Enhancing Adaptation and Resilience against multi-hazards along West Africa's Coasts (EARWAC)

SUMMARY

Key Points

- The EARWAC Dashboard brings together extant data, including from European Space Agency Climate Change Initiative (ESA CCI), and other local indicators from multiple stakeholder sources; and shows information on coastal multi-hazards. The dashboard could support climate adaptation priorities, decision-making, and alerts/preparedness for coastal multi-hazards across West African coastal cities.
- The Coastal Flood Vulnerability Index (2020 to 2022) during the rainy season falls between severe, critical, and very critical for most parts of coastal West Africa, especially the southernmost fringes, with tens of millions of people at-risk.
- Normal and extreme flash floods over the region are highly variable between 2005 to 2020 during the rainy months. However, extreme flash floods mostly occur in coastal Nigeria, Sierra Leone, Guinea, and parts of Côte d'Ivoire.

Service

- Adaptation
- Coastal management
- Disaster risk reduction (DRR)
- Flood management
- Mitigation
- Urban

End User(s)

- General Public
- Government agencies
- Industry
- Local communities
- Researchers

Intermediate User(s)

- Small and mid-size enterprises (SMEs) operating at the coasts
- Media (Premium Times, Space in Africa, China Global Television Network Africa, EnviroNews Nigeria)
- Operational and disaster response institutions (Public-serving)
- National and regional environment agencies

Application(s)

The Enhancing Adaptation and Resilience against multi-hazards along West Africa's Coasts (EARWAC) project commenced in mid-2019 and was publicly launched in November 2021. EARWAC works to better understand, prepare for, monitor, and manage coastal degradation and hazards; and also protect the coastal ocean environment and communities in West Africa using long-term climate records derived from Earth observation (EO) and other sources. In addition, EARWAC prioritizes regional coordination, community-based communication/literacy approaches, and citizen participation—common themes other local and international initiatives in the region fail to consider or sufficiently implement from country to country. The EARWAC Dashboard is the main product offering of the EARWAC project. It is a responsive web-based visualization and analysis-ready tool that combines EO data and local indicators to generate detailed maps and analytical charts on coastal flood vulnerability index, flash flood (historical and projected), land cover, and at-risk populations at different administrative levels. Users are able to switch from different forms of visualization and charts and retrieve and download the information that interests them in a given format (GeoJSON, raster, and CSV) based on user-defined specifications.

• Essential Climate Variables

—Atmosphere

- Precipitation
- Wind speed and direction

—Land

- Land cover

—Ocean

- Sea level

Models

- MPI-ESM1.2-HR (von Storch et al., 2017), https://cera-www.dkrz.de/WDCC/ui/cerasearch/cmip6?input=CMIP6.HighResMIP.MPI-M.MPI-ESM1-2-HR)
- HadGEM3-GC31-HM (Roberts, 2017), https://cera-www.dkrz.de/WDCC/ui/cerasearch/cmip6?input=CMIP6.HighResMIP.MOHC.HadGEM3-GC31-HM)
- CNRM-CM6.1 (CNRM-CM6.1 (Voldoire et al., 2019), http://www.umr-cnrm.fr/cmip6/spip.php?article11)

Climate Data Records

- Sea level (RecordID 12377)
- Land cover (RecordID 11520)
- Wind speed and direction (RecordID 10223)

Agencies

- ECMWF (ERA-interim)
- ESA (Climate Change Initiative program)
- European Commission (Copernicus Marine Service CMEMS)

Sustainability

Given further financing opportunities and institutional support, we plan to map hazard scenarios and include information on coastal erosion and pollution events in future phases of the EARWAC program. The EARWAC platform will serve as a one-stop shop for obtaining information on coastal hazards—flooding, coastal erosion, and marine pollution—peculiar to the region for first responders, SMEs, and policymakers. This will continue to improve decisions and priorities on preparedness and response coordination, better manage hazards, and minimize vulnerabilities.

