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The Vulnerability Sourcebook

Concept and guidelines for standardised vulnerability assessments

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Foreword

The recently published Fifth Assessment Report of the Intergovernmental Panel on Climate Change once again stresses the pervasive risks of climate change. Vulnerability to current climate variability and future climate change particularly threatens the development of poor and marginalised people. The findings of the report underline the need for recognising adaptation adequately in the 2015 climate change agreement in order to effectively address climate vulnerability.

But how do we know whether adaptation measures are effectively reducing vulnerability? At first, this requires a differentiated understanding of climate-induced vulnerabilities within a given regional context. In addition, we need to assess these vulnerabilities, develop and implement measures to address these, and continuously review the effectiveness of our adaptation actions. In this adaptation cycle, vulnerability assessments serve various purposes: in the initial planning phase they aim at identifying climate change impacts and prioritising adaptation options. If vulnerability assessments are repeated on a regular basis using the same methodology, they can serve as a valuable tool for monitoring and evaluating the effectiveness of adaptation as they would show whether we have indeed succeeded in reducing vulnerability.

The scope for using vulnerability assessments is extremely broad. They are site and context-specific, and range from developing adaptation measures in rural communities to preparing National Adaptation Plans, from short term climate variability to long term climate change, and they cover a multitude of sectors. This Vulnerability Sourcebook seeks to provide a step-by-step guide for designing and implementing vulnerability assessments suitable for each of these areas.

Building on the approach developed by Germany's 'Vulnerability Network' for assessing domestic vulnerability across different sectors at the various administrative levels in Germany, the Vulnerability Sourcebook offers a practical and scientifically sound methodological approach to vulnerability assessments and their application for monitoring and evaluation of adaptation. It is illustrated with examples and lessons learned from pilot applications in Bolivia, Pakistan, Burundi and Mozambique. It thus offers a rich compendium of practical and scientific knowledge on vulnerability assessments.

We hope the Vulnerability Sourcebook will contribute to the on-going debate about adaptation effectiveness and to the practical implementation of National Adaptation Plan processes. We are convinced that a stronger focus on effective adaptation will support developing countries in their endeavour to achieve climate-resilient sustainable development.

Gottfried von Gemmingen
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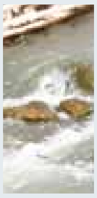

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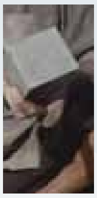

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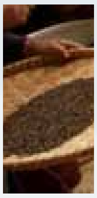

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Abbreviations

AC	Adaptive capacity
AR3	IPCC Third Assessment Report, 2001
AR4	IPCC Fourth Assessment Report, 2007
AR5	IPCC Fifth Assessment Report, 2013/2014
CI	Composite indicator
CIESIN	Center for International Earth Science Information Network
CRU	Climatic Research Unit at University of East Anglia
DHS	Demographic and Health Surveys Program
DJF	December January February
DRR	Disaster Risk Reduction
DSE	German Foundation for International Development
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPWv3	Gridded population of the world (version 3)
GCMs	Global circulation models
ILO	International Labor Organization
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least developed countries
LEG	UNFCCC Least Developed Countries Expert Group
M&E	Monitoring and evaluation
NAP	National Adaptation Plan
NAPAs	National Adaptation Programmes of Action
NGOs	Non-governmental organisations
NOAA-NCDC	National Oceanic and Atmospheric Administration - National Climatic Data Center (NCDC)
NSDIs	National Spatial Data Infrastructure
OECD	Organisation for Economic Cooperation and Development
RCMs	Regional circulation models
R&D	Research and development
UNDP	United Nations Development Programme
UNESCWA	United Nations Economic and Social Commission for Western Asia
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
UK	United Kingdom
UTM	Universal Transverse Mercator
VAs	Vulnerability assessments
WDI	World Bank world development indicators
WGII AR5	Working Group II of the IPCC Fifth Assessment Report
WHO	World Health Organization

I.

Introduction

Introduction

In recent years, vulnerability assessments (vulnerability assessments) have increasingly been used to identify climate change impact hotspots and to provide input for adaptation and development planning at local, national and regional levels. Vulnerability assessments assumed particular significance in the context of the National Adaptation Plan (NAP) process. This process was established in 2010 as part of the Cancun Adaptation Framework to complement existing short-term national adaptation programmes of action (NAPAs). It aims at reducing the vulnerability of developing countries, especially the least developed countries (LDCs) and the most vulnerable groups, by addressing medium- and long-term adaptation needs. Consequently, assessment of climate change vulnerabilities at different levels is an integral part of NAP implementation, as emphasised by the Technical Guidelines for the National Adaptation Plan Process (LEG 2012).

However, with so many varying definitions of vulnerability and related terms, and the variety of methodologies aiming to address them (see e.g. UNFCCC 2010b), there has been no dedicated conceptual approach for assessing vulnerability in the context of development cooperation. Moreover, vulnerability assessments have largely been confined to a supporting role in adaptation planning. But there is also a demand for compelling methods which assess adaptation efforts and incorporate lessons from adaptation experience, and so vulnerability assessments have assumed a new role in monitoring and evaluation (M&E) of adaptation.

Why this Vulnerability Sourcebook?

There are numerous guidelines and handbooks which provide advice and best-practice examples for analysing vulnerability. But the Vulnerability Sourcebook goes one step further: it provides a standardised approach to vulnerability assessments covering a broad range of sectors and topics (e.g. water sector, agriculture, fisheries, different ecosystems) as well as different spatial levels (community, sub-national, national) and time horizons (e.g. current vulnerability or vulnerability in the medium to long term).

The Vulnerability Sourcebook also offers step-by-step guidance for designing and implementing a vulnerability assessment which covers the entire life cycle of adaptation interventions, using consistent methods proven on the ground. This holistic focus on the full spectrum of adaptation measures, plans and strategies constitutes a new approach to vulnerability assessments. And it is this approach which represents the added value of the Vulnerability Sourcebook when compared with the growing number of reviews, guidelines and handbooks for conducting vulnerability assessments in a development context.

Who is the Vulnerability Sourcebook for?

The Vulnerability Sourcebook is targeted at governmental and non-governmental organisations and aims to support their efforts to substantiate and enhance adaptation and development planning. The document is of interest to institutions that are engaged in activities at the intersection of climate change and sustainable development.

The Vulnerability Sourcebook should be of particular interest to technical and adaptation experts looking for an effective tool which – at various spatial and administrative levels – can:

- provide a sound assessment of vulnerability to climate change,
- improve adaptation and development planning,
- enhance the development of adaptation measures, and
- support M&E of adaptation.

Users of the Vulnerability Sourcebook will most likely be familiar with issues of climate change and adaptation already. The document, however, does not presuppose advanced scientific expertise in developing and conducting vulnerability assessments. Rather, the Vulnerability Sourcebook is written for users with a basic understanding of the concept of vulnerability and methods for dealing with it.

The Vulnerability Sourcebook is particularly concerned with providing readily understandable, user-friendly guidance in the development and implementation of vulnerability assessments. It acknowledges the specific conditions which prevail in developing countries – requirements as well as constraints.

How was the Vulnerability Sourcebook approach developed?

The Vulnerability Sourcebook was inspired by the joint efforts of Germany's 'Vulnerability Network', which aims at providing a standard approach to vulnerability assessment across different sectors at the administrative district level (see http://www.netzwerk-vulnerabilitaet.de/).

The Vulnerability Sourcebook also reflects an extensive review of the existing literature dealing with the assessment of vulnerability as well as monitoring and evaluation. The team of experts from adelphi and EURAC studied a large number of guidelines, methodological papers, best-practice examples and vulnerability assessment reviews issued by GIZ and other international organisations, donors and development cooperation agencies as it compiled the Vulnerability Sourcebook.

Based on this extensive preparatory work, the Vulnerability Sourcebook approach has been successfully tested in four countries: Bolivia, Burundi, Mozambique and Pakistan. These four applications differ greatly in context, objectives and methodologies (see Annex 10 and 11 for documentation of test applications in Bolivia and Pakistan).

These test cases demonstrate the various advantages of the Vulnerability Sourcebook's approach and have provided a wealth of practical information which, in turn, has been incorporated in the Vulnerability Sourcebook.

When should the Vulnerability Sourcebook be applied?

The Vulnerability Sourcebook is particularly helpful in cases which require a consistent approach to information gathering on climate change vulnerability, and the further use of this information for adaptation and development planning. The Vulnerability Sourcebook can be applied at different stages of adaptation planning from high-level identification of key vulnerabilities to more in-depth analysis of particular vulnerabilities, as well as the development of concrete adaptation measures or strategies and monitoring and evaluation of adaptation interventions. Its applicability to a wide range of topics means the Vulnerability Sourcebook is not limited to one sector or spatial level but can be used in various contexts.

How should the Vulnerability Sourcebook be used?

The Vulnerability Sourcebook comprises four major parts:

Chapter II is devoted to the **Conceptual Framework** which describes the cornerstones of the Vulnerability Sourcebook's theoretical approach. Reflecting the current state-of-the-art in vulnerability assessments and best practise examples in monitoring and evaluation of adaptation measures, the Conceptual Framework explains key terminology and assumptions used in the Vulnerability Sourcebook, for example, how vulnerability analysis is linked to monitoring and evaluation.

The Conceptual Framework is particularly targeted at readers tasked with overall vulnerability assessment coordination who require a more profound understanding of the concepts behind vulnerability analyses.

Building on the Conceptual Framework, **Chapter III** of the Vulnerability Sourcebook – the **Guidelines** – provides detailed, practical instructions for implementing vulnerability assessments. The major tasks to conduct a vulnerability assessment are structured in modules which provide step-by-step instructions while also identifying potential pitfalls the user may encounter during implementation. Each module starts with a brief overview of key steps explained in the module as well as the resources and information required to execute them, and guidance on supplementary information and tools provided in the Annex (see below).

The Guidelines are not only targeted at vulnerability assessment coordinators and steering groups, but anyone implementing vulnerability assessments in full or in part who wants a deeper understanding of their tasks and how they relate to the overall vulnerability assessment.

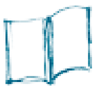
Chapter IV of the Vulnerability Sourcebook deals with ways in which vulnerability assessments can support **M&E of vulnerability and adaptation**. This chapter outlines the opportunities and challenges in using vulnerability assessments for this purpose, along with practical guidance.

There is a wealth of additional information throughout these three chapters:

Boxes labelled with the **expert** provide further **theoretical background information**.

Boxes labelled with the **practitioner** showcase **examples from practical applications** of the Vulnerability Sourcebook.

The **leaf** illustrates concise practical **tips for smooth implementation.**



The **book** icon points to recommendations for **further reading** on relevant topics.

The **Glossary** at the end of the Guidelines provides definitions of key terms used throughout the Vulnerability Sourcebook.

The Vulnerability Sourcebook also has a comprehensive **Annex** which includes supplementary information and tools which support practical implementation of the Guidelines. This includes sample indicator lists, indicator fact sheets and sample impact chains. The Annex also contains two detailed documentations from real-world examples – applications of the Vulnerability Sourcebook in Bolivia and Pakistan – to further inspire the user.

This is a living document informed by on-going, practical examples, so we warmly welcome any comments and lessons learned from your application of the Vulnerability Sourcebook. Please write to climate@giz.de. Thank you!

II.

Conceptual framework

1. Introduction

Climate change is one of the key future challenges for both developed and developing countries. With a growing world population, rising demand for food, water and energy and a dwindling natural resource base, climate change will act as a 'threat multiplier' (CNA 2007), aggravating resource scarcity and putting further stress on socio-ecological systems. Severe floods, storms, droughts and heat waves as well as land and forest degradation and salinization of groundwater resources that we already see today are often viewed as a foretaste of climate change interacting with other anthropogenic impacts on the environment.

