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Appendix

IVAVIA Guideline

IVAVIA

Guideline Appendix

Impact and Vulnerability Analysis of Vital Infrastructures and built-up Areas

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Appendix A:

Definitions of important terms and examples

1 Appendix A:

Definitions of important terms and examples

Term	Definition	Examples	Source
Adaptive Capacity (or adaptability)	The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to Consequences.	Diversity of economic activities, state of buildings, state of infrastructure, household income, distance to hospital, high network redundancy, diversity of land-use	IPCC 2014a
Consequence	The outcome of an event affecting objectives		ISO/IEC 27000: 2014 and ISO 31000: 2009
Coping Capacity	The ability of people, institutions, organizations, and systems, using available skills, values, beliefs, resources, and opportunities, to address, manage, and overcome adverse conditions in the short to medium term.		IPCC 2014a
	The ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters.		UNISDR 2009
Driver	Drivers are aspects which change a given system. They can be short term, but are mainly long term. Changes in both the climate system and socioeconomic processes including adaptation and mitigation are drivers of Hazards, Exposure, and Vulnerability. Drivers can, thus, be climatic or non-climatic. In the RESIN project, we will refer to drivers as climatic drivers and non-climatic drivers as 'Stressors'.	Climatic drivers include: increasing average temperatures, changes in precipitation amounts, snow cover, cyclones, sea level rise. Non-climatic drivers include: land use change, migration, population and demographic change, economic development.	Based on IPCC 2014b (SPM)

Term	Definition	Examples	Source
Exposure	The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected	Built infrastructure, critical infrastructure, population, agriculture, green and blue infrastructure, household, labour productivity, economic activities, public services, historical sites, leisure activities: Categories as well as specific instances	IPCC 2014a
Hazard	The potential occurrence of a natural or human-induced physical event or trend, or physical Impact, that may cause loss of life, injury, or other health Impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources...the term hazard usually refers to climate-related physical events or trends or their physical Impacts.	**Flooding**, coastal flooding, fluvial flooding, pluvial flooding, reservoir flooding, heat wave, **drought**	IPCC 2014a
Impact	Effects on natural and human systems (...) the term impact is used primarily to refer to the effects on natural and human systems of extreme weather and events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate changes of hazardous climate events occurring within a specific time period and the Vulnerability of an exposed society or system. Note: impacts are also referred to as Consequences and outcomes	Loss of working hours, number of dam-aged buildings, number of fatalities, number of injuries, cases of sickness, cases of diseases, loss of GDP, cost of reconstruction, number of damaged CI elements, hours of loss of service, lost harvest	Adapted from IPCC 2014a

Term	Definition	Examples	Source
Impact Chain	Impact Chains permit the structuring of cause - effect relationships between drivers and/or inhibitors affecting the vulnerability of a system. Impact Chains allow for a visualization of interrelations and feedbacks, help to identify the key Impacts, on which level they occur and allow visualising which climate signals may lead to them. They further help to clarify and/or validate the objectives and the scope of the Vulnerability Assessment and are a useful tool to involve stakeholders.		BMZ 2014
Probability	Measure of the chance of occurrence expressed as a number between 0 and 1 where 0 is impossibility and 1 is absolute certainty.		ISO Guide 73:2009
	The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome and 1 indicating an outcome is certain.		The Australian Emergency Management Glossary
Risk	The potential for Consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of Vulnerability, Exposure, and Hazard.		IPCC 2014a

Term	Definition	Examples	Source
Sensitivity	The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct … or indirect.	With respect to specific hazard or driver: Degrees of surface sealing, age of population, density of population, low household-income, elevation of buildings, high density of buildings, no network redundancy, lack of hospital beds	Adapted from IPCC 2014a
Stressor	Events and trends, often not climate-related, that have an important effect on the system exposed and can increase … climate related Risks. In the RESIN project, we will refer to drivers as climatic drivers and non-climatic drivers as 'stressors'.	Urban sprawl, changes of land-use, population growth, migration, population changes, demographic changes	Adapted from Oppenheimer et al. 2014: p. 1048.
Vulnerability	The propensity or predisposition to be adversely affected. vulnerability encompasses a variety of concepts including Sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Note: Please see contextual vulnerability and outcome vulnerability		IPCC 2014a
	Intrinsic properties of something resulting in susceptibility to a Risk source that can lead to an event with a Consequence.		CIPedia© 2015
	Weakness of an asset or control that can be exploited by one or more threats		ISO/IEC 27000: 2014

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Appendix B:

Indicators from Covenant of Mayors for Climate and Energy Reporting Guidelines

2 Appendix B:

Indicators from Covenant of Mayors for Climate and Energy Reporting Guidelines

Vulnerability type	Vulnerability-related indicators	UNIT	Potential use in IVAVIA
Climatic	Number of days/nights with extreme temperature (compared to ref. annual/seasonal temperatures at day/night times)	Number of days/nights	Hazard/driver
Climatic	Frequency of heat/cold waves	Average per month/year	Hazard/driver
Climatic	Number of days/nights with extreme precipitation (compared to ref. annual/seasonal precipitation at day/night times for each season)	Number of days/nights	Hazard/driver
Climatic	Number of consecutive days/nights without rainfall	Number of days/nights	Hazard/driver
Socio-economic	Current population vs. projections 2020/2030/2050	Number of inhabitants	Stressor
Socio-economic	Population density (compared to national/regional average in year X in country/region X)	People per km^2	Stressor
Socio-economic	% share of sensitive population groups (e.g. elderly (65+)/young (25-) people, lonely pensioner households, low-income/unemployed households) - compared to national average in year X in country X	%	Stressor
Socio-economic	% of population living in areas at Risk (e.g. flood/drought/heat wave/ forest or land fire)	%	Effective exposure
Socio-economic	% of areas non-accessible for emergency/fire-fighting services	%	Sensitivity
Physical & environmental	% change in average annual/monthly temperature	%	Driver
Physical & environmental	% change in average annual/monthly precipitation	%	Driver
Physical & environmental	Length of transport network (e.g. road/rail) located in areas at Risk (e.g. flood/drought/heat wave/ forest or land fire)	km	Effective exposure

