→ EO4SD - EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Climate Resilience | Liberia

Monrovia Integrated Development Project (MIDP)

TABLE OF CONTENTS

1. INTRODUCTION

The European Space Agency's (ESA) Earth Observation for Sustainable Development Climate Resilience (EO4SD CR) cluster, is working with the World Bank to provide Earth Observation (EO) data in support of its Monrovia Integrated Development Project (MIDP). Although focussed on the Liberian capital, the MIDP aims to identify pragmatic, spatially integrated, and location specific interventions that contribute to service delivery, improved welfare, and the creation of jobs throughout the country.

Improved decision-making required up to date information about the locations of the key city assets and areas of flood hazard. To do this, the World Bank established the Liberia Mappers Group, a network of agencies and organisations working with geo-spatial data in the country. As a member of the group, the EO4SD CR cluster developed EO-products that facilitate shoreline monitoring, coastal flood risk assessments, and assess exposure in Monrovia. When combined with other spatial and socio-economic data, these products allow for better understanding of the exposure and vulnerability of assets and people in the city, which is crucial to inform its investment decisions.

About ESA's EO4SD Climate Resilience Cluster

Since 2008, the European Space Agency (ESA) has worked closely with International Financing Institutions (IFIs) and their client countries to harness the benefits of EO in their operations and resources management. Earth Observation for Sustainable Development (EO4SD) is a new ESA initiative which aims at increasing the uptake of EO-based information in regular development operations at national and international level.

The ESA EO4SD Climate Resilience Cluster aims to provide insight about the potential of EO to support of climate-resilient decision making at the regional and national scale. In collaboration with several IFIs, the EO4SD CR cluster has developed EO-based integrated climate screening and risk management products and services to help manage climate-related risks and capitalise on the opportunities that climate resilience can create. The EO4SD CR cluster is also working to build the capacity of IFI staff and IFI client states, allowing stakeholders to autonomously use EO-based information for climate resilience decision making.

2. MONROVIA: EO-DATA FOR AREAS OF HIGH CLIMATE VULNERABILITY

Liberia has experienced dramatic levels of urbanisation over the past 50 years. In 1970 the County's urban population stood at around 365,000, representing slightly over 26 percent of the total population.[1] Today, nearly 2.5 million people live in cities in the country, over half of the population. With a history of instability and conflict, Liberia remains one of the poorest countries in the world, with its potential for economic growth and job creation remaining largely unexploited.[2] Low capital investments in economic and social infrastructure have exacerbated the development challenges in the country.

Liberia's capital, Monrovia, absorbed the lion's share of the population rise, growing from a city of 80,000 in the early 1960s to over 1.1 million people today.[3] The coastal city's growing population faces significant challenges form climate change, which is projected to aggravate existing developmental challenges, slowing down economic growth through reduced productivity from climate-sensitive sectors and damage to critical infrastructure.

Socioeconomic challenges such as high rates of extreme poverty, unemployment (56.6% in Greater Monrovia[4]), high population density, and under-developed infrastructure increase the vulnerability of large portions of the population to climate impacts. Climate impacts are also more severely felt due to the low adaptive capacity of the local population.

Climate change also poses critical threats to Liberia's public health, the agriculture sector, and its coastal zone where much of the population and assets are concentrated. Since 2013, sea level rise and coastal erosion has displaced more than 6,500 and destroyed 800 houses in the West Point township of Monrovia. Dwellings built in 2010, favoured by land gains due to the shoreline and river dynamics, are at a high risk of flooding.

