

ANNEX to the INFORM Subnational Risk Index for Bosnia and Herzegovina report

This annex provides an overview of indicators and data sources as well as of key methodological steps taken in the development of the INFORM Subnational Risk Index for Bosnia & Herzegovina (BiH) (see main report). A detailed overview about the general INFORM Subnational Risk methodology is provided by JRC: <https://drmhc.jrc.ec.europa.eu/inform-index/INFORM-Subnational-risk>. Our approach strongly builds on this methodology, but we have adapted it slightly to the local context in BiH, as outlined in the report to which this document serves as an annex.

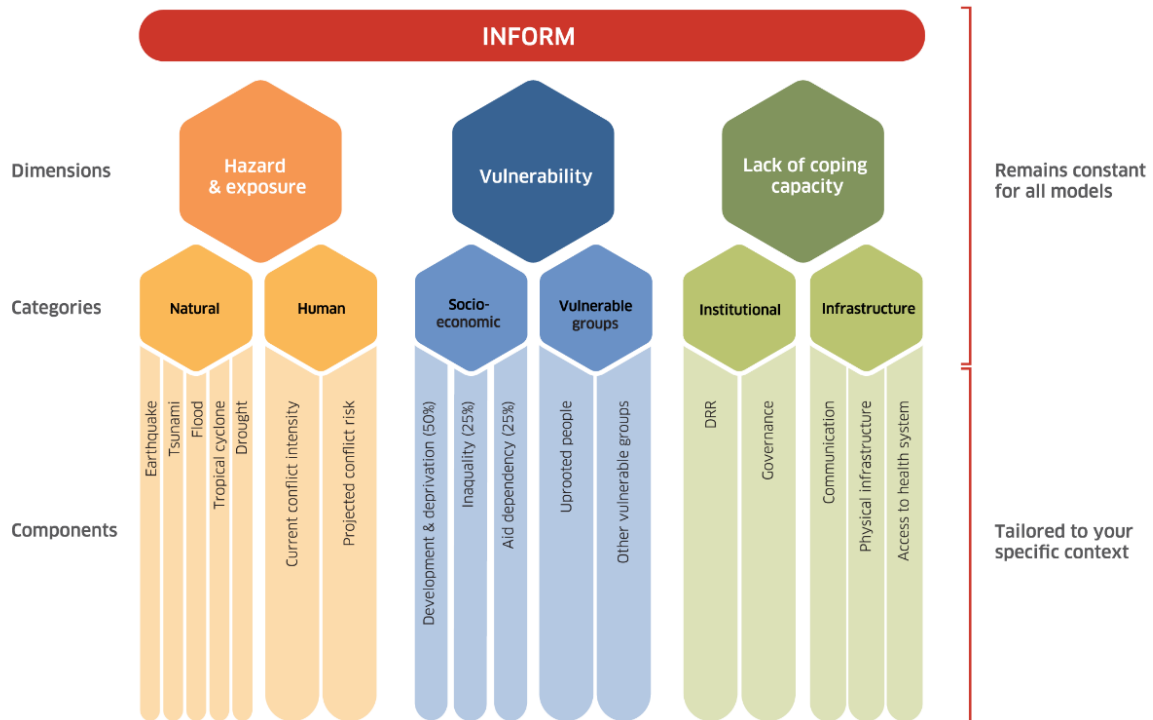


Figure 1: Original source on which figure 2 in the report is based. (<https://drmhc.jrc.ec.europa.eu/inform-index/INFORM-Subnational-risk>)

2. INDICATORS

The following tables provide an overview of the indicators (incl. source, year, resolution, coverage, and administrative level) for each component of the conceptual framework behind INFORM.

Hazard and exposure

Table 1: Indicator metadata for hazard and exposure

Natural Hazards					
Indicator	Source	Year	Resolution	Coverage	Link

Earthquakes	RP 475, PGA	JRC-GHSL	2023	100m	Global	Link
Landslides	5 levels of spatial probability of generic landslide occurrence	JRC-ESDAC	2018	200m	Europe	Link
Floods	RP 10, RP 20, RP 30, RP 40, RP 50, RP 75, RP 100, RP 200, RP 500	JRC	2024	90m	Global	Link
Droughts	Historical Drought Frequency in areas where >30% of cropland has been affected, based on Agricultural Stress Index	FAO	1984-2024	1km	Global	Link
	Average annual damages from droughts (in '000 US\$)	CRED EM-DAT	2000-2024	n. a.	Global	Link
Wildfires	Aggregated wildfire risk index	Copernicus EFFIS	2024	12.5km	Europe	Link
Exposure						
Population	Population grid	JRC-GHSL	2025	100m	Global	Link
Administrative boundaries	BiH municipalities	GADM	2025	n. a.	Global	Link

2.2. Vulnerability

Table 2: Indicator metadata for vulnerability

Socio-economic Vulnerability					
Component	Indicator	Source	Year (reference)	Level	Link
Development & Poverty	Human Development Index	Global Data Lab	2022	Region	Link
	Multidimensional Poverty Index	UNDP	2012	National	Link
	At-risk of poverty rate	National Agency for Statistics	2015	Entity	Link
Inequality	Gender Inequality Index	UNDP	2023	National	Link
	Income Gini coefficient	National Agency for Statistics	2015	Entity	Link
Economic Dependency	Remittances	World Bank	2024	National	Link
	Unemployment rate	Entity Agencies for Statistics	2023	Municipality	Link BD Link FBiH Link RS
		Social protection benefit users	Entity Agencies for Statistics	2024	Municipality

