

Description of datasets of the collection PESETA IV

Version: 3 October 2022

This collection contains a number of datasets originating from the research work carried out for the PESETA IV project (https://joint-research-centre.ec.europa.eu/peseta-projects/jrc-peseta-iv_en). Specifically, the collection includes the datasets generated in the PESETA IV tasks investigating future river flow and flood risk scenarios in Europe. The elaboration and scientific background of the datasets is described in Dottori et al (2020; 2022) and Mentaschi et al. (2020).

Dataset “Hazards: floods, drought and water resources”

This dataset contains XXI century projections of river-related hazards (floods, droughts, water resources) at European scale, used in the PESETA IV project.

The dataset includes the following spatial data:

- Flood hazard: high extreme of river runoff
- Water resources: annual mean river runoff
- Drought hazard: low extremes of river runoff

The dataset “Flood hazard: high extreme of river runoff” in netcdf format include these dimensions/variables:

- **laea**: empty variable containing all the parameters of the projection
- **x, y**: coordinates in the Lambert azimuthal equal area projection
- **lon, lat**: matrices containing the lon-lat coordinates of the pixels
- **baseline_return_level**: magnitude of the baseline 100-year event (year 1995)
- **return_level_perc_chng_XX**: relative changes in magnitude of the 100-year event, at warming level XX (1.5°C, 2°C and 3°C)
- **baseline_rp_shift_XX**: return period at wariming level XX, of the event with the same mangitude as the baseline 100-year one. This variable is a proxy for the change in frequency.

Dataset “flood impacts and adaptation strategies under future scenarios”

This dataset allows to appraise costs and benefits of different adaptation strategies to reduce river flood risk across Europe under future climate and socio-economic scenarios. All the data and methods have been developed in the PESETA IV project and following research (see Dottori et al. 2020 and 2022).

Description of the distributions

- **s04a-out_impact_maps_v4.zip**: folder containing the impact maps for Europe under different flood scenarios (return period), calculated for the present day. Available maps include i) economic damage (in euro) ii) population exposed; iii) built-up area exposed
- **scripts_HPC.zip**: folder containing the code used in the analysis. See the dedicated section for a description of each script
- **adaptation_measures.zip**: folder containing the data and elaborations used in the design of flood adaptation measures, derived from a literature review. It includes the following Excel spreadsheet files:
 - **adaptation_costs_PesetaIV_paper.xlsx**: report the data collected from literature about different flood risk reduction measures, and the elaborations of the variables applied in the cost-benefit analysis.
 - **construction_costs_PesetaIV_paper.xlsx**: report the data collected from literature about construction costs, and the elaborations applied to derive Europe-wide variables.
- **floodProtection_v2019_paper.zip**: map of estimated flood defence standards in Europe. It is a raster map in GEOTIF format at 500m resolution. Cell values indicate the estimated return period of design (in years) of local protection structures against river floods. The extent includes all countries in geographical Europe bar Russia, Belarus, Ukraine, and countries in the Caucasus (due to lack of information). For more details see Dottori et al. (2022).
- **tables.zip**: folder containing a series of input tables with geographical, climate and socio-economic data used by the code. See the dedicated section for a description of each table
- **Europe_input_maps.zip**: folder containing input geographical maps for Europe used by the code. See the dedicated section for a description of each map
- **script05-in-out**: folder containing the input and output data used by script 05 (future flood risk scenarios under climate change). For a complete description of each dataset see the documentation:
 - **S05-out_eapa_nuts2_AA_clim.zip**:
 - **s05-in_RP_scenario_impacts.zip** :
 - **s05-in_modelRuns_flowPeaks.zip**
 - **S05-out_ead_nuts2_AA_clim.zip/ S05-out_eapa_nuts2_AA_clim.zip**:
 - **s05-out_ead_ep_clim.zip / s05-out_eapa_ep_clim.zip**:
- **script06-c-d-e**: folder containing the input and output data used by scripts 06c,06d,06e (design of adaptation scenarios and related cost-benefit analysis). For a complete description of each dataset see the documentation:
 - **s06c-prep_HydroReg_reachId.zip**:

- **s06cde-out_adaptation_ep.zip:**
- **s06cde-out_adaptation_nuts2.zip:**
- **script06-in-out:** folder containing the input and output data used by script 06 (future flood risk scenarios under climate change and adaptation). For a complete description of each dataset see the documentation:
 - **s06-out_ead_ep_adapt_mean.zip:**
- **script06b-in-out:** folder containing the input and output data used by script 06b (future flood risk scenarios under climate change, socio-economic change and adaptation). For a complete description of each dataset see the documentation:
 - **s06b-in_spatial_projections.zip**
 - **s06b-out_ead_ep_adapt_PIV_mean.zip**
- **script07a-in-out:** folder containing the input and output data used by script 07a (aggregation of results for future flood risk scenarios under climate change). For a complete description of each dataset see the documentation:
 - **s07a-out_results_countries_clim_ensemble.zip**
 - **s07a-out_results_nuts2_clim_ensemble.zip**
- **script07b-in-out:** folder containing the input and output data used by script 07b (aggregation of results for future flood risk scenarios under climate change, socio-economic change and adaptation). For a complete description of each dataset see the documentation:
 - **s07b-out_ead_WL_2100_adapt_ens.zip**
 - **s07b-out_ead_nuts2_WL_2100_adapt_models.zip**
- **script07c-in-out:** folder containing the input and output data used by script 07c (elaboration of cost-effective adaptation scenarios). For a complete description of each dataset see the documentation:
 - **s07c-out_results_cba_models_SA.zip**

List of code and scripts

This is a list of all the scripts used in the research work described in Dottori et al. (2020; 2022). As of September 2022, all scripts are designed to run either on a desktop PC (local run), or on the JRC HPC infrastructure. In both cases, it is required to place all scripts in a dedicated folder within the directory containing all the data used in the elaborations.

Scripts used in the procedure are of two different kinds:

- `<scriptName>.sh` : shell script
- `<scriptName>.r` : R script

Note that numbering of steps start from 5 because they are preceded by other scripts used for flood hazard mapping (steps 1-3) and flood impact mapping (step 4)

Part 5: calculate future flood risk with present-day vulnerability

Note: the scripts are designed to run different sensitivity scenarios by selecting the level of flood protection `<prot_lev>`. The datasets of the collection PESETA IV include only the results for the central estimate of flood protection level, or `<prot_lev>=100`.

- **qsub_05_riskAnalysis.pbs**: submit scripts to calculate risk with present-day vulnerability and elaborate results at different spatial and temporal scales
- **05_run riskAnalysis.sh**: select step of part 5 to run
- **05_ risk_analysis.r**: calculate present and future risk (EAB, EAD, EAPA) with present-day vulnerability (protection standards) and socio-economic conditions; also, aggregate average annual impacts at NUTS2 level
 - Output: ead_ep_clim_<prot_lev> (same for eab – eapa)
 - Output: ead_nuts2_AA_clim_<prot_lev> (same for eapa)
- **05b_ risk_prj_analysis.r**: second step of risk analysis, with the following steps: 1) calculate socio-economic impacts including socio-economic projections 2) aggregate average annual impacts at NUTS2 level
 - Output: ead_nuts2_AA_2050_<prot_lev> (same for eapa)
 - Output: ead_nuts2_AA_2100_<prot_lev> (same for eab – eapa)
- **05d_ ensemble_avg.r**: calculate ensemble mean or median of discharge (used for adaptation scenarios) for WLS 1.5C , 2C , 3C

Part 6: calculate future risk under adaptation scenarios

Note: the scripts are designed to run different sensitivity scenarios <scenario> by selecting the level of the parameters of flood protection, maximum damage and adaptation cost. The datasets of the collection PESETA IV include only the results for the central estimate (i.e. prot100_edq50_ad050).

- **Qsub_06_riskAdaptation.pbs**: submit scripts to calculate risk including adaptation strategies and elaborate results at different spatial and temporal scales
- **06_runRiskAdaptation.sh**: select step of part 6 to run
- **06_adaptation_scenarios.r**: calculate future risk (EAB, EAD, EAPA) using transient climate simulations and future changes in protection structures, under socio-economic conditions
 - output: ead_ep_adapt_<ensemble>_<scenario> (same for eab – eapa)
- **06b_ risk_prj_analysis.r**: second step of risk analysis under adaptation including socio-economic projections and the range of adaptation scenarios
 - output: ead_ep_adapt_PIV_<ensemble>_<scenario> (same for eab – eapa)
- **06c_ad_storage.r**: design different levels of implementation of storage (retention) areas and calculate costs and benefits. Results provided at EP and NUTS2 level
 - output: adaptation_ep_<scenario>
 - output: adaptation_nuts2_<scenario>
- **06d_ad_relocation_proofing.r**: design different levels of implementation of relocation and flood-proofing measures and calculate costs and benefits. Results provided at EP and NUTS2 level
 - output: same as script **06c_ad_storage.r**
- **06e_ad_dikes.r**: design different levels of implementation of dyke strenghtening measures and calculate costs and benefits. Results provided at EP and NUTS2 level
 - output: same as script **06c_ad_storage.r**

Part 7: elaborate results

Note: the scripts are designed to run different sensitivity scenarios <scenario> by selecting the level of the parameters of flood protection, maximum damage and adaptation cost. The datasets of the collection PESETA IV include only the results for the central estimate (i.e. prot100_edq50_ad050).

