# Co-use of existing scenario sets to extend the Shared Socioeconomic Pathways: Quantified futures of social vulnerability in Europe


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## Rationale

Future climate risks and vulnerability are function of both:
- ❖ Future climatic conditions
- ❖ Future socioeconomic conditions

→ However, most of the assessments of future climate risks and vulnerability are based on climate scenarios superimposed on current socioeconomic conditions only → Therefore, the influence that varying levels of socioeconomic development have on future abilities to prepare for, respond to, and recover from climatic hazards is not accounted for

## Aim

The Shared Socioeconomic Pathways (SSPs) have the potential to enhance the integration of future socioeconomic conditions within assessments of future climate risks and vulnerability → However, the SSPs lack of regional and sectoral contextualization and lack of quantification in terms of both diversity of socioeconomic variables and spatial scale → We aim at using existing scenario sets to extend (*i.e.* contextualize) the SSPs and to quantify them for a wide range of socioeconomic variables at the sub-national scale

## Re-use of existing scenario sets

In Europe, 100+ scenario studies have been conducted in the past decade. Nevertheless, their re-use has been largely underestimated → These existing studies are always based on different scenario sets. Hence, to be able to co-use them, their narratives have to be matched → We present here a structured and semi-quantitative method to systematically match together multiple scenario sets → We exemplify this method by matching the global SSPs with three sets of European scenarios:
- ❖ DEMIFER, focus on demography, 5 scenarios (STQ, LSE, CME, EME, GSE)
- ❖ CLIMSAVE, focus on environmental issues, 4 scenarios (Ica, RS, WW, SSG)
- ❖ ET2050, focus on territorial development, 5 scenarios (Base, A, B, C)

## Scenario matching method

### 1st step

Detailed reading of each scenario's storyline and identification of elements classified into domains

| Domains | Elements | SSPs | ET2050 | DEMIFER | CLIMSAVE |
|---|---|---|---|---|---|
| Demography | **Population growth** | | | ▲ | |
| | **Fertility** | | | ▲ | |
| | **Mortality** | | | ▲ | |
| | **Migratory flows** | | | ▲ | |
| | **Intra-EU mobility** | | | ▲ | |
| | *Family-friendly incentives* | | | ▲ | |
| | *Assisted conception and abortion* | | | ▲ | |
| | *Lifestyle (smoking, drinking)* | | | ▲ | |
| Urbanization | **Urbanization rate** | | ▲ | | |
| | **Densification** | | ▲ | | |
| | **Housing inequalities** | | ▲ | | |
| | *Transportation systems development* | | ▲ | | |
| | *Transport modal split* | | ▲ | | |
| | *Territorial cohesion* | | ▲ | | |
| | *Accessibility and connections* | | ▲ | | |
| Economy | **Economic growth** | ▲ | | | |
| | **Economic inequalities** | ▲ | | | |
| | **Globalization** | ▲ | | | |
| | *International trade* | ▲ | | | |
| | *Regional diversity richness* | | ▲ | | |
| Society | **Social cohesion** | | | ▲ | |
| | **Social equity** | | | ▲ | |
| | **Consumption and diet** | ▲ | | | |
| | *Education* | ▲ | | | |
| | *Welfare system* | | | ▲ | |
| | *Medical advances* | | | ▲ | |
| | *Health inequalities* | | | ▲ | |
| | *Gender equity* | | | ▲ | |
| Policies | **Policy orientation** | | | | ▲ |
| | **International cooperation** | | | | ▲ |
| | **Cohesion among EU regions** | | | | ▲ |
| | **Family support** | | | ▲ | |
| | *Justice and security* | | | | ▲ |
| | *Geopolitical stability* | | | | ▲ |
| | *Institutions* | ▲ | | | |
| Technology | **Development** | | | | ▲ |
| | **Energy technology change** | | | | ▲ |
| | *Transfer* | ▲ | | | |
| | *Solutions for natural resources scarcity* | | | | ▲ |
| | *Agricultural mechanization* | | | | ▲ |
| | *Irrigation efficiency* | | | | ▲ |
| Environment | **Environmental degradation** | | | | ▲ |
| | **Natural land protection** | ▲ | | | |
| | **Environmental concern** | | | | ▲ |
| | *Water consumption and saving* | | | | ▲ |
| | *Ecosystem services* | | | | ▲ |