Mitigating climate change by reducing greenhouse gas emissions is one way of lessening the adverse effects of a more variable and changing climate. However, even if a radical reduction of global greenhouse gas emissions were possible today it would not completely prevent significant changes in the world's climate. Therefore, societies and economies at all levels and on every continent have to prepare for and adapt to the potential impact of climate change (IPCC 2013b).

What is adaptation?

Adaptation is the *'adjustment of natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation is a process and not an outcome'* (GIZ/WRI 2011, p. 65). In practice, there is often no clear distinction between development activities and climate change adaptation interventions (IDS 2008). Many adaptation measures contain a 'development' component, whether implicitly or explicitly. Conversely, climate change adaptation concerns are mainstreamed into development efforts. Because adaptation measures are applied in anticipation of future climate change impacts, they are accompanied by a high level of uncertainty (see Box 1). 'No regret' measures are one approach to this challenge. This refers to activities which create beneficial or desirable outcomes – not only in the future, but already today – even if the assumed climatic changes do not eventuate. Such no-regret measures include for example the improvement of irrigation systems to make them more water efficient or changing agricultural practices to reduce soil erosion.

Setting priorities for adaptation

Adaptation needs vary significantly between different locations, people and sectors. Effective and strategic adaptation planning targets those systems that will be most affected by adverse climate change impacts. In discussing climate change adaptation, the concept of 'vulnerability' can help us understand what lays behind adverse climate change impacts and also to identify hotspots that are most susceptible towards climate change. And one highly effective way of identifying and prioritising adaptation interventions is to conduct a vulnerability assessment.

1 EXPERT

Vulnerability assessments and uncertainty

Future changes in climate, and the effect they will have, cannot be predicted. This is why climate scientists usually talk of climate change scenarios or projections instead of predictions. Any assessment of climate change impacts and vulnerabilities is burdened with uncertainties for the following reasons:

- The magnitude of climate change depends on future greenhouse gas emissions, which are unknown. Climate models are usually driven by more than one emission scenario, which leads to multiple results.
- Different climate models produce different results. While all models agree that average global temperatures will increase, their projections for precipitation trends or the geographical distribution of changes often diverge.
- Climate extremes, which are often highly relevant for climate impact assessments, are more difficult to project than slow onset, long-term trends. Projections of extreme events (heavy rain, storms, hail), their frequency and severity, are particularly subject to uncertainty.
- Models used for impact assessments, such as changes in crop yields, encompass additional uncertainties.
- Finally, future changes driven by non-climatic factors in the natural and social environment (e.g. population growth) are volatile, increasing the uncertainty of vulnerability assessments.

Addressing these uncertainties is crucial when designing and conducting a vulnerability assessment. You can find practical instructions in the Guidelines (Module 1 – 8).

However, the uncertainties in climate change projections should not serve as an argument for inaction. There is high confidence from all models that climate will change severely if greenhouse gas emissions continue at the present level or even rise. Therefore, enough is known to react to climate change already today. You can find a short video on this topic here: http://vimeo.com/39053686).

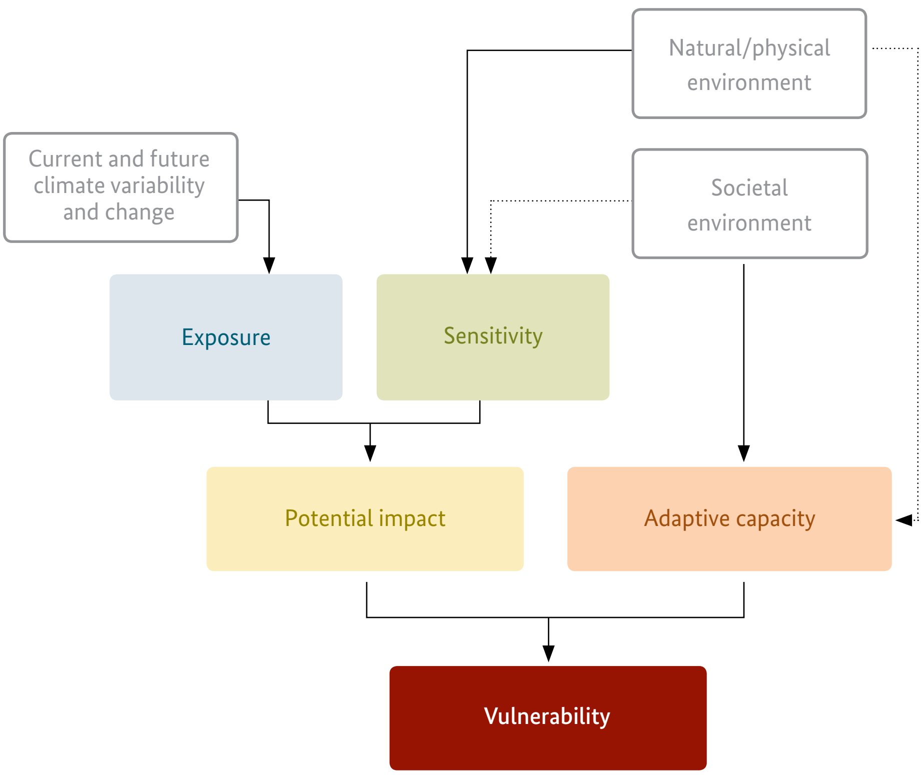
2. What is climate change vulnerability?

The concept of 'climate change vulnerability' helps us to better comprehend the cause/effect relationships behind climate change and its impact on people, economic sectors and socio-ecological systems. The Vulnerability Sourcebook's approach to vulnerability is based on the most widely used definition provided by the Fourth Assessment Report of the IPCC (AR4). It refers to vulnerability as:

'(...) the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (Parry et al. 2007).

Based on this definition, the Vulnerability Sourcebook distinguishes between four key components that determine whether, and to what extent, a system is susceptible to climate change: *exposure*, *sensitivity*, *potential impact* and *adaptive capacity* (see Figure 1).

Figure 1: Components of vulnerability



Source: adelphi/EURAC 2014.

Climate change *exposure*, and a system's *sensitivity* to it, determine the *potential impact*. However vulnerability to that impact also depends on the system's *adaptive capacity*. These four key components are described in further detail below.

2.1 Exposure

Of all the components which contribute to vulnerability, exposure is the only one directly linked to climate parameters, that is, the character, magnitude, and rate of change and variation in the climate. Typical exposure factors include temperature, precipitation, evapotranspiration and climatic water balance, as well as extreme events such as heavy rain and meteorological drought. Changes in these parameters can exert major additional stress on systems (e.g. heavy rain events, increase in temperature, shift of peak rain from June to May).

2.2 Sensitivity

Sensitivity determines the degree to which a system is adversely or beneficially affected by a given climate change exposure. Sensitivity is typically shaped by natural and/or physical attributes of the system including topography, the capacity of different soil types to resist erosion, land cover type. But it also refers to human activities which affect the physical constitution of a system, such as tillage systems, water management, resource depletion and population pressure. As most systems have been adapted to the current climate (e.g. construction of dams and dikes, irrigation systems), sensitivity already includes historic and recent adaptation. Societal factors such as population density should only be regarded as sensitivities if they contribute directly to a specific climate (change) impact.

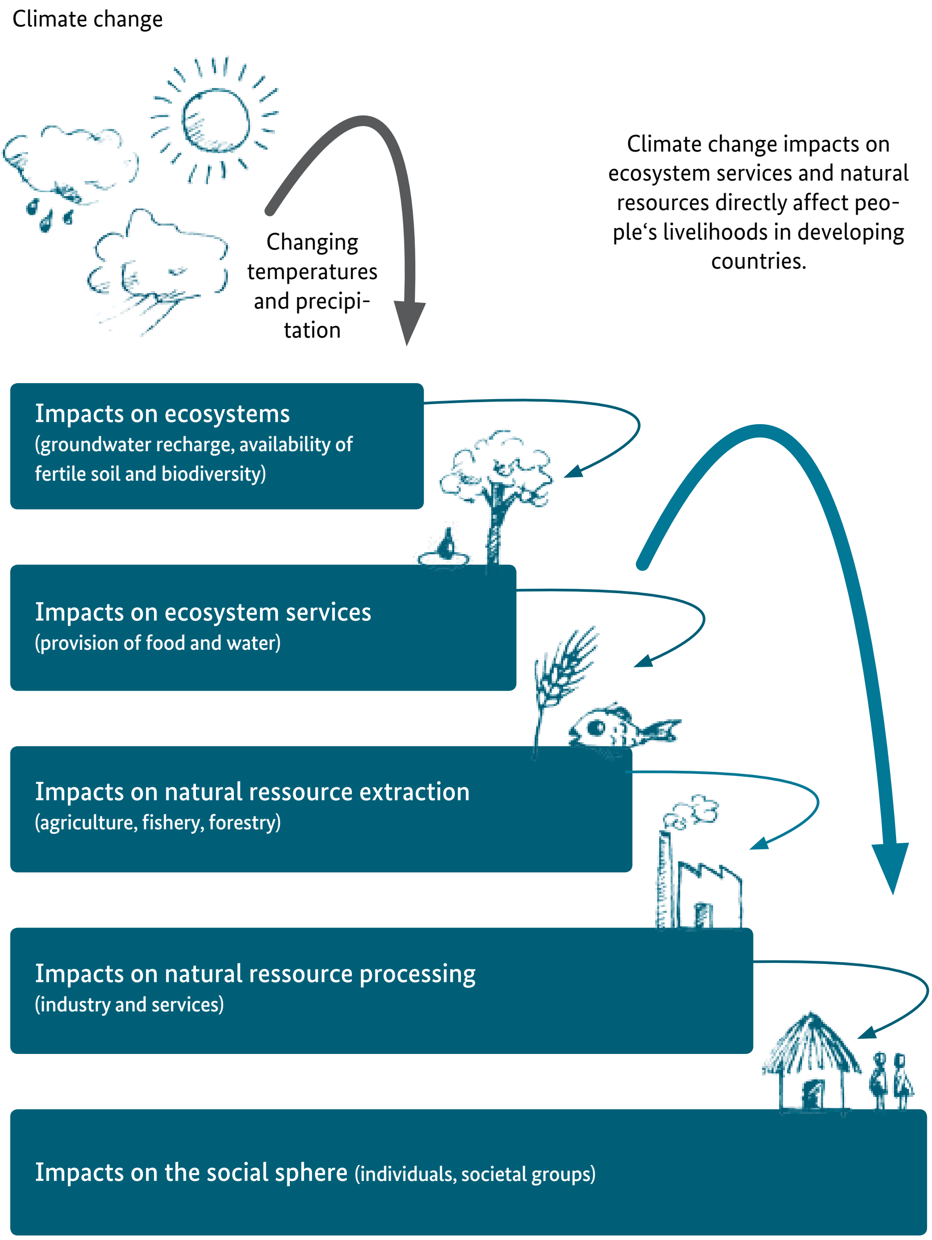
2.3 Potential impact

Exposure and sensitivity in combination determine the potential impact of climate change. For instance, heavy rain events (exposure) in combination with steep slopes and soils with high susceptibility to erosion (sensitivity) will result in erosion (potential impact). Climate change impacts can form a chain from more direct impact (e.g. erosion) to indirect impact (e.g. reduction in yield, loss of income) which stretches from the biophysical sphere to the societal sphere. In many developing countries, direct dependency on natural resources means that the link between biophysical impacts of climate change and human activities and well-being is particularly strong (see Figure 2).

2.4 Adaptive capacity

The IPCC's AR4 describes adaptive capacity as 'the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential

Figure 2: Chain of climate change effects on natural resources and livelihoods



Source: adelphi/EURAC 2014.