Vulnerability type	Vulnerability-related indicators	UNIT	Potential use in IVAVIA
Physical & environmental	Length of coastline/river(s) affected by extreme weather conditions/soil erosion (without adaptation)	km	Effective exposure
Physical & environmental	% of low-lying or at altitude areas	%	Sensitivity
Physical & environmental	% of areas at coasts or rivers	%	Sensitivity
Physical & environmental	% of protected (ecologically and/or culturally sensitive) areas / % of forest	% coverage	Coping capacity
Physical & environmental	% of (e.g. residential/commercial/agricul-tural/industrial/touristic) areas at Risk (e.g. flood/drought/heat wave/forest or land fire)	%	Effective exposure
Physical & environmental	Current energy consumption per capita vs. projections 2020/2030/2050	MWh	Stressor
Physical & environmental	Current water consumption per capita vs. projections 2020/2030/2050	m^3	Stressor

Impact sectors	Impact-related indicators	UNIT	Potential use in IVA-VIA
Buildings	Number or % of (public/residential/tertiary) buildings damaged by extreme weather con-ditions/events	number or % (per year / over a certain period)	Impact
Transport, Energy, Water, Waste, ICT	Number or % of transport/energy/water/waste/ICT infrastructure damaged by ex-treme weather conditions/events	number or % (per year / over a certain period)	Impact
Land Use Planning	% of grey/blue/green areas affected by ex-treme weather conditions/events (e.g. Heat Island Effect, Flood, Rockfalls and/or Land-slides, Forest/Land Fire)	%	Impact
Transport, Energy, Water, Waste, Civil Protection & Emergency	Number of days with public service interrup-tions (e.g. energy/water supply, health/civil protection/emergency services, waste)	days	Impact

Note: We have not included the indicators for impacts on agricultural and forestry mentioned in the original source, since they are not relevant for most cities.

Impact sectors	Impact-related indicators	UNIT	Potential use in IVAVIA
Transport, Energy, Water, Waste, Civil Protection & Emergency	Average length (in hours) of the public service interruptions (e.g. energy/water supply, public transport traffic, health/civil protection/emergency services)	hours	Impact
Health	Number of people injured/evacuated/relocated due to extreme weather event(s) (e.g. heat or cold waves)	number (per year/ over a certain period)	Impact
Health	Number of deaths related to extreme weather event(s) (e.g. heat or cold waves)	number (per year/ over a certain period)	Impact
Civil Protection & Emergency	Average response time (in min.) for police/ fire-fighters/emergency services in case of extreme weather events	minutes	Impact, sensitivity
Health	Number of water quality warnings issued	%	Impact
Health	Number of air quality warnings issued	%	Impact
Environment & Biodiversity	% of areas affected by soil erosion / soil quality degradation	%	Impact
Environment & Biodiversity	% of habitat losses from extreme weather event(s)	%	Impact
Environment & Biodiversity	% change in number of native species	%	Impact, stressor
Environment & Biodiversity	% of native (animal/plant) species affected by diseases related to extreme weather conditions/events	%	Impact
Tourism	% change in tourist flows / tourism activities	%	Impact, stressor
Tourism	% change in tourism activities	%	Impact
Other	€ annual direct economic losses (e.g. in commercial / agricultural / industrial / touristic sectors) due to extreme weather event(s)	€/year	Impact
Other	€ annual amount of compensation received (e.g. insurance)	€/year	Impact

Outcomes	Outcome-related indicators	UNIT	Potential use in IVAVIA
Buildings	% of (public/residential/tertiary) buildings retrofitted for adaptive resilience	%	Coping capacity
Transport, Energy, Water, Waste, ICT	% of transport/energy/water/waste/ICT infra-structure retrofitted for adaptive resilience	%	Coping capacity
Land Use Planning	% change in green & blue infrastructure/areas (surface)	%	Coping capacity
Land Use Planning	% change in connected green and blue areas	%	Coping capacity
Land Use Planning	% change in sealed surfaces / soil moisture level	%	Coping capacity / Sensitivity
Land Use Planning	% change in run-off of rainwater overflows (due to change in soil infiltration)	%	Stressor or Coping capacity
Land Use Planning	% change in shading (& related change in the Urban Heat Island effect)	%	Stressor, Sensitivity
Land Use Planning	% of coastline designated for managed realign-ment	%	Coping capacity
Water	% change in water loss (e.g. due to leakage in the water distribution system)	%	Stressor or Coping capacity
Water	% change in storage of rain water (for reuse)	%	Coping capacity
Waste	% change in solid waste collected / recycled / disposed of / burned	%	Stressor
Environment & Diversity	% of habitats restored / % of species protected	%	Coping capacity
Agriculture & Forestry	% change in crop yield due to adaptation measures	%	Driver
Agriculture & Forestry	% change in water consumption for agriculture/ irrigation	%	Stressor
Agriculture & Forestry	% of forest restored	%	Coping capacity
Tourism	% change in tourist flows	%	Stressor
Tourism	% change in tourism activities	%	Stressor

