Eco-DRR Opportunity Mapping Tool Update

Technical Note - June 2022

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Global datasets

Ecosystems

Layer theme	Title	Provider	Reference Period	Resolution	Url
Forest	MODIS Land Cover Type Version 6	NASA/MODIS	2020- 2020	0.004166 dd	https://lpdaac.usgs.gov/products/mcd12q1v006/
Mangroves	The Global Mangrove Watch	World Conservation Monitoring Center (WCMC) Ocean Data Viewer	1996 - 2016	0.00022 dd	http://data.unep-wcmc.org/
Sea grasses	WCMC Global Distribution of Sea grasses	WCMC Ocean Data Viewer	1934 - 2020	1:1,000,000	http://data.unep-wcmc.org/
Coral reefs	WCMC Global Distribution of Coral Reefs	WCMC Ocean Data Viewer	1954 - 2018	0.00027 dd	http://data.unep-wcmc.org/

Natural hazards

Layer theme	Title	Provider	Reference Period	Resolution	Url
Landslides	Frequency of landslides triggered by earthquakes	GAR 2009, PREVIEW / Global Risk Data Platform	model	0.008333 dd	http://preview.grid.unep.ch
Landslides	Frequency of landslides triggered by precipitations	GAR 2009, PREVIEW / Global Risk Data Platform	model	0.008333 dd	http://preview.grid.unep.ch
Tropical Cyclones	Estimation of global tropical cyclone wind speed probabilities using the STORM dataset.	4TU.ResearchData	10’000 years	0.1 dd	https://www.nature.com/articles/s41597-020-00720-x
Cyclones Surges	COAST-RP: A global COastal dAtaset of Storm Tide Return Periods.	4TU.ResearchData	38 and 10’000 years	23’226 points	https://data.4tu.nl/articles/dataset/COAST-RP_A_global_COastal_dAtaset_of_Storm_Tide_Return_Periods/13392314/1
Tsunamis	Tsunami hazard (run up) RP 500 years	GAR 2015, PREVIEW / Global Risk Data Platform	500 years RP model	0.008333 dd	http://preview.grid.unep.ch
River Floods	Flood hazard # years	GAR 2015, PREVIEW / Global Risk Data Platform	25 to 1000 years RP model	~ 0.01 dd	http://preview.grid.unep.ch

Population

Layer theme	Title	Provider	Reference Period	Resolution	Url
Population density	Population density map (HRSL-GSHL) 2022	UNEP/GRID-Geneva	2020	0.008333 dd	https://unepgrid.ch/en

World map

Layer theme	Title	Provider	Reference Period	Resolution	Url
Country boundaries	UN Map 2020	United Nations Geospatial	2020	vector	https://www.un.org/geospatial/

Methodology

The methodology applied for the Opportunity Mapping Tool update is similar to the one developed during the first phase of this project. Various modifications were applied in term of dataset inputs, spatial and statistical analysis, and GIS software:

The entire workflow process is developed in GRASS GIS software.

All scripts are written in python code for GRASS GIS.

The grid layer of 100 km^2 equal area cells is generated with a new method producing more reliable cell area.

Input layers are first formatted to match World Geographic projection and a 0.01 decimal degrees resolution.

Physical exposure calculation is applied to any type of hazard. Population located in affected areas is not used any more.

The last version of UN Map of the World (2020) is used in any spatial analysis as a reference to land surfaces and country boundaries.

The Population density map (HRSL-GSHL) 2022 replaces the GHS Population Grid 2015 (JRC).

WRI Current forest coverage is replaced by the MODIS Land Cover Type 2020 raster.

WCMC Global Distribution of Mangroves USGS layer is replaced by The Global Mangrove Watch layer.

Coral reefs and Sea grasses are updated using the new version of WCMC Global Distribution datasets.

New datasets are used for both Tropicalc cyclones wind and Cyclone surge.

GRASS GIS and python scripts

The entire workflow applied to generate this update is done using GRASS GIS software. Production of statistics and spatial layers at global and national scale is automated in one single script written in python for GRASS. This structure allows minimizing efforts for generating and modifying future outputs, adding new statistics or layers. Furthermore, GRASS GIS and python coding language being free and open source products, the entire workflow is not depending on any license purchase.

Grid layer

The base layer for generating spatial statistics is a vector grid of equal area cells. Equal area cells allow generating statistics that are comparable at global scale, even in term of absolute numbers (i.e. physical exposure to natural hazards).
Most of above listed input layers being published in World Geographic projection, the vector grid was generated in the same projection to avoid re-projection processes before various spatial analysis.

