Coastal Risk Information Service (C-RISe) Workshop

Hotel Panorama, Antananarivo. 11-12 February 2020.

Report and Recommendations

Executive Summary

On the 11th and 12th of February 2020 the C-RISe project held a workshop in Antananarivo, Madagascar on the impacts of climate change on Madagascar's coast and marine environment. It welcomed 45 participants from across Madagascar, including representatives from government agencies, NGOs and research institutions. Participants reviewed the project and discussed coastal risk priorities for decision makers; how satellite data can complement other data sources to address priorities; and how to increase local capacity to use satellite data in providing scientific support in strategy development and management of coastal areas.

Priority application areas highlighted included marine planning, coastal erosion and protection, impacts on marine ecosystems, tropical cyclone tracks, and impacts of all aspects of climate change on human activities and livelihoods.

Recommendations of priorities for building capacity in the use of marine satellite data and modelling and Madagascar are summarized below:

Availability of data and information products

In addition to those data sets already being supplied through C-RISe, a range of high resolution data sets, time series to monitor change, additional parameters, and derived products (ecosystem threats, maps of coastal change, oceanic fronts) were identified as priority requirements.

Modelling Capability

Development of capacity to use models for a range of applications was identified as a priority. These ranged from high resolution coastal modelling, through ecosystem models, large scale ocean-atmosphere models, flood risk modelling, and oil spill dispersion models and modelling for planning and resource management.

Capacity to access, analyse, combine and share datasets (skills and IT resources)

In addition to filling gaps in data requirements, and modelling capability, there is a need to build capacity to analyse, interpret and combine data from different sources, and to improve systems and policies so that data can be shared between different organisations. There is also a need to build capacity in IT resources, including improving internet connectivity.

Communication of information to non-scientific audiences

Building capacity to extract relevant science based information and communicate this to non-scientific audiences at different levels is essential for uptake of satellite data among decision makers in government and civil society, and to sensitise coastal communities to the need for healthy coastal and marine ecosystems.

Adaptive Capacity

Throughout the workshop a need for cross organisational working, the sharing of data, information, technical skills was emphasised. Currently, many organisations in Madagascar act independently in the generation, processing and management of coastal data, meaning that much useful data and information are not used effectively.

Acronyms

Acronym	Definition	Further Details
AIS	Automatic Identification System	Tracking system for ships fitted with transponders
APMF	Agence Portuaire Maritime et Fluviale	Maritime and river port agency
ARSIE	Association Reseau Systeme Information Environnementale	Madagascar Regional Coordinating Unit which holds details of environmental data
BNCCC	Bureau National de Coordination des Changements Climatiques	
CDN	Corredor de Desenvolvimento do Norte (Northern Development Corridor)	Ports developer in northern Mozambique
CI	Conservation International	
CNDO (NODC)	Centre National de Données Océanographiques (National Oceanographic Data Center)	Madagascar – run by IH.SM, full member of UNESCO-IOC, IODE (International Oceanaographic Data Exchange) and ODINAFRICA http://nodc-madagascar.odinafrica.org/a-propos-du-cndo.html
C-RISe	Coastal Risk Information Service	Name of Project - website here: http://www.satoc.eu/projects/c-rise/
CNRO	Centre National de Recherches Océanographiques	Madagascar Oceanographic Research Organisation http://cnro.recherches.gov.mg/
CSIR	Council for Scientific and Industrial Research	http://www.csir.co.za/
DGM	Direction Générale de la Météorologie	Madagascan Met Office http://www.meteomadagascar.mg/
DGHRP	Directeur Général des Ressources Halieutiques et de la Pêche	Directorate General of Fisheries Resources, Madagascar http://www.mrsi.gov.bf/index.php/182-les-services/les-services-centraux/267-direction-generale-des-ressources-halieutiques-dgrha
EO	Earth Observation	-
ICZM	Integrated Coastal Zone Management	

IHSM	Institut Halieutique et des Sciences Marines	Madagascar Institute of Fisheries and Marine Science, http://www.ihsm.mg/
INAHINA	Instituto Nacional de Hidrografia e Navegação	Hydrographic and Navigation office, Mozambique
MHRP	Ministère des Ressources Halieutiques et de la Pêche	Madagascar Fisheries Ministry http://www.maep.gov.mg/
MNP	Madagascar National Parks	
MPA	Marine Protected Area	-
NMIFC	National Maritime Information Fusion Centre	
NOC	National Oceanography Centre	C-RISe Project Partner https://noc.ac.uk/
NODC (see CNDO)	National Oceanographic Data Centre	
ODINAFRICA	Ocean Data and Information Network for Africa	
SAR	Synthetic Aperture Radar	
SatOC	Satellite Oceanographic Consultants	C-RISe Project Partner http://www.satoc.eu/
SST	Sea Surface Temperature	
RCU	Regional Co-ordinating Unit	
UKSA	UK Space Agency	C-RISe Project funder https://www.gov.uk/government/organisations/uk-space-agency
WCS	Wildlife Conservation Society	
WWF	World Wide Fund for Nature	
YPA	Young Progress Association	Local Consultancy in Madagascar, working with WWF https://youngprogress.mg/
YSO	Young (re)Searcher Organisation	Madagascar http://yso-madagascar.org/

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Introduction

On the 11th and 12th of February 2020 the C-RISe project held a workshop in Antananarivo, Madagascar on the impacts of climate change on Madagascar's coast and marine environment. It welcomed 45 participants from across Madagascar, including representatives from government agencies, NGOs and research institutions (Annex 1). Held over two days the meeting:

- Identified the key challenges faced by Madagascar due to a changing marine climate;
- Presented outcomes from the C-RISe project;
- Discuss recommendations for future research priorities on marine and coastal risks and building national capacity for accessing and applying satellite data to coastal risk.