Table 1: Description of datasets, sources, and format

Variables	Source	Format	Website
Rainfall	TAMSAT	NetCDF	http://www.tamsat.org.uk/data-subset/
Runoff	Copernicus Climate Service (ERA5)	NetCDF	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview
Significant Waves & Swells	Copernicus Climate Service (ERA5)	NetCDF	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview
Coastal Wind	Copernicus Climate Service (ERA5)	NetCDF	https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview
Mean Sea Level	AVISO+ Satellite Altimetry Data	NetCDF	https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/mean-sea-level.html
Elevation	Shuttle Radar Topography Mission (SRTM)	GeoTIFF	https://www.usgs.gov/centers/eros/science/usgs-eros-archive-digital-elevation-shuttle-radar-topography-mission-srtm-1?qt-science_center_objects=0#qt-science_center_objects
Population	WorldPop	GeoTIFF	https://www.worldpop.org/project/categories?id=18
Land Cover	ESA Land Cover Climate Change Initiative	GeoTIFF	https://catalogue.ceda.ac.uk/uuid/b382ebe6679d44b8b0e68ea4ef4b701c

Table 1: Tropical Applications of Meteorology Using Satellite data and Ground-based Observations (TAMSAT): based on Meteosat TIR
Shuttle Radar Topography Mission (SRTM)
Land Cover CCI: AVHRR, Envisat MERIS, PROBA-V, SPOT_VGT
Mean Sea Level: Jason-2, Jason-3, Sentinel-6, SARAL/Altika, Envisat, ERS-1 and ERS-2

DESCRIPTION

Ecosystems, livelihoods, properties, and the wellbeing of coastal communities and populations in West Africa are threatened by increasing global changes and local pressures that drive coastal degradation and multi-hazards. This region faces high rates of urbanization, population influx, and industrialized human activities that put a demand on land, water, energy, food, and other natural resources. Consequently, these pressures increase the vulnerability of coastal areas of West Africa to coastal degradation and hazards such as erosion, water pollutant flows, storm surges, and flooding. Impacts are already being felt and exacerbated by climate change and disaster risk.

The "Enhancing Adaptation and Resilience against multi-hazards along West Africa's Coasts (EARWAC)" project commenced in mid-2019 and publicly launched in November 2021 with initial funding from the Joint European Space Agency–Future Earth program, as well as institutional support from the Ocean Knowledge–Action Network and Future Earth Coasts. EARWAC works to better understand, prepare for, monitor, and manage coastal degradation and hazards and also protect the coastal ocean environment and communities in West Africa using long-term climate records derived from Earth observation (EO) and other sources. In addition, EARWAC prioritizes regional coordination, community-based communication/literacy approaches, and citizen participation—common themes other local and international initiatives in the region fail to consider or sufficiently implement from country to country. By focusing on these gaps, EARWAC also empowers coastal communities to take action for their own self-preparedness, build resilience, and engage public protection and disaster relief stakeholders for long-term action planning and prosperity. EARWAC's success and market uptake depend on the commitment, funding, and contributions of current (and future) partners and SMEs/industry networks with shared interests in collaboration, co-creation and development, and solutions built on EO data and other emerging technologies.

Our main product

Coastal hazards often do not happen in silos. They usually have cascading and costly effects with one hazard leading to another or increasing the risk of another hazard. For example, in 2017 coastal flooding, erosion, and pollution cost about 5.3% of the GDP ($3.8 billion) of Benin, Côte d'Ivoire, Senegal, and Togo (Croitoru et al., 2019). Examining vulnerability to coastal multi-hazards in West Africa is challenging given the complexity of multi-hazards themselves and sparsity/scarcity of environmental observations in the region.

The EARWAC Dashboard is the main product offering of the EARWAC program. It is a responsive web-based visualization and analysis-ready tool that currently combines EO data and local indicators to generate detailed maps and analytical charts on coastal flood vulnerability index, flash flood (historical and projected), land cover, and at-risk populations at different administrative zones. Users are able to switch from different forms of visualization and charts along with a portal to retrieve and download the information that interests them in a given format based on the user-defined specifications.

Developed primarily on the back of Climate Change Initiative (CCI) datasets, the ultimate purpose of the EARWAC Dashboard is to guide its users (responder institutions, media, and citizens) to improve decisions and priorities on preparedness and response coordination, better manage hazards, and minimize vulnerabilities.

How was the dashboard co-designed and developed?

Co-design of the dashboard involved 29 expert surveys and on-ground community consultations, reaching a range of 667 stakeholders in 11 West African countries. These consultations were implemented by 19 early-career professionals and two youth-focusing, grassroots organizations.

