



Vulnerability Framework

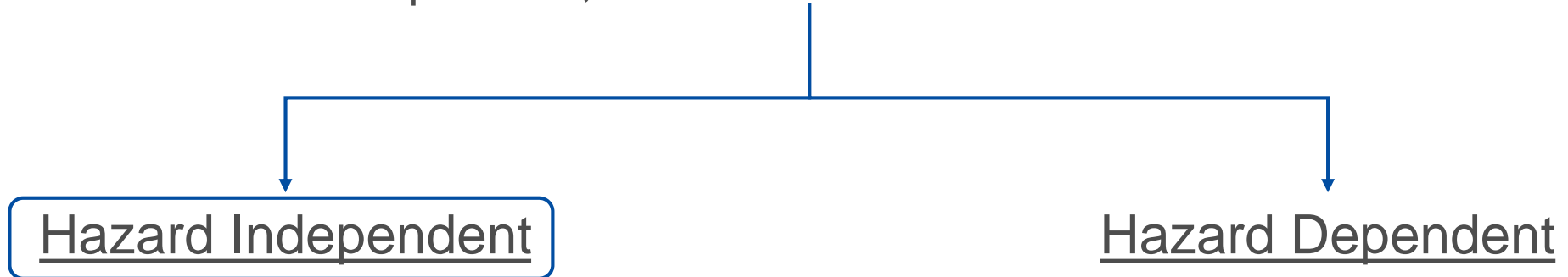
Implementation of the vulnerability component within the Risk Data Hub

Risk Data Hub Workshop – 15th June 2022

Background

$$R = f(\text{Time}, \text{Hazard}, \text{Vulnerability}_{i(\text{hazard}, \text{asset}, \text{capacity})}, \text{Exposure}_{g(\text{hazard})})$$

Vulnerability: the degree to which a system is susceptible to, and unable to cope with, adverse effect of an event¹.



¹Swart, Rob & Fons, Jaume & Geertsema, W. & Hove, Bert & Jacobs, C.M.J., 2012. Urban Vulnerability Indicators. A joint report of ETC-CCA and ETC-SIA.

Background

Hazard dependent component: it is the physical dimension, it is asset-specific and can be defined through three main sub-components that are *structural*, *exposure-based* and *hazard-based*.

Hazard independent component: based on socio-economic, political and environmental factors, it describes the vulnerability of the communities independently from their exposure to different kinds of hazards.

→ Currently, the only one implemented in the Risk Data Hub

Vulnerability in the Risk Data Hub

The conceptualisation of Vulnerability is performed through a **composite index**.

Essential aspects:

Multidimensional:

Comprised of:

- 4 Dimensions;
- 7 Sub-dimensions.

Multilevel:

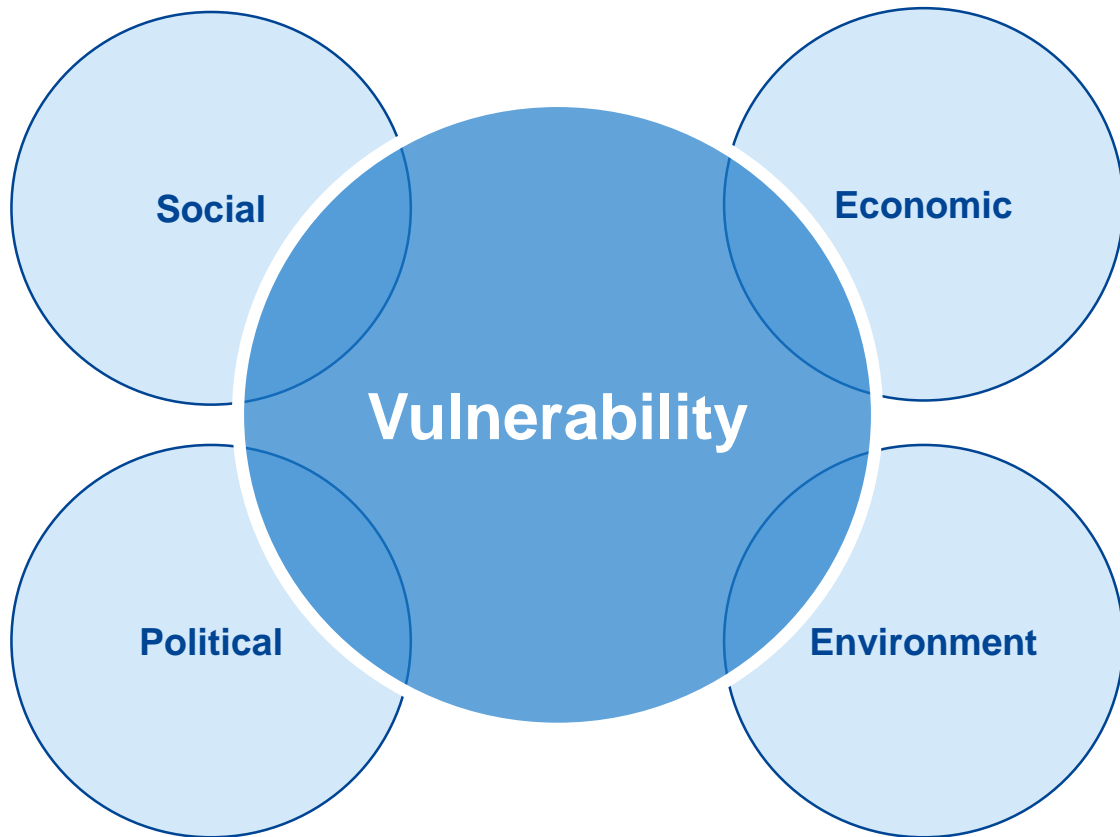
Vulnerability is estimated at different geographical levels.

Dynamic:

It provides information about to the near future trend of the vulnerability.