	Public aid per capita (US\$)	OECD	2023	National	Link
	Net ODA received (% of GNI)	World Bank	2023	National	Link
Vulnerable Groups					
Uprooted people	People of concern	UNHCR	2024	National	Link
	IDPs due to disaster	IDMC	2024	Entity	Link
Health conditions	Prevalence of HIV-AIDS	Entity Public Health Institutes	2024	Entity	Link FBiH Link RS
	Incidence of HIV	Entity Public Health Institutes	2024	Entity	Link FBiH Link RS
	Incidence of Tuberculosis	Entity Public Health Institutes	2024	Canton	Link FBiH Link RS
Children under 5	Infant Mortality	Entity Agencies for Statistics	2024	Municipality	Link BD Link FBiH Link RS
	Children Stunting	World Bank	2012	National	Link
Recent shocks	Population affected by natural disasters in the last 3 years	EM-DAT	2022-2024	Municipality	Link
Food security	Average dietary supply adequacy	FAO	2023	National	Link
Other vulnerable groups	Victims of family violence	/	/	/	/
	Pensioners	Entity Agencies for Statistics	2025	Municipality	Link BD Link FBiH Link RS
	People with disabilities	National Agency for Statistics	2013	Municipality	Link

Lack of Coping Capacity

Table 3: Indicator metadata for lack of coping capacity

Institutional					
Component	Indicator	Source	Year (reference)	Level	Link
Governance	Economic Freedom Index	The Heritage Foundation	2025	National	Link
DRR	Implementation score of national DRR in line with SFDRR	/	/	/	/
	Implementation percentage of local DRR strategies	/	/	/	/
	Programmes and initiatives to build capacity around DRR	/	/	/	/
	Awareness and availability score of early warning systems (EWS)	/	/	/	/
	Percentage of population informed through EWS	/	/	/	/
Capability	Number of national forces to manage disasters	/	/	/	/
	Training capacity (people trained, absolute)	/	/	/	/
Humanitarian	Local disaster response capacity	/	/	/	/
Infrastructure					
Physical Connectivity	Road length	OpenStreetMap	2025	Municipality	Link
Access to Healthcare	Immunization coverage DTP3	Entity Public Health Institutes	2024	Canton	Link FBiH Link RS
	Immunization coverage MCV2	Entity Public Health Institutes	2024	Canton	Link FBiH Link RS
	Physicians Density	Entity Agencies for Statistics	2023	Municipality	Link BD Link FBiH Link RS
	Density of nurses	Entity Agencies for Statistics	2023	Municipality	Link BD Link FBiH Link RS
	Number of hospital beds	Entity Public Health Institutes	2024	Canton	Link BD Link FBiH Link RS

Key Methodological Steps

Data collection & processing

Data for the individual components and indicators were collected to the extent that data were available. While the data for hazard and exposure largely draw on publicly available datasets from JRC, data for vulnerability and the lack of coping capacity were obtained from official authorities in BiH, or from international organizations for national level data, if subnational data were not available.

Since not all sources necessarily provide data in the format needed for the INFORM subnational risk index, some data had to be processed with regard to the unit of measurement, absolute vs. relative numbers, or the spatial scale. An overview of the general workflow describing these processes is shown in Figure 2. An in-depth description of the methodological steps undertaken for the respective components or indicators is provided below. ArcGIS was used to calculate the spatial distribution, and hence, the hazard exposure to earthquakes, floods, landslides, droughts and wildfires, as well as for road lengths per municipality under the lack of coping capacity component. For the remaining vulnerability and lack of coping capacity indicators, data was collected and compiled, with basic transformation processes into non-dimensional scales, e.g. utilizing percentages, per capita or density functions.

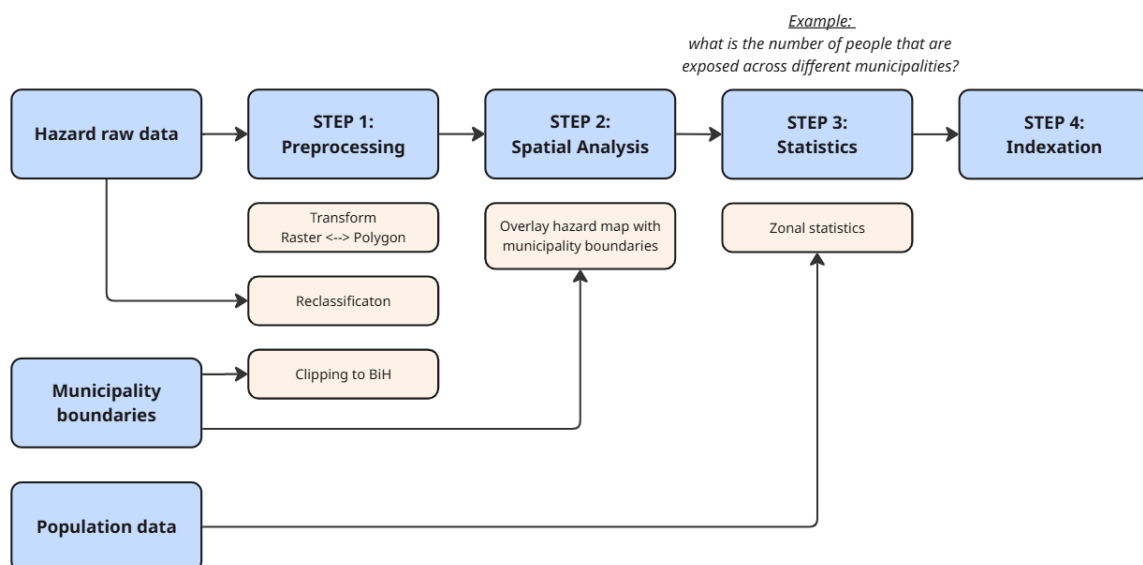


Figure 2: Illustrative workflow showing the step-by-step methodology for processing data

