→ EO4SD - EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Climate Resilience | Enhancing urban resilience using Earth Observation data

ACRONYMS

UN	United Nations
EO	Earth Observation
EO4SD	Earth Observation for Sustainable Development
ESA	European Space Agency
IFI	International Financial Institution
UHI	urban heat island
IPCC	International Panel on Climate Change
NEX-GDDP	Earth Exchange Global Daily Downscaled Projections
CGLS	Copernicus Global Land Service
CCI	Climate Change Initiative
GHS	Global Human Settlement
TEP	Thematic Exploitation Platform
EC	European Commission
WSF	World Settlement Footprint
RCP	Representative Concentration Pathway
SMOS	Soil Moisture Ocean Salinity
HR	High Resolution
C3S	Copernicus Climate Change Service
GPM	Global Precipitation Measurement mission
IMERG	Integrated Multi-satellitE Retrievals for GPM
GPCP	Global Precipitation Climatology Project
SM2RAIN	Soil Moisture to Rain
ASCAT	Advanced SCATterometer
PRD	Pearl River Delta
ADB	Asian Development Bank
LVB	Lake Victoria Basin
WRIS	Water Resources Information System
GIS	Geographic Information System
RS	Remote Sensing
NOAA	National Oceanic & Atmospheric Administration
STAR	Satellite Rainfall Estimates
AR5	Fifth Assessment Report 5
SPEI	Standardized Precipitation Evapotranspiration Index

INTRODUCTION

Today, more people live in urban areas than in rural areas, with 55 percent of the world's population residing in cities. Urbanisation rates are increasing in many regions, notably Asia and Africa, and by 2050, the UN estimates that 68 percent of the world's population will be urban. The pace of urbanisation is putting considerable pressure on critical infrastructure such as water, transport and housing. Climate change is adding to the complexity of urban management by way of shocks and stresses such as extreme heat, flooding and sea level rise. Responding to such challenges is made all the more difficult for fast-growing cities, especially those in developing countries, thanks to a lack of reliable data at resolutions that are appropriate for city-level planning.

Earth Observation (EO) data and services are vital tools for assessing the problems and exposure to future risks for urban areas by identifying structural constraints, informing modelling activities, and identifying development opportunities. The EO4SD Climate Resilience Cluster has worked on a several projects to integrate EO services into decision making and design processes to help solve a range of problems for urban areas. This document outlines some of the problems experienced by the urban sector and how EO data can help identify solutions. Table 1 shows some of the EO data and services that have been made available for urban projects by the European Space Agency's Earth Observation for Sustainable Development Climate Resilience Cluster (EO4SD CR).

Through an ongoing, multi-year engagement with several International Finance Institutions (IFIs), the EO4SD CR cluster, has identified real-world use cases for EO data in projects from IFIs. A selection of these cases is presented here.

EARTH OBSERVATION FOR URBAN CLIMATE RESILIENCE: USE CASES

Dealing with extreme heat and the urban heat island effect

Where: Xi'an city, China

IFI: Asian Development Bank

The problem: The province's most densely populated city, Xi'an suffers from extreme water shortages even with per capita consumption standing at just one sixth of that of the national average. Current technical standards for urban planning do not adequately incorporate climate change projections or their potential risks, including the impact of increased temperatures. As for many cities, extreme heat is a serious problem which is likely to become even worse with climate change. The urban heat island (UHI) effect can result in an additional 2–5ºC increase in air temperatures above those of surrounding non-urban areas[1]. Knowing which urban areas are most effected by heat and where the most vulnerable populations are is important when planning urban development to minimise the UHI effect and to allocate resources and to prepare for higher temperatures as a result of climate change.

How might EO data be deployed? EO data can detect urban heat islands by measuring land surface temperatures and deriving air temperatures at the city in many different time periods. It additionally can identify the green areas and the build-up land on the urban heat island. This data can then be used to analyse the impact of green areas on the urban heat island, understand and model thermal activity and ventilation in and around individual cities, and inform planning and 'climate-adaptive' building design to help deal with heat waves.