Vulnerability: essential aspects

Multi-dimensional

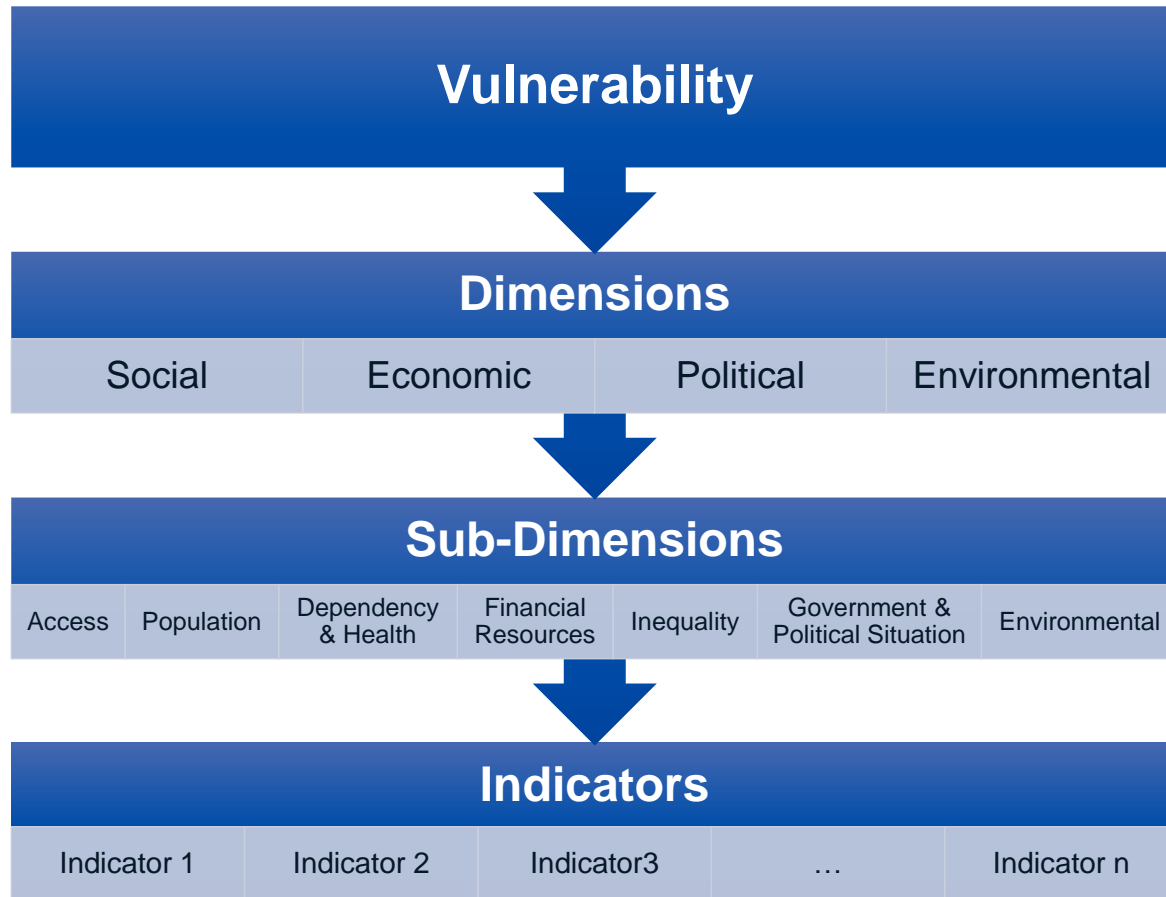


Vulnerability is influenced by different components and their interlinkages:

- **Social:** condition and processes of individuals and the entire population.
- **Economic:** resources of individuals, the population and the government.
- **Political:** quality of government and their actions.
- **Environmental:** status of the ecosystems and their ecological aspects.

Vulnerability: essential aspects

Multi-dimensional



Additionally, below the four main dimensions there are seven sub-dimensions:

- Access;
- Population;
- Dependency & Health;
- Financial Resources;
- Inequality;
- Government & Political Situation;
- Environmental.

Each sub-dimension provides a better description of the dimension to which it is related, by linking it to the indicators.

Vulnerability: essential aspects

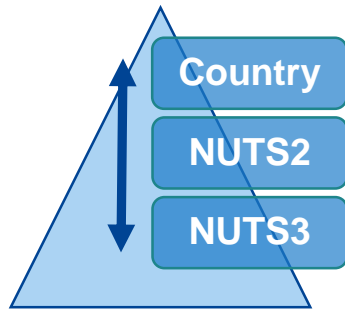
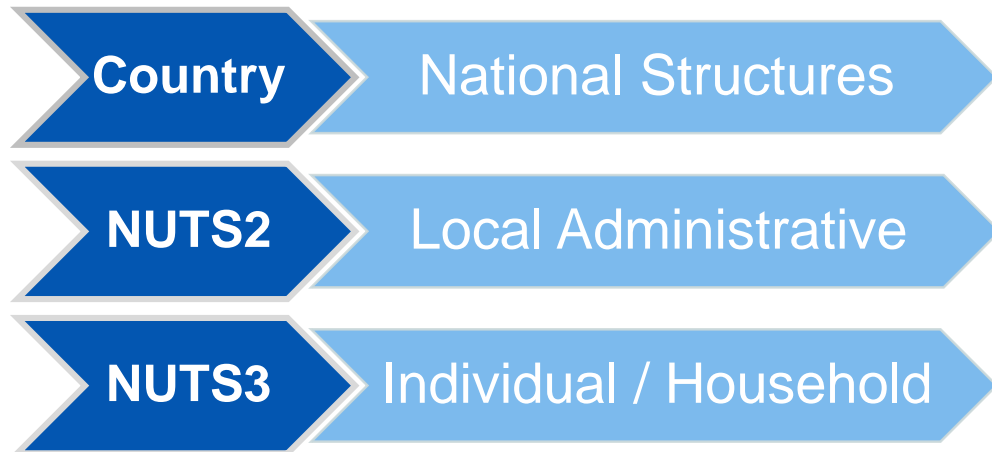
Multi-dimensional: Dimensions & Sub-dimensions