2 EXPERT

Dimensions of adaptive capacity

There is no one single approach to adaptive capacity as its components are highly dependent on the system at stake. There have been numerous attempts to structure the 'ingredients' of adaptive capacity and to introduce standard indicators to assessments. The key dimensions you will find in the literature include:

- **Knowledge:** this refers to general levels of education and awareness about issues such as climate change and its impact, as well as dissemination of information on climate and weather conditions.
- **Technology:** this includes the availability of and access to technological options for adaption and the technological stage in the development of a system. While it does not include pre-existing measures such as dams and irrigation schemes (which are categorised under sensitivity), it could incorporate new or the improvement of existing technological solutions.
- **Institutions:** this covers a multitude of governance, institutional and legal concerns, including the capacities and efficiency of key institutions, enforcement of environmental laws, transparency of procedures and decision making. This dimension could further include accountability, participation practices in ensuring sustainable management of natural, financial and human resources.
- **Economy:** includes GDP, employment/unemployment rate (in rural or urban areas), share of GDP for a given economic sector, and a country's dependency on food and energy imports. At a micro level this can also include household income, food expenditure, housing and dependency ratios.

The relevance of these dimensions varies from case to case and from system to system.

Further reading on the dimensions of adaptive capacity:

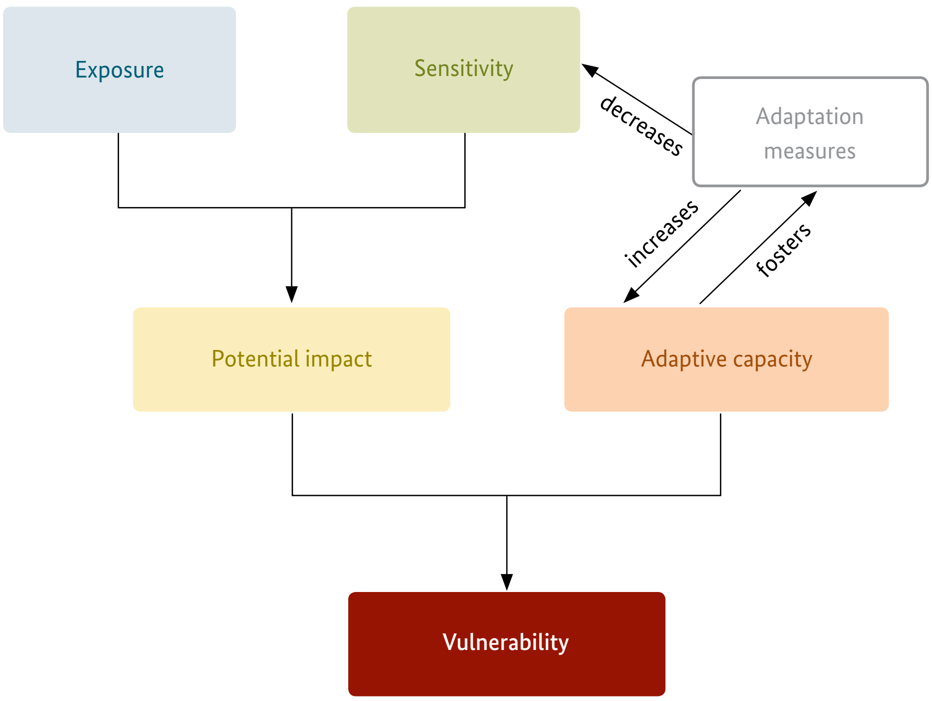
- Adger, W.N. et al. 2004: New indicators of vulnerability and adaptive capacity – Technical Report 7. Norwich: Tyndall Centre for Climate Change Research. Retrieved 25.03.2014 from: http://www.tyndall.ac.uk/sites/default/files/it1_11.pdf
- Preston, B.L. and Stafford-Smith, M. 2009: Framing vulnerability and adaptive capacity assessment. Discussion Paper. CSIRO Climate Adaption Flagship Working Paper No. 2. Retrieved 25.03.2014 from: http://www.csiro.au/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/CAF-working-papers/CAF-working-paper-2.aspx

damages, to take advantage of opportunities, or to cope with the consequences' (Parry et al. 2007). Consequently the Vulnerability Sourcebook takes the approach that adaptive capacity is a set of factors which determine the capacity of a system to generate and implement adaptation measures. These factors relate largely to available resources of human systems and their socio-economic, structural, institutional and technological characteristics and capacities (Box 2).

2.5 Reducing vulnerability through adaptation

Adaptation interventions are activities that aim to reduce climate (change) vulnerability at different levels – sectoral, national or local. They are based on the assumption of inherent adaptive capacity which can be used to lower its sensitivity to climate exposure. Such measures include efficient irrigation systems to overcome water scarcity and improvements to tillage systems for combatting soil erosion. Adaptation measures can also target the increase of adaptive capacity itself. Examples include training programmes for integrated water management and improved marketing strategies for small farm holders.

Figure 3: How adaptation measures can reduce vulnerability



Source: adelphi/EURAC 2014.

3 EXPERT

A gender-based perspective on vulnerability

Climate change affects women and men differently. In developing countries, especially women are far more susceptible to the negative impact of climatic change. With their lower socio-economic status and limited access to information and resources, women have reduced capacity to react and adapt to climate change (UNFPA 2009: 35, Nellemann et al. 2011), a fact which reflects '(…) wider patterns of structural gender inequality' (IPCC 2007a). In 2008, the UNFCCC Secretariat signalled the importance of this factor by appointing a gender coordinator and outlining 'gender focal points'. Consequently, the Vulnerability Sourcebook will help to address entry points for vulnerability factors specifically related to women, including:

- **High dependency on natural resources:** Women are overrepresented in agriculture and other natural resource-dependent activities (IPCC 2007), producing up to 80% of the food in developing countries (UNFPA 2009). Erratic weather reduces agricultural output and increases the burden on women to secure food, water and energy. Since women have less access to other income opportunities (UNFPA 2009) this results in a higher risk of poverty. Girls often drop out of school to help their mothers, resulting in a vicious circle.
- **Limited mobility and violence:** Women manage households and care for family members. This limits their mobility and increases their vulnerability to extreme natural events and changes in employment opportunities. Migration to less vulnerable regions is often more feasible for men, while women remain in areas prone to flooding and changing environmental conditions (UNFPA 2009). This climate-induced migration leads to scattered communities and disrupts social safety nets, increasing women's exposure to human traffickers and violence (Nellemann et al. 2011).
- **Adaptive capacity:** Women are often discouraged from adopting lifesaving strategies (e.g. swimming lessons) or evacuating their homes without permission from other family members (Nellemann et al. 2011). Yet the UNFCCC Secretariat has stressed that women are important actors in coping with climate change. Their multiple responsibilities mean that women possess broad knowledge of natural resource management, food security and resolution of community conflicts, which can all be used in developing adaptation solutions (UNFPA 2009, Nellemann et al. 2011).

2.6 Inclusive approach to vulnerability

The Vulnerability Sourcebook supports an inclusive approach to vulnerability assessments. That means paying particular attention to societal groups that are especially vulnerable to climate change, including children, the elderly and women, as well as other marginalised groups such as labour migrants. Including these groups requires careful selection of indicators to assess their vulnerability (see also Module 2 and 3). Many indicators from the categories outlined above (see Box 2) – including employment, education, income, and health – are broken down by gender to highlight differences (see Box 3 for a gender-based perspective on vulnerability).

3. How is vulnerability assessed?

Vulnerability is not a measurable characteristic of a system, such as temperature, precipitation or agricultural production. It is a concept that expresses the complex interaction of different factors that determine a system's susceptibility to the impacts of climate change. However, there is no fixed rule defining which factors to consider, nor of the methods used to quantify them. This is why we talk about 'assessing' rather than 'measuring' vulnerability.

3.1 Uses of vulnerability assessments

Numerous institutions and individuals have a pressing need for information on the challenges caused by climate change. They include policy and decision makers at all levels, donor organisations and other stakeholders from civil society, industry and other sectors. Vulnerability assessments therefore fulfil diverse purposes:

- **Identifying current and potential hotspots:** Vulnerability assessments can compare susceptibility to climate change in multiple systems. They also allow better understanding of the factors driving the vulnerability of particular climate change hotspot (e.g. a specific geographical area or industry, which is more severely affected by climate change than others).
- **Identifying entry points for intervention:** information on the factors underlying a system's vulnerability can serve as a starting point for identifying suitable adaptation interventions. Adaptation can reduce vulnerability by *increasing* a system's adaptive capacities and by *decreasing* its sensitivity to climate change (see Figure 3).
- **Tracking changes in vulnerability and monitoring & evaluation (M&E) of adaptation:** A relatively new approach is to use vulnerability assessments to track changes in climate change vulnerability over time. This complements existing methods for M&E of adaptation measures and generates additional knowledge on the effectiveness of adaptation (see 3.3 below). Chapter II, the Conceptual

Framework, provides a brief introduction to this topic. Chapter IV deals with the application of vulnerability assessments for M&E of adaptation in more detail.

For all of these requirements, vulnerability assessments help increase awareness of climate change among policy and decision makers as well as communities and other stakeholders. They provide ministries and government agencies with solid reasoning for responses to climate change impacts and contribute to an ever-growing pool of knowledge about adaptation planning.

Table 1: Attributes of vulnerability assessments

Attribute	Key question	Possible characteristics
Topic	How many potential climate change impacts are covered?	Narrow focus on a single sector and one primary impact (e.g. vulnerability of the agricultural sector to decrease in precipitation); wider scope including multiple sector impacts (e.g. vulnerability of agriculture and biodiversity to decrease in water availability and increased heat stress)
Spatial extension	Which units does the assessment focus on?	Spatial or administrative units (locations, municipalities), sectors, population segments
	What is the level of assessment?	Regional, national, community, local, ecosystem-level, basin-level
	How many entities are assessed?	One community, several communities
	What is the resolution of the assessment?	Sub-national at the level of communities, basin-wide at resolution of 10x10 km
Temporal scope	On which time periods does the vulnerability assessment focus on?	Current vulnerability, future time periods (e.g. 2030-3060, 2060-2090, etc.)
Inputs and methods	What methods does the assessment use to acquire relevant information?	Quantitative methods (measuring, modelling, statistical surveys, etc.); qualitative methods (narrative interviews with key experts, etc.); a mix of qualitative and quantitative methods

Source: adelphi/EURAC 2014.

3.2 Attributes of vulnerability assessments

There is no one-size-fits-all approach to vulnerability assessments. They can differ significantly in their set-up depending on scope and available resources. Table 1 provides an overview of key attributes.

Focused vs. explorative vulnerability assessments

The different attributes of vulnerability assessments can be combined in countless ways. However it is possible to distinguish two major types and purposes:

- **Explorative vulnerability assessments** focus on several topics, covering a large area with a low spatial resolution for data collection and including only rough climatic trends for the future. They are usually less resource and time-intensive and primarily based on expert opinion, existing literature and data.
- **Focussed vulnerability assessments** involve extensive stakeholder involvement, concentrating on a smaller spatial unit, a specific topic or system and/or defined period of time. While this requires more time and resources, the methods used produce the kind of focussed analysis which may well be required for concrete adaptation planning.

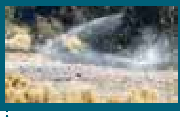
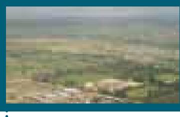
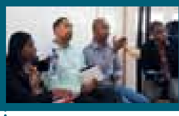
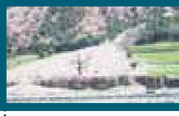
However there is no defined cut-off point between the two types of assessment. The form of a vulnerability assessment should always follow its function – subject to the availability of resources (see Module 1). Explorative assessments are often used at the outset of adaptation planning processes to identify key areas, sectors or population groups to focus on. As planning precision increases and more detailed information is needed, a focused vulnerability assessment can help target specific entry points and indicators. A more focused vulnerability assessment can also be used for M&E of an adaptation intervention.