This report summarises the main findings of the workshop discussions and provides recommendations for building capacity in the use of marine satellite data and modelling in Madagascar

The C-RISe Project

Title	C-RISe Coastal Risk Information Service
Starting Date	7th December 2016
Duration	3-years, from December 2016 to December 2019, with a follow up one-year legacy period ending in April 2021.
Partners	**Mozambique** Instituto Nacional de Hidrografia e Navegação (INAHINA) http://www.inahina.gov.mz/ Universidade Eduardo Mondlane http://www.uem.mz/ **Madagascar** Centre National de Recherches Océanographiques (CNRO) http://cnro.recherches.gov.mg/ Institut Halieutique et des Sciences Marines (IH.SM) http://www.ihsm.mg/ Direction Générale de la Météorologie (DGM) http://www.meteomadagascar.mg WWF Madagascar http://www.wwf.org.mz/ Conservation International http://www.conservation.org/global/madagascar/Pages/waves.aspx **South Africa** Council for Scientific and Industrial Research (CSIR) http://www.csir.co.za/ **Mauritius** University of Mauritius (UoM) http://www.uom.ac.mu/
Target Countries	Mozambique, Madagascar, Mauritius and South Africa

C-RISe - **C**oastal **R**isk **I**nformation **Se**rvice - is a project funded by the UK Space Agency through the International Partnership Programme (IPP), which has been working with local partners since 2017 to deliver a Coastal Risk Information Service to Mozambique, Madagascar and Mauritius, providing satellite-derived information about sea level, currents, wind and waves to support coastal vulnerability assessment and management.

During the project, partners in Madagascar, Mozambique and Mauritius ran Use Cases to apply the C-RISe data products in coastal risk applications across a range of themes, including: Marine Protected Area (MPA) management; sea state and surface current Information; sea level analyses; wind and wave climate variability; and climate change impact on marine ecosystems. The objective was to evaluate the benefit of using satellite data in such applications, to serve as examples for others with similar problems and, most importantly, to achieve real impacts for the local communities. Originally only four Use Cases were planned, but such was the interest and enthusiasm of the C-RISe partner organisations that 27 Use Cases have been developed.

A key objective of C-RISe was to provide training to develop local capacity to use satellite oceanography data in combination with other data sets and information sources to meet local needs. To achieve this C-RISe ran two training workshops: “Wind, wave and sea level information from satellites”, and “Tools to apply satellite data to coastal risk”. Workshops took place over a week and were presented through a mixture of taught material, exercises, demonstrations and one-to-one discussions on the application of satellite data within C-RISe Use Cases. Feedback was gathered to guide recommendations for future capacity building efforts.

In the final period of the project, the outcomes of the Use Cases and other achievements of the project are being evaluated and plans are being developed to ensure a sustainable and lasting benefit is achieved.

For further information visit the project website at www.c-rise.info

C-RISe Workshop Overview

The C-RISe team was pleased to welcome 45 participants to the workshop, which reviewed the project and discussed coastal risk priorities for decision makers; how satellite data can complement other data sources to address priorities; and how to increase local capacity to use satellite data in providing scientific support in strategy development and management of coastal areas.

The workshop was held over two days (the agenda is given in Annex 2). On the first day the C-RISe project was introduced, and the background context of the changing marine climate reviewed. The main part of the day was dedicated to presentations by Madagascar C-RISe partners on the Use Cases that they had been working on. The second day was focussed on discussion of coastal risk priorities, how satellite data can address these and recommendations to local build capacity. The sessions are listed in Table 1.

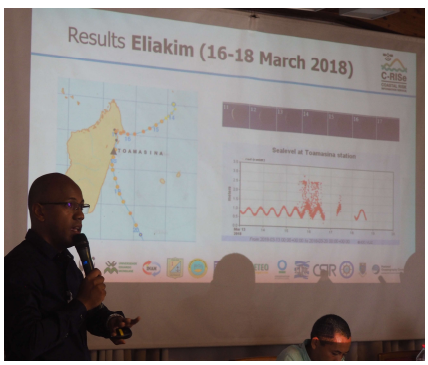
Table 1: C-RISe Workshop Sessions

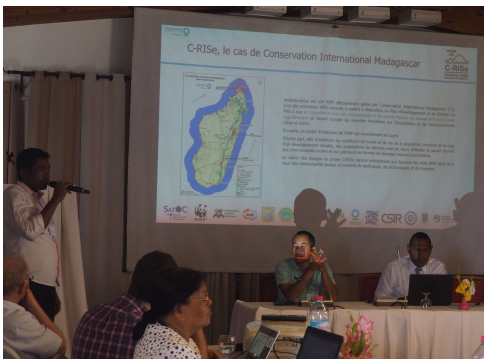
Day 1	1. Introduction – Workshop Objectives
	2. Setting the scene - The Changing Ocean Climate and Madagascar
	3. C-RISe Project – Satellite data for Coastal Risk: Presentation of the Use Cases developed by partners in Madagascar
	4. Discussion of coastal risk information priorities of decision makers
Day 2	5. Discussion Groups: Themes - Marine ecosystem monitoring and protection; Coastal zone management/coastal erosion; Maritime conditions and operational decision-making. • What are the priority gaps in capability to provide this information? • What further research is needed? • Priorities for Building Capacity in the use of marine satellite data in Madagascar
	6. Reporting on priorities and recommendations from discussion groups