Earthquakes

The raw data on earthquakes had to be reclassified from Peak Ground Acceleration (PGA) to the Modified Mercalli MMI (MMI) scale, using the reclassification tool in ArcGIS. For the INFORM Subnational Risk Index, two indicators are needed that account for earthquake hazards for $\geq MMI VI$ and $\geq MMI VIII$, respectively. After clipping the global earthquake model to BiH, it was already noticeable that the entire country is exposed to MMI VI, with none of the population exposed to MMI VIII.

An overlay analysis and zonal statistics were applied to calculate the number of people exposed to earthquakes in each municipality. For this specific case of BiH, it is the same as the total population of each municipality. Finally, the number for each municipality has to be divided by 475, which is the return period of the underlying earthquake model.

Floods

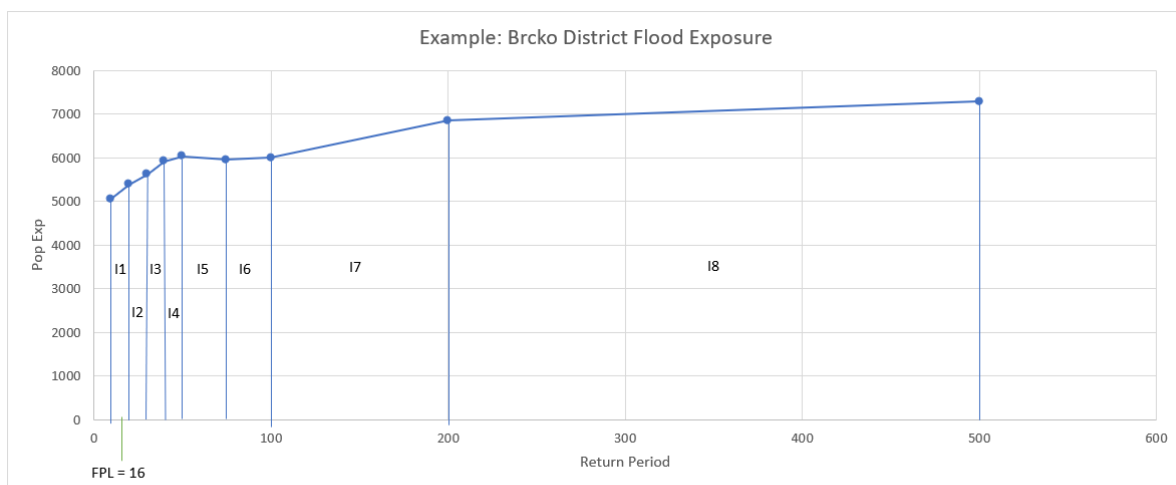
The metric used to assess flood exposure is the expected annual exposed population (EAEP). This requires

- hazard data in the form of flood maps for nine different return periods (10, 20, 30, 40, 50, 75, 100, 200, and 500 years), clipped to BiH
- population data per municipality in order to calculate the exposure to floods
- Data on the local flood protection level (FPL), existent on cantonal level for BiH (source: <https://doi.org/10.5194/nhess-16-1049-2016>)

Hazard (flood maps) and population data (population grid) were overlaid to run a binary (exposed – not exposed) zonal statistics analysis to derive the potential exposed population (PEP) per municipality, for each of the nine RPs.

EAEP is not calculated per event but as the integral sum of the PEP over all flood frequencies (RPs). The corresponding formula is:

$$EAEP = \int_{f=0}^{\frac{1}{FPL}} PEP \, df$$



$$\text{Total} = I1 + I2 + I3 \dots \quad EAEP = \int_{f=0}^{\frac{1}{FPL}} PEP \, df \quad \neq \quad EAEP = \sum PEP_i \cdot f_i$$

Figure 3: Visualization of EAEP calculation using the example of Brcko District.

In statistical terms, the integration is approximated by summing the PEP values weighted by the frequency intervals between consecutive return periods, with the upper integration limit set to the inverse of the FPL. In this example, the FPL of 16 assumes that at all frequencies above 16 years, there is no exposure due to the respective flood protection measures. Hence, $I_1 = 5386 * (1/16 - 1/20)$, $I_2 = 5622 * (1/20 - 1/30)$, ... The sum of all intervals yields the EAEP.

Landslides

The underlying dataset for the landslide hazard assessment is a landslide susceptibility map, covering most of Europe. Landslide susceptibility is coded across five categories, from very low to very high susceptibility. For INFORM, only the two most severe categories are relevant, i.e. category 4 (high) and 5 (very high). So, besides clipping the map to BiH, the two categories have to be selected as attributes to derive two individual maps for each category to then proceed with the analysis.

Overlay and zonal statistics were then applied to derive the absolute number of people exposed to "high" and "very high" landslide hazards per municipality.

Droughts

The drought hazard layer draws on FAO's data on agricultural drought probability. The metric used is the historical drought frequency (0-100%) in areas where >30% of cropland has been affected, as measured by the Agricultural Stress Index. The raw data contains values above 100 that represent cells with no data and have to be cut out through reclassification tools. In contrast to all other hazards, zonal statistics are applied not to obtain a number of exposed people, but instead the mean historical drought frequency for each municipality's land area. This means the final data is shown in percentages.