1 World Bank Data (2019) Retrieved from Macro Trends: https://www.macrotrends.net/countries/LBR/liberia/urban-population
2 World Bank Data (2018) From the Solomon Islands to Liberia: These are the 25 poorest countries in the world: https://usatoday.com/story/money/2018/11/29/poorest-countries-world-2018/38429473/
3 World Bank Data (2019) Retrieved from Macro Trends: https://www.macrotrends.net/countries/LBR/liberia/urban-population
4 World Bank Data (2019) Retrieved from Macro Trends: https://www.macrotrends.net/countries/LBR/liberia/urban-population

3. EO DATA FOR THE MONROVIA INTEGRATED DEVELOPMENT PROJECT (MIDP)

The World Bank's MIDP identifies adaptation policies that can help Monrovia be better prepared to absorb urban growth in a context of extreme poverty, fragility and increasing risks from climate change. Deciding what policies are most appropriate relies on reliable data about the type of hazards the area will face and what the level of exposure is to those hazards. This information can be used to understand the level of overall vulnerability of people and assets, and plan investments in programmes and infrastructure that can build resilience.

However, reliable data is scarce in Liberia, especially at spatial and temporal resolutions appropriate for analysis at the city level. "The lack of data compelled us to partner and collaborate, with a wide range of partners and start the Liberia Mappers Group, which includes the Earth Observation for Climate Resilience Cluster", explained Swati Sachdeva, Senior Urban Development Consultant, at the World Bank.

The EO4SD CR Cluster identified several EO products that can enhance the MIDP project team's understanding of climate hazards in Monrovia, in particular related to local assessments of coastal flood risk and shoreline monitoring.

Coastal erosion

Since 2013, sea level rise and coastal erosion has displaced more than 6,500 and destroyed 800 houses in the West Point town of Monrovia.[5] Sea level rise leads to erosion and causes the shoreline to retreat landwards, increasing the risk of displacement. Dwellings built since 2010 have often been built on reclaimed land and are therefore at a higher risk of flooding. The soil erosion service based on EO data helps the World Bank determine where to best make investments and identify hotspot areas that need immediate attention.

EO data was used to facilitate improved shoreline monitoring and change detection. The EO4SD CR cluster provided shorelines changes from a 34-year satellite[6] series along 41 km of Monrovia's coastline. The service uses a thoroughly tested methodology for consistent and reliable water body detection based on High Resolution optical imagery.

"The EO4SD CR cluster helped us identify coastal erosion over time using satellite imagery" said Sachdeva. "We can look at the historical trend of how much land was lost in the last 35 years and assess what this means with projected sea level rise by the end of the century."

The methodology included detection of surface water through the Modified Normalized Difference Water Index (MNDWI).[7] MNDWI allows for the discrimination of land area from water, however natural water flow of waves, heavy swells and tides also needs to be taken into account to get an accurate estimation of the shoreline. To account for this, the EO4SD CR cluster used a Land Frequency Index (LFI) which provides the frequency of a pixel being land.

The analysis estimates that the land loss area from 1984 to 2019 in the Greater Monrovia's coastline is not likely to be less than 0.8 square kilometres (Image 1). "Looking at West Point, one of the densest slums, you can clearly see areas that are definitely at risk of coastal erosion." Said Sachdeva, "of course there are also a lot of other factors that impact the damage including the high density of population and buildings in the area".

5 Hayden, S. (2018) As high seas threaten Liberian slum, residents await promised homes. Published July 30 2018 by Reuters: https://www.reuters.com/article/us-liberia-water-slums/as-high-seas-threaten-liberian-slum-residents-await-promised-homes-idUSKBN1KK014

6 1984-2019 co-registering Landsat 5/7/8 scenes, Sentinel-2A/2B scenes and Worlview-3

7 This is combined with retrieval of biophysical variables derived from the Sentinel-2 A/B, Landsat-5/7/8 and WorldView-3 images