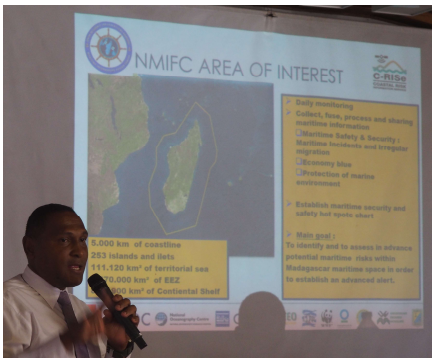
Use Case presentations were:

- Ambodivahibe Marine Protected Area: Clarck Rabenandrasana, CI
- Sea State Information for Improving maritime navigation security & safety in the North-Western of Madagascar: Franck Razafindraibe, CFIM
- Climatology study of wind, waves, current and sea level change in the North-west of Madagascar: Herilalaina Rasolonjatovo, DGM
- Tropical Storm Information: Zo Rakotomavo, DGM
- Wind and Wave Energy (Ste Marie Island): Rhino Rajaonarivony, DGM
- Madagascar Coastal and Marine Atlas: John Bemiasa, IHSM
- Vulnerability assessment of the mangrove ecosystem in Ambaro Bay: Fanja Razafindramasy, WWF
- Impact of Coastal Climate Change on Shrimp Fisheries: Haja Razafindrainibe, Independent Researcher
- Reef resilience in the Mahafaly Seascape: Fanja Razafindramasy, WWF

All presentations are available on request to d.cotton@satoc.eu.







Workshop Discussions and Recommendations

Introduction and aims

The second day of the workshop was given over to discussion sessions. The meeting participants split into three discussion groups to address three application areas or themes each tackling a major aspect of marine/coastal risk management and climate change adaptation planning. The discussion groups were:

A. Marine ecosystem monitoring and management
B. Coastal zone management/coastal erosion
C. Maritime conditions and operational decision-making

Each group discussed and provided recommendations on the same three themes:

1) Coastal risk information priorities for decision makers
2) Capacity gaps in coastal risk information (data, resources, research)
3) Priorities for building capacity in the use of marine satellite data and modelling in Madagascar

Below we list the major common findings and recommendations. Readers are referred to the individual reports from the three groups for more detail.

Findings and Recommendations

1. Coastal Risk Information Priorities for Decision Makers

The groups first identified who the decision makers are for the Madagascar coast, what decisions need to be made, and then what information is needed to make these decisions.

Decision makers at different levels

Decisions are made at many different levels, from national through regional to local. Decisions about national policy with supporting legislation are taken by the central government; this includes efforts to implement international agreements Madagascar has signed up to. These National polices are implemented at regional and local levels.

At **national level** the responsible agencies are:

- Ministry of Environment and Sustainable Development (MEDD), which also has responsibility for the Blue Economy
- Ministry of Agriculture, Livestock and Fisheries (MAEP) which includes Direction Générale de la Pêche et de l'Aquaculture (Directorate of Fisheries)
- Ministry of Justice, concerned with legislation and enforcement
- Ministry of Tourism (may be involved when tourism activities may affect marine parks or take advantage of relatively pristine environments that are attractive to tourists)
- Ministry of Spatial Planning (Land Management, MAHTP) – decisions on planning
- Ministry of Research (MESUPRES), including their representatives at different levels (national, sub-national, local)
- Ministry of National Defence, on deploying resources to take action against illegal activities
- Ministry of Transport
- National Agency for Disaster Relief (BNGRC)
- National network for Integrated Coastal Zone Management (GIZC), which has regional and local representatives (e.g. St. Marie Island is one of the pilot regions for this scheme)
- Madagascar National Parks
- Law enforcement agencies
- Territory Management

There are representatives at three different levels of government, National, Regional (subnational) and Local. State representative authorities include: Chief of Region, Prefect (government representative on the local level), Mayor, Chief of Fokontany (administrative delimitation of village). These representatives ensure the development actions in their zones.

At lower levels decision makers include:

- Regional representative of these ministries who are responsible for implementing national policies and regulating activities within their region. There are 23 regions in Madagascar

- Structured local communities with delegated environmental management responsibilities may take decisions designed to regulate use of local resources, to make this more sustainable.

Non-Governmental Organisations (NGOs) work with local and regional government, not with their own autonomy, managing and supporting actions to protect and manage the marine environment. They work as support entities and help with decision making on site. Environmental NGOs may manage marine protected areas in collaboration with local communities, providing advice on resource managements and developing plans for habitat protection and/or restoration.

What Decisions need to be made?

Decisions are mostly dependent on the policies and strategies established by the government/state at different levels. A number of reference documents exist, including:

- PRD (Regional Development Plan)
- SRAT (Regional Land Management Scheme)
- SAC (Commune Management Scheme)
- PANGIZC (National Action Plan for Integrated Management of Coastal Zones)

The workshop was also advised of the "Research development plan for marine science and oceanography" created in 2018 which involved inclusive participation of all stakeholders. This document has not yet been disseminated, but can be obtained from the Director General of Scientific Research.

Group B (Coastal Zone Management / Coastal Erosion) identified a number of local areas where there are significant tourist development plans, in particular Ste Marie Island (resort and hotels development) and Nosy Be (port development for tourist boats). Data are very important in these cases to support Marine Spatial Planning and to ensure the management of tourist developments takes account of existing activities (seaweed cultivation, aquaculture, shrimp fisheries) and protection of the marine environment. Also a management plan is being developed for the Mahajanga Region in NW Madagascar, which has a large area of mangroves, important as an economic and ecological resource and also for tourism.

