Vulnerability and Risk Assessment Tutorial

M1

See Annex n.1
(already sent by email on 20th Nov 2019)

M1 Preparing the risk assessment

Describes the context of the assessment: processes, knowledge, institutions, resources and external factors; identifies objectives, expected outcomes and scope; defines tasks, responsibilities and time planning

4 Interlinked steps

1. Understand the context of the risk assessment
2. Identify objectives and expected outcomes
3. Determine the scope of the risk assessment
4. Prepare an implementation plan

M1 STEP 1,2

Step 1: Understand the context of a climate risk assessment for adaptation

At what stage of adaptation planning is your assessment taking place? And what are the development and adaptation priorities (if already defined)?

Which institutions and resources can and should be involved in your risk assessment?

Step 2: Identify objectives and expected outcomes

Which processes will the climate risk assessment support or feed into?

What do you and key stakeholders wish to learn from the assessment?

Who is the target audience for the risk assessment results?

M1 STEP3,4

Step 3: Determine the scope of the assessment

What exactly is your risk assessment about?

What climate related risks do you intend to assess?

What is the time period of the assessment?

What are the right methods for your climate risk assessment?

Step 4: Prepare an implementation plan

Which people and institutions are involved?

What is the time plan of the risk assessment?

What resources are required?

M2

M2 Developing impact chains

An impact chain is an analytical tool that helps better understand, systemise and prioritise the factors that drive risk in the system of concern, as well as their cause-and-effect relationships.

M2 STEP 1

Identify climate RISKS affecting the system. This step will result in one (or a set of) impacts and risks to focus the assessment on. The final wording of the risk can be composed of the impact (risk of what), the hazard (impact from what) and the exposed elements (what or who is at risk).

HAZARD
Extreme precipitation events
Heavy rainfall and hailstorms

HARZARD: 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, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts

START FROM HERE

RISK OF DAMAGE TO ECONOMIC ACTIVITIES, INFRASTRUCTURES AND PEOPLE DUE TO FLOODING AND HAILSTORMS

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. In this report, the term risk is used primarily to refer to the risks of climate-change impacts

M2 STEP 2

Determine HAZARD and INTERMEDIATE IMPACTS.

IMPORTANT: starting with the selected risk, work from the bottom up by identifying related intermediate impacts that lead to the risk, until you reach the hazard (direct physical impact or climate signal) that represents the essential triggers.

HAZARD
Extreme precipitation events
Heavy rainfall and hailstorms

- LANDSLIDE
- SOIL EROSION
- FLOODING OF FARMING CULTIVATIONS WITH SEDIMENTS DEPOSIT
- INFRASTRUCTURE AND VIABILITY DAMAGE
- ALTERED DRAINAGE SYSTEM
- RIVER FLOODING
- CHANGE AND LOSS ON SPECIES AND HABITATS
- CHANGES IN GROWTH CYCLE
- LOSS ON QUALITY HARVEST

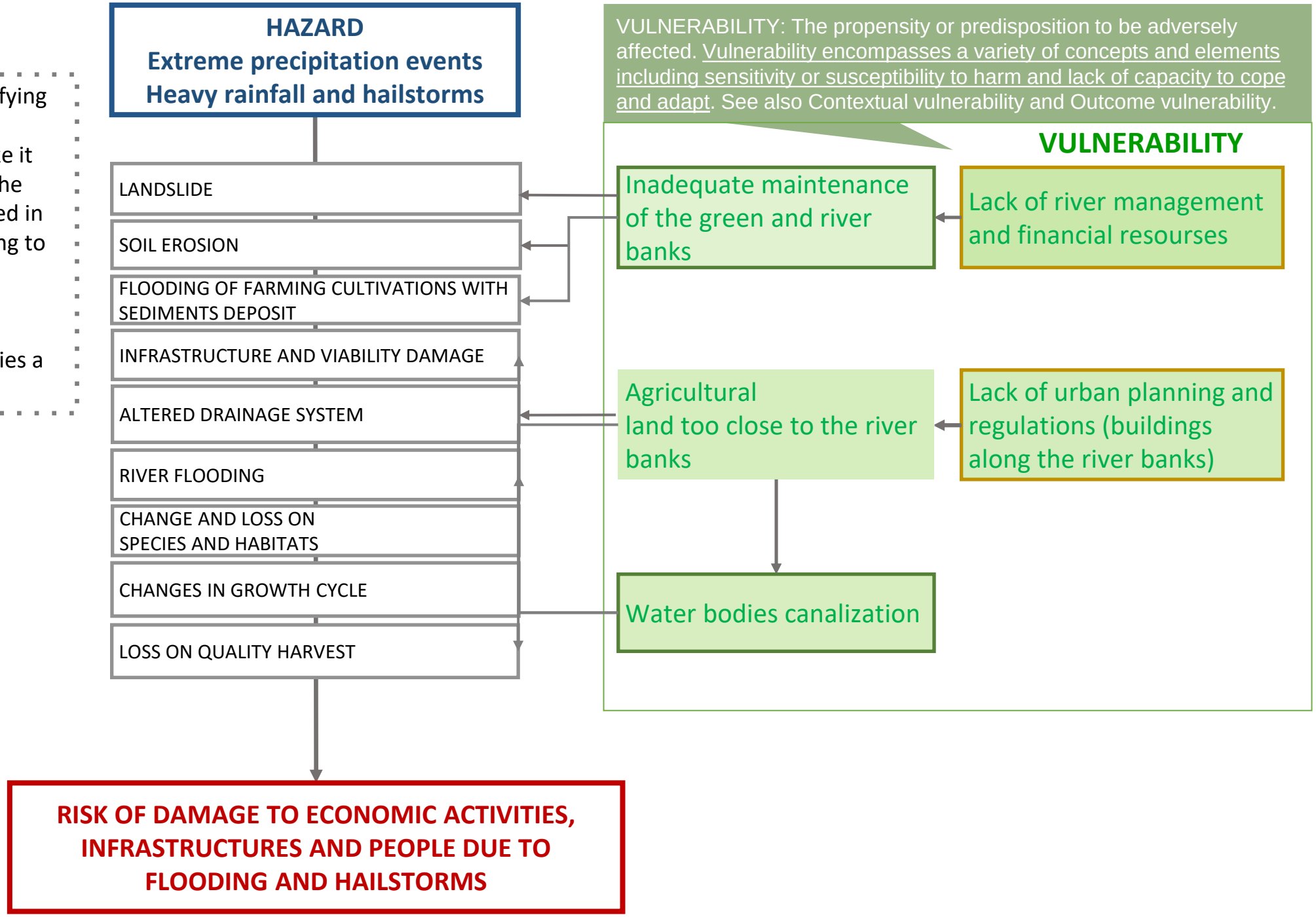
IMPACTS *(*Consequences, Outcomes): Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