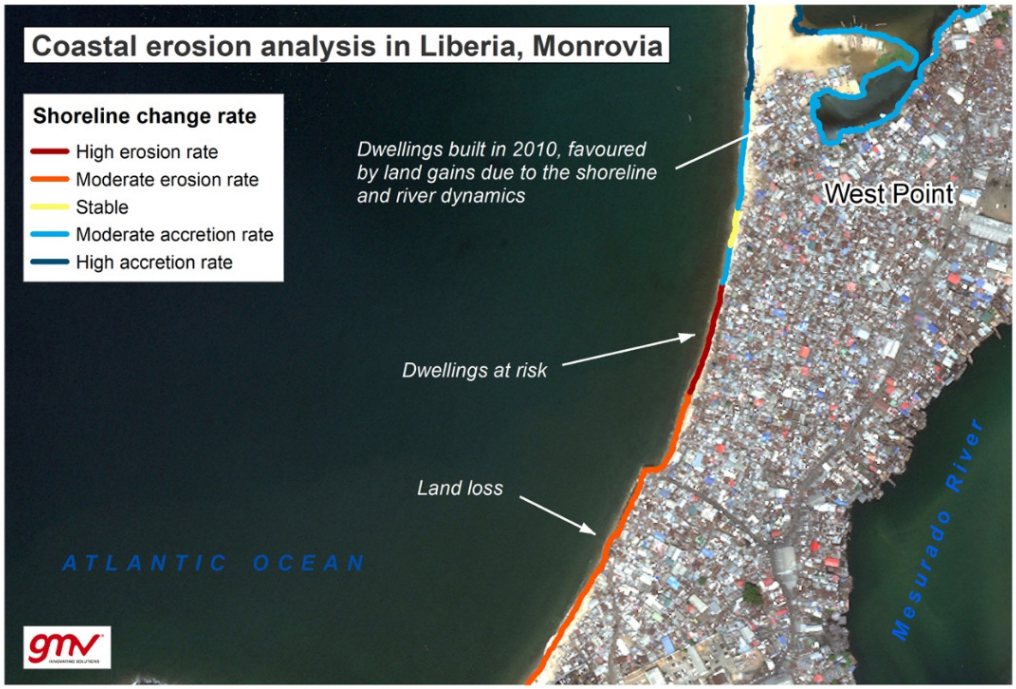

Image 1 Estimation of shoreline retreat from 1984 to 2019 in West Point (Greater Monrovia, Liberia) Source: GMV

Hot spot analysis of flood modelling

Another EO-based service involves hot spot analysis of flood modelling in Monrovia. This provides evidence of the potential coastal and inland flooding for the city for the year 2030. Using high-resolution sea-level rise data obtained from shoreline change in Monrovia's metropolitan area from 1985 to 2019, the sea level rise estimate is used to identify coastal and inland flood risk areas (Image 2).[8] Coastal erosion estimates have also been incorporated to provide a more accurate picture of flood risk.

The flood risk model will help to identify the most effective actions to manage flood risk, develop adaptation plans, consider where natural flood management could be most effective, and enable better planning decisions to avoid unnecessary development in flood risk areas.