Outcomes	Outcome-related indicators	UNIT	Potential use in IVAVIA
Other	% change in costs for recovery and reconstruction associated with extreme climate events	%	Impact
Other	€ investment in adaptation research (e.g. soil conservation, water/energy efficiency...) by the city / by other stakeholders	€	Adaptive capacity
Other	€ investment in education / in health & emergency systems by the city	€	Coping capacity
Other	Number of awareness-raising events targeting citizens and local stakeholders	number	Coping capacity
Other	Number of training sessions targeting staff	number	Coping capacity
Other	Number of direct beneficiaries involved in adaptation process milestone decision making through community participatory activities	number	Coping capacity

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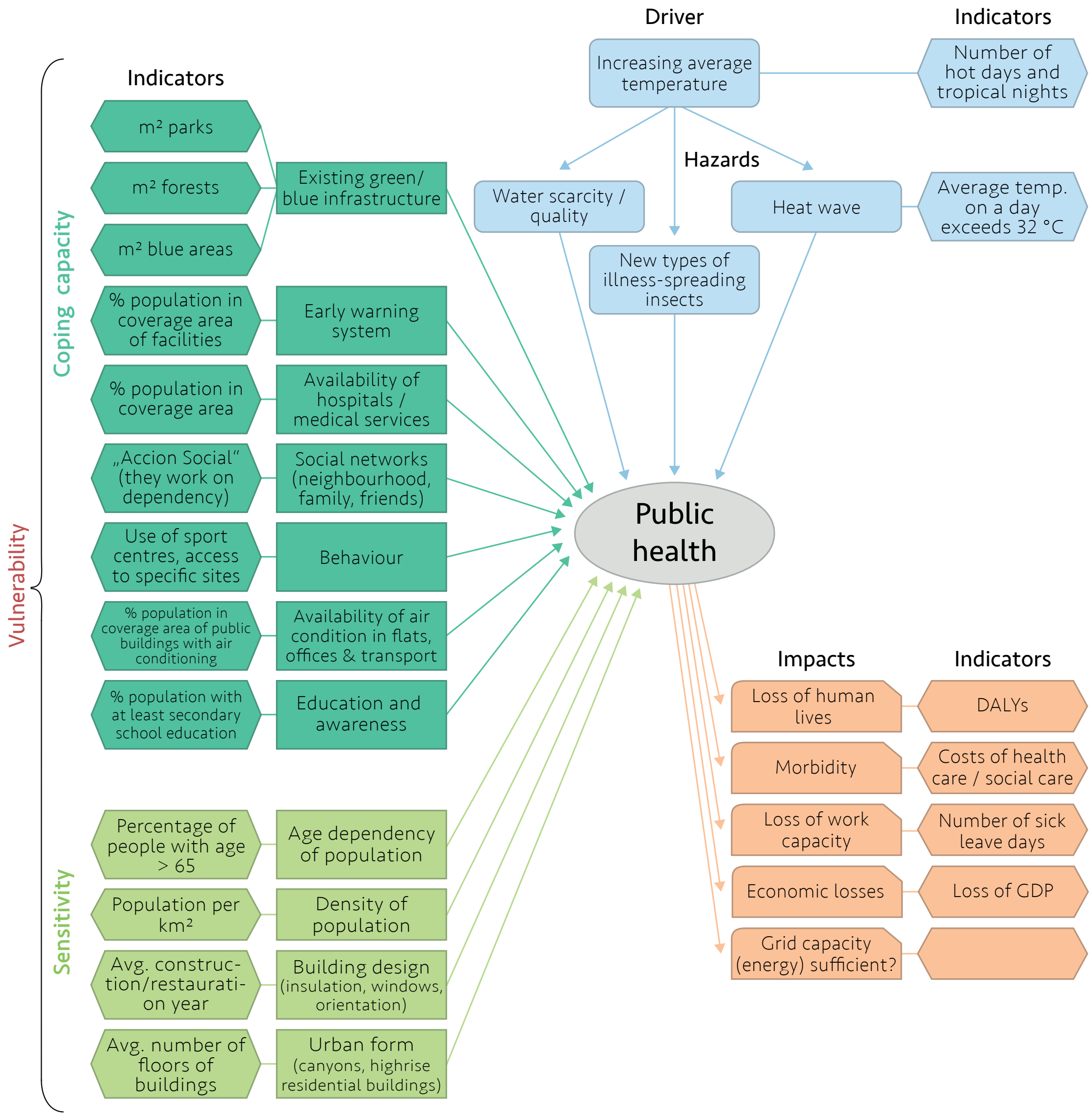
Appendix C:
Sample impact chain diagrams