RISK OF DAMAGE TO ECONOMIC ACTIVITIES, INFRASTRUCTURES AND PEOPLE DUE TO FLOODING AND HAILSTORMS

M2 STEP 3

Determine VULNERABILITY, identifying natural or physical attributes or properties of the system that make it susceptible to adverse effects of the changing climate signal(s) identified in the previous step, thus contributing to the risk.

IMPORTANT: Also for factors of vulnerability, a wording that implies a critical state is recommended.

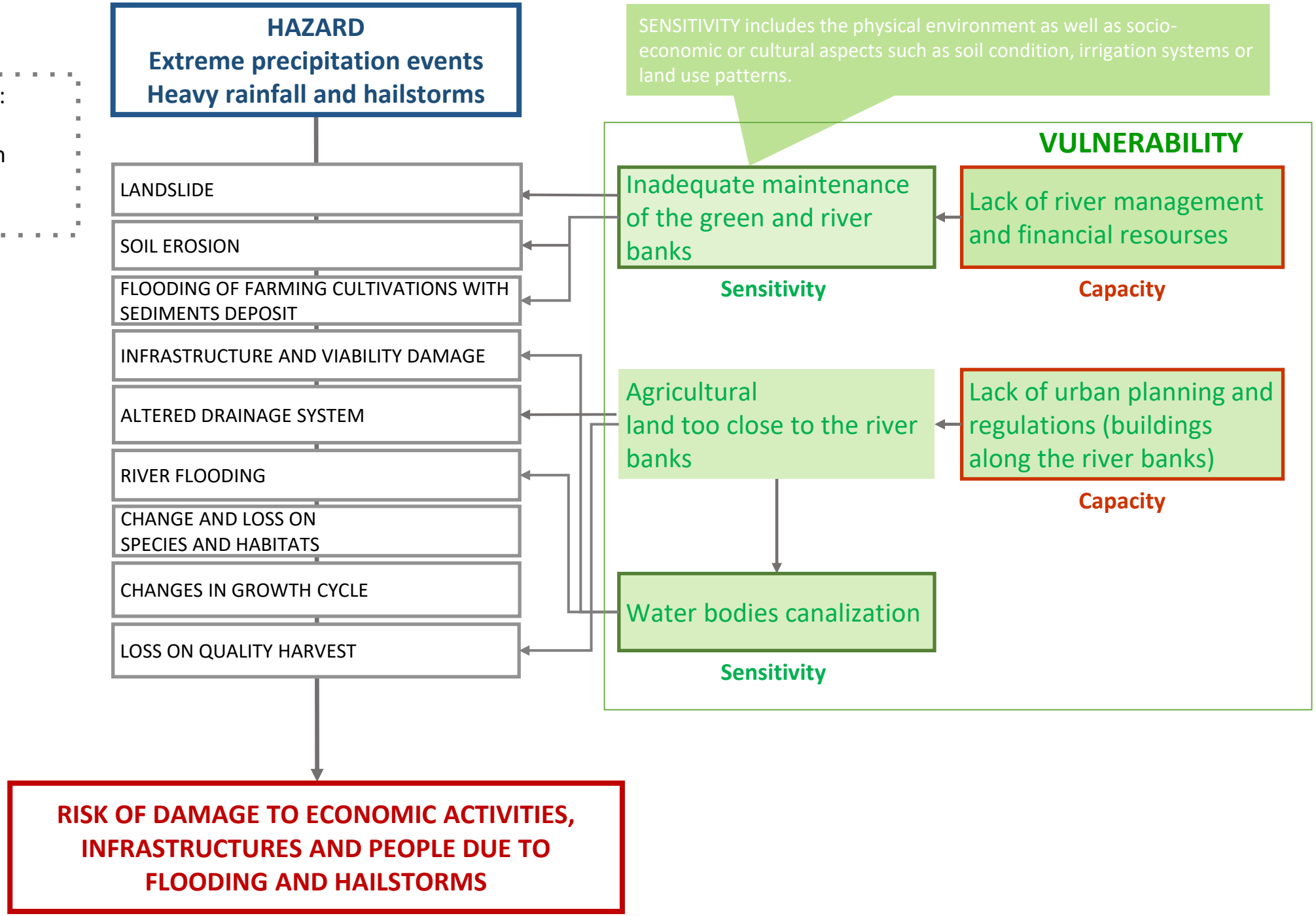


M2 STEP 3

Within the VULNERABILITY define:

- **Sensitivity:**

Which attributes make the system vulnerable to potential negative impacts of the hazard(s) under consideration?



M2 STEP 3