Dimensions and sub-dimensions are represented by a set of indicators for each level (based also on the data availability). Indicators are representative for a specific level and are chosen based on the literature review.

| Dimension | Sub-dimension | Country Level Indicator | NUTS2 Level Indicator | NUTS3 level Indicator |
|-----------|--|--|---|-------------------------------------|
| Social | Population | Projected population change | - | Population density Net migration |
| | Population / Access (Social Participation) | Children at-risk-of-poverty | Participation in Social Networks | - |
| | Population / Access (Social Participation) | Disabled people with need for assistance | Information (Frequency of internet access: once a week (including every day)) | - |
| | Population / Access (Social Participation) | Long-term care (health) expenditure | People at risk of poverty or social exclusion | - |
| | Dependency | Change in Age-dependency | - | Young dependency Old dependency |
| | Health | Self-reported unmet need for medical care Perceived Good Health | Life expectancy Hospital beds per 100'000 population | - |
| | Population (Education) | - | Primary and lower secondary education (levels 1 and 2) People with tertiary education (levels 5-8) | - |

Vulnerability: essential aspects

Multi-level

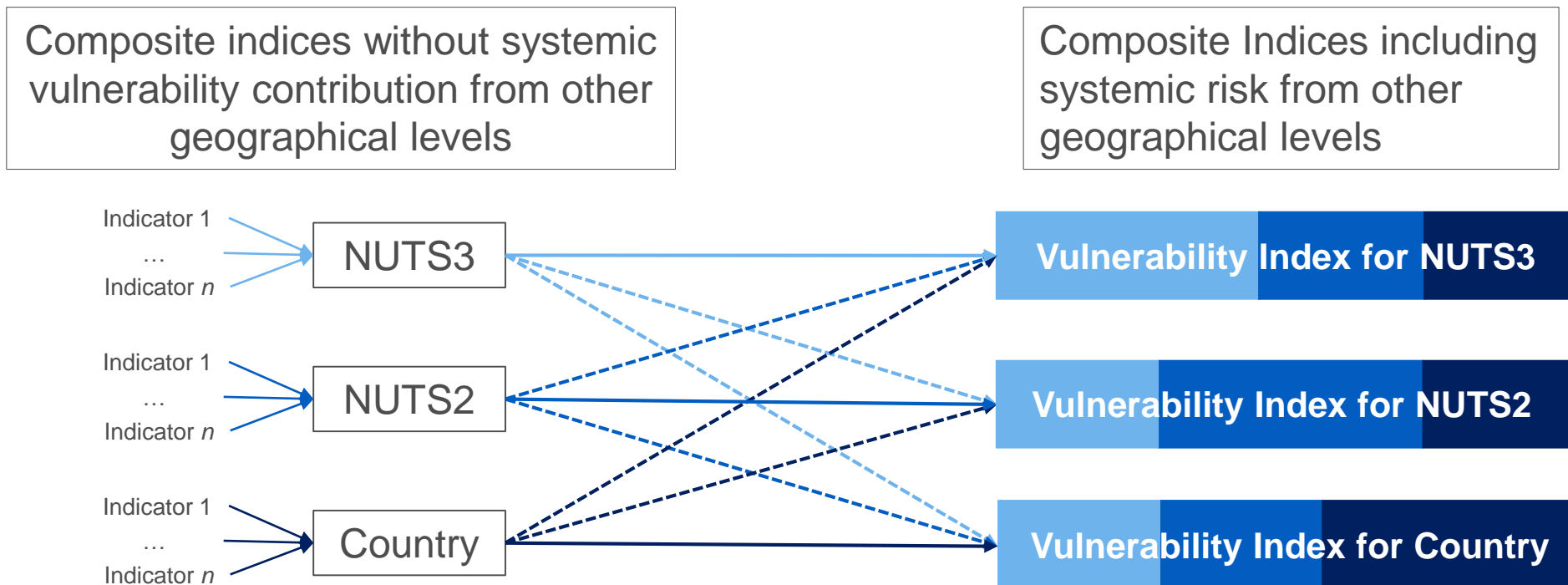


Vulnerability is tailored into levels for the integration into the RDH and is examined on three different levels: Country, NUTS2 & NUTS3.

