circulation and coastal sea state (data, analyses, imagery and mapping), for transboundary regions as well as downscaled to smaller coastal and marine management units. These products would have a wide variety of users; coastal flooding and coastal erosion events for property owners, planners and coastal managers, and coastal circulation, for example, for offshore oil and gas industry, ports, shipping and for safety at sea. EO data from Sentinel-3 satellites would provide relevant data on sea surface topography and temperature.

2. Operational biological productivity (data, analyses, imagery and mapping) would have fisheries and biodiversity applications. Zones of high productivity are useful for identifying fishing grounds and managing fishing effort, and harmful algal blooms have an impact on commercial fisheries and tourism. The reporting of chlorophyll, low oxygen and harmful algal blooms will be part of ecosystem health reporting through Long Term Ecosystem Research (LTER) observational networks in LMEs. EO data from Sentinel-3 satellites would provide ocean colour data from which chlorophyll concentrations may be derived.

3. Coastal sensitivity and vulnerability atlases and **state of environment reporting** is useful for coastal and marine managers, coastal land use planners, city managers, environmental impact assessments and the private sector (eg. the tourism industry, fishery, oil & gas sector). A range of EO data from Sentinel satellites-1, 2 and 3 could be used to develop sensitivity/vulnerability maps and feed into state of the environment reports.

4. Ship traffic situation and maps. A real-time view of the ship traffic is needed for operational monitoring for MCS activities as well as safety at sea. Historic patterns of ship traffic, by ship type, season, time of day, etc., are needed for long-term management and planning. Satellite imagery is essential to monitor ship traffic that cannot be tracked with coastal sensors or with voluntary ship reporting systems, providing a cost-effective alternative or complement to patrols. Sentinel-1 Synthetic Aperture Radar (SAR) data may be used to assist surveillance operations.

5. Regional weather forecast systems (5 to 7-day horizon) to complement sea state forecasts are essential for the safety of recreational and commercial vessels. Longer term climate forecasts (1-3 months) are dependent on ocean monitoring; for example the Indian Ocean Dipole and ENSO state can be used to improve seasonal rainfall forecasts over East and southern Africa.

6. Real-time Disaster Warning Systems such as storm surge warnings (sea state forecasts) and tsunami warnings (from strategically placed tide gauges and GPS monitoring of faults) rely on in-situ sensors as well as satellite communications for the rapid dissemination of warnings.

7. Mapping of coastal land use and nearshore coastal and marine habitats is essential for marine spatial planning, integrated coastal zone management and the monitoring of the health of the coastal and marine habitats that are so important for sustaining artisanal fisheries. EO data from Sentinel-2 satellites, for example, would be very valuable for the mapping and monitoring of nearshore marine habitats as well as coastal land use and change detection.

8. Mapping marine and coastal ecosystem services. In line with the Millennium Ecosystem Assessment (2005), quantification and mapping of marine ecosystem services is an important step for allocation of natural resources and for policy development and decision-makers to identify areas requiring specific protection measures. Satellite imagery and GIS are useful to monitor ecosystem changes in or out the protected areas, identify new marine protected areas and assess the degree of connectivity between two or more ecosystems.

On a scientific level, the LME focus will maximise the value of data from the Sentinel series of satellites, providing regional validation of core service products and ecosystem-contextualised products integrating satellite, in-situ and modelled data. From an operational service perspective, the network of centres will provide a common technical framework that will allow rapid service implementation and expansion, based on the existing Regional Implementation Centres from the 2013-2018 Monitoring of Environment and Security in Africa (MESA) project. AMESD and now MESA have the aim to ensure continuity of past investments in the use of Earth observation data in Africa, through securing the maintenance and upgrade of the EUMETCast reception stations deployed by AMESD, and supporting the development of new operational services based on EO data. Activities proposed under GMES and Africa will be broader than those covered by MESA, to include the strengthening of in-situ observation networks, monitoring/control and surveillance, and the development of new, integrated products derived from both in situ and remote sensed sources of earth observation data.

Organisational scheme of the GMES and Africa Service for Marine and Coastal Areas

Effective and sustainable coastal and marine management in Africa can only exist under predictable, efficient, and accountable governance systems. Four components are proposed for the organisational scheme of the GMES and Africa Service for Marine and Coastal Areas; illustrated in Figure 1 and discussed below. An overall management structure established under the African Union would facilitate continued consultation with the coastal and marine user community, ensuring the updating of current issues leading to information needs for management.

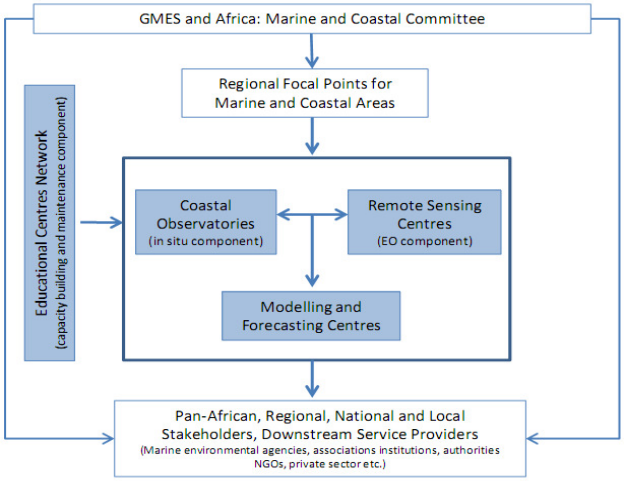

Figure 1. Organisational scheme of the GMES and Africa Service for Marine and Coastal Areas