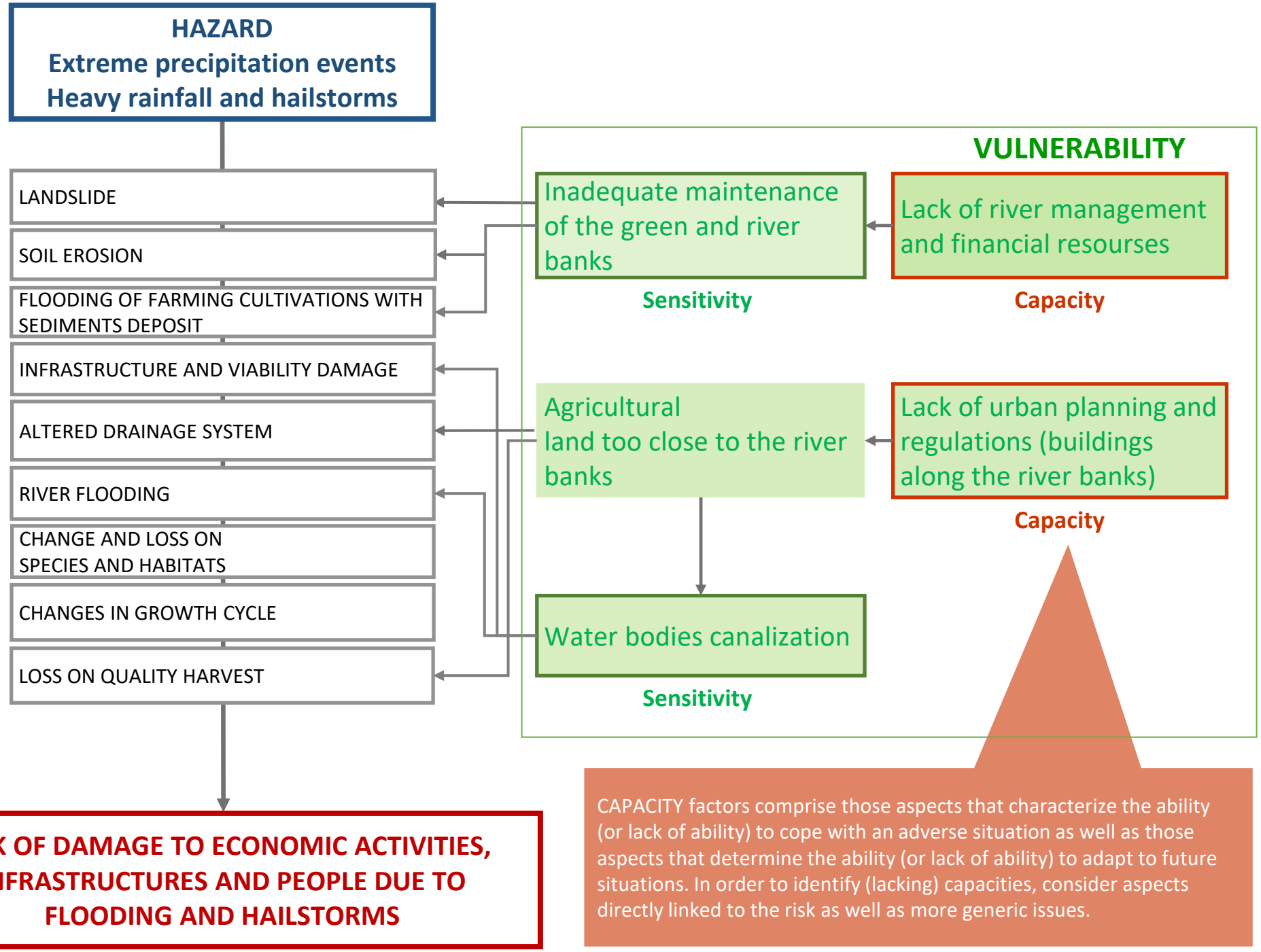
Within the VULNERABILITY define:

- **Capacity:**

Which abilities of the societal system are in place or missing to reduce the risk of concern – now and in future?

IMPORTANT: You may find it helpful to keep the four dimensions of adaptive capacity in mind:

- Knowledge: is there knowledge or expertise available or missing which might aid adaptation?
- Technology: are there technical options available or missing which could enhance capacity?
- Institutions: how does the institutional environment contribute to capacity?
- Economy: which economic and financial resources are available or missing for enhancing capacity or implementing adaptation measures?