Table 2 provides an outline of four practical examples of vulnerability assessments conducted using the Vulnerability Sourcebook approach. These four examples will recur throughout the Vulnerability Sourcebook to highlight different practical steps in implementing vulnerability assessments.

3.3 Using vulnerability assessments to monitor adaptation efforts

Funding for adaptation has significantly increased in recent years, while adaptation planning is often burdened by major uncertainties. Thus, there is a growing need for tools which enable monitoring and evaluation (M&E) of adaptation interventions – and any necessary adjustments thereof (GIZ 2013a; PROVIA 2013). Moreover, approaches are needed to create learning effects on effective adaptation

Table 2: Examples of vulnerability assessments

	Conducting a farm-level assessment in Bolivia 	Assessing vulnerability of water and soil resources in Burundi 	Comparative assessment of two districts in Mozambique 	Assessing vulnerability of agro-biodiversity in Pakistan 
Context	GIZ programme PROAGRO on adaptation to climate change in the dry regions of Bolivia	GIZ programme for reducing climate change impact on water and soil resources in Burundi	GIZ project on adaptation to climate change in Mozambique	GIZ programme on (agro-) biodiversity in two districts in North-Western Pakistan
Purpose	Assess vulnerability of small farm holders and evaluate effects of recent adaptation measures	Identify national and local hotspots for planning adaptation measures	Compare two districts in Mozambique to identify climate change hotspots	Identify adaptation measures and monitor and evaluate their influence on the vulnerability of local communities
Topic	Climate change and water supply in agriculture	Climate change impacts on agriculture (crops) and health (malaria prevalence)	Climate change impacts on rural livelihoods	Climate change impacts on (agro-)biodiversity
Inputs and methods	Combination of model-based, data driven approaches and expert opinion method	Combination of model-based and participatory approaches: quantitative analysis on the national level, more qualitative analysis on the local level	Interviews with key stakeholders and decision makers	Expert-opinion method conducted during a stakeholder workshop, participatory rural appraisal (PRA)
Spatial extension	Village to individual farm	Nationwide, more in-depth assessment of subnational hotspots	Two districts in Mozambique (Mabote and Inhassoro)	Village level in the two districts of Swat and Chitral
Temporal scope	Periods before and after introduction of measures, near future	Three time periods: present, 2031-2060, and 2071-2100	Current vulnerability	Current vulnerability
Resources needed	Hydrology, land planning	Modelling and GIS skills, processing large datasets, experience in conducting focal group discussions	Current vulnerability GIS skills, experience in developing surveys and conducting focal group discussions	Expertise in PRA techniques (surveys, focus group discussions, expert interviews)
Time needed	10 months	11 months	6 months	3 to 4 months

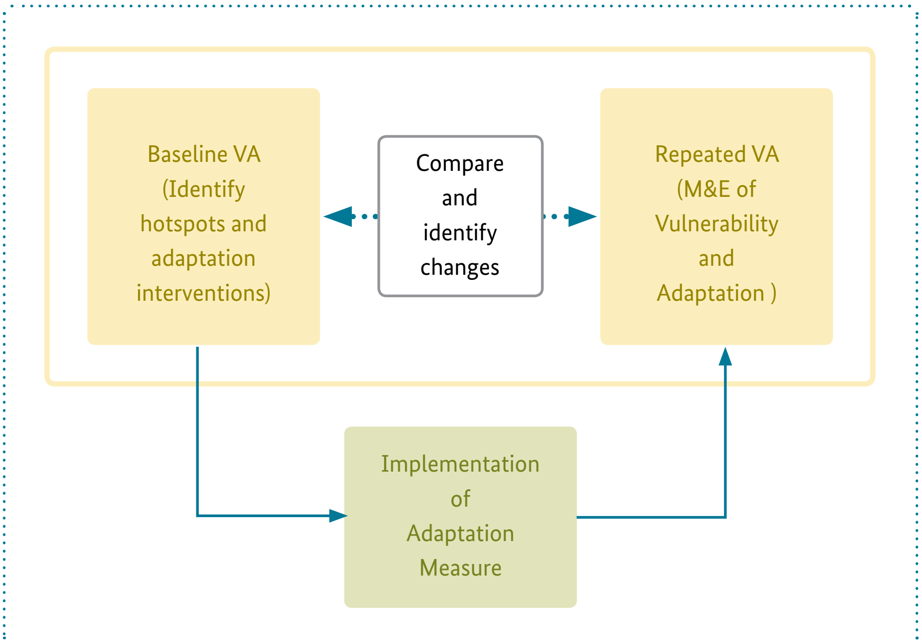
Source: adelphi/EURAC 2014.

measures and processes. Most current M&E schemes focus on adaptation measures at the project level. However the increase in national and strategic adaptation initiatives such as the National Adaptation Plan (NAP) process means that policy and decision makers require comprehensive information beyond individual adaptation projects (GIZ 2013a). A newly introduced concept in adaptation M&E is the use of vulnerability assessments which complement existing and approved M&E schemes.

The Vulnerability Sourcebook's approach to M&E is to repeat a vulnerability assessment one or more times at defined intervals. The results of the repeated vulnerability assessment are then compared to the initial (baseline) vulnerability assessment to identify changes in overall vulnerability, its components or key indicators (Figure 4). The underlying assumption here is that every adaptation measure, plan or strategy aims at either increasing adaptive capacity or decreasing sensitivity, and thus vulnerability.

Repeated vulnerability assessments can thus support M&E activities at various levels, providing varying amounts of detail with differing data and cost requirements (GIZ 2013b). They can complement existing M&E systems with individual (output) indicators (e.g. 'number of implemented adaptation measures'; 'number of awareness raising events') or provide complex, outcome-oriented M&E tools that examine the extent to which a project or program has reduced climate

Figure 4: The Vulnerability Sourcebook's approach to M&E: repeated vulnerability assessments



Source: adelphi/EURAC 2014.

change vulnerability. This information can also support developing countries in tracking their NAP process (LEG 2012).

The modules in the following Guidelines (Chapter III) outline the key steps in a vulnerability assessment. They highlight, where applicable, factors that should be taken into account if the assessment is required not just for adaptation planning or strategy development, but also M&E of adaptation. More detailed and practical advice on applying vulnerability assessments for M&E can be found in Chapter IV.

4. Linking new concepts

Anyone familiar with existing literature on the subject will know that the term 'vulnerability' is used in different ways across numerous disciplines. Even the IPCC concept of vulnerability – the basis of the Vulnerability Sourcebook – is undergoing changes although it is the most widely used vulnerability concept. Naturally this can lead to confusion. To avoid misunderstanding while also highlighting potential links to new concepts, this chapter outlines some of the key similarities and differences in terminology and how the Vulnerability Sourcebook approach integrates them.

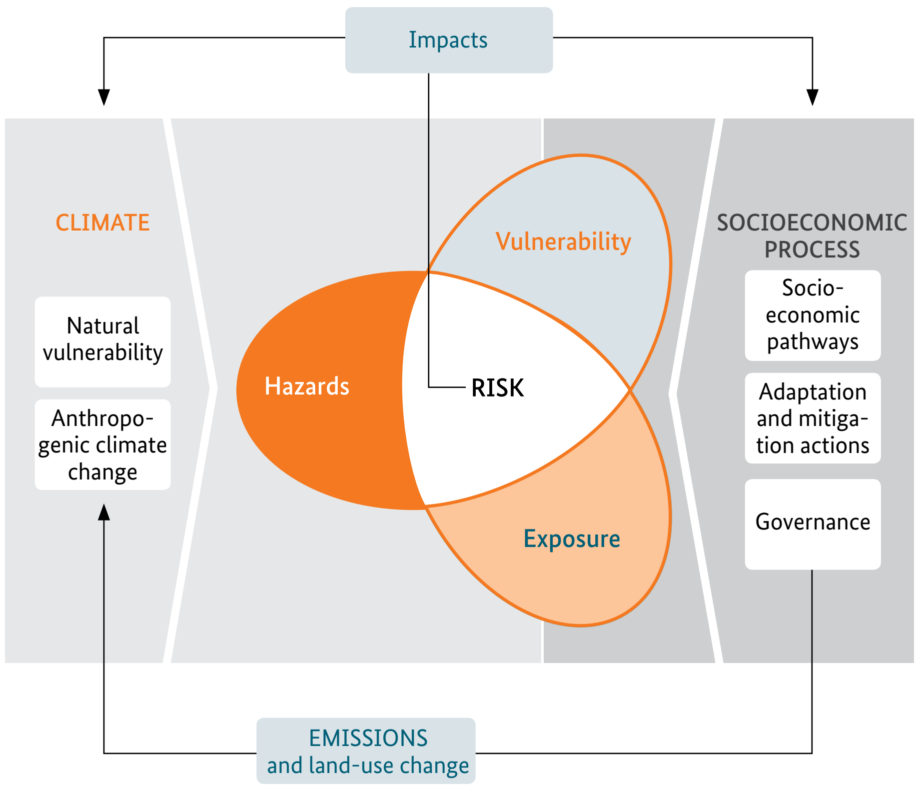
4.1 Vulnerability – a multi-faceted term

The disaster risk reduction (DRR) community uses the term vulnerability to describe the societal, physical and natural factors which contribute to disaster risk. This makes the DRR's conception of vulnerability closer to the IPCC AR4's definition of sensitivity and adaptive capacity. The ultimate result is disaster risk, which is congruent with vulnerability in the AR4 approach. There is sound reasoning behind both concepts, but transparency is essential when it comes to terminology.

To add to the multitude of vulnerability concepts already in circulation, the AR5 chapter on 'Climate Change 2014: Impacts, Adaptation, and Vulnerability' (released on 31 March 2014) introduces a new approach and terminology. This moves closer to the disaster risk concept (see Figure 5) and therefore differs from the current understanding of vulnerability as expressed in the IPCC AR4.

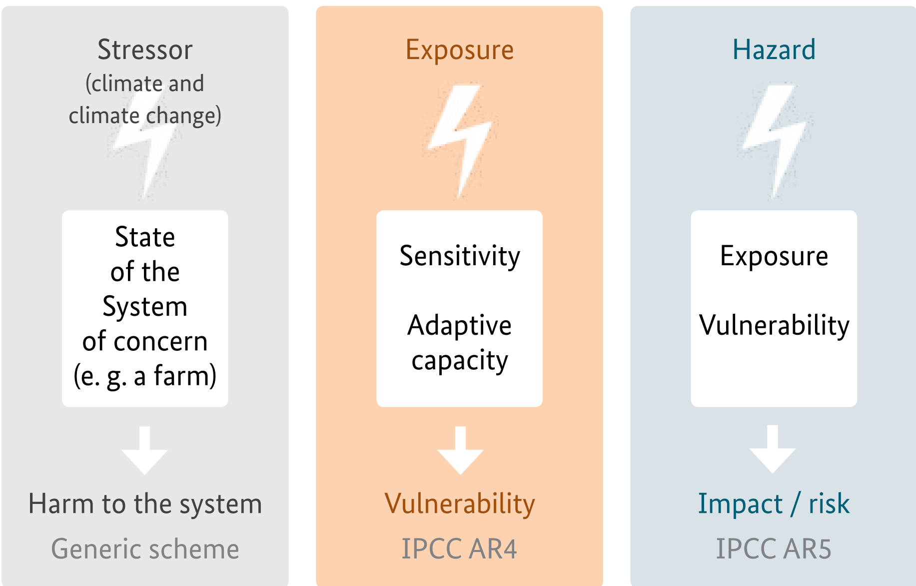
However, even if the terminology used to describe vulnerability changes, the basic underlying assumptions follow a similar logic. Figure 6 shows a system of concern (e.g. a farm) which is affected by climate-related stress such as weather extremes (in AR4, exposure; in AR5, hazard). This stress produces potential harm

Figure 5: Illustration of the core concepts of IPCC WGII AR5



Source: IPCC 2014.