3 Appendix C:
Sample impact chain diagrams

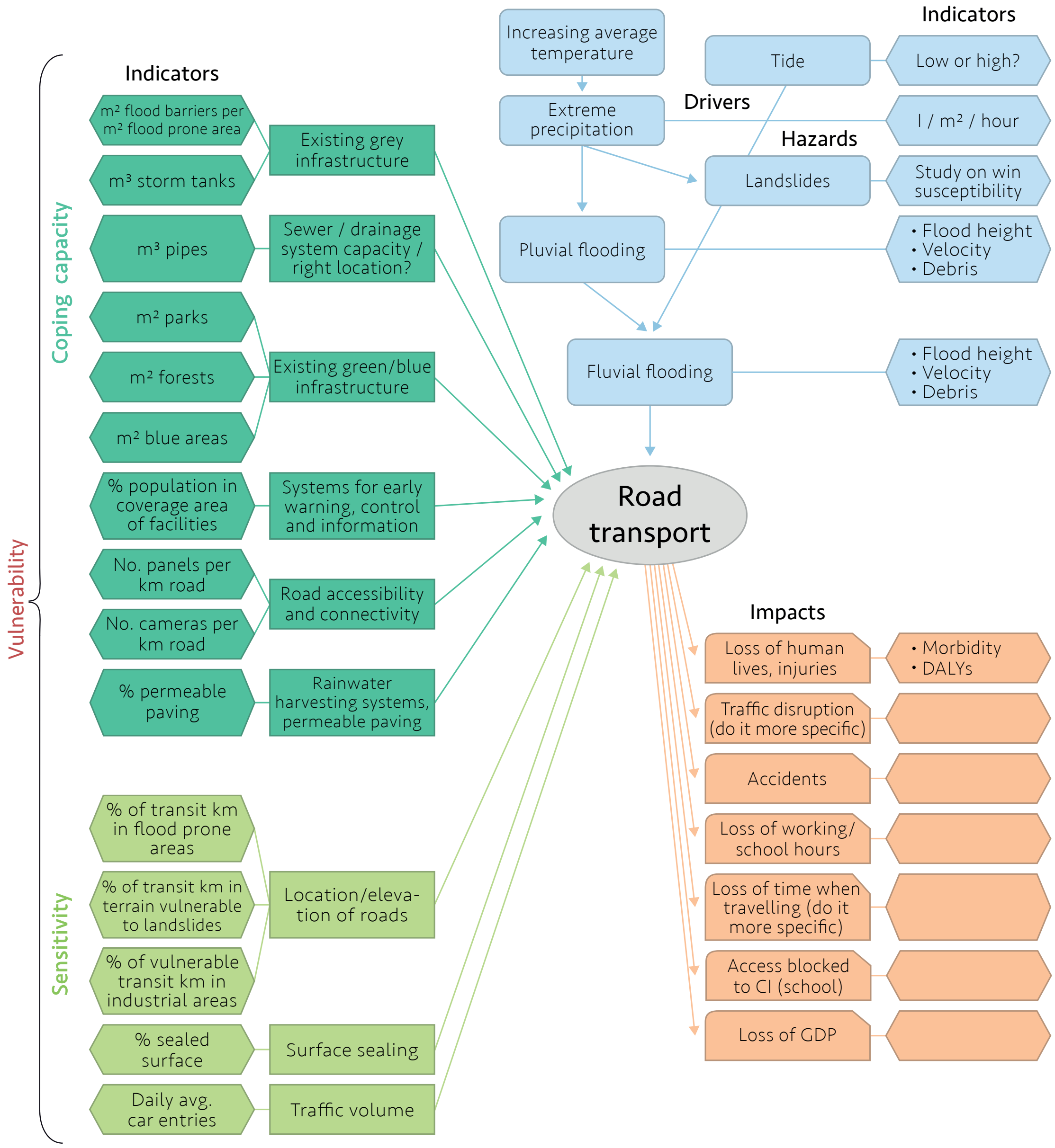
3.1 Heat wave on public health

This impact chain diagram models the effect a heat wave – measured as a day when the average temperate exceeds 32 °C – has on the health of the population of a city. Both the coping capacity as well as the sensitivity contain a mix of infrastructure related measures as well as social indicators, e.g. amount of green infrastructure or percentage of elderly people. The impact indicators on the other hand are mainly related to health related and economic consequences.



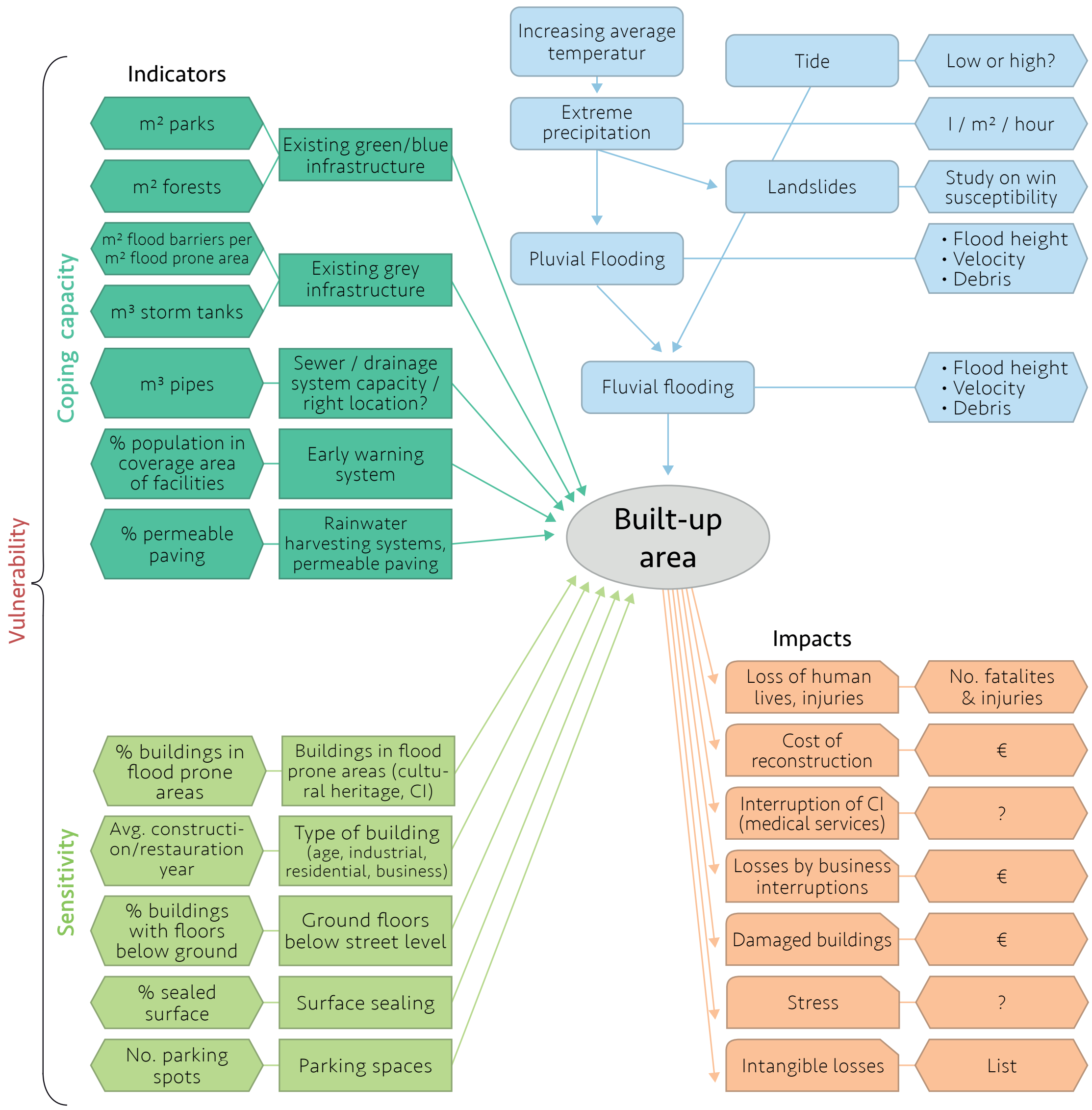
3.2 Extreme precipitation on road transport