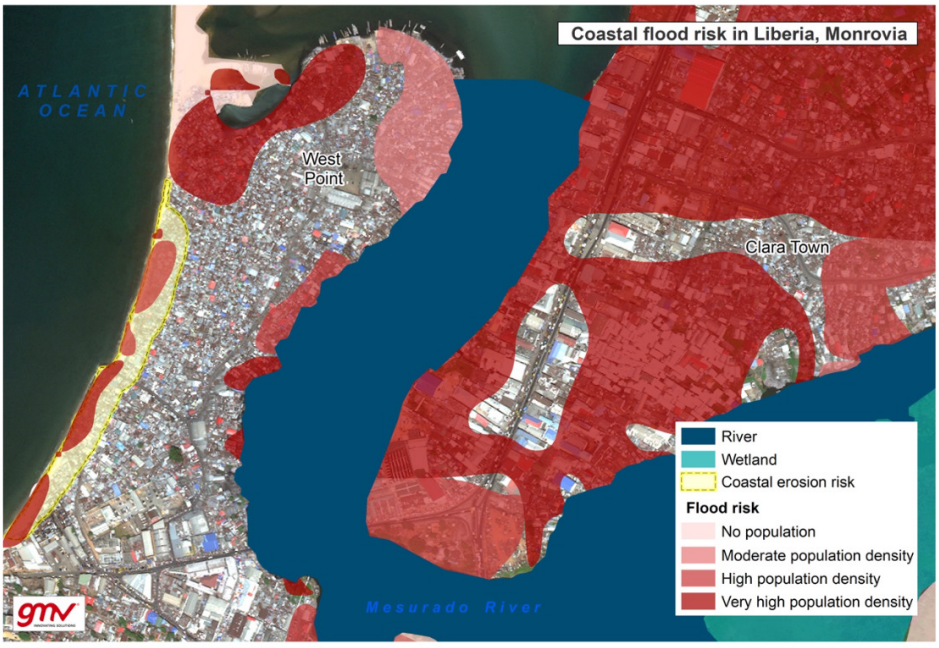

Image 2 Analysis of flood risk over West Point and Clara Town (Greater Monrovia, Liberia) estimated by the exposure (population) and hazard (potential coastal flooding). Source: GMV

8 Shoreline evolution is estimated co-registering 27 Landsat 5/7/8 scenes, four Sentinel 2A/2B scenes and one recent Worlview-3.

Exposure analysis

Valuable information can arise from combining EO-products used in hazard analysis with those used in analysing the exposure of assets and people. With this in mind, the E04SD CR cluster used EO data to provide details of infrastructure and buildings in relation to existing wetlands and areas at risk of flooding in Greater Monrovia.

Very high-resolution satellite imagery was used to identify critical infrastructure and settlements. The urban features were mapped against the wetlands and potential flooding areas to identify the critical urban elements threatened by coastal flooding (Image 3). Table 1 shows the results of the analysis, detailing the number of key assets likely to be flooded due coastal flooding.

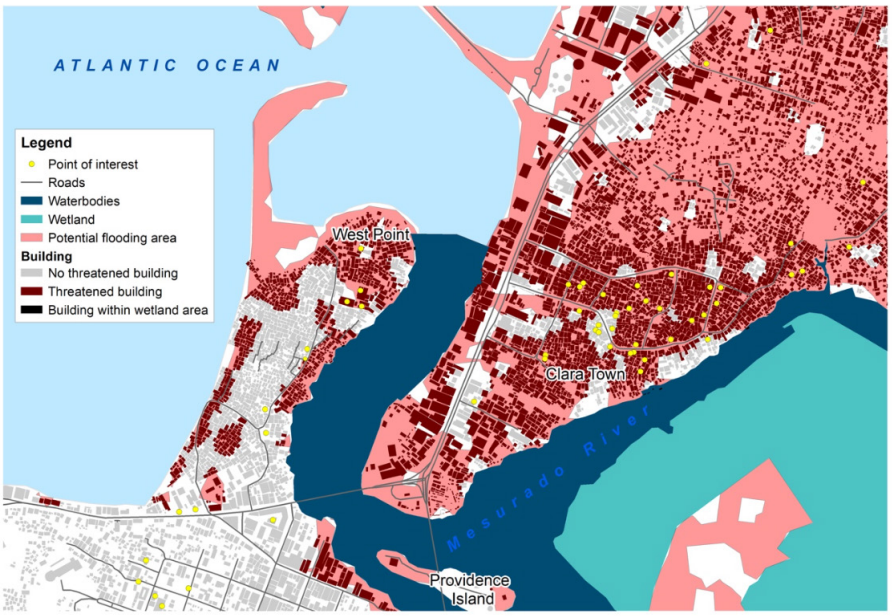

Image 3 Critical infrastructures and settlements likely to be flooded due to coastal flooding in West Point and Clara Town (Greater Monrovia, Liberia). Source: GMV