Overall there is a requirement for strategic framework development at a local and regional level for coastal and marine management.

Group C (Maritime Conditions and Operational Decision Making) also identified some specific examples of operational decisions requiring near real time marine data. These related to protection of corals from plundering; infractions within the national parks, illegal fishing, illegal traffic, and illegal migrants; and quick intervention requiring timely provision of information to support organisation of enforcement actions.

Information needs to inform decision making

At all levels there is a need for science-based information relevant to the issues being addressed, presented in summary form using in non-technical language, and giving clear information about levels of risk. These information briefs will often bring together data from different sources, including studies of

local perceptions of change, to synthesise relevant information about environmental and human pressures, and the changes these may bring.

The information briefs could be supported by more detailed reports, which may contain maps, diagrams, summary statistics and figures presenting the results of the data analysis and interpretation.

In *Group A* it was felt that there was no requirement for the underlying data to be presented in briefs for decision makers. Their argument was that presenting satellite images or model output to non-technical audiences is likely to be met with a lack of understanding, which may ultimately lead to indifference. However, as identified below, this view was not shared by the other groups.

Near Real Time Data and Forecasts

There is a need for *real time data and forecasts* for cyclones and related flooding events, particularly in western and northern Madagascar. Accurate forecasting, perhaps based on near real time data are very important in these situations. The information must be widely circulated through an alert system (currently this is received via local radio) in order to allow planning ahead to prevent disasters, to enable people to evacuate and to advise against travel to threatened locations. Alternative methods such as via "SMS" on mobile phones, which already happens in some cases, should be investigated further.

Other requirements for Near Real Time data and derived information were identified as:

- Improved maritime bulletins to NMIFC and the BNGRC (Disaster Risk Management Bureau), supplied by DGM.
- NMIFC requires data on daily conditions (winds, waves and currents) to: provide warnings of severe conditions; support partner agencies in planning operations against illegal activities; and support fisheries with information on locations of fronts, eddies which can indicate areas of high productivity and hence increased fish concentrations.
- The Ministry of the Environment require information on conditions at the coast line.
- NGOs (WCS) require information to advise the local community when it is safe to go fishing, and in support of alternative activities (e.g. ecotourism, locations for diving, aquaculture, agriculture, etc.)

Climatological and Historical Marine Information

Climatological and historical marine data (winds, waves, currents, sea level, sea surface temperature, ocean colour) is also needed to provide information on historical conditions, including analyses and statistics on historical trends, year to year variability, expected conditions at different times of year, or projections for future change. This information should be in the form of maps, graphs, tables, backed up by explanatory information to support use by non-experts. This type of information was needed by DGM (marine climate information for their users; information on coastal hazards, climate change projections, sea levels and storms for case studies, in support of agro-meteorology), NMIFC (to support investigations of previous events). Also NGOs need marine environmental data for understanding climate impacts on marine ecosystems and wetlands and to support actions to protect and manage the marine environment.

Infrastructure, Activity, Habitat and other Mapping information

Infrastructure, activity, habitat and other mapping Information was needed by the Ministry of the Environment to support development of the Blue Economy and for validation of a Maritime Atlas (jointly developed with Ministry of Land Development) and by DGM to support information of coastal hazards. More generally this information is needed to support mapping of the vulnerability of the coast.

Regional Information

Each region needs its own bespoke information/data depending on local factors. For example, higher resolution data are required for small islands such as Sainte Marie. It must be noted that whilst optical satellite data are now becoming available at higher resolutions, historical data are not available at these resolutions and some high resolution data may be expensive. Modelling might provide a solution in some cases.

Participants from Sainte Marie and Nosy Be identified the need for information on regular increased sea level during the equinox. They have observed increased sea level of up to 2m during surges and would like to receive predictions so that they can plan for these occurrences. There is a perception that these high sea levels are increasing in magnitude. Infrastructure is being flooded and it is important to get improved information to guide further infrastructure construction close to the coast.

2. Gaps in Coastal Risk Information (Data, Resources, Capacity)

In the second discussion session the groups looked at the information needs and identified where there were gaps in the currently available capacity. Discussion outcomes are listed below in terms of data and information availability (including access issues); resources for data analysis and interpretation (human, software and hardware); gaps in capacity which need to be prioritised.

Data availability and access

It was identified that, although there are some issues with data availability, often the problem is with accessing data, most often because mechanisms for sharing data are inadequate or do not exist. Different types of data are available from a range of agencies, dependent on their function and expertise.

Available data

The Madagascar National Oceanographic Data Centre (NODC, hosted at IH.SM) downloads and archives a number of satellite-derived parameters, including chlorophyll and SST (Sea Surface Temperature) at 1km resolution obtained from the GMES (Global Monitoring for Environment and Security) and Africa ground station; as well as surface current, wind and wave data provided by C-RISe and selected high resolution data sets from Sentinel-2 and Landsat. In principle other types of data, such as Synthetic Aperture Radar (SAR) imagery, could be added to this collection.

The ministry with responsibility for land development has, in consultation with an external consultant, created a maritime atlas, currently in the process of national validation. It provides environmental and activity information (including details on the legality of activities), assisting in the organisation of infrastructure (marine planning).

DGM are able to provide climate data, forecasts and near real-time alerts at a national scale, however there is a gap in their ability to provide regionally or locally focussed information.

Base mapping is provided by FTM (the national mapping agency), however they are often bypassed by users who simply access data available through Google maps.