This impact chain diagram models the effect of extreme precipitation on road transport. It contains cascading hazard effects, i.e. extreme precipitation results in pluvial and fluvial flooding as well landslides. The indicators for coping capacity and sensitivity mainly contain infrastructure related measures, e.g. the capacity of the sewer system or the percentage of sealed surfaces. The impact indicators are related to health, infrastructure, and economic consequences, e.g. injuries, traffic disruptions, and loss of working hours.



3.3 Extreme precipitation on built-up area

This impact chain diagram models the effect of extreme precipitation on road transport. It contains cascading hazard effects, i.e. extreme precipitation results in pluvial and fluvial flooding as well landslides. The indicators for coping capacity and sensitivity mainly contain infrastructure related measures, e.g. the capacity of the sewer system or the percentage of sealed surfaces. The impact indicators are related to health, infrastructure, and economic consequences, e.g. injuries, traffic disruptions, and loss of working hours.



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Appendix D:
Normalisation methods

4 Appendix D:
Normalisation methods

4.1 Min-max normalisation for metric scales

Min-max normalisation transforms a value of an indicator to a score ranging from 0 to 1 by subtracting the minimum value of the indicator measurements and dividing the result by the range of the indicator values, as shown in the following formula.

$$X_i^{Norm} = \frac{X_i - X_{Min}}{X_{Max} - X_{Min}}$$

Where

X_i represents the individual data point to be transformed,
X_{Min} represents the minimum value of the indicator,
X_{Max} represents the maximum value of the indicator, and
X_i^{Norm} represents the normalised value of the data point.

Usually, you will employ the minimum and maximum values from the corresponding data set for the normalisation, which will result in the measured indicator values occupying the full range from 0 to 1. However, this might not always be what you are aiming at, especially if the measured indicator values only represent a subset of the potential measurement range. For example, you might have measured monthly rainfall data for your three city districts of 51 mm, 52 mm, and 53 mm. Applying min-max normalisation as described above, the normalised indicator values for your city districts would be 0, 0.5, and 1, respectively. However, you might determine – for example, based on historical records – that 25 mm and 60 mm represent the actual minimum and maximum rainfall amount. In this case the three indicator values are actually near the maximum rainfall amount and the normalisation should represent this fact. In this case you would simply replace the minimum and maximum values X_{Min} and X_{Max} correspondingly, which would result in normalised indicator values of 0.74, 0.77, and 0.8.

As a rule of thumb, you will need to define your own threshold values, if the range of normalised indicator values is not a meaningful representation of high and low values in terms of vulnerability. However, the manual change in minimum and/or maximum values can have significant influence on the results of the vulnerability assessment. Therefore, it should be applied with care, based on reliable literature and/or expert knowledge, in agreement with your stakeholders, and be documented for future reference.

Lastly, threshold values may vary across different units of examination. For example, one city district may have more space for building new green infrastructure as other districts, which may be reflected in different maximum threshold values when normalising the corresponding indicator values.

4.2 Class-based normalisation for ordinal and nominal scales

Min-max normalisation cannot be applied to indicators with categorical, i.e. ordinal or nominal, scales. In this case, you need to normalise your data using a rating scale, i.e. you need to define a set of ordered positive and/or negative classes for each indicator to which its values can be assigned and that give the indicator values a meaning applicable to the vulnerability assessment. For ordinal scaled indicator values this might already be the case, for nominally scaled data you must allocate each indicator value to one of the defined classes, based on the best available knowledge, e.g. from existing literature, local experts, or any other reliable source. As a result, you change the measurement scale of these indicator values from nominal to ordinal.

The specific class allocation depends on the meaning of the particular indicator within its respective impact chain. For example, the land cover value 'densely vegetated' might receive a very positive classification when examining the impact chain 'extreme precipitation on road infrastructure' as such areas can help to reduce the risk of erosion, but it might get a negative classification when examining the impact chain 'malaria on public health', because such areas provide a better habitat for mosquitos.

A frequently used five-class classification scheme, with the most positive conditions represented by the lowest class and the most negative conditions represented by the highest class, is proposed by BMZ 2014a[1] and shown in the following table.

Class number	Description
1	Optimal (no improvement necessary or possible)
2	Rather positive
3	Neutral
4	Rather negative
5	Critical (system no longer functions)

Table 2: Five-class schema for classification of categorical indicators, cf. BMZ 2014a, p. 115

Once all indicator values have been assigned to one of the defined classes, they can be transformed to normalised values by dividing the normalised scale equally across the different classes. For example, using a normalised scale from 0 to 1, the five classes from Table 1 could be divided as shown in Table 2. In this example, each class is assigned one fifth of the metric value range from 0 to 1.