*Shared elements (bold) and non-shared elements (italic) – classified into domains – for which clear assumptions about their future state are made for certain scenario sets (grey cells). Symbol ▲ shows the leading scenario set of each element*

### 2nd step

Categorization of scenarios' assumptions for each shared element (per domain) and computation of pairwise matching scores (per domain)

| Elements | Categorized assumptions | Scenario sets: SSPs | ET2050 | DEMIFER | CLIMSAVE |
|---|---|---|---|---|---|
| Population growth | Moderate decrease | SSP3 | - | STQ | Ica |
| | Low decrease | SSP4 | Base | LSE ; CME | |
| | Stable / Low increase | SSP1 ; SSP2 | B ; A | GSE ; EME | WW ; RS |
| | Moderate increase | SSP5 | C | | SSG |
| Fertility | Low | SSP3 ; SSP4 | A | STQ ; CME | |
| | Medium | SSP1 ; SSP2 | Base ; B | LSE ; EME ; GSE | |
| | High | SSP5 | C | - | |
| Mortality | Low | SSP1; SSP5 | | EME ; GSE | |
| | Medium | SSP2 ; SSP4 | | STQ ; LSE | |
| | High | SSP3 | | CME | |
| Migratory flows | Low | SSP3 | C ; Base | LSE ; CME | Ica |
| | Medium | SSP1 ; SSP2 ; SSP4 | A ; B | STQ ; GSE | WW |
| | High | SSP5 | - | EME | SSG ; RS |
| Intra-EU mobility | Low | | C ; Base | LSE ; CME | |
| | Medium | | B | STQ ; GSE | |
| | High | | A | EME | |

| Demography domain | | SSPs ssp1 | ssp2 | ssp3 | ssp4 | ssp5 | ET2050 Base | A | B | C | DEMIFER STQ | CME | LSE | GSE | EME |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ET2050 | Base | 0.25 | 0.25 | 0.25 | 0.50 | 0.00 | | | | | | | | | |
| | A | 0.75 | 0.75 | 0.25 | 0.50 | 0.00 | | | | | | | | | |
| | B | 1.00 | 1.00 | 0.00 | 0.25 | 0.00 | | | | | | | | | |
| | C | 0.00 | 0.00 | 0.25 | 0.00 | 0.75 | | | | | | | | | |
| DEMIFER | STQ | 0.20 | 0.40 | 0.60 | 0.60 | 0.00 | 0.00 | 0.40 | 0.40 | 0.00 | | | | | |
| | CME | 0.00 | 0.00 | 0.60 | 0.60 | 0.00 | 0.80 | 0.20 | 0.00 | 0.40 | | | | | |
| | LSE | 0.20 | 0.40 | 0.20 | 0.60 | 0.00 | 1.00 | 0.00 | 0.20 | 0.40 | | | | | |
| | GSE | 1.00 | 0.80 | 0.00 | 0.20 | 0.60 | 0.20 | 0.60 | 1.00 | 0.40 | | | | | |
| | EME | 0.80 | 0.60 | 0.00 | 0.00 | 0.80 | 0.20 | 0.60 | 0.60 | 0.40 | | | | | |
| CLIMSAVE | Ica | 0.00 | 0.00 | 1.00 | 0.67 | 0.00 | 1.00 | 0.00 | 0.00 | 0.33 | 0.67 | 1.00 | 1.00 | 0.00 | 0.00 |
| | SSG | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.67 | 1.00 |
| | WW | 1.00 | 1.00 | 0.00 | 0.33 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.33 | 0.00 | 0.00 | 1.00 | 0.67 |
| | RS | 0.67 | 0.67 | 0.00 | 0.00 | 0.33 | 0.00 | 0.67 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 1.00 |