Madagascar has a Regional Coordinating Unit (RCU), Association Reseau Systeme Information Environnementale (ARSIE, www.arsie.mg) which holds information (metadata) on environmental data. It is a membership organisation and includes ministries, researchers and consultants, and is able to direct its members to the holders of data sets.

Priority data needs

There is a lack of high resolution data for baseline studies and change detection related to coastal land use, littoral forests, mangroves, seagrasses, coral reefs and fisheries (seasonal information, species and numbers of fish and vessel). Often, such data sets have been acquired for specific studies by NGOs and universities, but are not collected in a systematic way for sharing between researchers. Being able to access and use such data is a priority for monitoring and management of coastal ecosystems.

To take full advantage of high resolution satellite data, for example for habitat classification, there is a need for in situ data for validation. This include measurements of temperature, salinity, depth and habitat type. However, in Madagascar the capacity to collect such data is either very limited or absent. Developing the capacity to collect, quality control and analyse such data is thus a priority. Where such data is available, information about its existence, quality etc. is not available outside the organisations that collected the data, and there is often an unwillingness to share.

Data Access

Data Policy, Sharing and Standards were all identified as issues that hindered data sharing between organisations and limited cooperation. The NODC, at IH.SM in Toliara/Tuléar, holds a wide range of satellite oceanographic data sets in a national Marine and Coastal Atlas data base. However its resources are limited (meaning that it is understaffed), and the data sets are not currently available online, this makes accessing the information prohibitively slow as it must be requested on a case-by-case basis.

Other data and information are scattered across institutions and are not available centrally. Different institutions all have their own data policy and procedures which must be complied with. Some institutions share data freely, whilst others charge. The Marine Science Plan includes regional information centres, but it was felt that there should also be a national information centre, with responsibility for data sharing. Ideally a national centre would not be affected by changing political regimes to ensure continuity.

Where data is made available, methodologies vary between organisations, and that represents a problem when comparing data sets. There is an issue with variation in definitions and methodology for data collection and interpretation, which requires cross agency agreement on data standards. This was felt to be the responsibility of the national government, however, there was some concern that NGOs would not be bound by nationally set standards. There are also conflicting data management policies between government agencies, e.g. fisheries may develop their own data management plan that differs from other ministries.

The capacity to collect and share in situ data, and associated meta-data and quality information was identified as a priority. ARSIE, currently chaired by Luciano Andriamaro at CI, offers its members help in sharing data and writing policies.

Resources to access, analyse and interpret data

Analysis and interpretation of data are impacted by data availability, access issues and the lack of standard protocols (discussed above), in addition to issues of resource availability (hardware and software) and technical capability (see below).

Resource availability

There is a widespread common problem in terms lack of resources in terms of computer equipment. Data storage and computing capacity is limited, and people are often working with very old hardware which is unable to run the required software for data analysis. Limited internet connectivity and bandwidth is also an ongoing problem, preventing the direct download of data which is otherwise freely available online.

Technical and Skills

Gaps that exist in technical knowledge and skills in data processing and analysis also limit the capacity to apply satellite data to coastal risk. Further training in the access and analyse satellite data are needed, so that new users may learn these skills, these would be most useful in the form of tutorials, which individuals can access. This is important because there is a shortage of experts with time and resources to train new users and answer their various questions. On line tutorials could be developed from some of the C-RISe use cases.

At present there is very limited capacity to use high resolution satellite data to derive environmental information on coastal and benthic habitats. Developing the capacity to carry out the necessary analysis and teach this to future marine scientists is a priority. A train-the-trainer approach in the use of such data is important, but not sufficient in itself. They must also be equipped with hands-on, practical training resources based on relevant examples from different environments around Madagascar. Such resources may also be made available on-line for self-study or revision.

In some cases basic training in oceanographic/marine science is also needed. This is particularly true where agencies are expanding their remit to include the marine realm and, therefore have limited experience in this area.

Main capacity gaps in addressing priorities

In addition to issues with resources and data analysis skills, there are some additional gaps in capacity which hinder the addressing of the decision making priorities. These are around the communication of information to decision makers and communities in a format that is easily understandable, presented at the relevant scale and in a timely manner. Gaps were also identified on the internal coordination of the government agencies for a quick decision-making.

A lot of data/information is too technical for users. Information must be easily understood, and provided in a form that be used to support decision making. Map based information was suggested as a suitable basis to support easy interpretation. Madagascar has a long coastline with many difficult to access coastal communities, and there is a shortage of technicians especially at remote sites. There is a need to get information to local, remote communities, as well as to staff/technicians at remote stations.

There were felt to be a number of issues around weather prediction. Forecasts can be too generalized and so not accurate/relevant, and there is a need to split coastline into regions which have similar marine conditions. There can be very rapidly changing conditions during storms, and conditions can vary significantly in short distances. Providing reliable and useful forecasts in such situations is a huge challenge for forecasters with limited resources. There is also a difficulty in identifying suitable thresholds for wind speeds and wave heights, when sending alerts for severe weather.

There is some concern that when NGOs issue publications they do not comply with regulations set by the government or report findings to the government, they just publish. All government agencies must report findings to the government and there is a feeling that it would be useful if NGOs also drew attention to their findings in this way.

There are problems in establishing which ministry should have responsibility for issues which span the land/marine boundary (e.g. are mangroves a marine or land system?). Other coastal systems have similar problems, with lack of communication and competition between departments. There is also a need for additional expertise in establishing a system for the delimitation of marine protected areas. It was recommended that there should be a cross-governmental decision making, with final decisions going to the Ministry of Coastal Planning.