[1] BMZ, 2014a. German Federal Ministry for Economic Cooperation and Development: The Vulnerability Sourcebook. Concept and guidelines for standardised vulnerability assessments. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn and Eschborn. Available at: http://www.adaptationcommunity.net/?wpfb_dl=203

Categorical indicator values			Resulting metric indicator values
Class number	Class value range within 0 to 1	Description	
1	0 – 0.2	Optimal	0.1
2	> 0.2 – 0.4	Rather positive	0.3
3	> 0.4 – 0.6	Neutral	0.5
4	> 0.6 – 0.8	Rather negative	0.7
5	> 0.8 – 1.0	Critical	0.9

Table 2: Normalisation of transformed categorical indicator values, cf. BMZ 2014a, p. 118

Finally, the definite metric indicator value is calculated as the median value of the value range assigned to the different classes (see Table 2).

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Appendix E:
Aggregation methods

5 Appendix E:

Aggregation methods

There exists no standard approach for indicator aggregation. The literature covers several aggregation methods, each with their own (dis)advantages (see [OECD2008][1]). Two commonly used approaches are the weighted arithmetic mean and the weighted geometric mean.

5.1 General aggregation methods

5.1.1 Weighted arithmetic mean

The weighted arithmetic mean is a simple and transparent aggregation approach. Individual normalised indicators are multiplied by their weights, summed up and subsequently divided by the sum of their weights to calculate composite scores, as displayed in the following formula:

$$CRC = \frac{\sum_{i=1}^{n} I_i * w_i}{\sum_{i=1}^{n} w_i}$$

Where

CRC is the composite score, e.g. sensitivity,

I_i are the normalised indicator values, e.g. percentage of sealed surfaces, and

w_i are the corresponding indicator weights.

If equal weights are applied, indicators are simply summed up and divided by the number of indicators.

A (dis)advantage of the arithmetic mean is that it allows for 'full compensability' (see [OECD2008], p. 33), i.e. a high score for one indicator can offset a low score of another indicator. Subsequently, extreme values are absorbed to a certain extend

5.1.2 Weighted geometric mean

The weighted geometric mean is more complex than the arithmetic mean. Individual normalised indicators are raised to the power of their weight, multiplied with each other, and finally raised to the power of the reciprocal of the sum of the weights, as shown by the following formula:

$$CRC = \left(\prod_{i=1}^{n} I_i^{w_i}\right)^{\frac{1}{\sum_{i=1}^{n} w_i}}$$

[2] OECD, 2008. Handbook on constructing composite indicators: methodology and user guide. Technical Report. Paris: OECD Publishing. Available at: http://www.oecd.org/std/42495745.pdf.

Where
CRC is the composite score, e.g. sensitivity,
I_i are the normalised indicator values, e.g. percentage of sealed surfaces, and
w_i are the corresponding indicator weights.

In contrast to the arithmetic mean, the geometric mean only allows partial compensability, i.e. a very low value of one indicator can only partly offset a very high value of another indicator, which may be a desirable effect. However, due to its strong bias towards low values, it may result in counterintuitive aggregation effects that are difficult to comprehend. Furthermore, zero values are not allowed when employing the geometric mean, due to the multiplication of the indicator values.

5.2 Aggregation methods for vulnerability

5.2.1 Weighted arithmetic/geometric mean

The general aggregation methods described previously can also be employed to aggregate composite sensitivity and coping capacity indicators to vulnerability scores. The following table depicts the corresponding formulas.

Equation	Weighted arithmetic mean	Weighted geometric mean
	$V = \frac{S * w_S + C * w_C}{w_S + w_C}$	$V = (S^{w_S} * C^{w_C})^{\frac{1}{w_S + w_C}}$

Where
V is the vulnerability score,
S is the composite sensitivity indicator,
C is the composite coping capacity indicator, and
w_S, w_C are the corresponding weights for sensitivity and coping capacity.

One advantage of this approach is that it enables you to employ a consistent calculation method across the whole assessment process, which makes it easy to follow. Additionally, you will not have to worry about transforming and normalising the resulting vulnerability scores, as they will remain on the same scale as the sensitivity and coping capacity indicators. On the other hand, this approach can be somewhat counterintuitive, because for it to work properly, you have to make sure the value ranges of both composite risk components increase in the same direction. This is commonly done by reversing the value range of the coping capacity indicator, i.e. a low value indicates an optimal coping capacity, while a high value indicates a critical coping capacity. In this case, the value of the coping capacity indicator represents the coping capacity potential of a region under examination (i.e. how distant is it from its optimum coping capacity value) rather than the actual coping capacity.

Additionally, due to the multiplication of the weighted geometric mean, no zero values are allowed when employing this approach.

5.2.2 Subtracting coping capacity from sensitivity

A very intuitive approach to calculating vulnerability scores is to simply subtract the coping capacity indicator from the sensitivity indicator, as shown in the formula below.

$$V = S - C$$

Where
V is the vulnerability score,
S composite sensitivity indicator, and
C is the composite coping capacity indicator.

An advantage of this approach is its extreme simplicity, which makes it very intuitive and easy to understand. However, it might result in negative vulnerability scores for examination units with a higher coping capacity value than sensitivity value. In this case you would have to decide how to handle these negative values, e.g. by replacing them with the minimum value of your employed scale or standardising and re-normalising the vulnerability scores.

5.2.3 Dividing sensitivity by coping capacity

Another very simple approach to calculate vulnerability scores is to divide the sensitivity indicators by the coping capacity indicators, as shown in the following formula.

$$V = \frac{S}{C}$$

Where
V is the vulnerability score,
S composite sensitivity indicator, and
C is the composite coping capacity indicator.