What information is currently shown on the dashboard?

- **Coastal Flood Vulnerability Index (CFVI)**
  This index quantifies coastal flood vulnerability across the region between 2020 and 2022 as Low, Medium, Severe, Very Severe, and Critical (Hadipour et al., 2020). It is based on multiple variables including rainfall, runoff, coastal slope, surface wind velocity, significant waves and swells, and sea-level. These parameters were further ranked based on the relative degree of influence they have in predicting coastal floods through a Fuzzy Analytical Hierarchical Process (Hadipour et al., 2020; Tahri et al., 2017) to capture expert knowledge about the peculiarities of coastal floods in the region. CFVI can assist decision-makers in evaluating the impacts of different scenarios and facilitating adaptation and coping capacities.

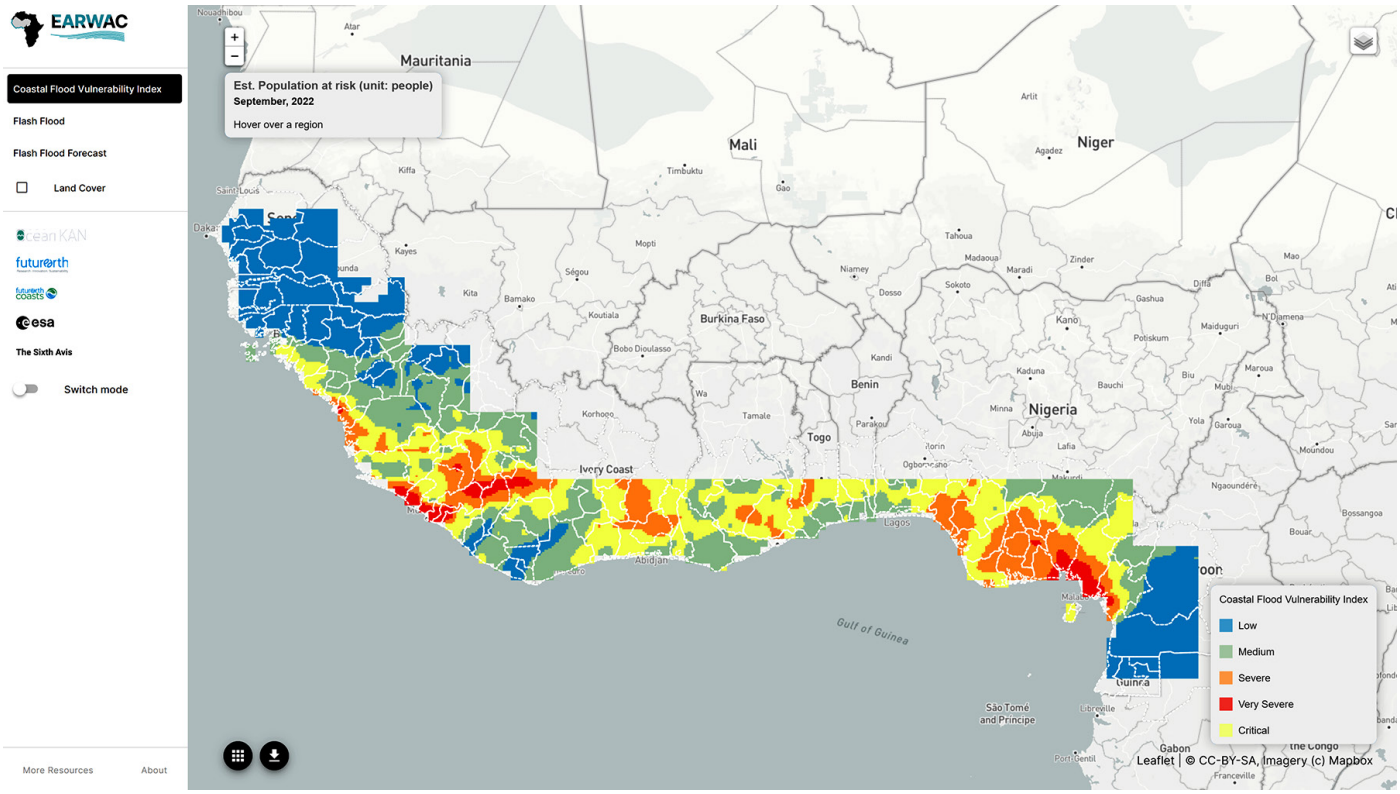

Figure 1. West Africa—Coastal Flood Vulnerability Index (CFVI) zone, September 2022.