The second drought indicator is average annual damages from droughts (in '000 US\$). The raw data contains numbers for individual regions and municipalities.

Wildfires

The data for wildfires were taken from Copernicus EFFIS Wildfire Risk Map and clipped to the country boundaries. Maps for this aggregated wildfire risk index exist for three different risk levels: high, intermediate and low risk, measured in percentage for each spatial cell. For the INFORM index only the high-risk map was used, but reclassified into three categories, depicting firstly cell values of 0 (zero), secondly cells with values between 1-50 (high) and thirdly cells with values between 51-100 (very high). After overlaying the layer of these three classes onto the administrative boundary layer, zonal statistics were applied to calculate the number of exposed people to either high or very high wildfire risk per municipality.

Road lengths

The length of roads per municipality is the only indicator under the vulnerability and lack of coping capacity components that require spatial analysis tools.

OSM data provides a comprehensive list of road types. However, only some of them are used to assess this indicator. These are shown in Table 4.

Table 4: OSM road types used for the calculation of road length per municipality

Roads	Link roads
motorway	motorway_link
primary	primary_link
secondary	secondary_link
tertiary	tertiary_link
trunk	trunk_link
unclassified	

After clipping OSM to BiH, these attributes were consequently selected in ArcGIS. Zonal statistics analysis was then applied to derive the absolute road lengths per municipality.

Index calculation

Transformations

Transformations are applied whenever justified to change the absolute differences among the municipalities. The log transformation is used to reduce the positive skewness of data. Such datasets include those in which the indicator is based on a people count with certain conditions. The log scale gives more weight to differences between municipalities with lower values and less weight to differences between countries with higher indicator values. Log transformations take into account not only the absolute difference between two municipalities with similar performance but also the proportion of the gap compared to the real value of the indicator. The same gap on the lower side of the range is more important than being on the upper side of the range. Therefore, the transformed data more clearly differentiates small differences across all ranges of performance and improves the interpretation of differences between the municipalities on opposite ends of the ranking.

Normalization

Re-scaling normalizes indicators to have an identical range of 0.0-10.0, with the notion that higher is worse. The normalized indicators are rounded to the first decimal place. As outliers often cause the min and max values to differ significantly from the bulk of values in the dataset, rescaling with predefined min and max values is applied.

Identification of outliers and setting min and max values:

(source: <https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Methodology#inline-nav-1>)

Fixed min and max values for each indicator dataset are preferred in order to:

- preserve the rescaling factor and make the transformation stable through the time series;
- exclude the distortion effect of outliers on the indicator's set
- consider the nature of the topic reflected, which predefines the reasonable min and max values (e.g. expert opinion).

$$x_{i,norm}^j = \frac{x_i^j - x_{i,min}}{x_{i,max} - x_{i,min}} \cdot 10$$

$x_{i,norm}^j$ – normalized data point or the j – th country from i – th indicator ' s dataset

x_i^j – data point for the j – th country from i – th indicator ' s dataset

$x_{i,max}$ – max value for i – th indicator ' s dataset

$x_{i,min}$ – min value for i – th indicator ' s dataset

An outlier is a data point that is distinctly separate from the rest of the data. Outliers are indicative of a heavy-tailed distribution, a mixture of two distributions, or errors. In the first two cases, they indicate that the distribution has high kurtosis and skewness, or that there may be two distinct subpopulations; in such cases, one should be very cautious in using tools or intuitions that assume a normal distribution. In the case of errors, one wishes to discard them or use statistics that are robust to outliers. There are many techniques to identify outliers, but in the INFORM Risk Index a combination of the following two has been used:

- Interquartile range (IQR) where the lowest datum is still within 1.5 IQR of the lower quartile, and the highest datum is still within 1.5 IQR of the upper quartile and the rest of the data are treated as outliers. This approach focuses on the range containing 50 % of the municipalities and then extends that range independently of the distribution. So, the number of data points that exceeds the limits varies.
- Anomalous values of skewness and kurtosis: the min and max values for which skewness is lower than 2 AND kurtosis is lower than 3.5. Skewness and kurtosis are calculated iteratively for the entire dataset without the obvious outliers, until pre-set conditions are met. The minimum and maximum data points of the remaining dataset are taken as min and max.

Aggregation

The INFORM methodology implements the arithmetic and geometric averages. Aggregation rules are applied to indexes at each level to progress hierarchically from the indicator level through the component level, the category level, to the dimension level. The final score of the INFORM index is calculated with the overall risk equation:

$$Risk = Hazard Exposure^{1/3} \times Vulnerability^{1/3} \times Lack\ of\ coping\ capacity^{1/3}$$

Indexation

Table 5: Classification based on gamma distribution (break points at 0.2, 0.5, 0.8 and 0.95)

	Hazard Exposure			Vulnerability			Lack of coping capacity			Overall Risk		
	Class	n	%	Class	n	%	Class	n	%	Class	n	%
Very low	0 – 4.1	29	20	0 - 5.4	24	16	0 - 3.6	29	20	0 - 4.6	28	19
Low	4.2 - 5.1	42	29	5.5 - 6.0	44	30	3.7 - 4.4	42	29	4.7 - 5.1	40	27
Moderate	5.2 - 6.2	41	28	6.1 - 6.6	48	33	4.5 - 5.3	43	29	5.2 - 5.5	46	32
High	6.3 - 6.9	26	18	6.7 - 7.2	20	14	5.4 - 5.9	23	16	5.6 - 6.0	24	16
Very high	7.0 - 10	8	5	7.3 - 10	10	7	6.0 - 10	9	6	6.1 - 10	8	5