1United Nations (2018). World Urbanization Prospects: The 2018 Revision. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

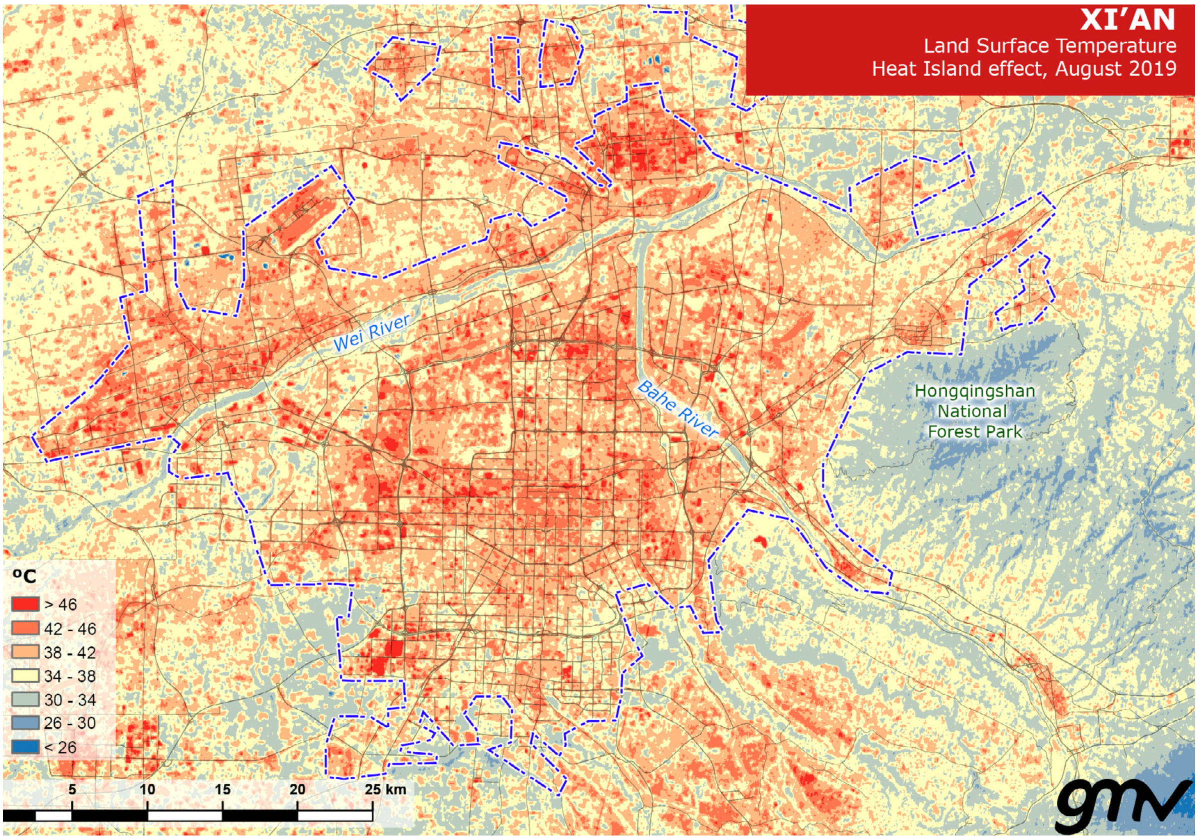

Image 1: Map of land surface temperatures derived from Landsat-8 for the urban areas of Xi'an, China in August 2019. Source: GMV

Mapping shoreline erosion in coastal cities

Where: Greater Monrovia, Liberia

IFI: World Bank

The problem: 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, Liberia. Sea level rise leads to erosion and causes the shoreline to retreat landwards, increasing the risk of displacement. Dwellings built in 2010, favoured by land gains due to the shoreline and river dynamics, are at a high risk of coastal flooding. An ongoing World Bank project aims to identify 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.

How might EO data be deployed? The shoreline evolution is monitored through a satellite series of near 40 years. The shorelines are obtained by satellite imagery in different time periods taking into consideration the natural water flow (waves, heavy swell and tides). The coastline erosion rate is estimated from the shoreline changes and adjusted by the coastal geomorphology obtained from very high spatial resolution satellite images. By monitoring and mapping the impact of historical and future coastal erosion, the coastline can be categorised according to its resilience and decisions can be made to either adapt, defend, or move coastal communities and assets. EO supports World Bank' studies to determine where to best make investments and identify hotspot areas that need immediate attention.