Table 1 People and assets at risk of coastal flooding within the coastal region of Greater Monrovia. Source GMV

People/assets at risk	Unit of measurement		Threatened	Within wetlands	Total
Estimated population	No.		288,434	N/A	1,357,007
Facilities of interest	No.		66	0	335
Settlements	No.		27,566	797	133,787
Transportation	Roads	Km	185	26	1,641
	Railways	Km	2	0	12

The power of EO data is magnified when it is combined with other datasets. “The satellite data is complemented by land use and other data that can build a picture of the exposure of assets. We have also collected community data, which will allow us to better understand the vulnerability of populations.” Said Sachdeva, “the EO data will feed into a multi-risk analysis by the MDIP team”.

"EO data has opened up discussions in the Bank about how we invest in such areas, where hundreds of thousands of people live, which will be submerged in the next 20 years" - Soraya Goga, Lead Urban Specialist World Bank in Monrovia and Task Team Leader of the MDIP project.

Soraya Goga, Lead Urban Specialist World Bank in Monrovia and Task Team Leader of the MDIP project, emphasised the importance of EO data for decision making under the MDIP "The EO data shows that large areas of central Monrovia are flooded built on swampy land that is regularly inundated" she explained, "putting in huge infra investments in these areas, especially with sea level rise, will mean that you will lose money over time".

The new insights gained from the EO data analysis has even begun to change the way the Bank thinks about future investments in the country. "It has opened up discussions in the Bank about how we invest in such areas, where hundreds of thousands of people live, which will be submerged in the next 20 years" said Goga. "We have been able to engage our colleagues on how we invest in off-grid infrastructure; alternative service delivery that is not reliant on government, such as community-based enterprises that tackle waste; and also looking at social-enterprises to invest in stand-alone interventions such as small water treatment".

4. CAPACITY BUILDING

Alongside the EO service provision, the EO4SD Climate Resilience Cluster delivers capacity building support to foster the sustained uptake of EO-based data and services by IFIs and Client States to support climate change resilience. The goal of the capacity building is to enable the sustainable and autonomous application and use of the provided services and data.

Led by the National Observatory of Athens' Centre of Excellence BEYOND with support from EO4SD Climate Resilience Cluster partners GMV, Acclimatise, Telespazio VEGA UK and GeoVille, the capacity building activities provide both targeted support through practical training, and awareness raising and knowledge transfer through online courses and webinars.

A series of capacity building activities will be undertaken to facilitate increased and better application of EO services related to the MIDP project. Specific capacity building needs that have been identified are to facilitate World Bank staff and other relevant project stakeholders to:

- Assess the valuable information they can get from EO data;
- Use open source tools and produce basic information;
- Use the EO4SD CR data platform to extract EO-derived info and understand what can be offered by EO;
- Produce and interpret EO-based maps; and
- Understand how EO can be fused with other sources of information.

In addition to targeted support and training, the EO4SD Climate Resilience Cluster has also delivered a webinar series to raise awareness, acceptance and understanding of EO-based information services and the associated benefits, impacts and usefulness with regard to the specific priorities of the stakeholders.

The seven-part webinar series, delivered in June and July 2020, is aimed at all those interested in developing a foundational knowledge of EO and how it can be applied practically in the context of climate-resilience projects and programmes.

The series draws on the EO4SD Climate Resilience Cluster's experience working with IFIs including the Asian Development Bank, The World Bank, the International Finance Corporation, Africa Risk Capacity and the European Bank for Reconstruction and Development, to provide 'hands-on' sessions and guided tutorials for existing climate resilience platforms.

Over the course of the series, participants learned the basics of EO data in the context of climate resilience; how, why and when to use EO data to inform decision making,; how to applying EO data to manage key climate risks including flooding and drought; and practical skills about accessing and using EO data tools and platforms.

Partners of the Climate Resilience Cluster

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Cover image: Map showing the flood extent in Monrovia. E04SD.