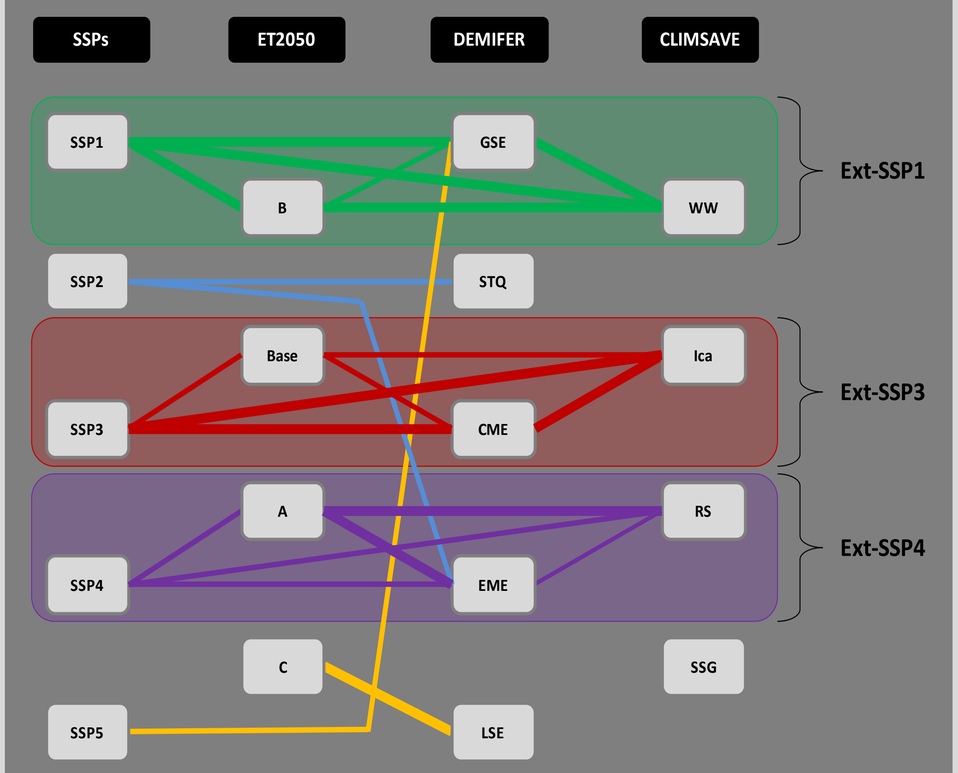
### 3rd step

Computation of a mean pairwise matching scores (based on the average of domains' pairwise matching scores)

| Averaged over all domains | | SSPs ssp1 | ssp2 | ssp3 | ssp4 | ssp5 | ET2050 Base | A | B | C | DEMIFER STQ | CME | LSE | GSE | EME |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ET2050 | Base | 0.04 | 0.38 | 0.75 | 0.21 | 0.04 | | | | | | | | | |
| | A | 0.46 | 0.58 | 0.13 | 0.75 | 0.17 | | | | | | | | | |
| | B | 1.00 | 0.33 | 0.00 | 0.54 | 0.08 | | | | | | | | | |
| | C | 0.38 | 0.17 | 0.29 | 0.33 | 0.17 | | | | | | | | | |
| DEMIFER | STQ | 0.05 | 0.68 | 0.32 | 0.48 | 0.25 | 0.50 | 0.35 | 0.35 | 0.25 | | | | | |
| | CME | 0.00 | 0.00 | 0.90 | 0.40 | 0.00 | 0.70 | 0.30 | 0.00 | 0.35 | | | | | |
| | LSE | 0.63 | 0.10 | 0.22 | 0.15 | 0.33 | 0.50 | 0.00 | 0.30 | 0.85 | | | | | |
| | GSE | 1.00 | 0.37 | 0.00 | 0.22 | 0.65 | 0.05 | 0.40 | 0.75 | 0.60 | | | | | |
| | EME | 0.20 | 0.65 | 0.25 | 0.75 | 0.62 | 0.05 | 0.90 | 0.40 | 0.10 | | | | | |
| CLIMSAVE | Ica | 0.00 | 0.05 | 0.81 | 0.20 | 0.32 | 0.67 | 0.00 | 0.00 | 0.44 | 0.33 | 1.00 | 0.42 | 0.00 | 0.25 |
| | SSG | 0.00 | 0.08 | 0.46 | 0.14 | 0.46 | 0.22 | 0.00 | 0.00 | 0.33 | 0.00 | 0.58 | 0.00 | 0.17 | 0.50 |
| | WW | 0.93 | 0.14 | 0.00 | 0.24 | 0.39 | 0.00 | 0.33 | 0.83 | 0.33 | 0.08 | 0.00 | 0.58 | 1.00 | 0.33 |
| | RS | 0.49 | 0.49 | 0.14 | 0.71 | 0.18 | 0.17 | 0.94 | 0.56 | 0.17 | 0.58 | 0.00 | 0.00 | 0.33 | 0.75 |