As World Geographic projection is not an equal area global projection, it is not possible to generate a grid maintaining square cells at any latitude. A relatively easy way to generate this grid is first to fix the x axis cell dimension in decimal degrees. It has to be close to the square root of expected cell area at equatorial latitude. As the real distance on earth of 1 degree along x axis decrease when moving to higher latitudes, y axis cell dimension has to be stretched progressively to maintain equal area cells.
The y size of cells is obtained by generating a finer resolution raster (1/10 or 0.01 decimal degrees) showing real area values. Applying to one column of this raster a cumulative value classification from 0 to 90 degrees of latitude, we obtain the y axis limits of each cell. This classification method is cumulating sample values - real area - following the sample order - ascending latitude - and create a new class when reaching a specific condition. In this case, the condition is the expected final grid cell area multiplied by the same ratio (1/10).

The present grid layer has cells of approximately 100 km^2. The cell area error is due to the raster resolution used when generating this layer. This error range is considered as acceptable compared to the overall precision and resolution of input datasets. Nevertheless, decreasing the error range in cell area is possible using a finer resolution raster for delimiting y cell size.

Global, regional or national grid of finer resolution than 100 km^2 could easily be generated reproducing the above described process in a python script for GRASS.

Population dataset

A new population dataset is used for physical exposure calculation: Population density map (HRSL-GSHL) 2022.
The layer integrates data from the High Resolution Settlement Layer (HRSL) - META (originally Facebook), the Global Human Settlement Layer (GHSL) - JRC, and the national population count for 2018 reported on the World Population Prospects 2019. Pixel counts are recalculated for 2022 based on the country population data reported for 2022 by the World Population Prospects 2019.

UN Map of the World

The last update of the country administrative boundaries of the UN Map of the World (2020) was used in this project. The land/ocean area statistics were based on this vector layer as well as the global and national EcoDRR classification. New classification on other administrative boundaries (region, continent) could be produced with minimal effort as the whole process is compiled in a python script.

Ecosystems

Using an equation that approximate Earth ellipsoid, a 0.01 degree resolution raster of real area was generated for each of the four considered ecosystems.

The updated forest coverage is derived from the The MODIS Terra and Aqua Combined Land Cover Type Version 6 (MCD12Q1). The year 2020 of the Land Cover Type Yearly L3 Global 500m is used. Among the IGBP classes, seven are selected: all of the "Forests" classes, "Closed Shrublands" and "Woody Savannas". The main advantage of using MODIS Land Cover Type Dataset is its yearly update.

The Global Mangrove Watch layer shows a better global coverage and replaces the WCMC Global Distribution of Mangroves.

There is no modification for Coral reefs and Sea grasses layer sources, but the last version of WCMC Global Distribution datasets are used for both ecosystems.

The quality of ecosystem in a 100 km^2 grid cell is expressed as its area percentage, considering cell land area for forest, ocean area for coral reef and sea grass, and total cell area for mangroves. This value is used for the final Opportunity Mapping Tool classification.

Natural hazards and physical exposure

For each natural hazard, a 0.01 degree resolution raster is generated, showing hazard annual frequency weighted with portion of pixel potentially affected.

The landslide hazard is separated in two categories: landslides triggered by earthquakes or precipitations. In our case, the final frequency raster is the sum of both hazard annual frequencies. The postulate being that a pixel affected by an earthquake landslide event could still be affected by a precipitation landslide event during the same year and somewhere else in the pixel.

In the case of Tropical cyclones, annual frequency raster is calculated with the “fixed wind speeds” dataset, using the 30 m/s mean wind speed return period estimates. The six regions layers are merged together and resampled to match the required 0.01 degrees input datasets.

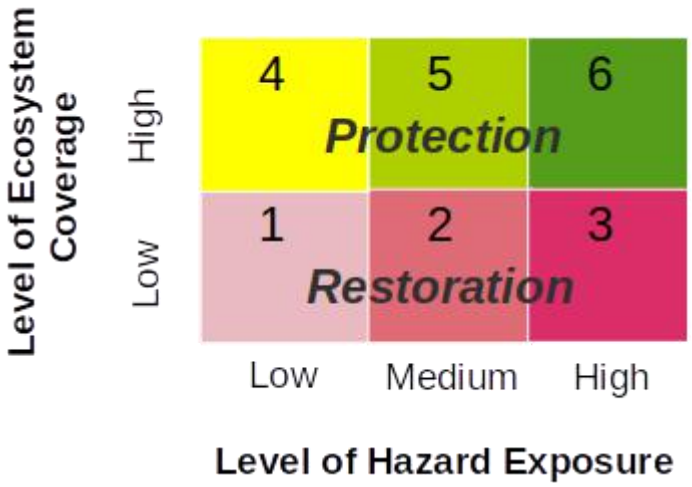
To generate the new Cyclone surge layer, the original point dataset water height values corresponding to each available return period are interpolated alond the coastline.
To account for surface roughness that reduces the water level inland, the resulting water height is decreased with distance away from the coastline using a recommanded attenuation factor of 0.5 m/km. Pixels values higher than land elevation are conserved to generate each return period water height layer. The final storm surge frequency layer is obtained by summing each layer return period value.

Physical exposure was calculated for each natural hazard multiplying the hazard frequency raster with the population raster. Flood hazard model having various return period layers, the final physical exposure is the sum of each single physical exposure.