Figure 6: General logic of the different assessment approaches



Source: adelphi/Eurac 2014.

to the system (in AR4, vulnerability; in AR5, impact/risk). Harm is moderated by attributes of the system itself, which might be physical (e.g. soil type) or perhaps socio-economic (e.g. financial means to improve irrigation systems or using different crop varieties).

While AR4 uses the concepts of sensitivity and adaptive capacity to describe the moderating attributes of the system, AR5 uses the concept of exposure (the presence of a system in places that could be adversely affected) and vulnerability (predisposition to be adversely affected). Please bear in mind that the terms 'exposure' and 'vulnerability' are used differently in AR4 and AR5! For applying the Vulnerability Sourcebook's approach to vulnerability assessments, however, differences in terminologies can be left aside. The level of vulnerability or risk will not be affected.

4.2 Could the Vulnerability Sourcebook be adapted to the IPCC AR5 concept?

The Vulnerability Sourcebook's approach of basing every assessment on a detailed analysis of the underlying cause/effect relationships of climate change impacts (see Module 2) reflects the general logic of an assessment scheme in the context of climate change as depicted above. This logic is inherent in both concepts (AR4 and AR5), even where they use differing terms and definitions.

That means the Vulnerability Sourcebook's approach can also be adapted to the AR5 terminologies: climate change and climate hazard factors, exposure factors and vulnerability factors are structured along impact chains. Indicators are selected for each individual factor, factors are then aggregated into components (hazard, exposure, vulnerability) and finally to impact or risk.

However, key questions and instructions on defining indicators for each component will have to be adapted, since the new terms cannot be related to the current IPCC vulnerability concept on a one-to-one basis. There are still many inconsistencies and ambiguities in the AR5 concept when it comes to practical application. It adopts the DRR concept which is designed for individual, well-defined events (hazards) which usually affect well-defined areas and elements (exposure) and can be statistically expressed as a probability (risk). However climate change deals with long term trends which affect the entire globe with graduated spatial differences, without statistical probability. In the Vulnerability Sourcebook, the different modules and steps for conducting a vulnerability assessment are therefore based on the terminology of the IPCC AR4 and may be adapted in a later step when more clarity on the application of the new concept exists.

4.3 Resilience and vulnerability – Two sides of the same coin?

Another term which has gained wider attention in recent discussion on the impact of climate change is 'resilience'. Again, to avoid confusion, the concept and its relation to vulnerability and the Vulnerability Sourcebook's approach are explained below.

Originally an engineering term, 'resilience' is now increasingly used to describe sustainable development pathways of social-ecological systems. In this context, resilience-building has entered the political agendas of both rich and poor countries as activities 'that can facilitate holistic, positive and lasting changes in communities and nations who are most at risk of harm' (OECD 2013a).

Like 'vulnerability', the term 'resilience' embraces numerous different notions. Most refer to a system's capacity to cope with and recover from disruption. The term can relate to general stressors or events including current physical, economic, ecological and social risks (UNISDR 2013). 'Climate resilience', in particular, focuses on disturbances and events caused by climate change and investigates future climate-related risks which may pose new challenges for traditional risk management (OECD 2013b).

The relationship between vulnerability and resilience is not clearly defined. Many researchers who work with these two concepts from a theoretical point of view underline their complementary nature (e.g. Turner 2010, Gallopin 2006). They point out that resilience focuses on a system's processes rather than its status. Many authors think that resilience also highlights the learning capacity of a society and its ability to reorganise itself in response to negative events. The clearest links between the two concepts are seen in socio-economic, institutional, political and cultural adaptive capacities. Reducing vulnerability by enhancing adaptive capacity increases resilience.

In practice, there is a wide overlap between vulnerability and resilience in the form of negative correlation. That is, communities or societies with high vulnerability are usually less resilient while high resilience typically implies less vulnerability. This overlap is demonstrated particularly in the ability to prepare for future changes (including those in the longer term) – a factor that plays a significant role in both concepts.

Climate-resilient development, attempts to reduce vulnerability to risk by exploiting potential opportunities and increasing adaptive capacities (OECD 2013b). Hence, assessing a community or society's vulnerability is also in part an assessment of its resilience. The Vulnerability Sourcebook's approach can therefore provide a meaningful contribution to assessing the level of resilience as well as to the monitoring and evaluation of changes in the level of resilience.

III.

Guidelines

The Guidelines provide detailed instructions on how to conduct a vulnerability assessment in practice. For that purpose, they are structured along eight different modules, each dedicated to a specific field of activities necessary to implement a vulnerability assessment. Table 3 provides an overview of the modules and their contents.

Each module includes key questions to guide you through the implementation. The modules build on each other and therefore refer to relevant steps and outcomes of previous modules, where relevant. Furthermore, to facilitate the practical application, references are made to more detailed supplementary information or practical tools in the Annex of the Vulnerability Sourcebook.

In the beginning of each module, you will find an overview on:

- **What you will learn in this module:** provides a concise description of the module's content.
- **Key steps and questions:** shows the key steps that need to be carried out in the module and highlights the key questions to be answered.
- **Inputs needed:** lists the information or products you need to fulfil the module, so you can check if you are well prepared to conduct the planned activities.
- **Generated outcomes:** a list of outcomes that are achieved in each module. This helps you to find out if you completed all relevant steps and can go ahead in the assessment. The results often feed into the next module.
- **Tools and information provided in the Annex:** provides a list of tools and additional information provided in the Annex as well as further resources and links.

The complexity of vulnerability assessments can vary widely from low budget options using nothing more than paper and pencil to highly complex computer-based models. The methodology you decide to use to fulfil the different tasks depends on your objective, scope and resources. That is why the guidelines provide you with detailed guidance which helps you to choose the best methodology for your purpose.

Table 3: The eight modules of the Vulnerability Sourcebook

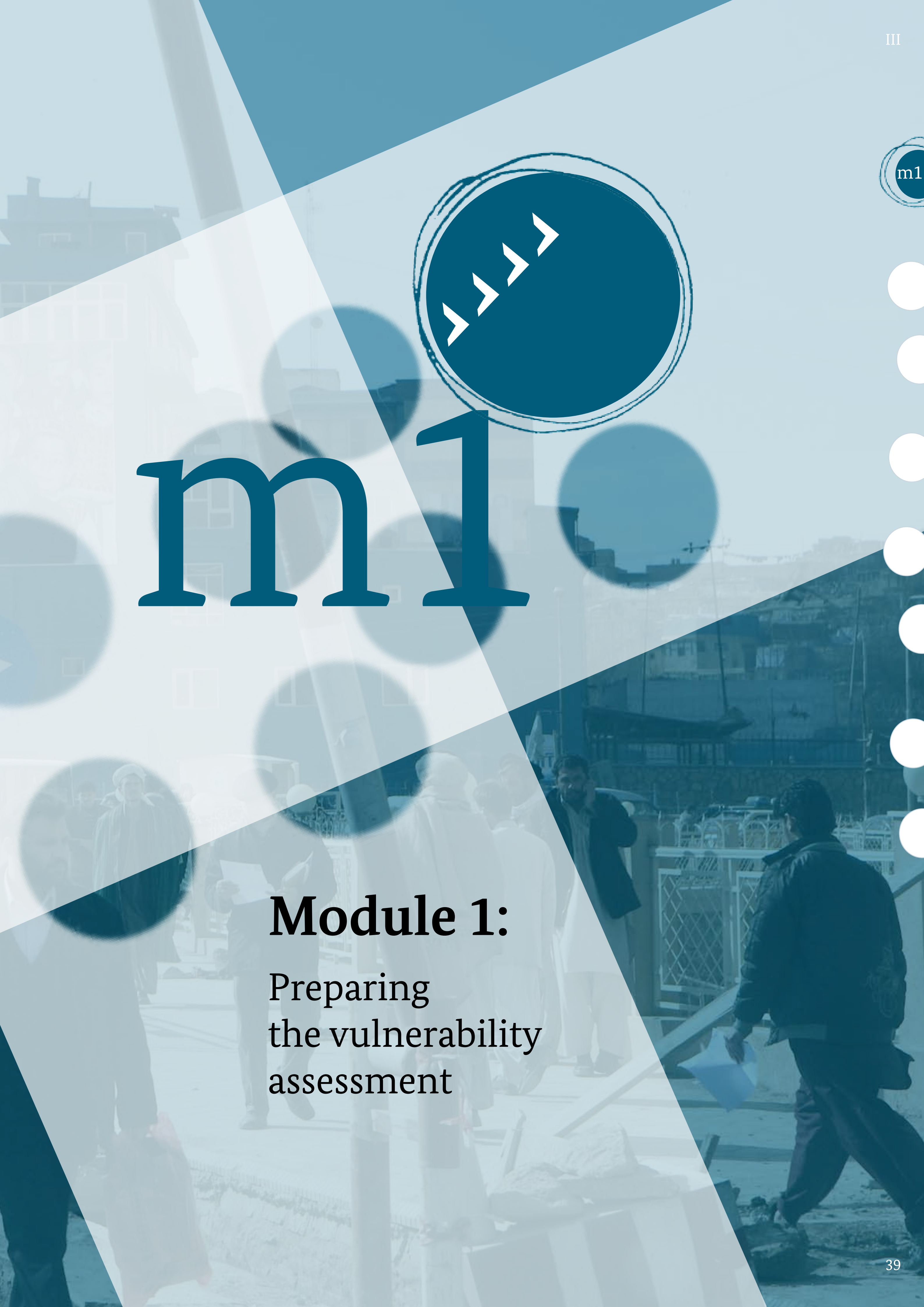
Module	What you will learn in this Module	Key tools the Annex provides
1 Preparing the vulnerability assessment	This module outlines the essential steps for preparing your vulnerability assessment. It shows you how to assess the initial situation your analysis takes place in, define objectives and make key decisions on the topic and scope of the assessment. Module 1 also helps you estimate time and resources needed.	• Template VA implementation plan
2 Developing impact chains	This module will show you how to define the potential impacts addressed in your vulnerability assessment and develop an impact chain using it as a starting point. Impact chains can help you better understand the cause-and-effect relationship underlying vulnerability in the system under review.	• Sample impact chains from different sectors
3 Identifying and selecting indicators	This module will show you how to select indicators for your assessment. It provides you with the criteria for deciding which indicators are suitable for quantifying the factors identified in Module 2.	• List of standard indicators including potential data sources
4 Data acquisition and management	This module shows you how to acquire, review and prepare data for your vulnerability assessment. This includes guidance on data collection, database construction and linking relevant data to your chosen indicators to allow analysis and modelling of vulnerability.	• Indicator fact sheet
5 Normalisation of indicator data	This module will first show you how to transfer your different data sets into unit-less values on a common scale. It then explains how to interpret these values in terms of vulnerability in order to prepare them for aggregation in Module 6 and 7.	• Examples of the evaluated indicators from a vulnerability assessment conducted in Burundi
6 Weighting and aggregating of indicators	This module demonstrates how to assign weights to the various indicators and how to aggregate indicators to vulnerability components.	• An Excel template for aggregating indicators of exposure, sensitivity and adaptive capacity
7 Aggregating vulnerability components to vulnerability	This module shows you how to aggregate the vulnerability components exposure and sensitivity to a potential impact. It also explains how to combine the potential impact and adaptive capacity (AC) into a composite vulnerability indicator.	• An Excel template for aggregating vulnerability components into a composite vulnerability index
8 Presenting the outcomes of your VA	This module will show you how best to summarise and present the findings of your vulnerability assessment	• Sample structure of a VA report • Documentation of test applications

Source: adelphi/EURAC 2014.