1. An Africa Network of Modelling and Forecasting Centres
A major need exists for specific value-added EO products to support African coastal and marine user communities. A network of centres would enable the exchange of information and expertise, the development of consistent products, and the efficient dissemination of information using the same (or interoperable) protocols. These centres should be concerned with LME-scale, transboundary product development, with support from Universities and National Departments. (Coordinated by IOC/UNESCO, Large Marine Ecosystem Projects with Universities & National departments)

2. A GMES and Africa Network of Marine Remote Sensing Centres
These regional centres would be the fully operational successors to various existing pilot facilities such as www.gmis.jrc.ec.europa.eu, www.eamnet.eu, www.rsmarinesa.org.za, www.africanmarineatlas.org which already provide maps, data, and statistics of various parameters at continental scale and for selected regions. AMESD/MESA and GeoNetCast Receiving stations would be used. The development of new satellite products at an operational level would be initiated and would be closely linked to the new generation of satellites and infrastructure from space agencies, including EuMetSat and ESA. These centres would form an African Marine Remote Sensing Core Service (Institutions with receiving stations; with MESA, IOC/UNESCO and LME Projects, universities and training facilities).

3. A GMES and Africa Network of Coastal Observatories
These coastal observatories will be established at key locations along the coasts and seas of Africa, and would be responsible for collecting in situ observations. Mega cities, ports, areas with offshore industrial activity and sites of particular significance for ocean/atmosphere monitoring and forecasting are examples of priority locations. Coastal observatories would take continuous measurements from coastal weather stations, in-situ monitoring of ocean temperature, oxygen and currents, and facilitate regular active monitoring of inshore water quality, productivity, and coastal habitats. Measurements from these

stations would be of value in their own right (for the improved monitoring of artisanal fisheries, protected areas management, coastal management), and they would also provide validation data for satellite observations in coastal and marine areas not only in Africa but at a global scale. The network would build on existing national monitoring programmes, such as those of the LME Projects, GOOS Africa / IOGOOS components, such as the sea-level GLOSS network, the Research Moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA), SAEON and other national stations. Benefits of an integrated network include consistent and standardised data collection, standard data exchange protocols, better uptake of data across platforms, and better coverage at continental scale. (Coordinated by LME Projects with GOOS Africa and national observing systems)

4. A GMES and Africa Capacity Development Network of Higher Education Institutions
This Network will be the final link in the chain of networks proposed for GMES and Africa. The long term viability of GMES & Africa will be dependant on personnel, infrastructure and stable institutions. Capacity development is an ongoing process involving training, exchange of personnel and practices, and the ongoing support for infrastructure and institutions. The other requirement will be a stable level of financial support into the future. The Capacity Development Network should not only support the building of new capacity in Africa, but also the effective utilisation and maintenance of existing capacity and networks such as OceanSAfrica and AfriCOG. (Coordinated by IOC/UNESCO, AUC, EU/JRC, MESA, LME Projects, national universities and training facilities)

Priority Activities and Timeline

Short term (months 1-24)

In the short term, GMES and Africa activities will be concerned with consolidating the contributions from partners that have committed to supporting the strategy for marine and coastal areas, as set out in the Marine & Coastal Areas chapter. There needs to be a deeper and more robust engagement with partners and stakeholders - not only to secure co-financing, but also to benefit from existing funded work and to ensure that GMES and Africa is used and developed in the long term. It needs to be properly integrated into the landscape of M&C Earth Observation in Africa so a short period of consolidation is necessary for this process to achieve success.

Assessments of requirements for infrastructure and training have already been carried out by AMESD, MESA, EAMnet, LME projects and the IOC/UNESCO; short term activities would be dedicated to validating these and securing proposed partnerships. The development of high priority operational products would also commence, including:

- **Operational coastal sea level, coastal circulation and coastal sea state products (data, analyses, imagery and mapping)**
- **Operational biological productivity products (data, analyses, imagery and mapping)**
- **Development of the organisational structure for governance, and capacity building and training** are also high priority, underpinning all operational activities.

Medium term (24-36 months)

In the medium term, strategies for long term financial and technical support must be established. An integrated capacity building/retention programme must be implemented built on the activities of regional partners. This could use the existing Large Marine Ecosystem and EAMNet reviews of needs and the draft roadmap already produced. Integrated operational products and dissemination systems for products would mature:

- **Strengthen vessel monitoring systems to assist monitoring, control and surveillance.**
- **Integrated training programmes across countries should be operational.**
- **The African Marine and Coastal Atlas,** supported by ODINAFRICA of the IOC/UNESCO should be supported for additional functionality to organise and disseminate data and metadata from GMES services.

Medium-term to long-term (36 months onward)

These activities would begin in the short term, with demonstration projects and product development, but the continent-wide roll-out of operational products would only be seen after the first 24 months:

- **Integrated methods and protocols for data collection, EO and modelling need to be finalised and operational across the continent**, based on the operational systems developed

and expanded from year 1. This will ensure a sustainable, consistent approach to long term monitoring and product development.

- **Gaps in in-situ networks should be filled**; for example in the array of temperature recorders, coastal weather stations and coastal tide gauges. Regional coastal observatories should be identified in the short term and established in the medium to long term, based on the Large Marine Ecosystems.
- **Strengthen and expand the monitoring of critical habitat**s for artisanal fisheries – including reefs, mangroves, seagrass beds, soft-bottom habitats and sandy beaches depending on regional priorities.