Workflows for spatial analysis

Earthquakes

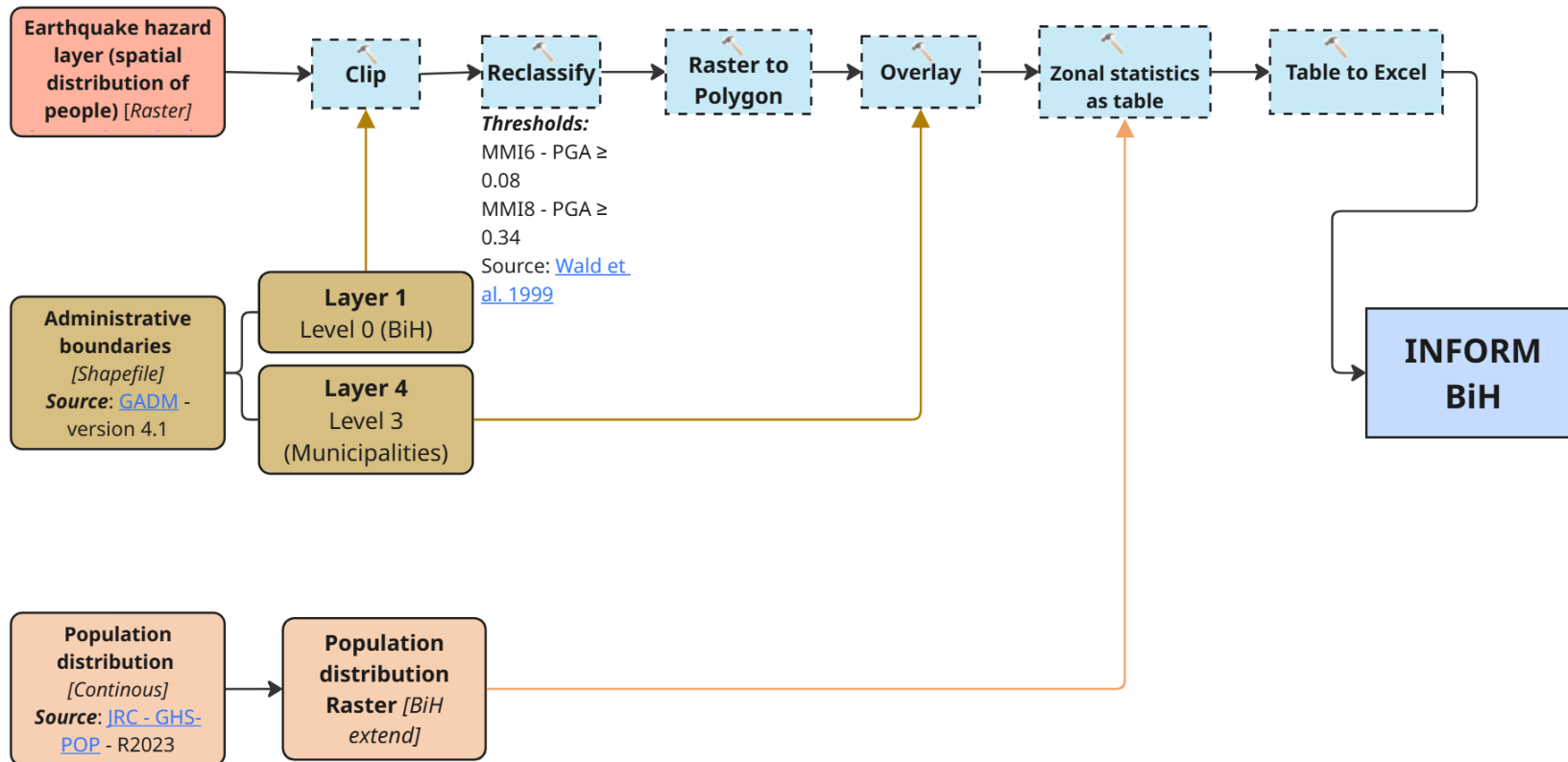


Figure 4: Spatial analysis workflow for earthquakes

Floods