- **Qsub_07_riskAggregation.pbs**: submit scripts to aggregate the outcomes of the analysis of adaptation strategies at different spatial and temporal scales
- **07_runOptAdaptation_template.sh**: select step of part 7 to run

- **07a_risk_aggregation_na.r**: aggregate model results for present-vulnerability scenario; produce summary tables at country scale; aggregate results for the baseline and warming levels
 - output: ead_countries_<scenario> (same for eapa)
- **07b_risk_aggregation_ad.r**: aggregate model results for all adaptation scenarios (present-day and increased protection standards) for the year 2100; produce summary tables at NUTS2 and country scale.
 - output: ead_nuts2_WL_2100_adapt_models <scenario> (same for eapa)
 - output: ead_WL_2100_adapt_ens <scenario> (same for eapa)
- **07c_optimal_adaptation.r**: elaborate results from all adaptation scenarios to identify optimal adaptation strategies and aggregate results at NUTS2 and country scale
 - output: results_cba_models <scenario>
- **07d_graphs.r**: prepare boxplot graphs to illustrate results (only climate sensitivity)
- **07e_statistics_graphs.r** : elaborate ensemble statistics; prepare boxplot graphs to illustrate results of the comparison of adaptation options (full model sensitivity included)
 - output: ensemble_results
- **07f_validation_graphs.r** : compare modelled and reported flood losses

Description of the data in each distribution

tables.zip: the folder contains the following tables (all in csv format):

- **/damage_functions/:** datasets of depth-damage functions for all NUTS2 regions and land cover types (indicated by their code)
- **/EP_LU_tables/:** tables with the area occupied by broad classes of land use for each EFAS point. Used by script **06c_ad_storage.r** to determine available extent for detention areas
- **/landuse/:** including the following files:
 - Tables with the legend for all landuse maps CORINE (<https://land.copernicus.eu/pan-european/corine-land-cover>), LUISA (https://joint-research-centre.ec.europa.eu/luisa_en), and GlobCover considered in the EFAS extended domain (www.efas.eu).
 - Tables with the percentage of land occupied by each economic sectors (RES, IND, INF,COM,AGR) for each type of land use class
- **/maxDamage/:** tables with maximum damage values for each economic sector and NUTS2 area considered in the EFAS extended domain. Versions refer to type of damage functions used in Huizinga et al. (2017) and 2015 GDP reference values.
- **/projections/:** projections of population and gross domestic product for the period 2010-2100, derived from different sources. In PESETA IV and subsequent studies we use the projections from PESETA III.
- **/protection_levels/:** design level of flood protections for each LISFLOOD point of the river network
- **/Qratio/:** ratios between daily values of flood hydrographs and the peak values. Used by the script **06c_ad_storage.r** to calculate overall flood volumes and dimension detention areas.

s05-in_RP_scenario_impacts.zip: expected flood impacts (damage, population exposed, built up) for each point of the LISFLOOD river network under eight reference flood scenarios (return periods from 2 years to 1000 years).

s05-in_modelRuns_flowPeaks.zip: raster grids of river flow peaks (discharge in m³/s) for several reference return periods over the period 1981-2100. Elaborations based on LISFLOOD simulations over the river network with upstream area >500km². One grid for each model run, in NETCDF format (resolution 5km, ETRS LAEA projection).

s05-out_ead_ep_clim.zip : annual EAD values (EP scale) for the period 1981-2100 (every 5 years), calculated using transient climate simulations (simulations “as they are”). Tables are for each combination model run –WL, under present socio-economic and protection scenario. Tables produced by the script **05_risk_analysis.r**

s05-out_eapa_ep_clim.zip: same as **s05-out_ead_ep_clim.zip** but for EAPA values.

S05-out_ead_nuts2_AA_clim.zip: annual EAD values (NUTS2 scale) for the period 2010-2100 under present conditions (climate change only). One csv file for each model run. Tables produced by the script **05_risk_analysis.r**

S05-out_eapa_nuts2_AA_clim.zip: same **S05-out_ead_nuts2_AA_clim.zip** but for EAPA values.

s06-out_ead_ep_adapt_mean.zip: annual EAD values (EP scale) for the period 1981-2100 (every 5 years), calculated using stabilized climate conditions (see technical notes) and present socio-economic scenario. Tables are for each for each combination model run –WL, under no adaptation scenario (na) and for each level of adaptation of protection standards (RP2 to RP2000, protection design based on the ensemble mean). Tables produced by the script **06_adaptation_scenarios.r**

s06b-out_ead_ep_adapt_PIV_mean.zip: annual EAD values (EP scale) for the period 2010-2100 (every 5 years), calculated using stabilized climate conditions (see technical notes) and changing socio-economic scenario. Tables are for each for each combination model run –WL, under no adaptation scenario (na) and for each level of adaptation of protection standards (RP2 to RP2000, protection design based on the ensemble mean). Tables produced by the script **06b_risk_prj_analysis.r**