The physical exposure in a 100 km^2 grid cell is the sum of the included physical exposure raster cells. This number is used for the final Opportunity Mapping Tool classification.

Statistics and Classifications

The EcoDRR classification scheme applied to the global and country level grid cell layer has been modified regarding the firts version of the Opportunity Mapping Tool. A simplificated and clearer six classes scheme is replacing the previous nine classes scheme.



For each considered combination of hazard physical exposure and ecosystem, the six classes are obtained by finding the tertiles of physical exposure and the median of ecosystem datasets. At global scale, these statistics are done on a selected sample of grid cells that include positive values for both physical exposure and ecosystem percentage area.

The country level classification is obtained the same way, but on a selected sample of cells overlapping the considered country area. It generates tertiles and median based

respectively on each country hazard exposure and ecosystem area sample range. It creates a classification that better suits the national conditions of both parameters.

Two additional classes allow to display information about special cases:

Value 11: attributed to cells including hazard occurrence and ecosystem area, but with no population.

Value 12: attributed to cells including hazard occurrence and population (physical exposure), but no ecosystem area.

Global and country level classification grid layer are provided in vector or raster format. In addition, a table is provided including the tertiles and medians for each combination at global and country scale. Values required to apply the previous nine classes scheme are maintain in any of these output datasets.

Datasets outputs

Various outputs are provided. Spatial layers are all in World Geographic projection:

Global grid layer in vector format with complete attribute table.

Global grid layer in raster format at 0.1 decimal degrees resolution, showing EcoDRR classification values for each hazard exposure vs ecosystem combination.

National grid layers in vector format with complete attribute table.

Independent statistic table including hazard exposure and ecosystem median and tertiles for each combination, at global and national level.

Base raster layers at 0.01 decimal degrees resolution, including hazard physical exposure and frequency, ecosystem surfaces and population.

UN Map of the World 2020 in vector format.

Grid layer attribute table columns an definitions. Each combination is provided for both six and nine classes scheme. A suffix is added accordingly to the column title.

cellid:	Grid cell unique ID
gc:	Numeric unique code affected to ISO3 code
iso3:	ISO3 code
terr_name:	Country name
buff:	Distance in meters from de center of the cell to the closest coast line
cell_km2:	Grid cell total area in km^2
land_km2:	Grid cell land area in km^2
population:	Absolute number of inhabitants in the cell
closed_km2:	Closed forest total area in km^2
opened_km2:	Opened forest total area in km^2
woodl_km2:	Woodland total area in km^2
mangr_km2:	Mangroves total area in km^2
seagr_km2:	Sea grasses total area in km^2
coral_km2:	Coral reefs total area in km^2
flo_fr:	Flood hazard frequency
lds_fr:	Landslide hazard frequency
tcs_fr:	Tropical cyclone surge hazard frequency
tcw_fr:	Tropical cyclone hazard frequency
tsu_fr:	Tsunami hazard frequency
flo_pe:	Flood hazard exposure
lds_pe:	Landslide hazard exposure
tcs_pe:	Tropical cyclone surge hazard exposure
tcw_pe:	Tropical cyclone hazard exposure
tsu_pe:	Tsunami hazard exposure
for_pc:	Forest percentage area
cor_pc:	Coral reefs percentage area
man_pc:	Mangroves percentage area
sea_pc:	Sea grasses percentage area
flo_for_gl:	Combination Flood/Forest at global level
flo_for_na:	Combination Flood/Forest at national level
lds_for_gl:	Combination Landslide/Forest at global level
lds_for_na:	Combination Landslide/Forest at national level
tcs_cor_gl:	Combination Tropical cyclone surge/ Coral reefs at global level
tcs_cor_na:	Combination Tropical cyclone surge/ Coral reefs at national level
tcs_for_gl:	Combination Tropical cyclone surge/Forest at global level
tcs_for_na:	Combination Tropical cyclone surge/Forest at national level
tcs_man_gl:	Combination Tropical cyclone surge/ Mangroves at global level
tcs_man_na:	Combination Tropical cyclone surge/ Mangroves at national level
tcs_sea_gl:	Combination Tropical cyclone surge/ Sea grasses at global level
tcs_sea_na:	Combination Tropical cyclone surge/ Sea grasses at national level
tcw_for_gl:	Combination Tropical cyclone/Forest at global level
tcw_for_na:	Combination Tropical cyclone/Forest at national level
tsu_cor_gl:	Combination Tsunami/Coral reefs at global level
tsu_cor_na:	Combination Tsunami/ Coral reefs at national level
tsu_for_gl:	Combination Tsunami/Forest at global level
tsu_for_na:	Combination Tsunami/Forest at national level
tsu_man_gl:	Combination Tsunami/Mangroves at global level
tsu_man_na:	Combination Tsunami/ Mangroves at national level
tsu_sea_gl:	Combination Tsunami/Sea grasses at global level
tsu_sea_na:	Combination Tsunami/ Sea grasses at national level

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