- **Flash Flood (historical and projected)**
  Information on flash floods is provided for 2015–2021 (historical) and 2022–2023 (projection). This is based on intense or extreme maximum consecutive wet days that lead to surface flash floods.

- **Land Use/Land Cover**
  The ESA CCI Land Cover[1] dataset is used as an optional base map to identify various land cover components affected by flooding visually. The land cover classes correspond to the UN Land Cover Classification System (LCCS)[2], which provides a consistent categorization for developing land cover classes. Primarily, the LCCS consists of eight main land cover types: i.) Cultivated and managed terrestrial areas, ii.) Natural and semi-natural terrestrial vegetation, iii.) Cultivated aquatic/regularly flooded areas, iv.) Natural and semi-natural aquatic/regularly flooded vegetation, v.) Artificial surfaces and associated areas, vi.) Bare areas, vii.) Artificial water bodies, snow, and ice, and viii.) Natural water bodies, snow, and ice. These a-priori defined land-cover classes in the ESA CCI land cover were reclassified into seven main categories for the West African region: i.) Water body, ii.) Tree cover, iii.) Cropland, iv.) Grassland, v.) Urban areas, vi.) Bare areas and vii.) Mangroves. We are working on updating the land cover dataset to ESA's global land cover product at 10 m resolution for 2020 based on Copernicus Sentinel-1 and -2 data.

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[1]ESA Land Cover CCI project team; Defourny, P. (2019): ESA Land Cover Climate Change Initiative (Land_Cover_cci): Global Land Cover Maps, Version 2.0.7. Centre for Environmental Data Analysis, date of citation. https://catalogue.ceda.ac.uk/uuid/b382ebe6679d44b8b0e68ea4ef4b701c.

[2]https://www.fao.org/land-water/land/land-governance/land-resource-planning-toolbox/category/details/en/c/1036361