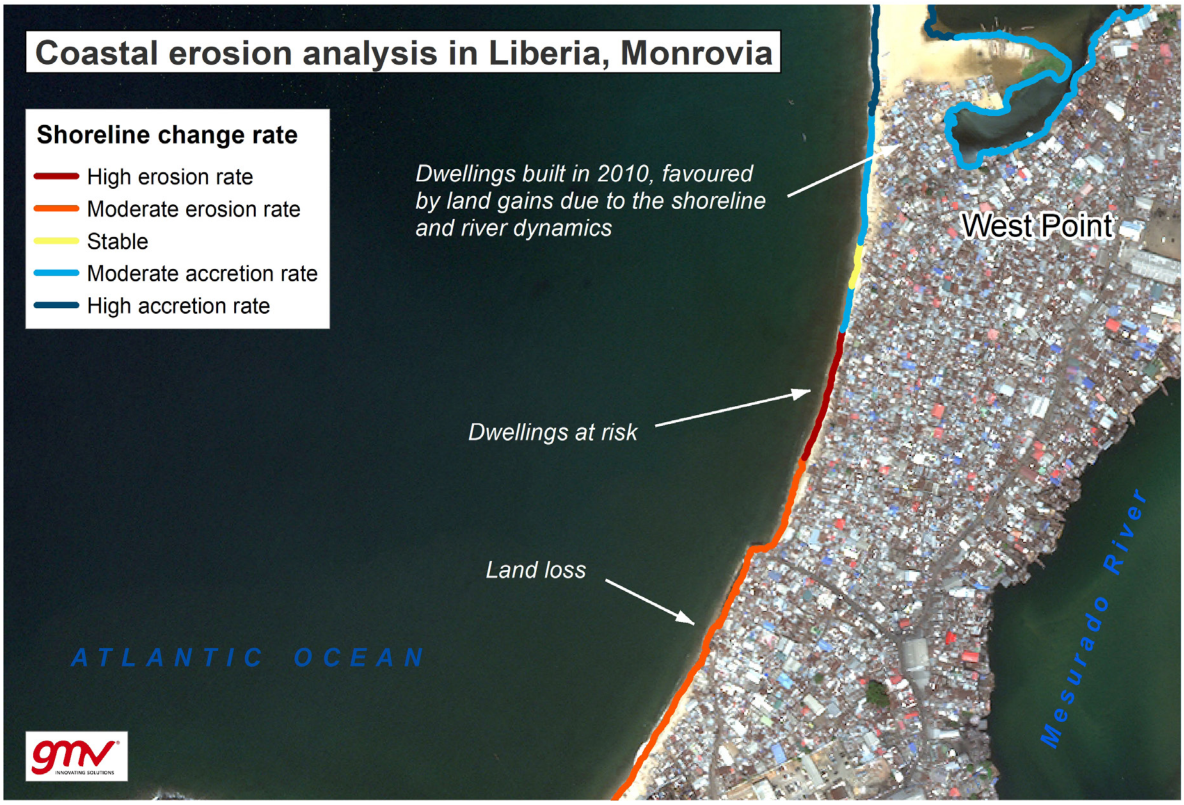

Image 2: Rate of shoreline erosion in coastal region of Greater Monrovia, Liberia. Source: GMV

Modelling coastal flooding risk in coastal cities

Where: Greater Monrovia, Liberia

IFI: World Bank

The problem: Flood risk maps shows the several probabilities of the potential adverse consequences associated with floods. Following IPCC's definition, the climate risk is the function of hazard, exposure and vulnerability. The analysis performed for the World Bank project includes the analysis of the coastal hazards such as sea-level rise, subsidence and coastal erosion and the identification of the socio-economic features to assess the exposure and vulnerability of the Monrovian society.