CAPACITY factors comprise those aspects that characterize the ability (or lack of ability) to cope with an adverse situation as well as those aspects that determine the ability (or lack of ability) to adapt to future situations. In order to identify (lacking) capacities, consider aspects directly linked to the risk as well as more generic issues.

M2 STEP 4

Identifying the elements of the system that could be adversely affected, thus determining EXPOSURE.

HAZARD
Extreme precipitation events
Heavy rainfall and hailstorms

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- LOSS ON QUALITY HARVEST

VULNERABILITY

- Inadequate maintenance of the green and river banks
  - Lack of river management and financial resourses
- Agricultural land too close to the river banks
  - Lack of urban planning and regulations (buildings along the river banks)
- Water bodies canalization

EXPOSURE

- People living, properties in flood prone areas
- Farming activities and cultivation in flood prone areas
- Critical infrastructures in flood prone areas
- Ecosystems and protected areas
- Buildings of hIstorical value

EXPOSURE: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

RISK OF DAMAGE TO ECONOMIC ACTIVITIES, INFRASTRUCTURES AND PEOPLE DUE TO FLOODING AND HAILSTORMS

M3

M3 Identifying and selecting indicators

M3 is aimed at identifying parameters that allow to quantify, assess and measure the relevant factors that intensify or mitigate climate change factors, as identified in the previous module. IMPORTANT: At least one indicator has to be selected for each relevant factor. These indicator values will be aggregated to risk components (hazard, vulnerability and exposure) and thus contribute to the compositive risk score

M3 STEP 1

Selecting indicators for hazards, i.e. biophysical or physical characteristics, or climate parameters. Potential data availability and frequency of data values required should be considered in this phase.

HAZARD
Extreme precipitation events
Heavy rainfall and hailstorms

No. of days with precipitation> 100mm

- LANDSLIDE
- SOIL EROSION
- FLOODING OF FARMING CULTIVATIONS WITH SEDIMENTS DEPOSIT
- INFRASTRUCTURE AND VIABILITY DAMAGE
- ALTERED DRAINAGE SYSTEM
- RIVER FLOODING
- CHANGE AND LOSS ON SPECIES AND HABITATS
- CHANGES IN GROWTH CYCLE
- LOSS ON QUALITY HARVEST

VULNERABILITY

- Inadequate maintenance of the green and river banks ← Lack of river management and financial resourses
- Agricultural land too close to the river banks ← Lack of urban planning and regulations (buildings along the river banks)
- Water bodies canalization

EXPOSURE

- People living, properties in flood prone areas
- Farming activities and cultivation in flood prone areas
- Critical infrastructures in flood prone areas
- Ecosystems and protected areas
- Buildings of hIstorical value

RISK OF DAMAGE TO ECONOMIC ACTIVITIES, INFRASTRUCTURES AND PEOPLE DUE TO FLOODING AND HAILSTORMS

M3 STEP 2

Selecting indicators for vulnerability…

HAZARD

Extreme precipitation events
Heavy rainfall and hailstorms

No. of days with precipitation> 100mm

EXPOSURE

- People living, properties in flood prone areas
- Farming activities and cultivation in flood prone areas
- Critical infrastructures in flood prone areas
- Ecosystems and protected areas
- Buildings of historical value

- LANDSLIDE
- SOIL EROSION
- FLOODING OF FARMING CULTIVATIONS WITH SEDIMENTS DEPOSIT
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- LOSS ON QUALITY HARVEST

VULNERABILITY

- Inadequate maintenance of the green and river banks
  - *Number of fluvial strips rehabilitation and re-naturalization interventions*
- Lack of river management and financial resourses
  - *% of financial resources for river management*
- Agricultural land too close to the river banks
  - *% of agricultural area next to the river banks*
- Lack of urban planning and regulations (buildings along the river banks)
  - *Number of (unauthorized) buildings next to the river banks*
- Water bodies canalization
  - *% canalization per km of water bodies*

RISK OF DAMAGE TO ECONOMIC ACTIVITIES, INFRASTRUCTURES AND PEOPLE DUE TO FLOODING AND HAILSTORMS

M3 STEP 2

Selecting indicators for … exposure

EXPOSURE

People living, properties in flood prone areas

Number of people per km2 in flood-prone area

Farming activities and cultivation in flood prone areas

Hectares of farming activities in flood prone areas

Critical infrastructures in flood prone areas

Meters of services linear infrastructures in flood prone areas

Meters of linear transportation in flood prone areas

Ecosystems and protected areas

Hectares of protected areas vulnerable to flooding per sq.km

Buildings of historical value

Numbers of historical buildings prone to flooding events

HAZARD

Extreme precipitation events
Heavy rainfall and hailstorms

No. of days with precipitation> 100mm

- LANDSLIDE
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VULNERABILITY

Inadequate maintenance of the green and river banks

Number of fluvial strips rehabilitation and re-naturalization interventions

Lack of river management and financial resourses

% of financial resources for river management

Agricultural land too close to the river banks

% of agricultural area next to the river banks

Lack of urban planning and regulations (buildings along the river banks)

Number of (unauthorized) buildings next to the river banks

Water bodies canalization

% canalization per km of water bodies

RISK OF DAMAGE TO ECONOMIC ACTIVITIES, INFRASTRUCTURES AND PEOPLE DUE TO FLOODING AND HAILSTORMS

Check if your indicator is specific enough

Does it have a clear direction and, if possible, an ‘event character’? What is the exact spatial extent which should be covered by your data? What spatial resolution should your data have? What time period will the data need to cover? How frequently and at what intervals do you plan to repeat the assessment for monitoring purposes?