III

m1

GUIDELINES



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Module 1:

Preparing the vulnerability assessment

What will you learn in this module?

This module outlines the essential steps for preparing your vulnerability assessment. It shows you how to assess the initial situation of your analysis, define objectives and make key decisions on the topic and scope of the assessment. Module 1 also helps you estimate time and resources needed and avoid known pitfalls in the early planning phase of a vulnerability assessment.

Key steps and questions addressed in this module:

Step 1
Understand the context of the vulnerability assessment

- At what stage of adaptation planning is the assessment taking place?
- Are there already vulnerability or impact assessments for your topic or region?
- What are the development and adaptation priorities (if already defined)?
- Which institutions and resources can and should be involved in your vulnerability assessment?

Step 2
Identify the objectives and expected outcomes

- What do you and key stakeholders wish to learn from the assessment?
- Which processes will the vulnerability assessment support or feed into?
- Who is the target audience for the vulnerability assessment results?

Step 3
Determine the scope of the vulnerability assessment

- Which topics (sectors, groups) should the vulnerability assessment cover?
- Are there known key impacts and vulnerabilites you want to assess?
- What is the scope – area(s), period – of your vulnerability assessment?
- To which time frame will the vulnerability assessment refer (past, current, future vulnerability)?

Step 4

Prepare an implementation plan

- Vulnerability assessment team: Who are the people and institutions involved?
- Tasks and responsibilities: Who does what?
- What is the time plan of the vulnerability assessment?

What do you need to implement this module?

To get started with your vulnerability assessment, you will need:

- A good overview of institutions and individuals relevant for your assessment.
- Key strategic documents of the organisations involved, such as programme documents, sector strategies, community or national development plans.
- Information – where available – on adaptation priorities, plans, strategies and ongoing or planned adaptation measures.
- Information on climatic conditions, past extreme events, climate change projections as well as potential climate change impacts.
- Information on socio-economic conditions, such as livelihoods, education, health issues, natural resource dependency, etc.
- Information – ideally in form of maps – on key environmental challenges, such as water scarcity, soil degradation, loss of biodiversity and existing infrastructure.

What are the outcomes of this module?

After completing Module 1, you will have:

- A precisely formulated set of objectives – overall and specific – agreed with key partners and stakeholders.
- A clearly defined scope for the spatial, thematic/sectoral and temporal dimensions of the vulnerability assessment.
- A list of outputs to be produced.
- A vulnerability assessment implementation plan that defines tasks, responsibilities and timetable for the vulnerability assessment.

Which tools and information does the Annex provide?

In the Annex you will find:

- Template vulnerability assessment implementation plan (Annex 1)

Getting started

Every vulnerability assessment takes place in a unique setting and serves specific purposes. So before starting with the practical implementation, make sure you:

- understand the context in which the assessment is taking place (Step 1),
- define clear objectives and expected outcomes for the assessment (Step 2),
- determine the thematic, spatial and temporal scope of your vulnerability assessment and outline potential methods (Step 3), and
- prepare an implementation plan that defines tasks and responsibilities for different participants and stakeholders, as well as the schedule for the vulnerability assessment, taking into account available resources (Step 4).

In practice, these four steps are closely interlinked and preparing a vulnerability assessment is an iterative process balancing objectives, context, scope and resources.

Steps 1 to 4 result in important decisions which will influence the entire vulnerability assessment, so it is essential that you document the results of this preparatory phase well and share it with any actors who will be involved in your vulnerability assessment. This ensures transparency and provides substantiation for any decisions as well as pending questions. There is a template implementation plan (Annex 1) for documenting the results of Module 1 (see Step 4); fill this in jointly with key institutions and stakeholders and use it for further communication and planning of the assessment.

TIP

Sound documentation and distribution of results (including intermediate results) and any related processes, such as household surveys, is vital in any vulnerability assessment. As well as creating transparency, it helps increase the credibility of your vulnerability assessment, while also improving the uptake of your results and recommendations.

Step 1

Understand the context of the vulnerability assessment

Since each vulnerability assessment takes place in a unique setting, the very first step of the assessment is to take time to explore its context. This will help you specify the objectives of the assessment, determine its scope and find the right balance of available resources and intended outputs. In doing so, keep in mind the five key factors and guiding questions depicted in Figure 7 and further outlined below.

Figure 7: Key questions in assessing the context of a vulnerability assessment

Processes
- What are ongoing or planned processes related to adaptation?
- Which (ongoing) activities should or could benefit from the VA?
- Which activities could the VA benefit from?

Knowledge
- What is already known about climate change and its impacts?
- Have there already been vulnerability or impact assessments?
- Which information gaps should be filled by the VA?

Institutions
- Which institutions will or should be involved in the VA?
- What are their specific interests and objectives regarding the VA?
- What and how can they contribute to the VA?

Resources
- When are results from the VA needed?
- Which (financial, human, technical, etc.) resources can be dedicated to conducting the VA?
- Which relevant information and data are available for the VA?

External developments
- Are there important external factors that should to be taken into account?
- How do these external factors potentially influence the system under review?

Source: adelphi/EURAC 2014.

Processes

The vulnerability assessment – a process in itself – usually occurs in the context of broader processes and activities in the field of adaptation. That could be the development of a national adaptation strategy or a framework for M&E of adaptation measures as well as any past climate change adaptation activities in the area under review. Identifying and understanding such processes can assist you in articulating the objective of the assessment, as well as highlighting potential synergies and mutual benefits between your assessment and other processes.

Knowledge

Try to get an overview of existing knowledge on climate change and its impacts as it applies to the areas covered by your assessment (see Box 4). This can guide you in specifying the particular climate change impact your analysis will concentrate on and help you determine the scope of the assessment. You will also get an idea of the kind of data and information which might be useful for your analysis. And by taking stock of existing climate knowledge, you may find major information gaps which your vulnerability assessment could help fill.

4 EXPERT

Scoping and gathering information on climate change vulnerability

To encourage discussion about the scope and objectives for the vulnerability assessment, you should consider a pre-assessment, or 'scoping'. The scoping should provide an overview of existing relevant information on climate change, particularly information on impacts with the potential to become major threats. You will often find that there is already a lot of information and published material available from national and international sources that you can use in scoping. This could include:

- national communications and adaptation plans
- studies on socio-economic, environmental and development issues
- IPCC reports and national studies on climate change
- climate change information portals

Below are some links to information on climate change and its impacts which might be useful for your vulnerability assessment:

- ci:grasp: web-based climate information service which supports decision makers in developing and emerging countries in adaptation planning: http://www.pik-potsdam.de/~wrobel/ci_2/
- Climate Change Knowledge Portal (CCKP): the World Bank's central information hub on climate change: http://sdwebx.worldbank.org/climateportal/index.cfm.
- Climate Information Portal (CIP): The University of Cape Town's climate information platform: http://cip.csag.uct.ac.za/webclient2/app/.
- IPCC Data Distribution Centre (DCC): climate, socio-economic and environmental data (past and future scenarios): http://www.ipcc-data.org/
- UNDP Climate Change Country Profiles: a database of observed and modelled climate data for 61 developing countries: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
- Permanent Service for Mean Sea Level (PSML): observed sea level data from the global network of tide gauges: http://www.psmsl.org/
- Socioeconomic Data and Applications Center (SEDAC): part of NASA's Earth Observing System Data and Information System (EOSDIS), focussing on human interactions in the environment: http://sedac.ciesin.columbia.edu/

Institutions

Exploring institutions relevant to your assessment (also called 'stakeholder-mapping') will help you better understand their specific interests and expectations. They will be decisive when you come to outlining the objectives of your assessment, as this analysis is often driven by specific information requirements – yours or those of your partner institutions. You should also get an overview of the ways in which different institutions can contribute to the assessment. Stakeholders can be 'mapped' according to their resources relevant for your vulnerability assessment (e.g. financial, knowledge, access to networks, access to data, experience, political influence, reputation). Helpful questions for determining stakeholders can be (after GIZ 2011b):

- Who can contribute how to the assessment?
- How does cooperating with a stakeholder influence the project-results?
- Is it possible to create synergies?
- Can you acquire strategic resources (time, money, expertise etc.) by cooperation?
- Are there any conflicting interests and how can they be dealt with?

Local institutions, experts and stakeholders should be involved throughout the entire vulnerability assessment. This will not only ensure that their perspectives and local expertise are considered, but will also increase acceptance and impact of your vulnerability assessment (see Box 5).

FURTHER READING on participatory methods, key institutions and stakeholders

Further reading on participatory methods and tools on how to engage with key institutions and stakeholders:

GIZ 2011: Private Sector Cooperation - Stakeholder Dialogues. Manual on behalf of the BMZ, Federal Ministry for Economic Cooperation and Development. Eschborn: GIZ. Retrieved 16.04.2014 from *http://www.wageningenportals.nl/sites/default/files/resource/giz_stakeholder_dialogues_kuenkel.pdf*

GTZ/KfW 2008: Participatory Development Programme in Urban Areas – Knowing Local Communities. Manual. Cairo: Participatory Development Programme In Urban Areas (PDP). Retrieved 16.04.2014 from *http://egypt-urban.pdp-gtz.de1.cc/wp-content/uploads/2010/03/Manual-Knowling-Local-Communities-2009_EN.pdf*

GTZ 2007: Multi-stakeholder management: Tools for Stakeholder Analysis: 10 building blocks for designing participatory systems of cooperation. Sector Project: Mainstreaming Participation. Report series: Promoting participatory development in German development cooperation. Eschborn: GTZ. Retrieved 16.04.2014 from *http://www.fsnnetwork.org/sites/default/files/en-svmp-instrumente-akteuer-sanalyse.pdf*

Kienberger 2008: Toolbox and Manual: Mapping the vulnerability of communities – Example from Búzi, Mozambique. Retrieved 19.06.2014 from *http://projects.stefankienberger.at/vulmoz/wp-content/uploads/2008/08/Toolbox_CommunityVulnerabilityMapping_V1.pdf*

Resources

An overview of the technical, human and financial resources available to you is crucial for determining the scope of your assessment. Time is a particularly critical resource for any vulnerability assessment and will probably be decisive in determining the methods you choose. Is there a fixed deadline for delivering results, or is your timeframe more flexible?

External developments

During this preparatory phase of the vulnerability assessment, it can be useful to take a moment and consider a broader view of other important (external) factors that might have an influence on the system under review. This might include conflicts, movements of refugees or the influence of global developments, such as trade policies, on local living conditions. These factors may not be part your assessment framework, but they might be well worth considering when designing, implementing and analysing your results. Such a 'plausibility check' can indicate whether changes are mainly driven by climatic factors or rather driven by non-climatic factors.

Step 2
Identify objectives and expected outcomes

The decision to conduct a vulnerability assessment is usually driven by a particular need or information gap, such as: 'We want to know where climate change will become a (major) threat to agricultural production, and why' or 'We want to find out which sections of the population are most vulnerable to climate change impacts'. The objective of the assessment and intended outputs should be defined as clearly as possible; this transparency will help in managing the expectations of participating institutions and stakeholders. It will also help when you come to choosing a methodological approach to fulfil your objective (see Step 3).