How might EO data be deployed? EO-based services support the flood modelling analysis in Monrovia, evidencing the coastal flooding risk for the city in the near future. Estimating the sea-level rise rate from shoreline changes in Monrovia's metropolitan area from the 80's and the land subsidence rate using altimeters on-board satellites, the coastal low-lying areas likely to be flooded in the next decade are identified. The flooding hazard is then combined with the exposure and vulnerability analysis obtained from the population density, critical infrastructures and settlements detected from satellite imagery to estimate a flood risk assessment. A flood modelling and mapping can help authorities to identify the most effective actions to manage flood risk and develop adaptation plans, considering where risk management could be most effective, and enable better planning decisions to avoid unnecessary development in risk areas.

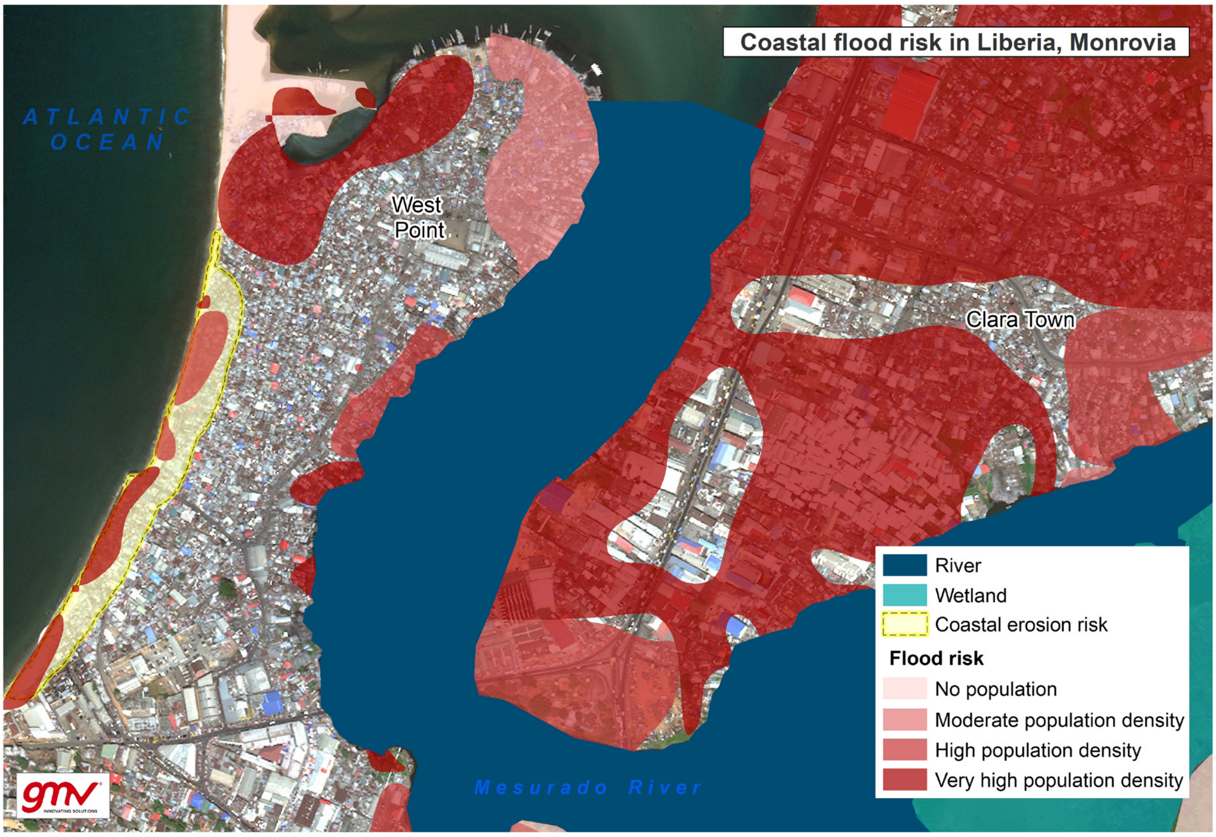

Image 3: Coastal flood risk analysis in West Point and Clara Town (Greater Monrovia, Liberia) derived by the exposure/vulnerability (population density, critical urban elements) and potential hazards (coastal flooding, land deformation, sea-level rise, coastal erosion). Source: GMV