3. Priorities for Building Capacity in the Use of Marine Satellite data and Modelling in Madagascar

The final discussion session drew on the previous two discussions to identify the priorities for building capacity in Madagascar to use satellite data and modelling to address coastal risk.

Where can satellite data and modelling make the best contribution?

Group B, coastal zone management/coastal erosion, began this session by discussing in what areas satellite data and modelling could make the most useful contributions to understanding.

It was identified that all NGOs need satellite information at regional level since they intervene locally. This was also thought to be true for public institutions. It was therefore recommended that there should be a common information base and collaboration with rigorous decision-making.

Madagascar has specialists working in marine spatial planning led by the Ministère de l'Aménagement du Territoire, de l'Habitat et des Travaux Publics (MAHTH). There needs to be organisation/synergy between those carrying out activities/data collection. In this area it is important to know the different

parameters/contexts that govern each area such as economic zone; specific ecosystems; the actors present; etc. In summary, who does what, where and how?

An issue seen to be a priority, which could be addressed through the use of satellite data and modelling, is coastal erosion. The representative from Sainte Marie raised this as, in that location, simple observation over a few years makes it possible to say that the coastline is being eroded. There is a need to understand why this is occurring (there is both gradual erosion and larger scale erosion during cyclones), perhaps the use of modelling would contribute to identifying how the coastline can be protected. There have been proposals for hard engineering solutions to protect the coast and hoteliers are calling on the authorities to implement this proposal. Before any coastal protection scheme can be implemented, it is necessary to know the effects of this initiative on the other parts of the island coastline to avoid unintended effects elsewhere. A range of data are necessary to be able to establish an appropriate management plan, including wave height, tides, winds, currents, sea level rise, etc. Protective ecosystems such as reefs and mangroves, which mitigate the effect of waves on the coast, also need to be better understood. There is the potential to understand the evolution of coastal erosion and its magnitude using satellite imagery.

Cyclones affect the Southwest Indian Ocean region every year. At the regional level, it has been observed that Comoros and Seychelles are now being affected by cyclones, whereas previously they were not in the cyclones trajectory. The need to study of cyclone paths to better understand the likely tracks and if these are changing. This is important in the long-term, but forecasting tracks also needs to be improved in the short term to make better warning possible, so that populations can act to protect themselves.

The importance of recognising the human factors was also flagged by discussion participants. Coastal populations are increasing, with increased pressures on the land (e.g. for agriculture) and increased fishing. There is a need for a change in mind-sets at all levels to change the way decisions are made around construction and land use which exacerbate the impacts of climate change. People need to be informed of the downstream effects of any decisions.

What are the priorities for capacity development?

Priorities for capacity development in the use of marine satellite data and modelling falls into four broad categories:

- Availability of data and information products
- Modelling capability
- Building capacity to access, analyse, combine and share datasets (skills and IT resources)
- Communication of information to non-scientific audiences

Access to/availability of data and information products

The following data sets, integrated information products and analysis capabilities were identified as priorities:

- Higher resolution data on total current velocities (near-shore and off-shore) for use to improve understanding of coastal erosion, pollution transport, etc. Such products can be derived from SAR, SST and optical images, and validated against models.
- Time series satellite data analysis to monitor shoreline change and capacity to use this information with climatology data on currents, wind, waves and sediment transport to inform predictive modelling of future risk.
- Capacity to use satellite data for shallow water bathymetry, based on high resolution optical data and targeted in situ measurements of depth and bottom substrate (including the capacity to make and use the necessary in situ measurements).
- High resolution tides, waves and sea level data at the coast
- SST, Salinity, chlorophyll, and information on eddies and currents
- Identify threats on the ecosystem through mapping of risk related to activities, infrastructure, marine conditions and severe events
- High resolution maps of coastline change
- Front maps (to identify areas of probable high productivity and possible fishing “hot spots”)

Building Modelling Capability

Development of capacity to use models for a range of applications was identified as a priority. Applications include:

- Use of models and other methods for linking low-resolution off-shore data to conditions affecting coastal environments
- Ecosystem models to develop an understanding of the relationship between climate and marine ecosystems
- Multi-factoral analyses e.g. understanding the different impacts of SST, salinity, etc.
- Oil spill dispersion modelling
- Digital elevation models (DEM) for modelling potential flood risk in coastal zone, and monitor changes in the intertidal zones
- Coupled ocean-atmosphere models
- Modelling for planning and resource management, based on past data
- Coastal evolution modelling, to support assessment of the impacts of different coastal defence developments

Building capacity to access, analyse, combine and share existing and new datasets

In addition to filling gaps in data requirements, and modelling capability, there is a need to build capacity to analyse, interpret and combine data from different sources, and to improve systems and policies so that data can be shared between different organisations.

Priorities identified for skills development were:

- Training to use existing and new data, through classroom education and/or self-study online courses, subjects to include:

- Software creation
- Image interpretation
- Data Visualisation
- Fishing applications, e.g. interpreting data such as SST and chlorophyll
- Development of tools to automate the processing chain for EO data: selection and identification of images, download, processing according to themes of interest. Tools that allow users to submit analysis 'jobs' for data analysis by cloud servers would help overcome the size of high resolution satellite datasets (sentinel 1, 2, …), which require considerable time and resources to download and process locally.
- An improved system for sharing information about datasets held by different organisations is important for better use of existing and new data. The first step is to change the mind-set of decision-makers/data holders so that data is shared.