Vulnerability is measured through a multi-level up and down aggregation. This is performed by aggregating each single level first, and then by gradually aggregating the levels together.

Vulnerability: essential aspects

Multi-level, key concept: vulnerability of a country reflects the overall vulnerability of the communities; however local variations can affect the “global score”. In the same way, the local vulnerability should not ignore the global background to which it belongs.



Methodology: data collection

The vulnerability index is composed of 43 indicators.

No. of indicators by data source:

- EUROSTAT: 34
- World Bank: 1
- UNESCO: 1
- Worldwide Governance Indicators: 2
- European Environment Agency: 1
- University of Gothenburg: 1
- World Resources Institute: 1
- Copernicus: 1

No. of indicators by geographic level:

- Country: 19
- NUTS2: 15
- NUTS3: 9

Note: the current implementation of the vulnerability on the RDH involves a set of 30 indicators overall, but there is an ongoing review to expand this set and improve the framework.

Methodology: selected indicators (Country)

| Scale | Dimension | Sub-dimension | Hazard-independent Indicator | Type | Vulnerability | Data Provider | Implemented |
|---------|-------------|-----------------------------------|--|-----------------|---------------|----------------|-------------|
| Country | Social | Population | Projected population change | Sensitivity | (+) | Eurostat | ✓ |
| Country | Social | Population (Social Participation) | Children at-risk-of-poverty | Sensitivity | (+) | Eurostat | ✓ |
| Country | Social | Population (Social Participation) | Disabled people with need for assistance | Sensitivity | (+) | Eurostat | ✓ |
| Country | Social | Population (Social Participation) | Long-term care (health) expenditure | Adapt. Capacity | (-) | Eurostat | ✓ |
| Country | Social | Dependency | Change in Age-dependency | Sensitivity | (+) | Eurostat | ✓ |
| Country | Social | Health | Self-reported unmet need for medical care | Sensitivity | (+) | Eurostat | ✓ |
| Country | Social | Health | Perceived Good Health | Sensitivity | (-) | Eurostat | ✓ |
| Country | Economic | Financial resources | Gross National Saving | Adapt. Capacity | (-) | WBG | ✓ |
| Country | Economic | Financial resources | GDP per capita | Adapt. Capacity | (-) | Eurostat | ✓ |
| Country | Economic | Inequality | Income Inequality | Sensitivity | (+) | Eurostat | ✓ |
| Country | Economic | Environmental | Cultural heritage | Sensitivity | (+) | Unesco | ✓ |
| Country | Political | Government | Governmental efficiency | Adapt. Capacity | (-) | WGI | ✓ |
| Country | Political | Political situation | Political Stability | Sensitivity | (-) | WGI | ✓ |
| Country | Political | Government (Strategy) | National Adaptation Strategies | Adapt. Capacity | (-) | ClimateAdapt | ✓ |
| Country | Environment | Environmental / Government | Environmental protection expenditure | Adapt. Capacity | (-) | Eurostat | |
| Country | Environment | Environmental / Government | Climate related economic losses | Adapt. Capacity | (+) | Eurostat / EAA | |
| Country | Environment | Environmental / Government | Production, value added and exports in the environmental goods and services sector | Adapt. Capacity | (-) | Eurostat | |
| Country | Environment | Environmental | Common farmland bird index | Sensitivity | (-) | Eurostat | |
| Country | Environment | Environmental | Natura 2000 protected areas | Sensitivity | (-) | Eurostat | ✓ |