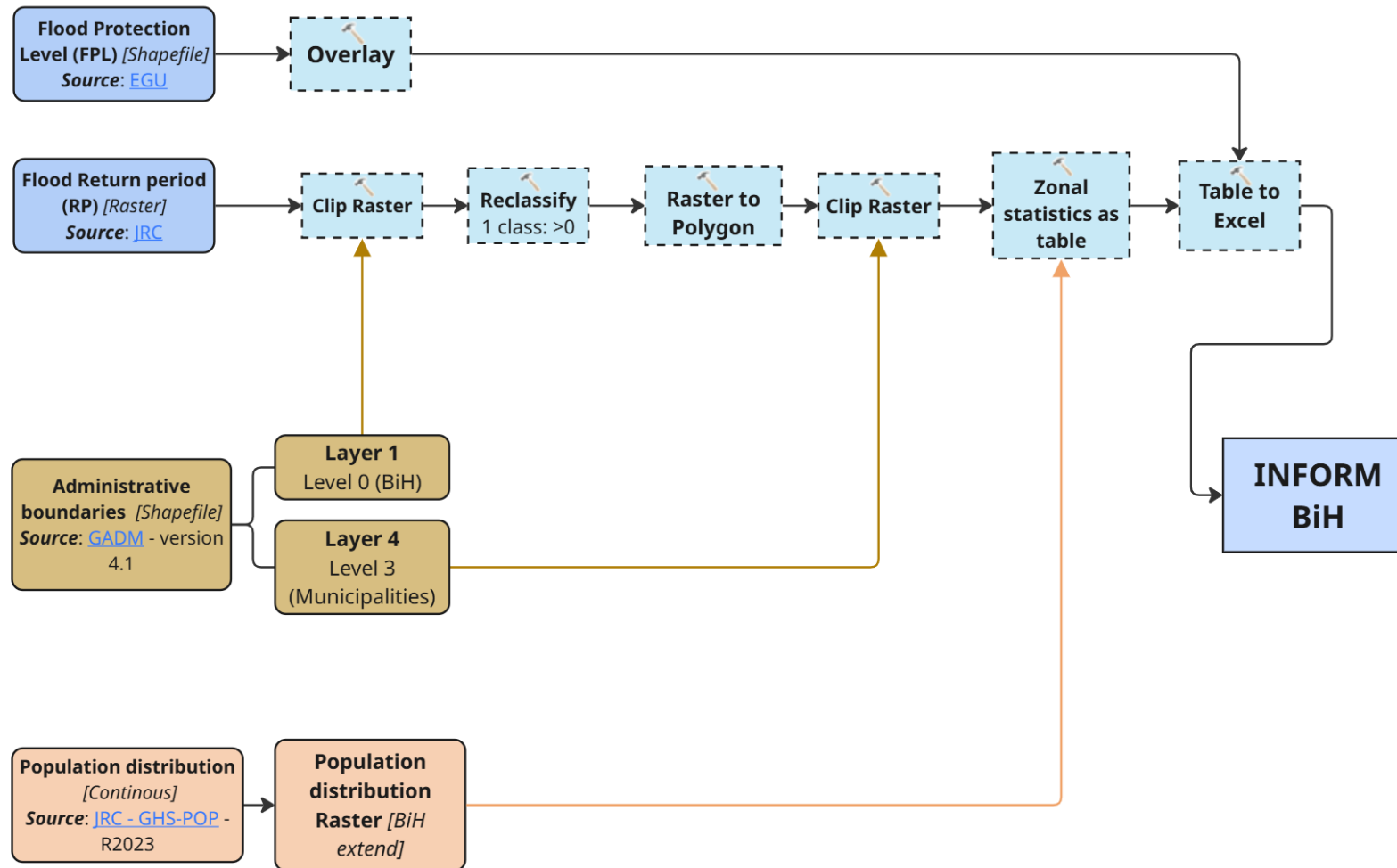


Figure 5: Spatial analysis workflow for floods

Landslides

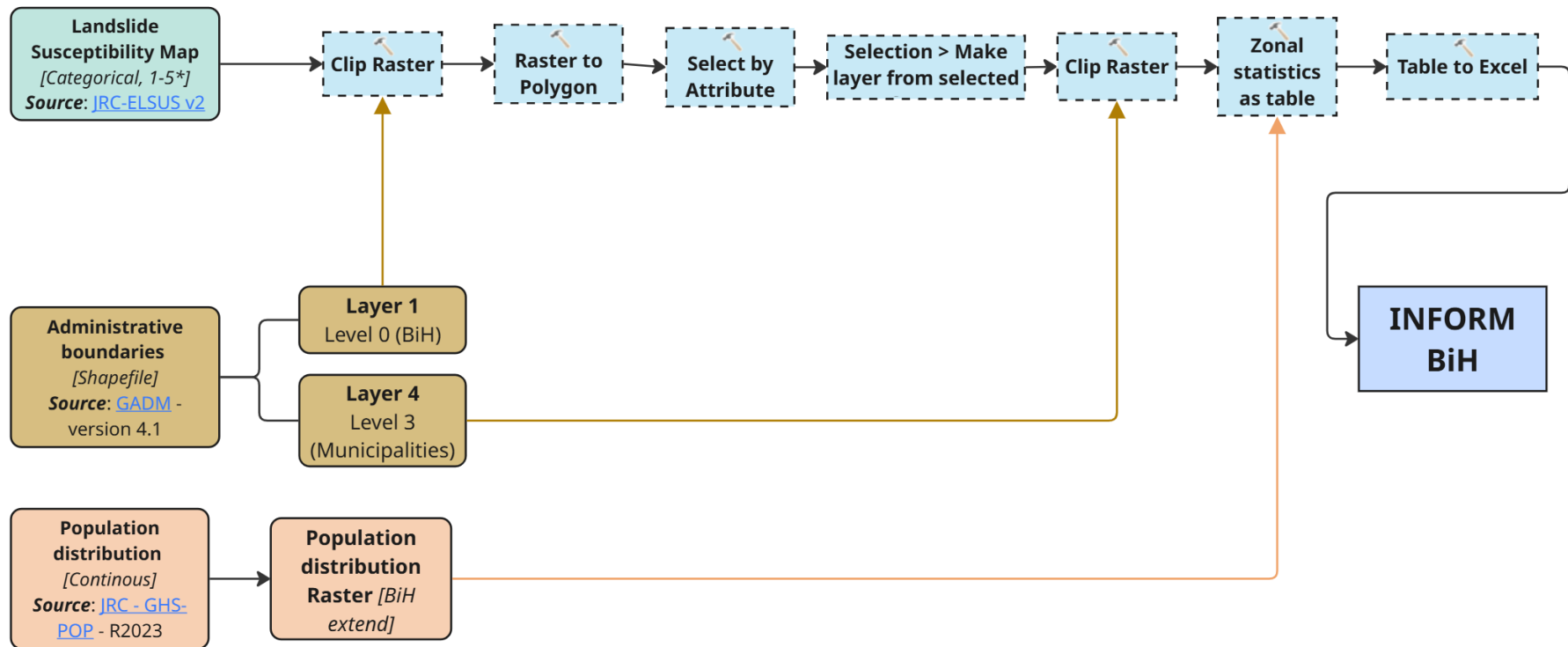


Figure 6: Spatial analysis workflow for landslides