s06c-prep_HydroReg_reachId.zip: vector map of the river network considered in the flood risk assessment. Each river segment (reach) is identified with a unique ID and used to calculate the parameters for the design of detention areas (**script 06c_ad_storage.r**)

s06cde-out_adaptation_ep.zip: tables of the results of adaptation strategies (EP scale), calculated by the scripts (**06c_ad_storage.r; 06d_ad_relocation_proofing.r ; 06e_ad_dikes.r**)

s06cde-out_adaptation_nuts2.zip: tables of the results of adaptation strategies (NUTS2 scale), calculated by the scripts (**06c_ad_storage.r; 06d_ad_relocation_proofing.r ; 06e_ad_dikes.r**). Tables are for each combination model run –WL-strategy. Results include total costs, benefits (reduction in damage), reduction in population exposed, net present value (NPV), increase in dikes height (only for “dikes” strategy). Costs, benefits and NPV are calculated using discounted economic values

s07a-out_results_countries_clim_ensemble.zip: tables of impacts (EAD and EAPA) aggregated at country scale under the reference warming scenarios (baseline period (1981-2100), 1.5°C, 2°C, 3°C) and present-day socio-economic conditions

s07a-out_results_nuts2_clim_ensemble.zip: tables of impacts (EAD and EAPA) aggregated at NUTS2 scale under the reference warming scenarios (baseline period (1981-2100), 1.5°C, 2°C, 3°C)) and present-day socio-economic conditions

s07b-out_ead_WL_2100_adapt_ens.zip: EAD values (NUTS2 scale) for the ensemble average, for the three WLs, under 2100 socioeconomic conditions. Tables produced by the script **07b_risk_aggregation_ad.r:**

s07b-out_ead_WL_2100_adapt_models.zip /: EAD values (NUTS2 scale) for each model run, for the three WLs, under 2100 socioeconomic conditions. One csv file for each model run. Tables produced by the script **07b_risk_aggregation_ad.r:**

s07c-out_results_cba_models_SA.zip: statistics of the cost-benefit analysis for all adaptation scenarios (adaptation measure + warming level), referred to identified optimal adaptation strategies. Results are aggregated at NUTS2 and country scale

Glossary

- AGR : (land use type) agricultural sector
- CAP : (land use type) capital sector (union of commercial, agricultural and industrial sectors, used for the economic analysis in PESETA IV)
- COM : (land use type) commercial sector
- DI : (adaptation strategy) dyke strengthening
- EAB : expected annual built-up exposed
- EAD : expected annual damage
- EAPA : expected annual population affected (exposed)
- EFAS : European Flood Awareness System
- EP : EFAS point (pixel of the 5km EFAS grid)
- FP : (adaptation strategy) flood proofing of buildings
- IND : (land use type) industrial sector
- INF : (land use type) infrastructure sector
- LUISA : Land Use-based Integrated Sustainability Assessment
- NPV : net present value
- NUTS2 : administrative level 2, see Eurostat classification
- RE : (adaptation strategy) relocation of buildings
- RES : (land use type) residential sector
- RP : return period
- ST : (adaptation strategy) building of retention (storage) areas
- WLs : warming levels

References

- Dottori, F., Mentaschi, L., Bianchi, A., Alfieri, L., & Feyen, L. (2022). Adaptation is cost-effective to offset rising river flood risk in Europe. Accepted for publication in Nature Climate Change.
- Dottori F., Mentaschi L., Bianchi A., Alfieri L. and Feyen L., (2020) Adapting to rising river flood risk in the EU under climate change, EUR 29955 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-12946-2 , doi:10.2760/14505, JRC118425.
- Feyen L., Ciscar J.C., Gosling S., Ibarreta D., Soria A. (editors) (2020). Climate change impacts and adaptation in Europe. JRC PESETA IV final report. EUR 30180EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-18123-1, doi:10.2760/171121, JRC119178.
- Huizinga, H.J., (2007). Flood damage functions for EU member states. Technical Report, HKV Consultants. Implemented in the framework of the contract #382441-F1SC awarded by the European Commission - Joint Research Centre.
- Huizinga, J., Moel, H. de, Szewczyk, W. (2017). Global flood depth-damage functions. Methodology and the database with guidelines. Publications Office of the European Union, Luxembourg, EUR 28552 EN. doi: 10.2760/16510
- Mentaschi, L.; Alfieri, L.; Dottori, F.; Cammalleri, C.; Bisselink, B.; Roo, A.D.; Feyen, L., 2020. Independence of future changes of river runoff in Europe from the pathway to global warming. *Climate*, 8, 22
- Rosina K., et al. (2018). Increasing the detail of European land use/ cover data by combining heterogeneous data sets, *International Journal of Digital Earth*, DOI: 10.1080/17538947.2018.1550119.