Similar to the subtraction approach, the simplicity of this method makes it very intuitive and understandable. However, when employing this approach, no zero values are allowed.

6

Appendix F:
Clustering results of impact chain workshops

6 Appendix F:

Clustering results of impact chain workshops

Most steps in IVAVIA Module 2 will be conducted in participatory workshops. Inputs from the workshop participants may range from very detailed to more abstract. Also, the number of named elements of impact chain diagrams might be too large to handle. In such cases, clustering techniques may yield suitable results at an agreed level of abstraction. Figure 1 shows the steps of a clustering process for named impacts in a participatory workshop:

1. Gathering named impacts
2. Sorting and clustering named Impacts. Similar impacts could be merged.
3. Naming each cluster.
4. Optional final step in case there are still too many clusters: prioritizing and selecting an agreed set (cluster) of Impacts

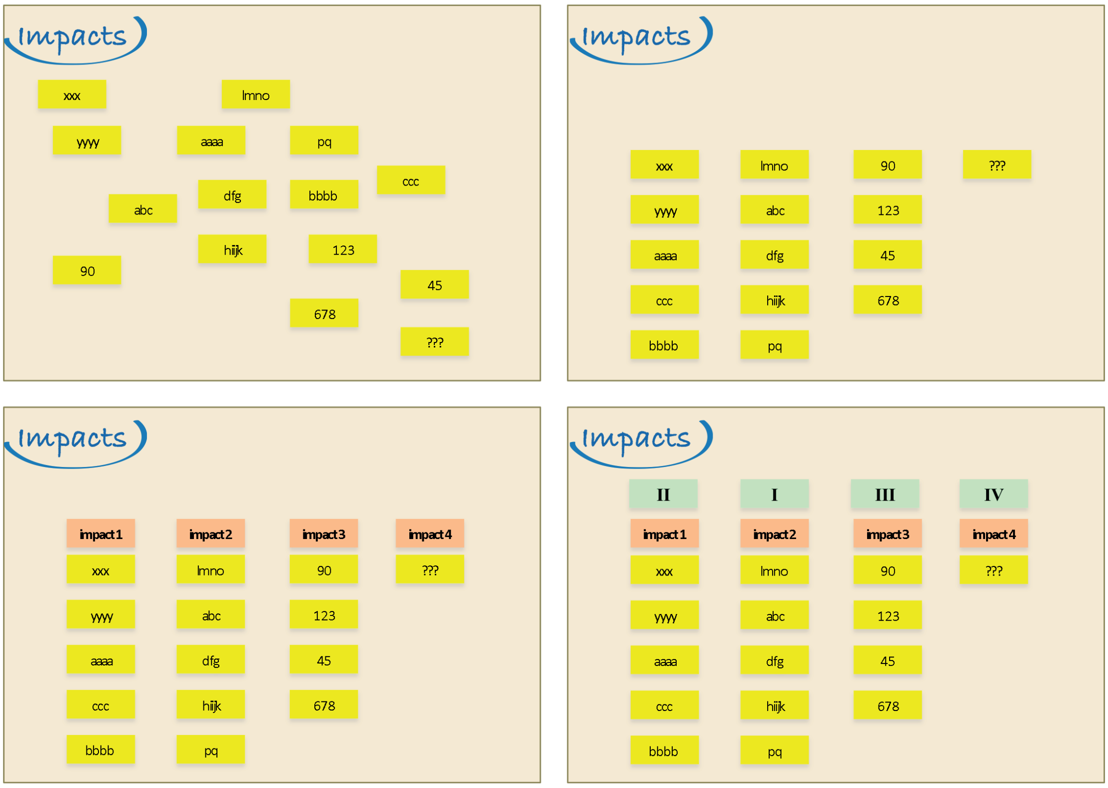

Figure 1: Clustering technique. From left to right, top row: a) gathering and b) clustering potential Impacts; bottom row: c) naming Impact clusters; d) optional step – in case there are too many clusters, then rank, prioritize, and select.

7

Appendix G:
Useful tools

7 Appendix G:
Useful tools

Tool name	Category	Description	Where to find it
Data and Map Service of the European Environment Agency EEA	Climate and environmental data and maps	Provides numerous data sets and maps about several indicators across all of Europe, e.g. annual temperature changes or annual precipitation changes.	https://www.eea.europa.eu/data-and-maps
CCAFS-Climate	Maps for several climate change scenarios	The CCAFS-Climate data portal provides global and regional future high-resolution climate datasets that serve as a basis for assessing the climate change impacts and adaptation in a variety of fields including biodiversity, agricultural and livestock production, and ecosystem services and hydrology.	http://ccafs-climate.org
KNMI Climate Explorer	Climate data / statistical analysis	A web application from the Royal Netherlands Meteorological Institute (KNMI) for the analysis of statistical climate data. Its Climate Change Atlas provides climate change projection maps for several data sets.	https://climexp.knmi.nl/start.cgi?id=someone@somewhere
EM-DAT	Historic data on mass disasters / impact assessment	Emergency Events Database. Historical data on the occurrence and effects of over 22,000 mass disasters in the world from 1900 to today	http://www.emdat.be/
Worldbank's The Climate Change Knowledge Portal	Historical climate data / Projected Climate data / Climate data by sector	Here you can query, map, compare, chart and summarize key climate and climate-related information.	http://sdwebx.worldbank.org/climateportal/
NOAA National Oceanic and Atmospheric Administration	Historical climate data and maps	Global and US datasets on climate. Climate data primer	https://www.climate.gov/maps-data