Create a list of provisional indicators for each factor

Component	Factor	Indicator
Hazard	Extreme precipitation events Heavy rainfall and hailstorms	No. of days with precipitation> 100mm
Exposure	People living, properties in flood prone areas	Number of people per km2 in flood-prone area
	Farming activities and cultivation in flood prone areas	% of agricultural area next to the river banks
	Critical infrastructures in flood prone areas	% canalization per km of water bodies
	Ecosystems and protected areas	% of financial resources for river management
	Buildings of historical value	Number of (unauthorized) buildings next to the river banks
Vulnerability	Inadequate maintenance of the green and river banks	Number of fluvial strips and re-naturalization interventions
	Agricultural land too close to the Tronto river banks	% of agricultural area next to the river banks
	Water bodies canalization	% canalization per km of water bodies
	Lack of river management and financial resourses	% of financial resources for river management
	Lack of urban planning and regulations (buildings along the river banks)	Number of (unauthorized) buildings next to the river banks

M4

M4 Data acquisition and management

M4 Based on the draft list of indicators developed in Module 3, the next steps are gathering the required data (Step 1), checking their quality (Steps 2), and documenting and storing them in a suitable database (Step 3). Steps 1 and 2 could show that data is either not available or has significant quality constraints: in this case the indicator framework should be revised. Module 4 will however result in a final indicator list

M4

Module 3
Proposed indicators list with name, unit of measurement and potential data sources

Module 4

STEP 1
Gather your data assessment

1. **What kind of data do you need?**
2. **Do the data already exist or do they have to be generated?**
3. **What can you commit in terms of time and other resources for generating data?**

STEP 2
Data quality check

1 **Are the data in the format you expected?**
2 **Are all the files legible and ready for further processing?**
3. **Is the temporal and spatial coverage as planned?**
4. **Are there any missing values or 'outliers' in your data?**
5. **Are the data in the right geographical projection?**

STEP 3
Data management

1. **How are data transformed into relevant, readable formats?**
2. **How do you structure and compile your data in a common database?**
3. **How can you document your data with metadata and/or data fact sheets?**

See Annex n.2

OUTCOMES

A final indicator list

A database containing all the data for assessment

A complete indicator factsheets

Data that you planned to use is not available?

Poor data quality ?

M5

M5 Normalisation of indicator data

Module 5 aims at providing normalised data for each indicator in a standardised value range from 0 to 1, ready for aggregation. The term ‘normalisation’ refers to the transformation of indicator values measured on different scales and in different units into unit-less values on a common scale. The Vulnerability Sourcebook uses a standard value range from 0 to 1, where ‘0’ means ‘optimal, no improvement necessary or possible’ and ‘1’ means ‘critical, system no longer functions’.

Step 1 Determine the scale of measurement

In a **metric scale** you have ordered, numerical values where the difference between two values is clearly defined and of the same interval (temperature, pressure, and so on).

An **ordinal scale** indicates that one given value is greater or lesser than another, but the interval between values is undefined or unknown (school marks, education level and so on).

For a **nominal scale** you simply name or categorise your values (names, postal codes, crop types).

Table 9: Examples of indicators, units and scales of measurement

Indicator	Measurement unit	Scale of measurement
Amount of precipitation	mm	metric
Temperature	° C	metric
Soil type	none (descriptive classes)	nominal
Land use land cover	none (descriptive classes)	nominal
Willingness to implement climate adapation measures	ranking in 5 classes (very low, low, medium, high, very high)	ordinal
Access to water	ranking in classes	ordinal
Governance efficiency	ranking in classes	ordinal

Source: adelphi/EURAC 2014.

Table 10: Level of measurement

Scale of measurement		Main characteristic	Example
Generic category	Category		
Metric		Order, equal interval, =/≠ ; <> ; +/-	Temperature
Categorical	Ordinal	Order, interval undefined, =/ ≠ ; <>	Education level
	Nominal	No order =/≠	Type of crop

Step 2 Normalise your indicator values

- Normalisation of metric indicator values
- Normalisation of categorical indicator values

Normalisation of metric indicator values

Indicators measured using a metric scale are normalised by applying the minmax method. This method transforms all values to scores ranging from 0 to 1 by subtracting the minimum score and dividing it by the range of the indicator values.

Formula 1

$$X_{i,\,0\ to\ 1} = \frac{X_i - X_{Min}}{X_{Max} - X_{Min}}$$

where

X_i represents the individual data point to be transformed,

X_{Min} the lowest value for that indicator,

X_{Max} the highest value for that indicator, and

$X_{i,0\ to\ 1}$ the new value you wish to calculate, i.e. the normalised data point within the range of 0 to 1.