Priorities for access to improved IT resources to the full exploitation of satellite data in coastal risk applications in Madagascar were identified as:

- Internet connectivity (currently cloud computing or downloading data remotely is not a practical option)
- Increased server capacity at DGM
- Greater infrastructure for high levels of processing at a higher resolution, making data (e.g. forecasts) available at a local level

Capacity development in science communication

- Decision makers want information, not data sets. Building capacity to extract relevant science based information and communicate this to non-scientific audiences at different levels is essential for uptake of satellite data among decision makers in government and civil society.
- There is a need for science communication specialists, people who can translate scientific output into information suitable for busy policy makers. Collaboration between science communication champions and ministries could help to identify and provide information in forms that are useful and used.
- There is also a need to sensitise coastal communities and others about the need for healthy coastal and marine ecosystems, and potential threats to these from environmental conditions and human actions. This means providing the information in forms they can relate to and find useful.
- There is the need to create capacity in producing news and policy briefs.

Adaptive capacity

Several of the above recommendations (and those made throughout the workshop) identify the need for cross organisational working, the sharing of data, information, technical skills. In addition:

- The holders of information tend to sit in the capital, Antananarivo, while those who need it live outside of cities in rural locations, on the coast. There is a need to ensure good links with those based locally.

- This could potentially be solved by having more technicians in the regions. Additionally, if they are based locally, they will have better access to local information for farmers and fishermen which can be fed into decision making.
- In addition to local links there need to be better links with central policy makers. Application of data together with policy considerations to explore future scenarios could enhance capacity to plan for potential changes and develop more effective management responses.
- In addition to technical capacity building, addressed above, there could also be capacity building for managers and decision makers.

Annex 1: Workshop Participants

Name	Organisation
A. Rakotomavo	
Adelaide Sylvie Razafiherisoa	
Amani Becker	NOC
Christelle Razafindrakoto	
Clarence Razakamihaja	Pactworld
Claude Anne Gathier	Institut de Recherche pour le Développement
Clément Jerson Raheriniaina	NMIFC (CFIM)
David Byrne	NOC
David Cotton	SatOC
Eulalie Ranaivoson	GAPCM (Groupement des Aquaculteurs et Pêcheurs de Crevettes de Madagascar)
Fanja Razafindramasy	WWF
Fanomezantsoa Randrianarison	Ministère de l'Aménagement du Territoire, de l'Habitat et des Travaux Publics
Feno Randriandrison	
Franck Razafindraibe	NMIFC (CFIM)
Haja Razafindrainibe	C-RISe
Harison Randriansaolo	CI
Harivelo "mparany" Rakotondramasy	Pactworld
Herilalaina Rasolonjatovo	DGM
Jamal Mahafina	IHSM
Jean Clarck N. Rabenandrasana	CI
Jean Maharavo	CNRO South East
John Bemiasa	IHSM
Juliana RABESAHARISON	CR-GIZC BOENY
Lala Noelison Jacques Ranaivomanana	Ministry of Environment and Sustainable Development
Lei Parla	UKSA
Luciano Andriamaro	CI
Mamy Nirina RAJAONARIVELO	CNRO Nosy Be
Minosoa Ravololoharinjra	RESOLVE
Miora Andriamonohisoa	Directeur de l'Economie Bleue
Miora Ramarojaona	Ministry of Environment and Sustainable Development
Nirivololona Raholijao	DGM
Phil Boyle	FCO
Rasolohery Andriambolantsoa	World Bank
Ravaka Ranaivoson	WCS

Name	Organisation
Rhino Rajaonarivony	DGM
Serge Rafanoharana	World Resource Institute/Hay Tao : Usaid Project
Soary Ratsimbazafy	FCO
Tantely Ravelomanantsoa	Directeur de la Gouvenance de l'Océan
Tatiana Andry Arivelo	DGM
Tiana Rahagalala	USAID Hay Tao
Tiana Randriambola	Direction Générale de la Pêche et de l'Aquaculture
Tim Hayward	Caribou
Tsilevo Zolà	Ministry of Environment & Sustainable Development
Tsiory Razanamparany	CL-GIZC SAINTE MARIE
Val Byfield	NOC
Ventsotarlaina Ramilison	
Zo Rakotomavo	DGM

Annex 2: Workshop Schedule

Coastal Risk Information Service (C-RISe) Workshop

Antananarivo, Madagascar, 11th and 12th February 2020

Hotel Panorama, BP 756, route d'Andrainarivo, 101 Antananarivo, Madagascar

Time Table

Please Note: Presentations may be made in French or English, and simultaneous translation between French and English will be available

Time	Day 1 - Tuesday 11th February
09:00	Arrival and registration
09:40	*Welcome, Workshop Agenda and Objectives*
09:55	*IPP (Leire Parla, UKSA)*
10:00	*Setting the scene - The Changing Ocean Climate and Madagascar* *Observations and projections of marine climate change: Sea Level and Storminess: David Cotton, SatOC*
10:15	*The potential hazard from storm surge and CRISC: David Byrne, NOC*
10:30	*Impacts of Climate Change on the Coastal and Marine Environment: Amani Becker, NOC*
10:45	*Effects of climate change for coastal Madagascar: Haja Razafindrainibe, Independent Researcher*
11:00	Coffee
11:20	*C-RISe Project overview (AB and DC)*
11:40	*Ambodivahibe Marine Protected Area: Clarck Rabenandrasana, CI*
11:50	*Sea State Information for Improving maritime navigation security & safety in the North-Western of Madagascar: Franck Razafindraibe, CFIM*
12:00	*Climatology study of wind, waves, current and sea level change in the North-west of Madagascar: Herilalaina Rasolonjatovo, DGM*
12:10	*Tropical Storm Information: Zo Rakotomavo, DGM*
12:20	*Discussion*
12:40	Lunch
13:40	*Wind and Wave Energy (Ste Marie Island) Rhino Rajaonarivony, DGM*
13:50	*Madagascar Coastal and Marine Atlas: John Bemiasa, IHSM*
14:00	*Vulnerability assessment of the mangrove ecosystem in Ambaro Bay: Fanja Razafindramasy, WWF*
14:10	*Impact of Coastal Climate Change on Shrimp Fisheries: Haja Razafindrainibe, Independent Researcher*