Tool name	Category	Description	Where to find it
NatCatSERVICE Munich Re climate-related web-services	Historical / statistical data on natural disasters / impact assessment	Munich Re's NatCatSERVICE is one of the world's most comprehensive databases for analysing and evaluating natural catastrophes. • Access to data on natural catastrophes since 1980 • Interactive analysis to match individual needs • Results presented in various forms	https://www.munichre.com/en/reinsurance/business/non-life/natcatservice/index.html
eSurge	Historical data on extreme weather	Freely available database with past storm surge events	http://www.storm-surge.info/
CIMP5 Coupled Model Intercomparison Project –Phase 5	Research on climate models /scenarios	A notable product of PCMDI's leadership of coordinated modeling activities is the Coupled Model Intercomparison Project (CMIP) which subjects models worldwide to an evolving set of standardized numerical experiments. This has produced multi-model ensembles of simulations that have led to a better understanding of the limitations of any individual model.	https://pcmdi.llnl.gov/mips/cmip5/index.html
OECD Handbook on constructing composite indicators	Indicator development	Handbook on constructing composite indicators: methodology and user guide	http://www.oecd.org/std/42495745.pdf
USISCVT	Indicator development	Developing Urban Climate Adaptation Indicators	http://us.iscvt.org/wp-content/uploads/2017/01/Urban-Adaptation-indicators-Guide-2.9.16.pdf
CLIPC Climate Information Portal	Data for climate models, climate variability / tools for indicators	Provides access to information of direct relevance to a wide variety of users, catering for consultant advisers, policy makers, private sector decision makers and scientists, but also interested members of the general public. Furthermore, CLIPC provides a toolbox to generate, compare, manipulate and combine indicators.	http://www.clipc.eu/

Tool name	Category	Description	Where to find it
MOVE Indicator Database Visualizer	Database of indicators for vulnerability assessment	A web-based indicator database from the MOVE project. Collects the indicators to assess vulnerability used in Barcelona, Cologne/Bonn, London, North-Western Portugal, Prato, Pistoia, Florence Lucca, Salzach River and South Tyrol, the seven case study areas involved in the project. The tool allows people to search for indicators mainly to assess vulnerability, but also in relation with risk, risk governance and adaptation; also it offers the possibility to look for indicators in all the dimensions and capacities in the vulnerability field, as well as indicators related with the potential impacts of risk, factors included in risk governance, and the interventions required for adaptation.	http://www.gi4drr.org/move/move_query/

Digital file formats for better data handling

The table provides a non-exhaustive list of frequently used file formats that enable easy data handling, i.e. they are well-structured, easy to interpret, need no (or only little) manual reformatting and can likely be handled by colleagues without the need for specific (software) tools.

File format	Potential use in IVAVIA
Shapefile	Geospatial vector data format for Geographic Information Systems.
Spreadsheet	From Excel, Open Office, Libre Office, or another spreadsheet software. Should have a well-structured and documented format.
CSV	Comma-separated values files that store tabular data in plain text.
JSON	JavaScript Object Notation. An open-standard file format using human-readable text to transmit data objects.
XML	Extensible Markup Language. A markup language for encoding documents in a format that is both human-readable and machine-readable

Table 1: Frequently used file formats enabling easy data handling

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Appendix H:
Recommendations for a comprehensive risk assessment report

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Recommendations for a comprehensive risk assessment report

Vose (Vose, 2008, p.68) proposes a detailed structure for a comprehensive risk assessment report. If you are not obliged to follow a standard reporting structure of your adaptation framework(s) or your local or national reporting standards, you might check if that structure (or elements thereof) would be suitable for your own report. As a practical guidance, Vose summarises his recommendations for writing a risk assessment report (Vose, 2018, p.69). We have adapted this list for IVAVIA:

1. Design your report to the target audience

2. Use only a minimum of statistics and avoid too much technical detail

3. Use appropriate visuals (graphs, maps, impact chain diagrams) to underline your findings

4. Explain the assumptions underlying your assessment and its limitations

Another set of recommendations has been published by the FAIR institute on their website. We have selected a suitable set from FAIR1018a and FAIR2018b:

> "**Build a Deliverable that Tells a Story** – When conducting a risk analysis, there is always a purpose or objective behind it – use that to paint a picture for the audience. It is not about just throwing into the report a whole bunch of quantitative numbers and charts. It's important to create a report, presentation or deliverable that walks the au-dience through the problem and results. Creating the story or narrative that supports your results helps you as the analyst, inform the stakeholders. While this may be time consuming to adjust a report specific to the narrative you want to convey, you will provide more value to your audience.
>
> **Be Direct and Specific** – Deliverables to stakeholders should not be bloated or convoluted. Make them lean and mean, quickly and concisely highlighting the following:
>
> **Purpose of the Analysis** – Why did we assess this topic? Who is the audience for the results? What decisions can be made from these results?
>
> **Assumptions** – Indicate any important scoping or data assumptions you may have made. Note any uncertain data you may have used, hoping it may get refined in the future. These are all important apects that should not be ignored, but directly addressed in your reporting.
>
> **Results** – Results should be analytically based but communicated in layman terms. It should not be a requirement to be certified in FAIR to understand your results. Stakeholders want to know that there is rigor in the analysis, but details should be summarized, so the report can be digested in a short amount of time.

Interpretations – Spell out the interpretations to the results and how they can be used. Is the reporting effectively showing the value of a control improvement or initiative? Our role as risk analysts is to inform decision-makers, but providing interpretation and recommendations is of value to our audience.

Disclose Your Confidence – If you cannot find data, don't have Subject Matter Experts, or simply are not confident in your ranges, explain why."

References

FAIR, 2018a. Blog of the FAIR institute: 3 Tips for Better Risk Analysis Reporting, https://www.fairinstitute.org/blog/3-tips-better-risk-analysis-reporting, visited 15-05-2018

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Vose, 2008. Vose, D., 2008: Risk Analysis: A Quantitative Guide, 3rd Edition. Wiley, ISBN: 978-0-470-51284-5