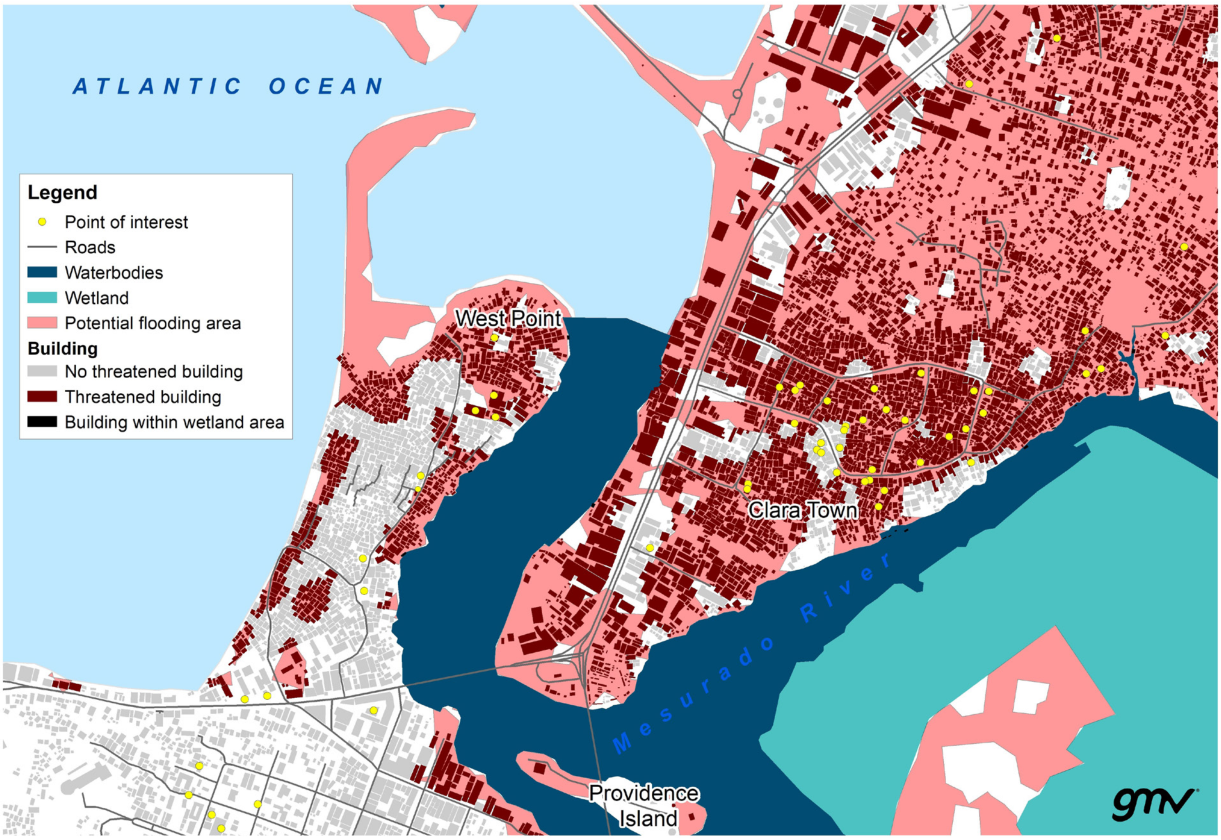

Image 4: Critical infrastructures and settlements likely to be flooded due to coastal flooding in West Point and Clara Town (Greater Monrovia, Liberia). Source: GMV

Encouraging economic and social development through infrastructure planning

Where: Changzhi City, China

IFI: Asian Development Bank

The problem: Changzhi City, a regional centre in the Southeast of the Shanxi Province in the central region of the People's Republic of China, is at the beginning of a transition towards a modern and diverse urban economy supported by improved education and urban liveability. Its current dependency on coal-mining and traditional industries, has led to air, water, and soil pollution, as well as subsidence from underground mining which poses a threat to public safety and public health. Climate change is expected to bring increased temperatures, which will only exacerbate the health issues associated with poor air quality.