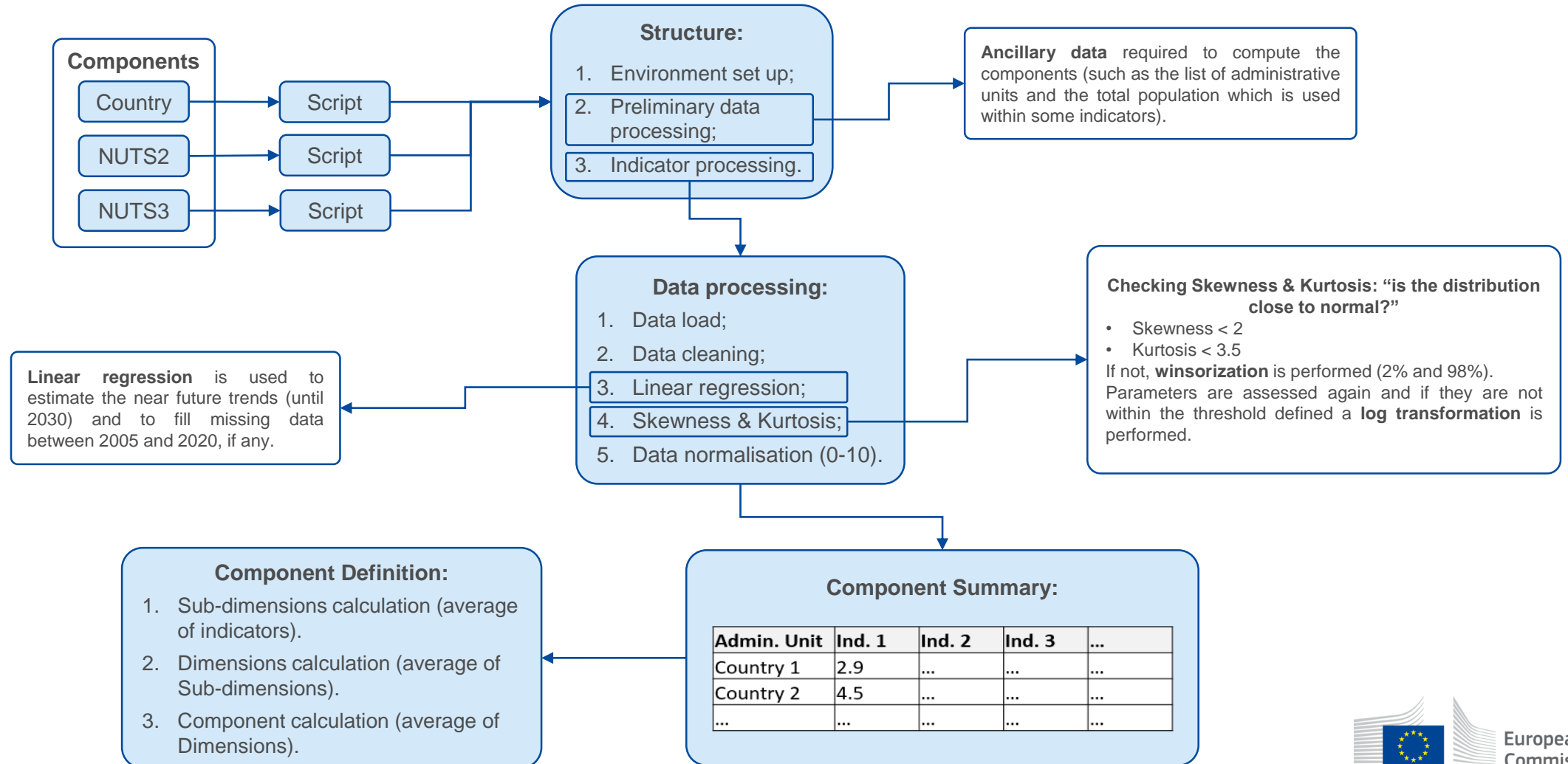
Methodology: selected indicators (NUTS2)