5 EXPERT

Involving stakeholders and institutions throughout a vulnerability assessment

Cooperation with stakeholders is a crucial success factor: vulnerability assessments combine knowledge from different disciplines, require specific expertise in different sectors or regions and often rely on information gathered on the ground for analysis and validation. Local institutions and experts can often provide such knowledge and access to data sources and thus improve the quality of the assessment. Moreover, involving local institutions can help increase acceptance – and thus uptake – of your vulnerability assessment results and recommendations. Finally, it facilitates learning among institutions working on adaptation and can lead to up-scaling of identified measures. Involvement of local institutions can be through bilateral consultations or take the form of a 'kick-off' workshop which aims at defining the cornerstones of the assessment outlined in this module in Steps 1-4.
The objectives, subject matter and spatial scale of your vulnerability assessment will determine which institutions to approach. Since these aspects are defined in steps (specifically, Step 2 and 3), identifying and involving different institutions will often be a gradual and reciprocal process. The table below lists the kind of institutions you may want to approach at each different level.

Table 4: Key Institutions to Consider When Developing a vulnerability assessment

Level	Potential partners and stakeholders
Community Level	Local communities, farmer associations, community leaders, local NGOs and authorities, local businesses and companies, donor organisations
District or provicial level	District or provincial governments, national entities such as ministries, statistical offices, meteorological offices, local NGOs, scientific institutes, private sector companies, international organisations, donor organisations
National level	Ministries responsible for environment, spatial planning, natural resources (particularly water), planning and finance as well as resource-related sectors (such as agriculture), statistical offices and meteorological offices, NGOs working at the national level, international organisations, donor organisations, private sector companies
Science & research	Local universities (specifically, departments working on natural resources, rural or urban development, biodiversity, geography, disaster risk reduction etc.), research institutions

Source: adelphi/EURAC 2014.

To ensure robust, on-going dialogue with participating institutions, consider setting up a steering committee or technical working group to monitor and support assessment. This encourages exchange and helps to continually reinforce a common understanding of the assessment's goals and outputs.

Key questions

The following questions will help you define overall objectives for your assessment:

- **What processes will the vulnerability assessment support or feed into?**
  Are there on-going activities in the field of adaptation that should be taken into account when designing and implementing the vulnerability assessment?

- **What do you want to learn from the assessment? What is the information gap?**
  What are the climate change hotspots in your region? Or do you want to identify suitable adaptation measures and test whether they help reduce vulnerability?

- **What do you want to use this knowledge for?**
  Input into on-going adaptation efforts, planning concrete adaptation measures at the local level, developing a national adaptation strategy, or an overview of potential sectoral climate change hotpots?

- **Who is the target audience for the results of the vulnerability assessment?**
  Local communities, ministries and national agencies tasked with adaptation planning, decision makers at different administrative levels?

- **What outputs do you expect?**
  A map of vulnerability hotspots, ranking of vulnerable sectors, narrative analysis of vulnerability and its determining factors?

In practice, you can answer these questions with or without stakeholder involvement, depending on whether your objectives are predetermined or subject to stakeholder input (see Box 5).

In all likelihood, discussion of the scope (Step 3) and available resources for the assessment (Step 4) will help you focus on the objectives and provide the right degree of pragmatism. Consequently, Step 2 and Step 3 of this module should be seen as an iterative process.

Step 3

Determine the scope of the vulnerability assessment

Having explored the context of the vulnerability assessment and identified its overall objectives, it is time to define the scope of your vulnerability assessment in greater detail, including factors like spatial level. This is also important preparation for the development of impact chains. They form the key conceptual component of the Vulnerability Sourcebook in exploring the underlying cause-and-effect relationships that influence vulnerability, and will be developed in Module 2. Use the following questions as a guide when determining the scope of your assessment:

- **What exactly is your vulnerability assessment about?**
  What is the subject or thematic focus of your assessment (e.g. a certain sector or application field, such as wetland ecosystems, agricultural production, water provision, biodiversity etc.). Are you considering particular social groups? And will the assessment focus on just one subject, or combined subjects (for example, vulnerability of agricultural production affecting crops *and* livestock)?

- **Do you already have potential climate impacts and vulnerabilities in mind?**
  Potential impacts will be identified in detail in Module 2. However, you might already be aware of key impacts and vulnerabilities related to your subject(s) which you want to address in a vulnerability assessment. This knowledge of key impacts and vulnerabilities might come from previous studies or literature (see Box 4).

- **What is the geographical scope of the assessment?**
  Will it cover a specific community, district/province or country? Or will it focus on specific entities such as a clearly definable ecosystem (e.g. a river delta or protected natural area)? And are you focusing on a single spatial unit (e.g. one district) or comparing areas (e.g. two or more districts)? This decision on spatial scale might also be influenced by the availability of data relevant to your assessment (e.g. are education and income data available at the district level or are they also broken down to the community or even household level?)

- **What is the time period of the assessment?**
  A vulnerability assessment can refer to different time (reference) periods. We recommend starting with vulnerability to current climate for a baseline assessment (vulnerability before an adaptation activity). Ideally this means a reference period covered by 30 years of climate records (e.g. 1981-2010). Anything below 15 years will not be sufficiently representative. You can use non-climatic data (e.g. household income) which covers shorter periods, although it should be as recent as possible.

TIP

Focusing on current climate will often provide all the information you need, as the impact of past and current climate extremes and observed trends can tell you more about vulnerability than projections.

In some cases there may be a need to consider vulnerability to future climate as well, e.g. for long-lived infrastructure. This will, however, require an understanding of how the climate will change for a given location, i.e. sufficiently reliable climate projections, or at least plausible scenarios will be needed as an input. Reference periods typically cover 30 years (e.g. 2021-2050). When considering future climate, you should ideally also have scenarios for socio-economic developments, such as population growth or anthropogenic land-use change. Climate data usually come from climate scenarios (see Box 4). Socio-economic scenarios are usually difficult to get and comprise additional uncertainties. Periods which reach too far into the future are of little relevance for adaption planning, and we do not recommend looking beyond 2050. In monitoring and evaluating adaptation measures, baseline vulnerability before and vulnerability after the implementation of a particular measure is usually assessed for the same climate reference period (current or future) in order to be able to identify any changes as an effect of the adaptation measure.

- **What are the right methods for your vulnerability assessment?**
  Which methods do you intend to use in your vulnerability assessment? As the conceptual framework indicates (see Chapter II.3.2), a vulnerability assessment can incorporate various different methods (see also Table 5). Do you plan to run quantitative models (e.g. climate or hydrological models) or will you primarily rely on participatory approaches or a mixture of the two (see Module 4)? Selection of methods will depend on your available resources (time, finances, software) and technical expertise. It will also depend on the expected outcome of your vulnerability assessment: are you hoping to deliver robust, objective results (focus on quantitative models) or are you aiming to create awareness or to identify adaptation priorities for key vulnerabilities (focus on participatory approaches)?

Again, you could theoretically answer these questions without engaging external stakeholders. However, involving stakeholders at this early stage of the vulnerability assessment is highly recommended. This will create a sense of shared ownership and so increase acceptance and uptake of your results. Kick-off workshops, in which participants discuss these questions, have proved a very successful way of achieving this. Box 6 provides an example of a kick-off workshop with stakeholders and experts which was used to refine the scope of a vulnerability assessment in Burundi. But as this example also shows, the kick-off workshop does not necessarily need to address every element of your assessment.

Step 4
Prepare an implementation plan

Building on your understanding gained through Step 1 to 3 of this module, you can start to develop a concrete work plan for implementing your vulnerability assess-

6 PRACTICE

m1

Defining the scope of a vulnerability assessment in Burundi

A vulnerability assessment focusing on climate change impacts on soil and water resources was carried out in Burundi. The overall objectives of the vulnerability assessment – in particular the identification of local climate change hotspots – were derived from an overarching project and defined through stakeholder consultations.

Figure 8: Participants of the kick-off workshop for a vulnerability assessment in Burundi

The assessment was launched with a 'kick-off' workshop which involved around 25 key experts and stakeholders from relevant ministries, national research institutions and civil society. The objective of the 2-days workshop was to present the work plan for the assessment, to create interest and ownership among relevant stakeholders, to ensure their specialist expertise was incorporated and to define the overall scope of the vulnerability assessment. A smaller group of experts further refined the scope of the assessment, concentrating on analysis of vulnerability to climate change-related water scarcity and soil erosion in Burundi's agricultural sector. Additionally, the pressing, climate-related health issue of malaria was selected as a secondary subject for the vulnerability assessment. These decisions provided the basis for the next step, i.e. the definition of impact chains (see Module 2).
The workshop also provided an early opportunity to discuss data availability with local experts (see Module 2) and to establish personal contact with representatives of institutions which hold relevant data. Finally, the workshop also expanded participants' capacities with relation to climate change vulnerability.

ment. This should define specific tasks (what needs to be done?) and responsibilities (who does what?) and time planning (what happens when?). A template vulnerability assessment implementation plan is provided in the Annex (see Annex 1).

You should involve participating institutions and stakeholders as you put together your implementation plan. To keep your scheduling realistic, carefully consider the resources you have and the resources you still need from other partners. Consider the following points before you start with time and resource planning:

- More explorative vulnerability assessments – even those covering a wide scope – are usually less time-consuming (see Table 5). A well-structured, two or three day workshop should result in a good understanding of vulnerability (see Annex 10 for a documentation of the Vulnerability Assessment in Pakistan), even in larger regions. Note, however, that you will need to carefully select participants who can bring high levels of expertise to your assessment topics.
- More focused, in-depth assessments generally take longer as they usually require a large amount of data, either sourced from relevant institutions or from tailored surveys conducted as part of the vulnerability assessment. Data acquisition (as well as data preparation and processing – see Module 4) can often represent a scheduling bottleneck. If your schedule is particularly tight, evaluate data availability and quality as early as possible, leaving yourself plenty of time to explore different resources, or to change the methods or focus of your vulnerability assessment.

Table 5 provides an overview of the time and resources needed for the four example vulnerability assessments presented in the Vulnerability Sourcebook:

POTENTIAL PITFALLS

One of the most obvious pitfalls in this module is overestimating the resources available, or underestimating what your vulnerability assessment will require. An overly ambitious scope which calls for a high level of detail is another danger. This means that realistic planning is key, and you will need to ensure that you have sufficient resources – time, in particular – so that you can deal with unexpected challenges. A few hints which can help:

- Take your time in determining objectives, thematic area(s) and spatial scale, as well as outputs. Changing these cornerstones once the vulnerability assessment is underway can cause major delays.
- Make sure that there is a sound, shared understanding among all participating partners and stakeholders.

- Ensure that all key stakeholders have a thorough understanding of the assessment's objectives; this will encourage cooperation in identifying solutions as challenges.
- Be clear in assigning tasks and responsibilities to individuals, institutions and other stakeholders.
- The more data-driven your assessment, the higher the quantity and quality requirements of your data and the more technical capacities and skills required. Consider whether the effort matches your objectives.
- When planning your assessment, include milestones and monitor them once implementation is underway.

Table 5: Resources used to conduct different vulnerability assessments

	Bolivia	Burundi	Mozambique	Pakistan
Approach	Mostly quantitative methods (water balance model, expert judgment)	Mix of quantitative and qualitative methods (climate projections, hydrological model, participatory approaches such as focus group discussions)	Participatory methods (e.g. focus group discussions and interviews)	Participatory methods (e.g. focus group discussions, budget allocation process)
Human resources	4 national experts (engineers, planners), 2 international experts (1-2 months), local stakeholders.	International experts in social science methods, climate science, hydrology (10 months). Local survey experts (2 months)	Team of local experts to conduct interviews (3-4 months). International backstopping (0.5 months)	Team of local extension workers (3-4 months). Support from local consultant (3-4 months). International support during workshop (5 days).
Technical resources and skills	Climate change, hydrology, land planning	GIS expertise and software, climate and hydrological modelling	Expertise in questionnaire development and GIS	Local experts on agriculture and biodiversity. Good knowledge of local communities.
Time	10 months	11 months	6 months	3 to 4 months

Source: adelphi/EURAC 2014.

m2

Module 2:

Developing impact chains

What will you learn in this module?