Droughts

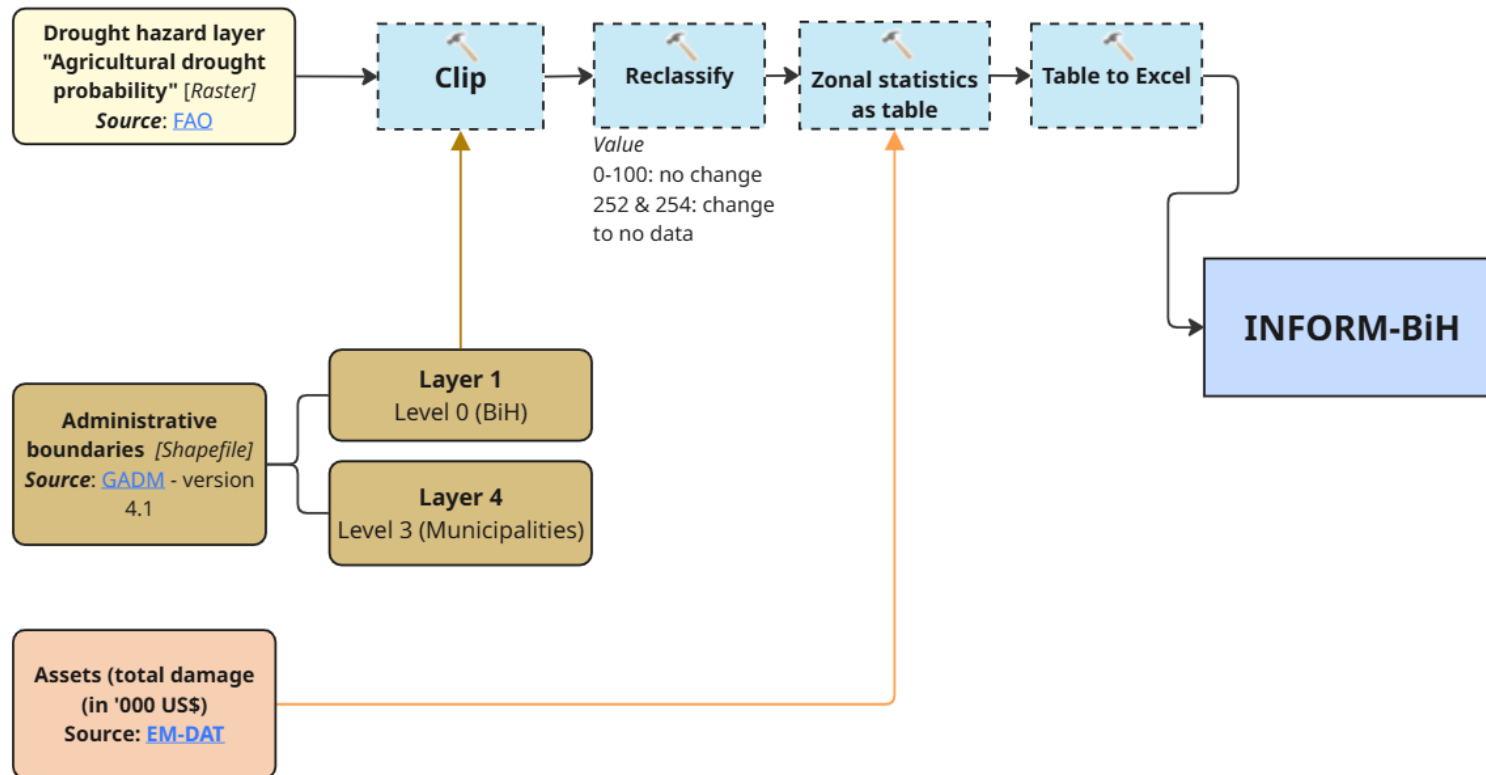


Figure 7: Spatial analysis workflow for droughts

Wildfires

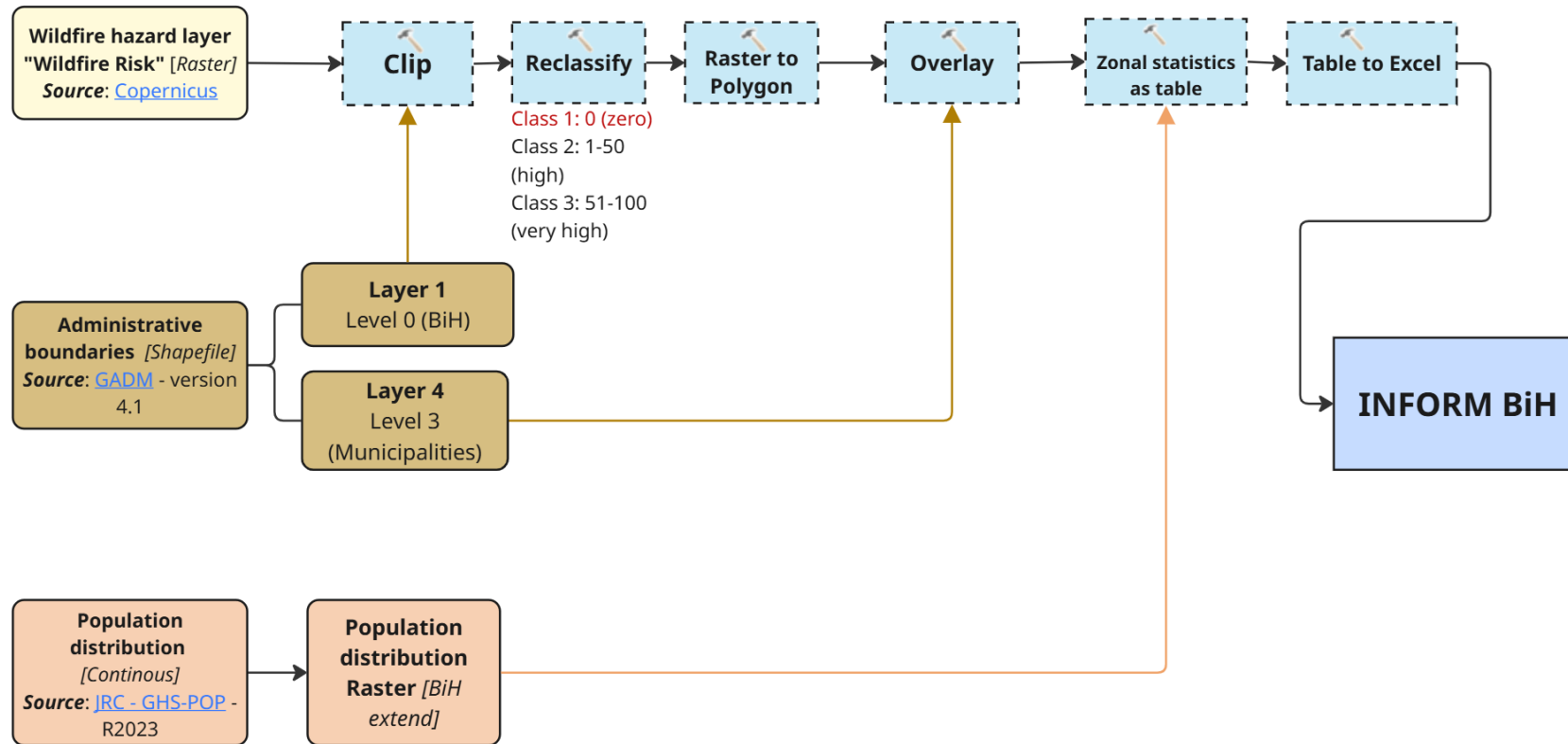