| Scale | Dimension | Sub-dimension | Hazard-independent Indicator | Type | Vulnerability | Data Provider | Implemented |
|-------|-------------|-------------------------------|---|-----------------|---------------|---------------|-------------|
| NUTS2 | Social | Health | Life expectancy | Sensitivity | (-) | Eurostat | ✓ |
| NUTS2 | Social | Health / Access | Hospital beds per 100'000 population | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Social | Access (Social Participation) | Participation in Social Networks | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Social | Access (Social Participation) | Information (Frequency of internet access: once a week (including every day)) | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Social | Access (Social Participation) | People at risk of poverty or social exclusion | Sensitivity | (+) | Eurostat | ✓ |
| NUTS2 | Social | Population (Education) | Primary and lower secondary education (levels 1 and 2) | Sensitivity | (+) | Eurostat | |
| NUTS2 | Social | Population (Education) | People with tertiary education (levels 5-8) | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Economic | Financial resources | Severe material deprivation rate | Sensitivity | (+) | Eurostat | ✓ |
| NUTS2 | Economic | Financial resources | Household income | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Economic | Access | Motorways | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Economic | Access | Railways | Adapt. Capacity | (-) | Eurostat | |
| NUTS2 | Economic | Inequality (Employment) | Employment rate | Adapt. Capacity | (-) | Eurostat | ✓ |
| NUTS2 | Political | Government | Regional Quality of Government index | Sensitivity | (-) | QoG | ✓ |
| NUTS2 | Environment | Environmental | Urban area classified as green space | Sensitivity | (-) | CORINE | |
| NUTS2 | Environment | Environmental | Urban land cover | Sensitivity | (+) | CORINE | |

Methodology: selected indicators (NUTS3)

| Scale | Dimension | Sub-dimension | Hazard-independent Indicator | Type | Vulnerability | Data Provider | Implemented |
|-------|-------------|---------------------|---|-----------------|---------------|---------------|-------------|
| NUTS3 | Social | Population | Population density | Sensitivity | (+) | Eurostat | ✓ |
| NUTS3 | Social | Population | Net migration | Sensitivity | (+) | Eurostat | ✓ |
| NUTS3 | Social | Dependency | Young dependency | Sensitivity | (+) | Eurostat | ✓ |
| NUTS3 | Social | Dependency | Old dependency | Sensitivity | (+) | Eurostat | ✓ |
| NUTS3 | Economic | Financial resources | NUTS3 GDP per capita vs country average | Adapt. Capacity | (-) | Eurostat | |
| NUTS3 | Economic | Financial resources | Gross Value Added (at basic prices) | Adapt. Capacity | (-) | Eurostat | |
| NUTS3 | Economic | Access | Power plants per 100'000 inhabitants | Adapt. Capacity | (-) | WRI | |
| NUTS3 | Economic | Access | Patent applications to the EPO | Adapt. Capacity | (-) | Eurostat | |
| NUTS3 | Environment | Environmental | Soil erosion | Sensitivity | (+) | Eurostat | |

Methodology: data processing workflow



Methodology: data processing workflow

Data normalisation

The process is required in order to bring all indicators on a common scale. If higher values of the indicators correspond to a higher vulnerability, rescaling is performed in the following way:

$$\text{Indicator score} = \frac{x - \text{Min } x}{\text{Max } x - \text{Min } x} * 10$$

Else, if higher values of the indicator correspond to a lower vulnerability, then the rescaling is:

$$\text{Indicator score} = 10 - \frac{x - \text{Min } x}{\text{Max } x - \text{Min } x} * 10$$