### 4th step

Identification of groups of scenarios sharing high pairwise matching scores
→ These groups are then viewed as extended SSPs (Ext-SSPs)




*Graphical analysis based on the mean (averaged multi-domains) pairwise scores. Thin and thick lines stand for pairs with good match (score > 0.65) and very good match (score > 0.8) respectively. Colors have no particular meaning but facilitate identification of the three Ext-SSPs.*

## Use of the Ext-SSPs to explore future social vulnerability in Europe

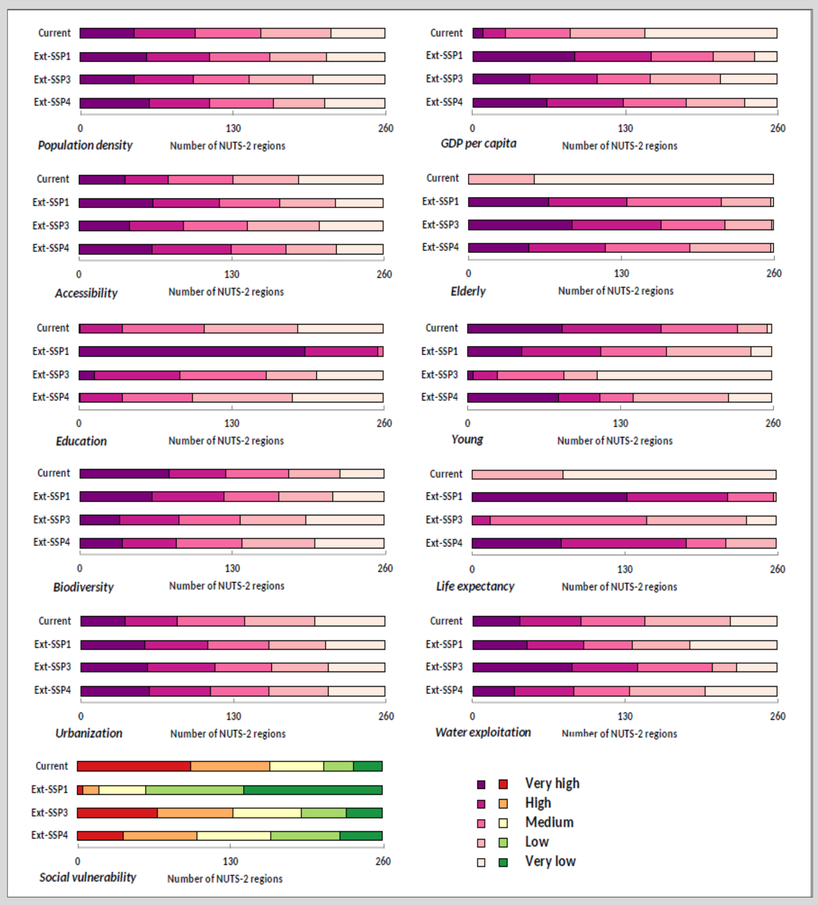
### Detailed and contextualized narratives for Europe

| Domains | Elements | Ext-SSP1 | Ext-SSP3 | Ext-SSP4 |
|---|---|---|---|---|
| Demography | Population growth | | *Decrease* | |
| | Fertility | | | |
| | Mortality | | | |
| | Migratory flows | | | |
| | Intra-EU mobility | | | |
| | Family-friendly incentives | | | |
| | Assisted conception and abortion | *Permissive* | *Restrictive* | *Restrictive* |
| | Lifestyle (prevalence smoking, drinking) | | | |
| Urbanization | Urbanization rate | | | |
| | Densification | | | |
| | Housing inequalities | | | |
| | Transportation systems development | | | |
| | Transport modal split | *Rail-based* | *Air & Maritime* | *High-speed rail* |
| | Territorial cohesion | | | |
| | Accessibility and connections | | | |
| Economy | Economic growth | | | |
| | Economic inequalities | | | |
| | Globalization | | | |
| | International trade | | | |
| | Regional diversity richness (exploitation) | | | |
| Society | Social cohesion | | | |
| | Social equity | | | |
| | Consumption and diet | | | |
| | Education | | | |
| | Welfare system | *Nationalized* | *Budget cuts* | *Privatized* |
| | Medical advances | | | |
| | Health inequalities | | | |
| | Gender equity | | | |
| Policies | Policy orientation | *Sustainability* | *Internal issues* | *Benefits of elite* |
| | International cooperation | | | |
| | Cohesion among EU regions | | | |
| | Family support | | | |
| | Justice and security | | | |
| | Geopolitical stability | | | |
| | Institutions (effectiveness) | | | |
| Technology | Development (rapidity) | | | |
| | Energy tech. change towards renewables | | | |
| | Transfer (rapidity) | | | |
| | Solutions for natural resources scarcity | | | |
| | Agricultural mechanization | | | |
| | Irrigation efficiency | | | |
| Environment | Environmental degradation | | | |
| | Natural land protection | | | |
| | Environmental concern | | | |
| | Water savings | | | |
| | Ecosystem services (protection) | | | |