Figure 8: Spatial analysis workflow for wildfires

Road density

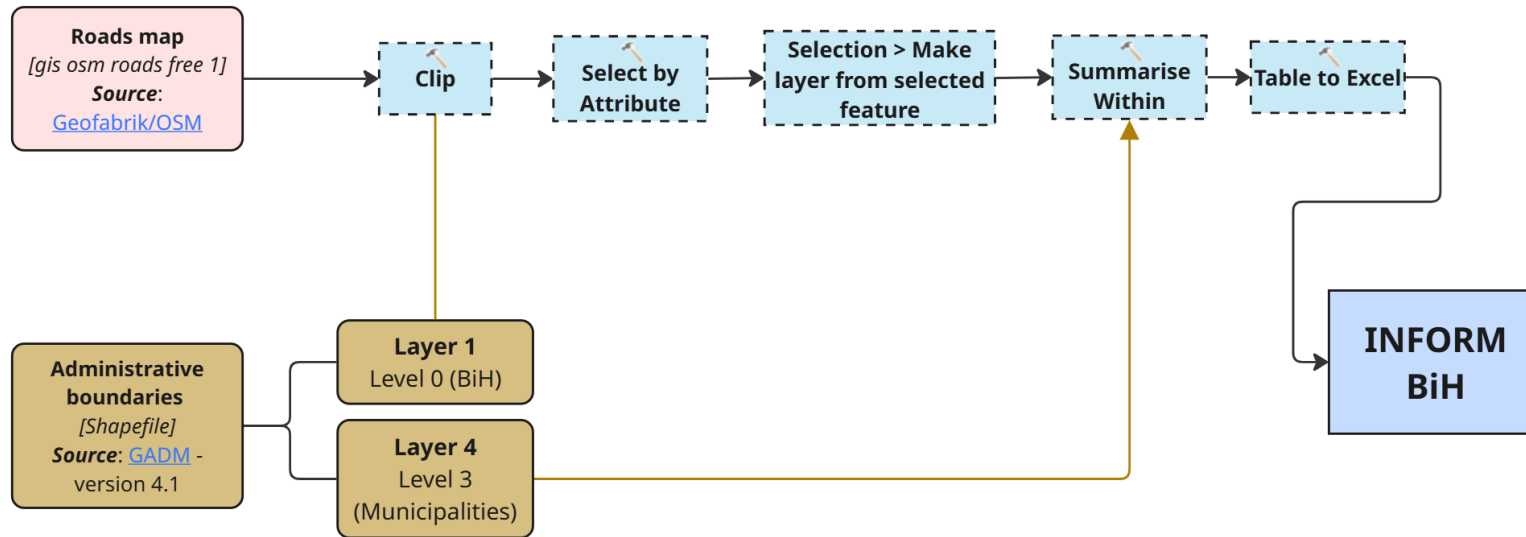


Figure 9: Spatial analysis workflow for road density