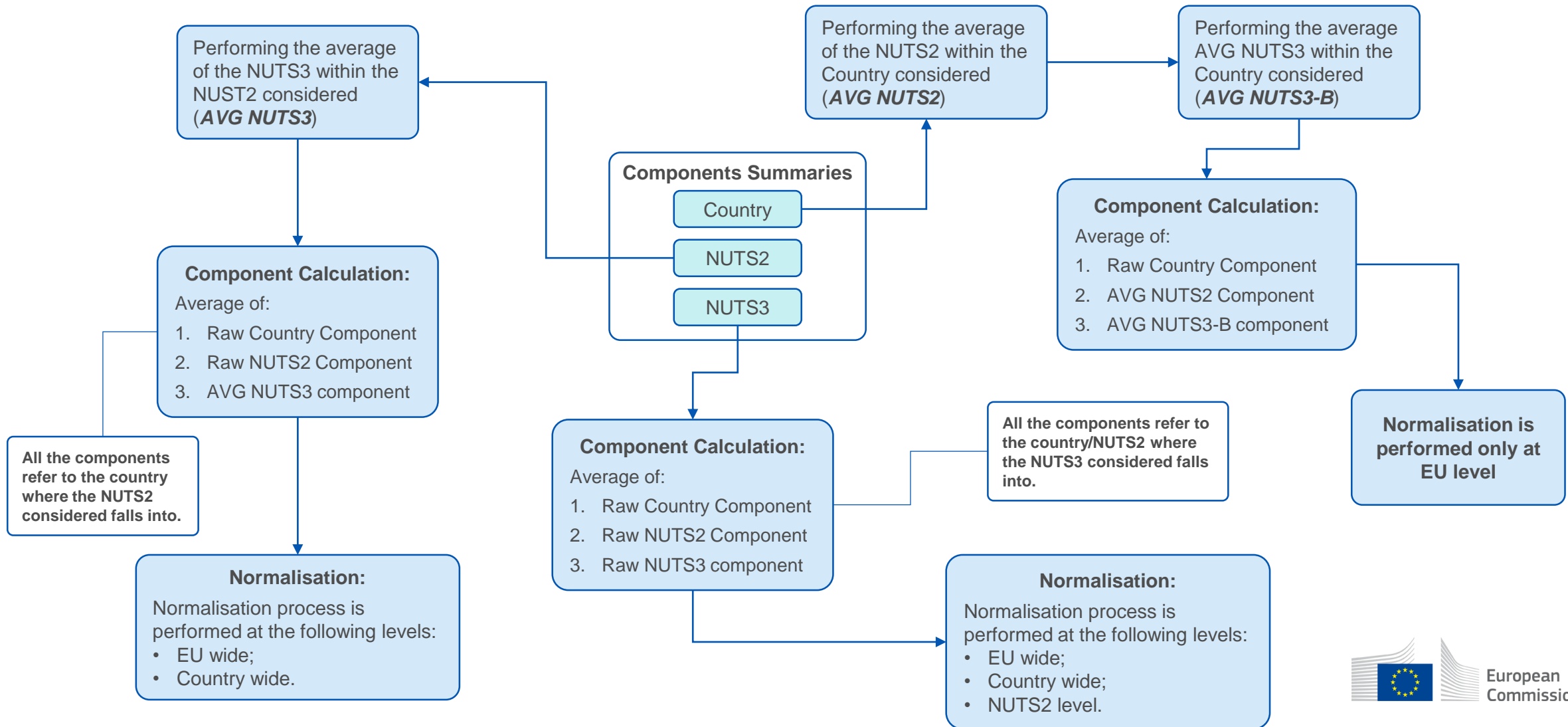
Methodology: data processing workflow

Missing data

The missing information is addressed through a proportional split of the data of the higher administrative unit among the empty areas (split is performed by using ancillary datasets).

If the proportional split cannot be performed, then it is used the value of the higher administrative unit level.

Methodology: components' aggregation



Methodology: weighting

Within this vulnerability framework all the dimensions have the same weight at each level and all the indicators within a dimension have equal weights.

Weight distribution within the updated framework.

| | Country | NUTS2 | NUTS3 | |
|---------------|---------------|---------------|---------------|-------|
| Social | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{3}$ | 27.8% |
| Economic | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{3}$ | 27.8% |
| Political | $\frac{1}{4}$ | $\frac{1}{4}$ | | 16.7% |
| Environmental | $\frac{1}{4}$ | $\frac{1}{4}$ | $\frac{1}{3}$ | 27.8% |
| | 1 | 1 | 1 | |

Remarks

- Flexibility of the method given by its essential aspects.
- Effectiveness of the multi-level approach (from local to general and vice versa).
- Capability to provide information about possible vulnerability drivers (multi-dimension approach).
- Capability to provide information over a period of time instead of returning just a snapshot.

Thank you



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