Legend: Very low | Low | Moderate | High | Very high

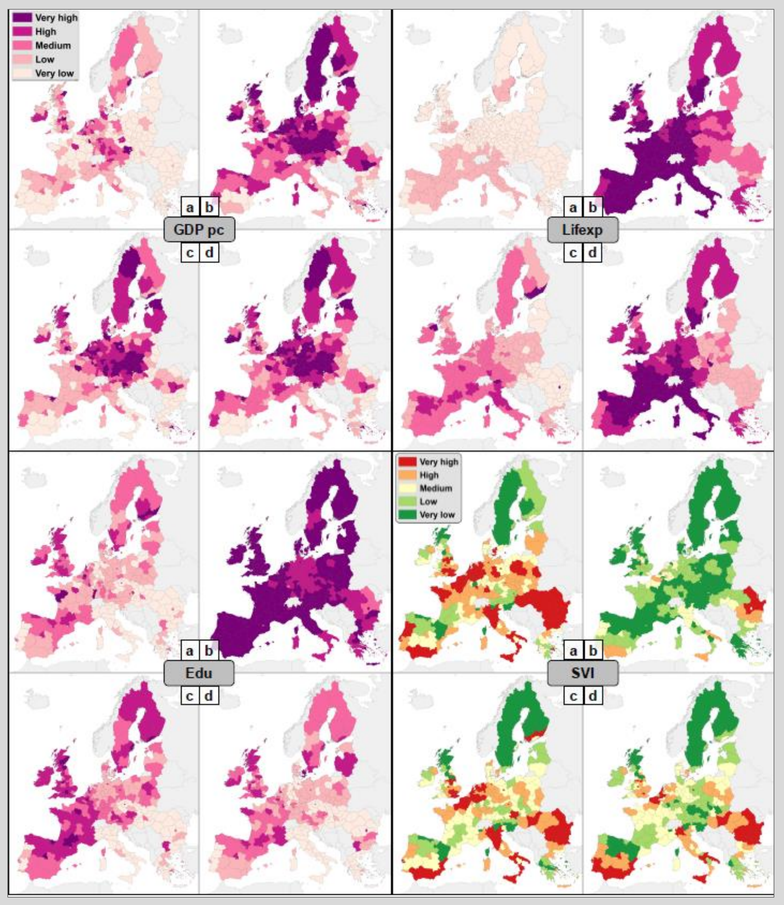
*Categorized narratives' assumptions of the three Ext-SSPs, based on combinations of the assumptions of the different scenarios contained in each Ext-SSP*

### Quantified until 2050 for a wide range of socioeconomic variables




*Number of NUTS-2 regions per class for a selection of key determinants of social vulnerability and for the SVI, under current (2012) and future (2050) socioeconomic conditions for the three Ext-SSPs*

### Spatially-explicit at NUTS-2 level (or higher)




*Spatial patterns of GDP per capita, life expectancy, education, and social vulnerability for the current (2012) situation (a) and for year 2050 under Ext-SSP1 (b), Ext-SSP3 (c), and Ext-SSP4 (d)*


Rohat et al., 2017. Co-use of existing scenario sets to extend the Shared Socioeconomic Pathways: Quantified Futures of social vulnerability in Europe. In Review, *Global Environmental Change*.



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