Normalisation of metric indicator values

Number	Household income [US$/month]	Normalised value
1	1,150	1.00
2	1,009	0.81
3	949	0.73
4	780	0.51
5	775	0.5
6	620	0.29
7	570	0.23
8	490	0.12
9	410	0.01
10	400	0.00

$$X_{i,\,0\ to\ 1} = \frac{X_i - X_{Min}}{X_{Max} - X_{Min}}$$

Normalise your categorical indicator values

Five-class evaluation scheme

It’s necessary to allocate indicator values on the basis of the best knowledge available (be it from existing literature, local experts or any other reliable source).

Class No.	Description
1	optimal (no improvement necessary or possible)
2	rather positive
3	neutral
4	rather negative
5	critical (system no longer functions)

Transformation from five-class scheme into a “ 0 to 1 scheme”

Table 16: Transformation of normalised indicator values on a categorical scale to the value range 0 – 1

indicator values — categorical			Indicator value range (0 to 1) metric
Class No.	Class value within range of 0 to 1	Description	Values
1	0 – 0.2	optimal (no improvement necessary or possible)	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	critical (system no longer functions)	0.9

M6

NOTE: You can use the excel template for aggregating indicators of exposure and vulnerability components

M6 Weighting and aggregating of indicators

This module explains how to weight indicators if some of them are considered to have a greater influence on risk components (hazard, vulnerability and exposure) than others, and how to aggregate individual indicators of the three risk components to combine the information from different indicators into a composite indicator representing a single component.

Step 1 Weighting indicators

Weighting indicators helps you describe the risk components *hazard, vulnerability* and *exposure*. The different weights assigned to indicators can be derived from existing literature, stakeholder information or expert opinion. There are different procedures for assigning weights: from sophisticated statistical procedures (such as principal component analysis) to participatory methods.

Step 2 Aggregation of indicators

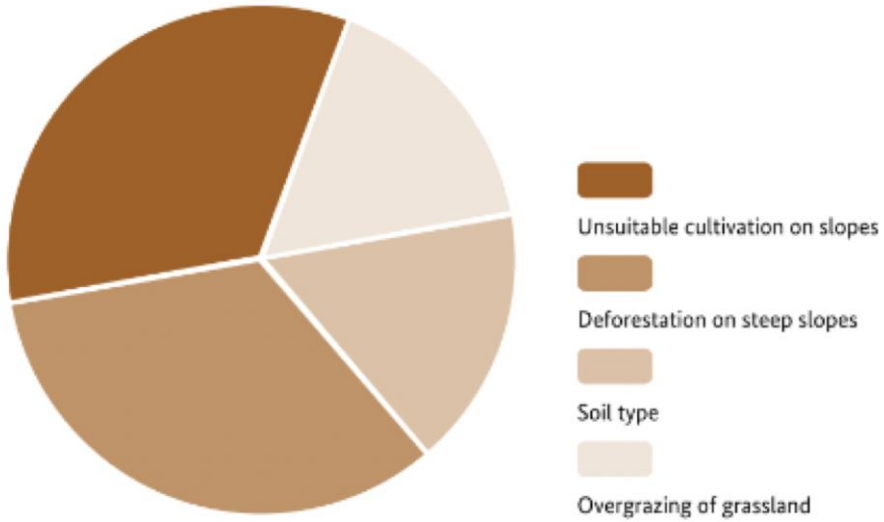
Aggregation allows you to combine the normalised indicators into a composite indicator representing a single risk component.