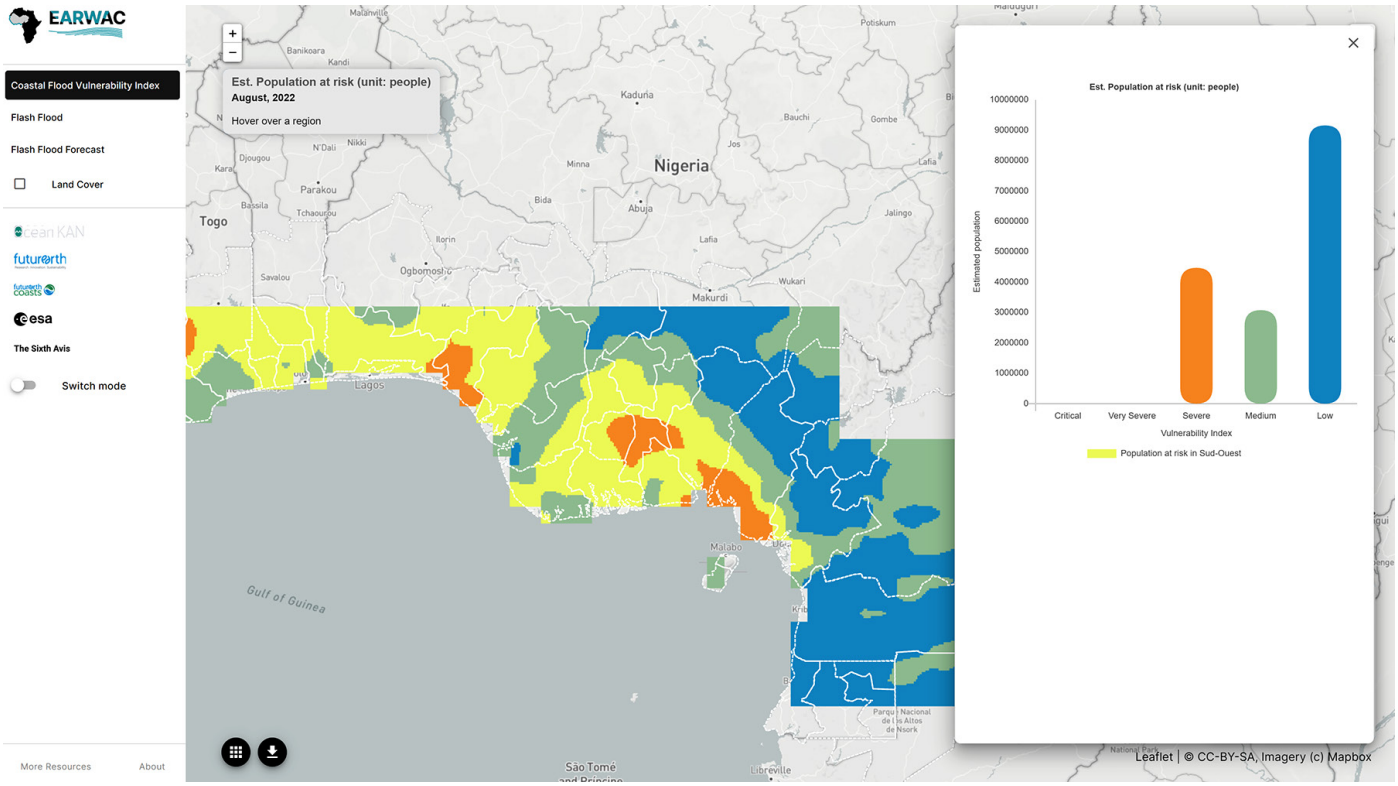


Figure 2. (Sud-Ouest) Cameroon, population at risk, CFVI , August 2022.

- **At-risk Population**
  The at-risk population in each hazard severity or vulnerability zone and the administrative boundary are estimated using population density data (Global Administrative Unit Layers, 2015; WorldPop, 2020).
- We plan to map hazard scenarios and include information on coastal erosion and pollution events in future phases of the EARWAC program.

References:

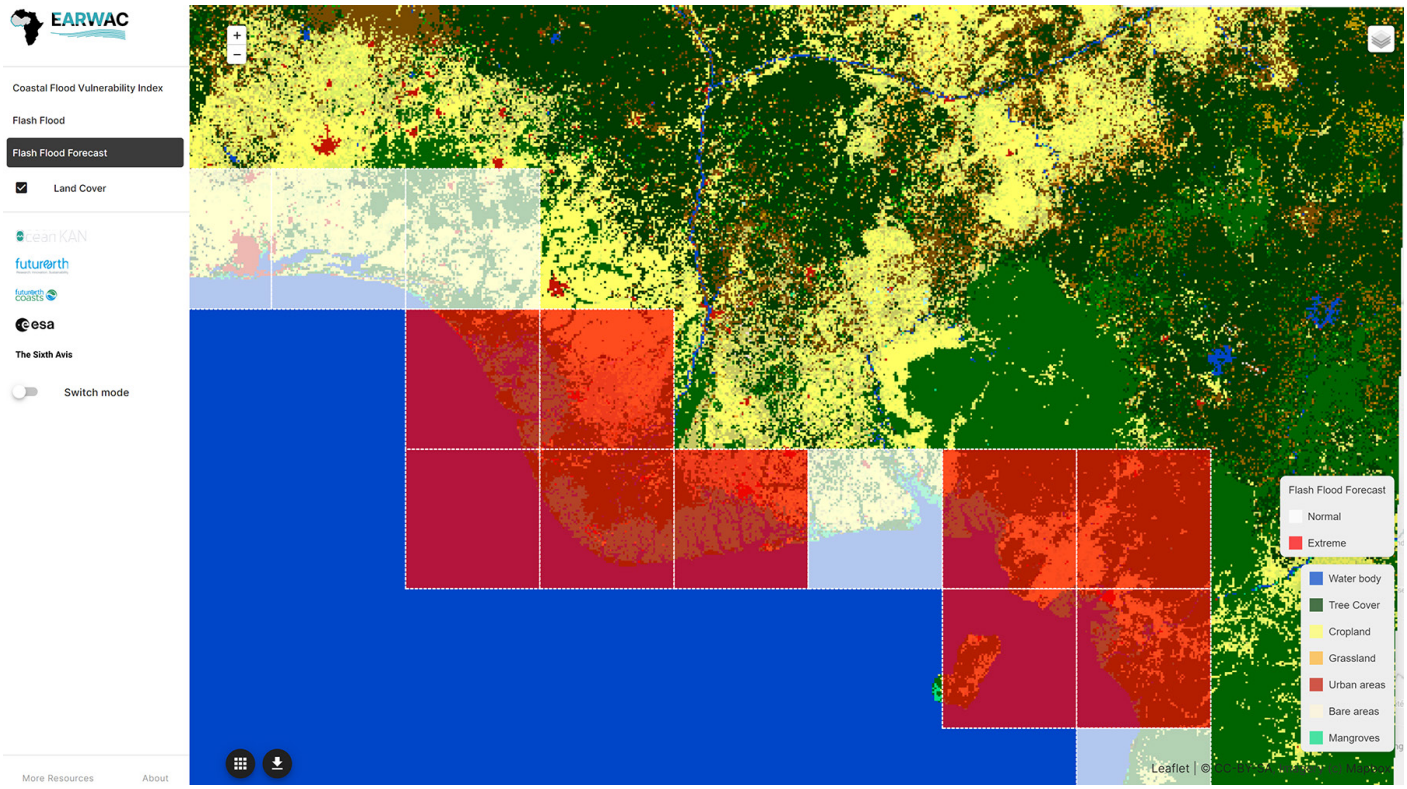


Figure 3. Flash flood forecast for August 27, 2022, with ESA CCI Land Cover as the base map.