How might EO data be deployed? A mix of Earth Observation and climate projection-derived information can support the integration of climate resilience into investments. For example, EO data can be used to assess an area of land for its suitability for industrial park infrastructure that would reduce climate risks and incorporate innovative nature-based designs. Including EO data in new economic prospects can also help decision makers to identify nature-based, environmentally sensitive, green and inclusive tourism, trekking paths, and preserve historic villages, all whilst taking into account the impact of future climate change. In this way, EO data can be used as an awareness raising tool for inclusive design of urban development, and act as a knowledge exchange tool to share best practice with other countries.

Image 5: Vegetable strata of green infrastructure cover observed in Changzhi, China.
Source: GMV

Table 1: Examples of relevant Earth Observation products and services provided by the EO4SD climate resilience cluster and possible matched city data layers. This table is illustrative only of the types of data and information available. Source: EO4SD Climate Resilience Cluster.

Climate shocks and stresses	EO climate data	Applicable EO urban data
Extreme heat	**Temperature** • 30m land surface temperature from Landsat data (1982 - present). • 0.1 degree air temperature from ERA5-land (1979 - present). • Heat island intensity (temperature difference between urban and rural locations within a given time period). • 0.25 degree air temperature projection (RCP 4.5 and RCP 8.5) from NEX-GDDP (present - 2099).	• Land use / land cover maps from the CGLS Global Land Cover (100m, 2015) and the CCI Land Cover (300m, 1992-2015) • Demographic data from the EC's Global Human Settlement framework (250 m) and ESA Urban TEP's World Settlement Footprint (WSF) (10m). • 30m/10m vegetation indexes from Landsat and Sentinel-2 data (1982 - present) • 30m/10m build-up area indexes from Landsat and Sentinel-2 data (1982 - present)
Flooding	**Flood extent** • Flood extent analysis of historic events • Continuous monitoring of flood extents • Baseline flood extent (including water extent fluctuations over a certain 'baseline' time period from a time-series of images with each pixel showing an inundation frequency, and a classification of water body type). **Soil moisture** • Soil moisture from SMOS (0.1 degree, 2010 - present) and C3S (0.25 degrees, 1978 - present) **Precipitation** • 30 min global satellite observations from GPM IMERG (0.1 degree) from 2000 to present. • Daily global satellite observations from GPCP (1 degree) from 1996 to present. • Daily global satellite observations from SM2RAIN-ASCAT (0.11 degree) from 2007 to 2019. • Hourly reanalysis data from ERA5-Land (0.1 degree) from 1979 to present. • 0.25 degree rainfall projection (RCP 4.5 and RCP 8.5) from NEX-GDDP (present - 2099). • 15 min global satellite observations from NOAA STAR (50m) from 2006 to present.	• Land use / land cover maps from the CGLS Global Land Cover (100m, 2015) and the CCI Land Cover (300m, 1992-2015) • Demographic data from the EC's Global Human Settlement framework (250 m) and ESA Urban TEP's World Settlement Footprint (WSF) (10m). • Critical infrastructure and settlements analysis from HR EO data (i.e. 10-30m spatial resolution) or available ancillary information. • 30m/10m vegetation indexes from Landsat and Sentinel-2 data (1982 - present) • 10m urban land subsidence from Sentinel-1 (2014 - present)
Sea-level rise	• Sea Level Anomaly from C3S (0.25 degree, 1993 –present). • 1 degree sea level rise projection (RCP 4.5 and RCP 8.5) from IPCC AR5 (present - 2100).	• Land use / land cover maps from the CGLS Global Land Cover (100m, 2015) and the CCI Land Cover (300m, 1992-2015) • Critical infrastructure and settlements analysis from HR EO data (i.e. 10-30m spatial resolution) or available ancillary information.
Coastal erosion	**Shoreline detection** • Mapping of historical shoreline positions • Estimation of annual average erosion rates • Monitoring of coastal erosion • Projection of the shoreline change	• Critical infrastructure and settlements analysis from HR EO data (i.e. 10-30m spatial resolution) or available ancillary information.
Saltwater intrusion	• Mapping of saltwater intrusion (upon availability of in-situ saline measurement data from the location of interest)	• Critical infrastructure and settlements analysis from HR EO data (i.e. 10-30m spatial resolution) or available ancillary information. • 10m urban land subsidence from Sentinel-1 (2014 - present)

Partners of the Climate Resilience Cluster

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