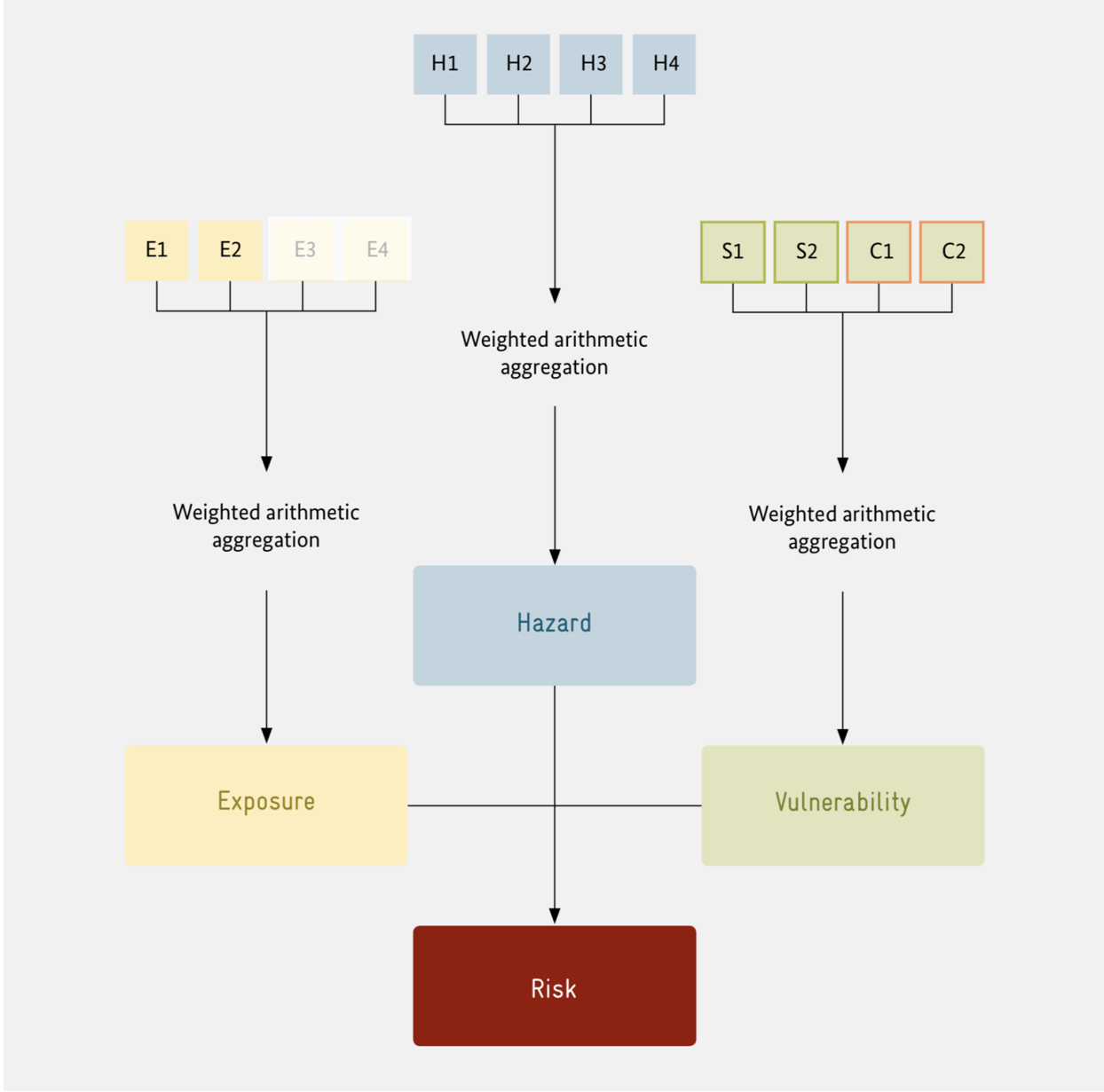
See Annex N.3

Step 2 Aggregation of indicators

If certain factors are more important than others, different weights should be assigned to them and corresponding indicators. This means that indicators that receive a greater (or lesser) weight thus have a greater (or lesser) influence on the respective vulnerability component and on overall vulnerability.

Figure 28: Different weighting applied to four factors describing sensitivity to erosion





Aggregating single factors to risk components (in practice the number of indicators may derivate from the count of indicators shown in this conceptual visualisation) *Source: Giz- Eurac 2018,*

Step 2 Aggregation of indicators

For aggregating individual indicators into composite indicators, the Vulnerability Sourcebook recommends a method called 'weighted arithmetic aggregation'.

CI is the composite indicator

I is an individual indicator

w is the weight assigned to the indicator

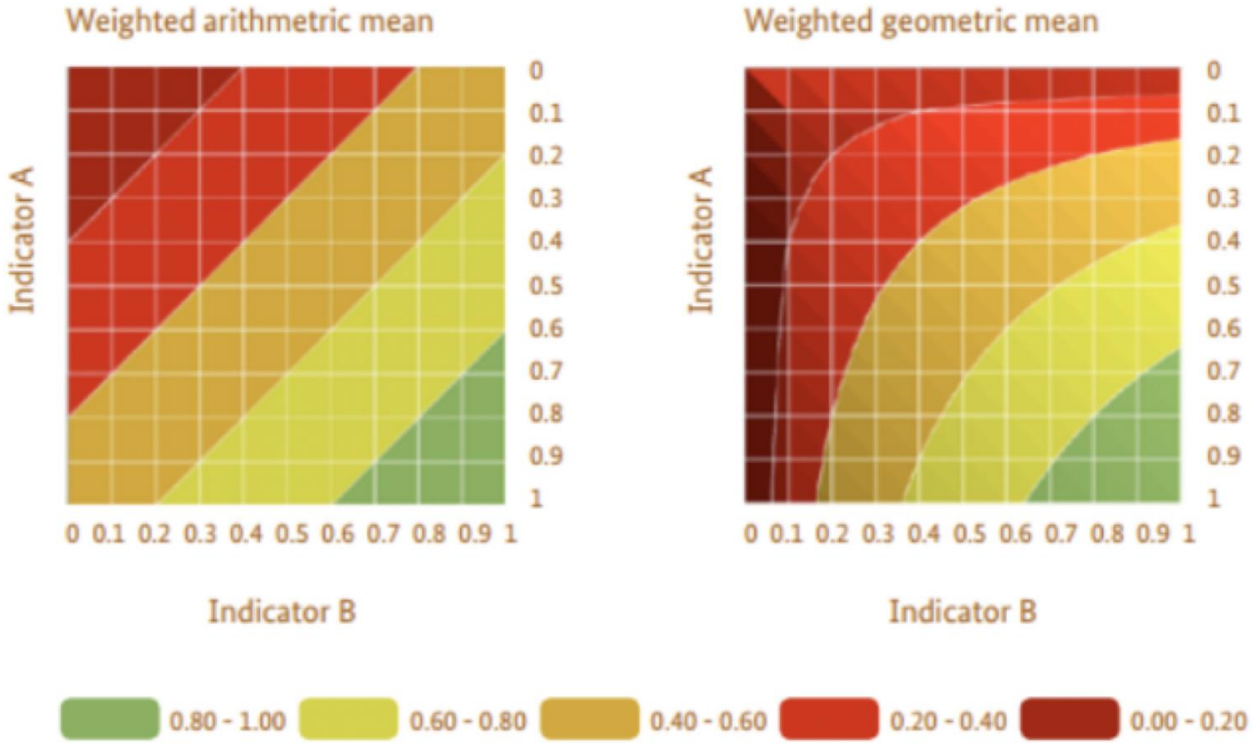
$$CI = \frac{(I_1 * w_1 + I_2 * w_2 + \dots I_n * w_n)}{\sum_{1}^{n} w}$$