14:20	*Reef resilience in the Mahafaly Seascape: Fanja Razafindramasy, WWF*
14:30	*Discussion*
14:50	Coffee
15:10	*Round up of C-RISe discussions*
15:30	*Look Forward to Day 2*
16:00	Close

Time	**Day 2 - Wednesday 12th February**
09:00	Arrival and registration
09:30	*Welcome, First Day Review, Objectives and Agenda for Day 2*
09:40	*Beyond C-RISe, planned future projects (AB)*
09:50	*Other EO datasets and EO4SD: Val Byfield, NOC*
10:05	*The potential for models to fill data gaps and enhance decision making (DB)*
10:20	*Intro to discussions (AB)* Attendees will split into groups according to the theme they are most interested in, discussions will be held within these groups and reported back on following each session. **Themes** - Marine ecosystem monitoring and management (VB); Coastal zone management/coastal erosion (AB); Maritime conditions and operational decision-making (DC).
10:30	Coffee
10:45	*Discussions Groups – **Session 1** - Coastal Risk Information Priorities of Decision Makers*
11:35	*Report back*
11:45	*Discussions Groups – **Session 2** - Capacity Gaps in Coastal Risk Information (Data, Resources, Research)*
12:35	*Report back*
12:45	Lunch
13:45	*Discussions Groups – **Session 3** - Priorities for Building Capacity in the Use of Marine Satellite data and Modelling in Madagascar*
14:35	*Report back*
14:45	Coffee and prep of reporting
15:15	*Final Plenary Session - Reporting on priorities and recommendations from discussion groups*
16:00	Close

C-RISe Workshop Discussions (Day 2)

Three sets of discussions will take place over the course of workshop Day 2, they will run in three groups addressing different themes (see below). Please select which group you would like to be part of at registration on Day 1.

Objectives:

- Identify the key challenges faced by Madagascar due to a changing marine climate.
- Identify the extent to which C-RISe has contributed to meeting these challenges, and how we can build on this going forward Discuss development of local capacity for accessing and applying satellite data.
- Agree recommendations for future research priorities on marine and coastal risks.

Split into three **discussion groups** to address three application areas or themes each tackling a major aspect of marine/coastal risk management and climate change adaptation planning. The discussion groups will be:

D. Marine ecosystem monitoring and management (Val Byfield);
E. Coastal zone management/coastal erosion (Amani Becker);
F. Maritime conditions and operational decision-making (David Cotton).

Each group will discuss the following in the light of their chosen theme (50 minutes per topic):

4) Coastal risk information priorities for decision makers
5) Capacity gaps in coastal risk information (data, resources, research)
6) Priorities for building capacity in the use of marine satellite data and modelling in Madagascar

<u>Discussion Sessions</u>

1) Coastal risk information priorities for decision makers (10:45 – 11:35)

Who are the **decision makers** within the theme?
(e.g. Central Government; Local Government; Operational Agencies; Local Communities; NGOs; Other)

What **decisions** do they need to make?
(e.g. Real time operational decisions; Planning operations; Management activity planning; Coastal defence design; Other)

What **information** do they need to inform these decisions?

- Maps
- Level of risk/threat to habitats, populations, infrastructure
- Summaries of marine/coastal climate conditions (by season, projected change)
    - What detail?
    - Analysis/statistics?
- Information about present conditions
- Others

And – of these, what are the **priorities** and **why?**
(e.g. biggest impact on most people; urgent need to address before irreversible/major impact; etc.)

2) Capacity gaps in coastal risk information (data, resources, research) (11:45 – 12:35)

What sources of **data** and **information** are already available?
(e.g. Data sets (Local/Regional/Online); Monitoring; Research Projects; Computer Models; Others)

What ***resources*** do you have access to for analysis and interpretation of the data?
(e.g. Computing resources (Hardware/Software/Internet connectivity); Scientific expertise (to interpret the data); Analysis; Others)

Thinking of the Priorities Identified in Session 1, **what are the main gaps in your capacity,** involving satellite data and modelling?

- Data sets, data bases (and derived analysis)
- Scientific Expertise
- IT capability (Hardware, software, connectivity)
- Other

3) Priorities for building capacity in the use of marine satellite data and modelling in Madagascar (13:45 – 14:35)

Review major findings from first two sessions in terms of major information requirements and capacity gaps.

1. Where can satellite data and modelling make the best contribution?
2. Priorities for improving capacity
    - Data sets
        - Higher resolution (in space and/or time)?
        - More parameters (SST, Chl*a*, mapping, etc.)?
        - Higher levels of processing (integrated data sets, statistical analyses, interpreted data, etc.)
        - Modelling
        - Other?
    - Access to Data
    - Data Processing Capability
    - Training
    - IT resources
3. What about adaptive capacity? Examples could include:
    - Creating a self-supporting regional network to enhance data sharing and learning across organisations and countries;
    - Application of data together with policy considerations to explore future scenarios could enhance capacity to plan for potential changes and develop more effective management responses;
    - Identifying champions within organisations who can connect lessons from the data with decision making activities and identify windows of opportunity to actively connect science with policymaking.