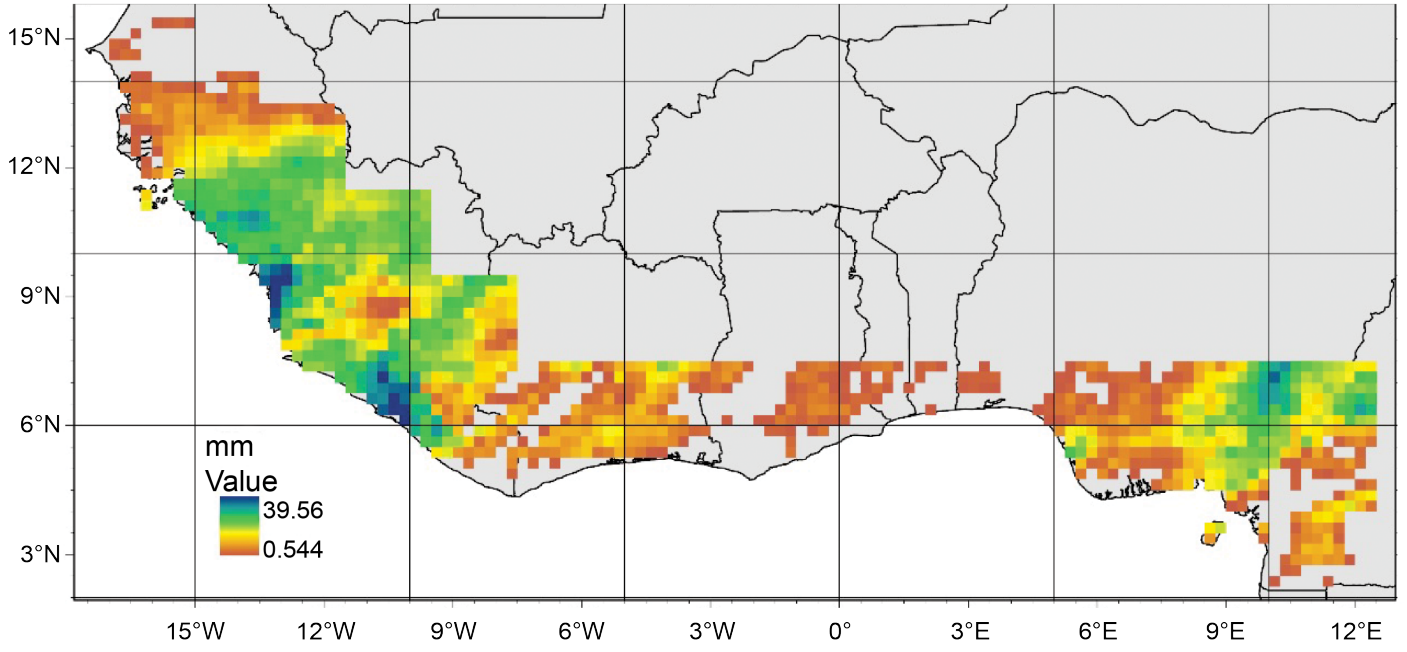
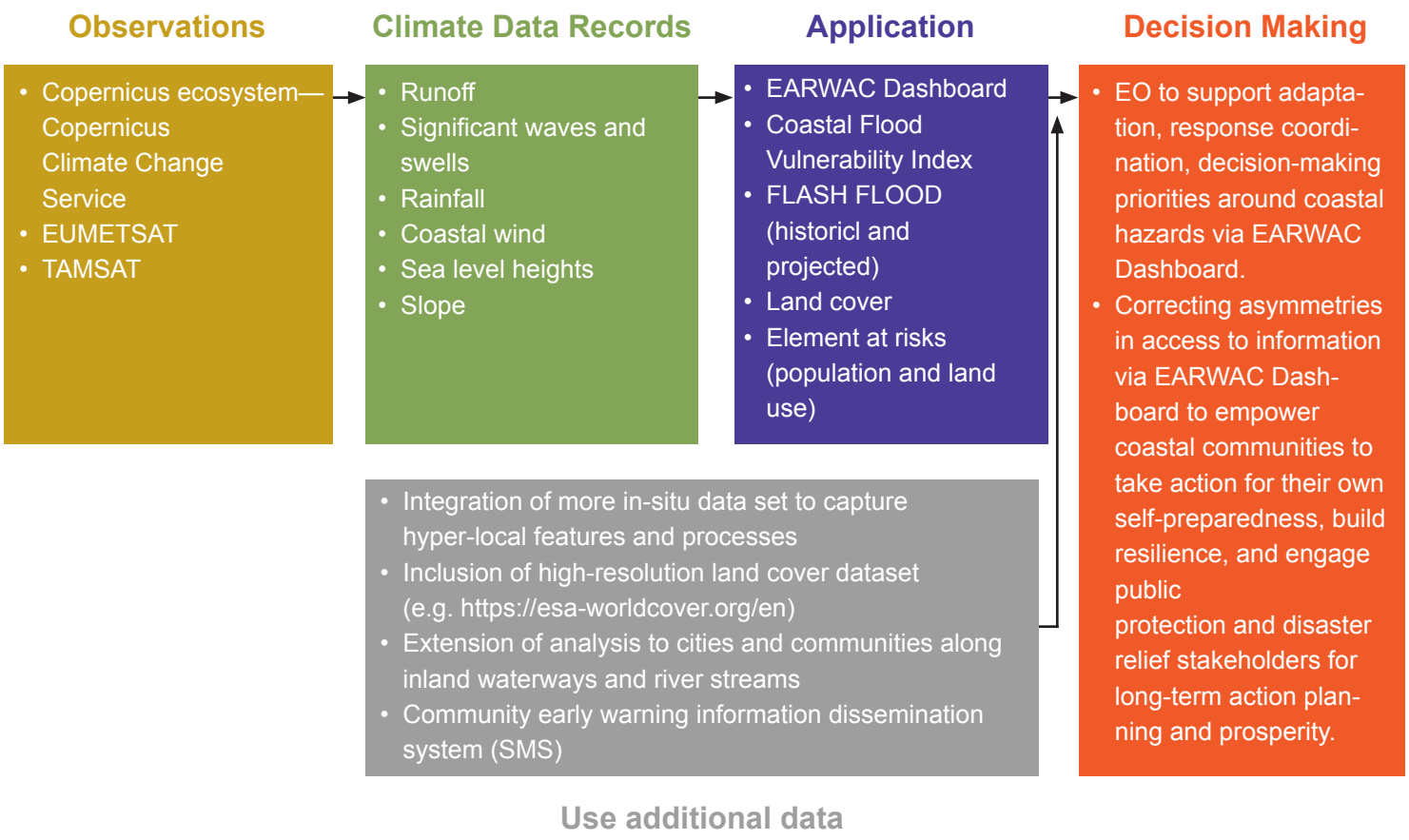


Figure 4. Precipitation for September 10, 2020 (0.25 x 0.25 degree); TAMSAT.

INFORMATION FLOW



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