NOTE: *It is important to consider especially extreme negative values for single indicators or vulnerability components throughout a vulnerability assessment. They indicate aspects of the system under review that are especially problematic, and that are to be taken into account when planning adaptation measures. This, again, highlights the importance of considering not just aggregated values but individual indicators as well*

NOTE: *See example: Giz- Eurac 2018, Climate Risk Assessment for Ecosystem-based Adaptation, a guidebook for planners and practitioners (page 61-62)*

Step 2 Aggregation of indicators

Another method for aggregating individual indicators into composite indicators is 'weighted geometric aggregation'. Weighted geometric aggregation involves a multiplication of individual indicators to arrive at a composite indicator. In contrast to arithmetic aggregation, it only allows partial compensability (OECD 2008)



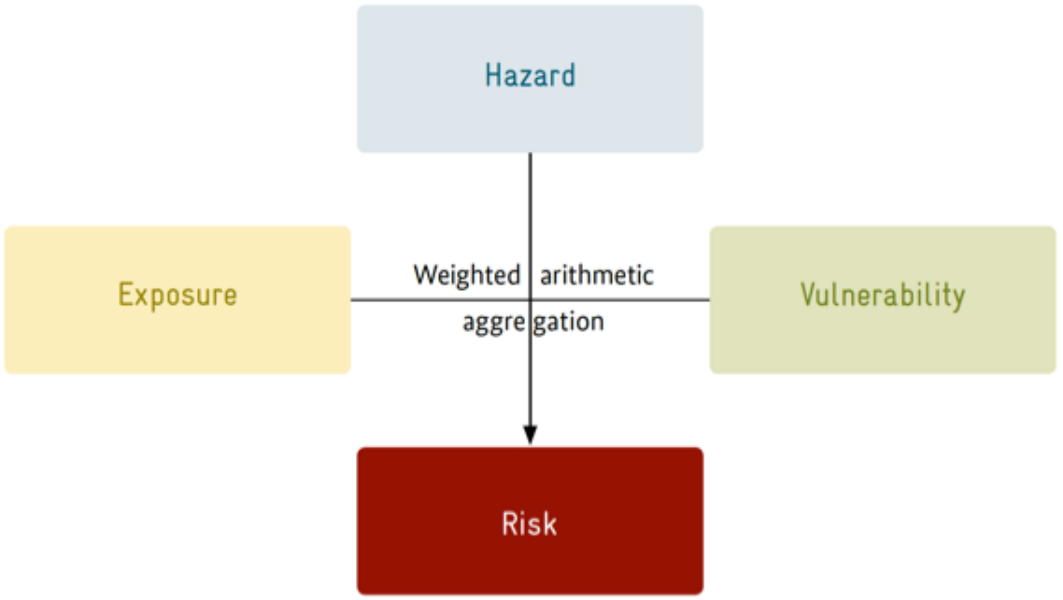
M7

M7 Aggregating risk components to risk

This module shows how to aggregate the risk components hazard, vulnerability and exposure into a composite risk indicator through a one-step approach - consistent with the IPCC AR5 risk concept – that uses the weighted arithmetic mean to combine the three components.

One step approach

$$Risk = \frac{(Hazard * w_H) + (Vulnerability * w_V) + (Exposure * w_E)}{w_H + w_V + w_E}$$



NOTE: there is an alternative approach for aggregation based on the combination of risk factors with the help of an evaluation matrix. For more detail see *GIZ-2017 Risk Supplement to the vulnerability sourcebook*

Source: GIZ-2017 Risk Supplement to the vulneability sourcebook

Risk Classes

Metric risk class value within range of 0 to 1	Risk class value within the range of 1 to 5	Description
0 – 0.2	1	very low
› 0.2 – 0.4	2	low
› 0.4 – 0.6	3	intermediate
› 0.6 – 0.8	4	high
› 0.8 – 1	5	very high

Source: GIZ-2017 Risk Supplement to the vulneability sourcebook

M8

M8 Presenting the outcomes of your risk assessment

This module will show you how best to **SUMMARISE** and **PRESENT THE FINDINGS** of assessment.

M8

Module 1

Module 2

Module 3

Module 4

Module 5

Module 6

Module 7

+

Standard Office software, and some specialist software geographical information systems, or GIS)

Module 8

STEP 1
Plan your vulnerability assessment report

STEP 2
Describe your assessment

STEP 3
Illustrate your findings

OUTCOMES

A vulnerability assessment report, findings and method of presentation

Visualization of your findings