This module will show you how to define the potential impacts addressed in your vulnerability assessment and develop an impact chain using it as a starting point. Impact chains can help you better understand the cause-and-effect relationship determining vulnerability in the system under review. This in turn will help you identify indicators which you will use later in your assessment.

Key steps and questions addressed in this module:

Step 1
Identify potential impacts

- Which direct and indirect impacts are relevant for the vulnerability assessment?

Step 2
Determine exposure

- To which changing climate signals is your system exposed?

Step 3
Determine sensitivity

- What characteristics make your system susceptible to changing climate conditions?

Step 4
Determine adaptive capacity

- Which adaptive capacities allow your system to handle adverse climate change impacts?

Step 5
Brainstorm adaptation measures (optional)

- What measures could help increase adaptive capacity and decrease sensitivity in the system?

What do you need to implement this module?

To develop an impact chain, you will need:

- Clear objectives and sound understanding of the scope of the assessment (developed in Module 1)
- A priori information on climate change in the region under review and initial understanding of potential climate change impacts (also gathered in Module 1)
- Core information on the natural environment of the system under review
- Core information on socio-economic aspects affecting the vulnerability assessment subject

What are the outcomes of this module?

After completing Module 2, you will have:

- One or more impact chains describing the cause-effect-relationship determining vulnerability
- Results from an initial brainstorming session on potential adaptation measures

Which tools and information does the Annex provide?

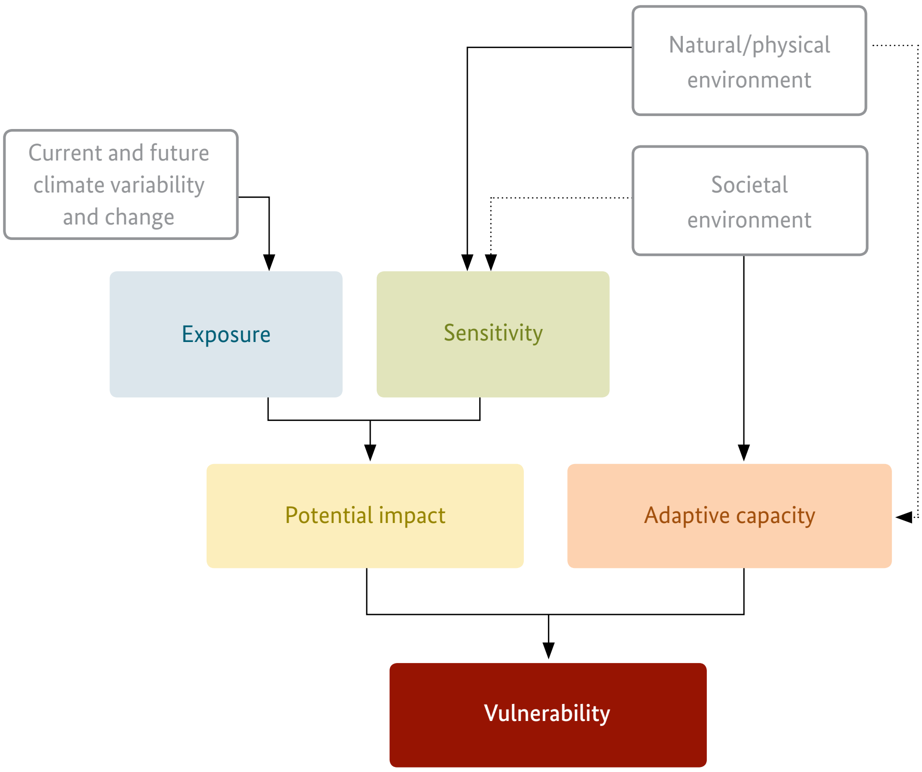
In the Annex you will find:

- Sample impact chains from different sectors (Annex 2)

What is an impact chain?

An impact chain is an analytical tool that helps you better understand, systemise and prioritise the factors that drive vulnerability in the system under review. The structure of the impact chain is based on the Vulnerability Sourcebook's understanding of vulnerability, as seen in Figure 9. Refer to the Conceptual Framework for more information on the different components of vulnerability.

Figure 9: Structure of an impact chain



Source: adelphi/EURAC 2014.

Impact chains form the core of the Vulnerability Sourcebook's approach. They are a valuable outcome in themselves, since they create a comprehensive understanding of climate change vulnerability (i.e. a vulnerability hypothesis) shared by various stakeholders and also help in the identification of suitable adaptation activities. The entire vulnerability assessment will follow the logic of the impact chains which you develop in this module.

In developing impact chains, expert knowledge and a sound understanding of the system at the heart of the vulnerability assessment are indispensable. We recommend the following breakdown of steps:

- Prepare the process within the project team with the help of external experts where necessary (review of known impacts and cause-and-effect relationships).
- Use participatory methods such as workshops involving key institutions and experts as well as representatives of affected sectors or communities to broaden knowledge, create a common concept and encourage ownership (brainstorming on additional impacts, prioritization of impacts, drafting impact chains).
- Finalise the process within the project team with the help of external experts where necessary (fine-tuning and finalisation of impact chains).

Building an impact chain is an iterative process, and new aspects can arise throughout. You can always return to previous steps when creating a chain.

The following sections will show you how to develop an impact chain, from the starting point of potential impact to identification of relevant exposure, sensitivity and adaptive capacity factors that influence vulnerability. To facilitate this exercise, the Vulnerability Sourcebook provides key questions for each step and sample impact chains in Annex 2.

Step 1
Identify potential impacts

The first and most crucial step in developing an impact chain is identifying a potential impact. If your vulnerability assessment covers more than one topic (addressing the sectors agriculture and health, for instance) you will need to select potential impacts separately. Each impact will be covered by a discrete impact chain but they can later be combined and interlinked. While you may be tempted to fill your assessment with as many topics and climate change impacts as possible, remember that the more impacts you include the more complex (and usually more resource- and time-intensive) your vulnerability assessment will be. This increased complexity may also reduce the clarity and practicability of assessment results.

Identifying impacts starts with a broad view, including a review and brainstorming process. Later you can cluster them and narrow your choice down to one or more potential impacts according to the focus of your assessment. The process for identifying impacts proceeds as follows:

Review the results of Module 1

Start with a desktop review of potential impacts based on the knowledge sources you identified in Module 1. Document known impacts for each of the topics you identified.

Brainstorm potential impacts

Take the impacts you collected during the review and use a brainstorming session with key stakeholders to complete the list. Make sure that you stay within the system under review as defined in Module 1 (e.g. vulnerability in agriculture at the local level).

TIP

Brainstorming and identifying potential impacts can best be done by conducting a participative workshop with experts and key stakeholders. Use pin boards and cards to collect and arrange the impacts identified with the participants.

If your vulnerability assessment addresses more than one topic or sector (e.g. agriculture and health), examine them separately. Key questions in identifying relevant potential impacts include:

- How have weather phenomena and extreme climate events impacted your system in the past?
- Have you observed any new trends or recent events (e.g. in the last decade)?
- What socio-economic impacts have you observed in the past as a result of these climate events (e.g. loss in yields, increase in disease)?

TIP

Rather than asking 'what is the impact', try to formulate every impact with the question 'impact on what?'. For instance, '(change in) water availability' makes a better potential impact than 'less water'.

Cluster the impacts

After collecting potential impacts from the review and brainstorming, cluster them into larger groups united by similar topics, giving each cluster a unique title (e.g. 'erosion and land degradation', 'water scarcity', 'food insecurity').

TIP

Make sure you have captured all relevant impacts affecting your system of interest for each cluster. Therefore, once you are done compiling the impacts by their subject take a second look if you miss any relevant aspects.

Prioritise and select key clusters

The next step is to discuss how many clusters you wish to use in order to prioritise one or more as the focus of your assessment. The key question here is: in your opinion, which issues affect your system the most?

One method of prioritisation is to give each workshop participant a number of 'votes' (in the form of sticker dots, for instance) and have them distribute them to the clusters which they regard as most important.

Arrange impacts within clusters

Once you have identified your priority clusters, take a closer look at the impacts within each cluster which resulted from the brainstorming session. You will probably have already noticed that one impact often occurs as a consequence of another in your cluster (e.g. impact A 'erosion' leads to impact B 'loss in yield due to erosion'). Highlight these causal relationships by arranging impacts accordingly (B is a consequence of A). This will often form a preliminary impact chain on its own (for examples of such impact chains in coastal areas see GIZ, 2014).

Next, you need to do a plausibility check to identify your potential impact to focus your vulnerability assessment on. For that purpose, discard any impacts which are significantly influenced by factors unrelated to climate change, retaining only those impacts clearly related to or aggravated by climate signals as your starting point. Let this task be guided by questions such as:

- Which other factors (such as forest degradation, groundwater exploitation, etc.) affect the impact?
- Are these or climatic factors dominating?
- If other factors are dominating, does climate change significantly aggravate the impact?

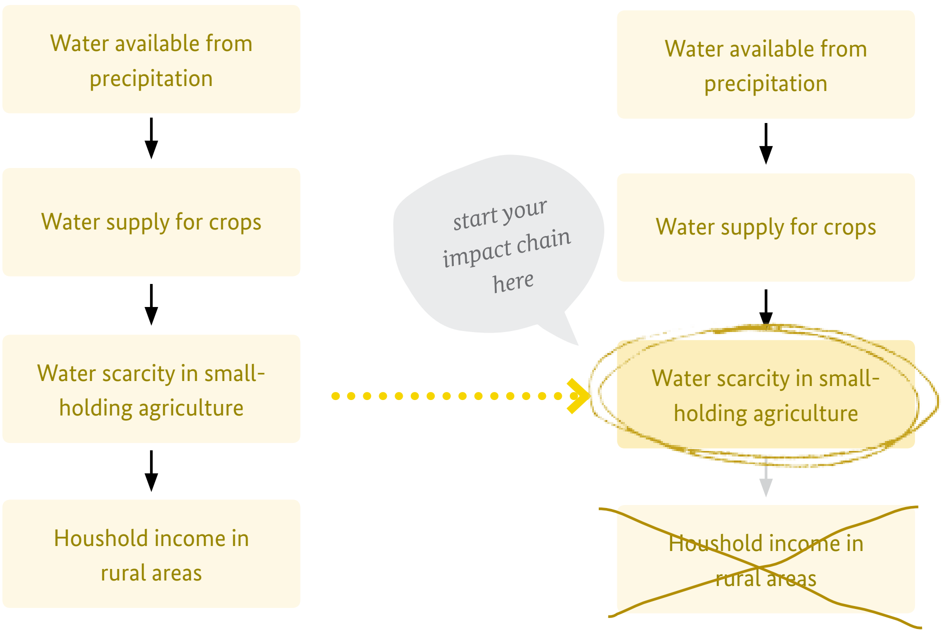
In case you have difficulties answering these questions, consult experts to gain further guidance.

m2

TIP

When brainstorming potential climate change impacts, it is sometimes hard to find an end – and you might end up with a very long and complex list of interlinked impacts. In particular when thinking about the socio-economic consequences of climate change try to keep it simple and do not get lost in details.

Figure 10: Selecting the impact 'Water scarcity in small-holding agriculture'



Source: adelphi/EURAC 2014.

Having chosen one impact as your starting point, you can start constructing your chain by identifying key factors determining the vulnerability of your system.

Figure 11: Prioritisation of impacts at a kick-off workshop in Pakistan

Source: adelphi/EURAC 2014.

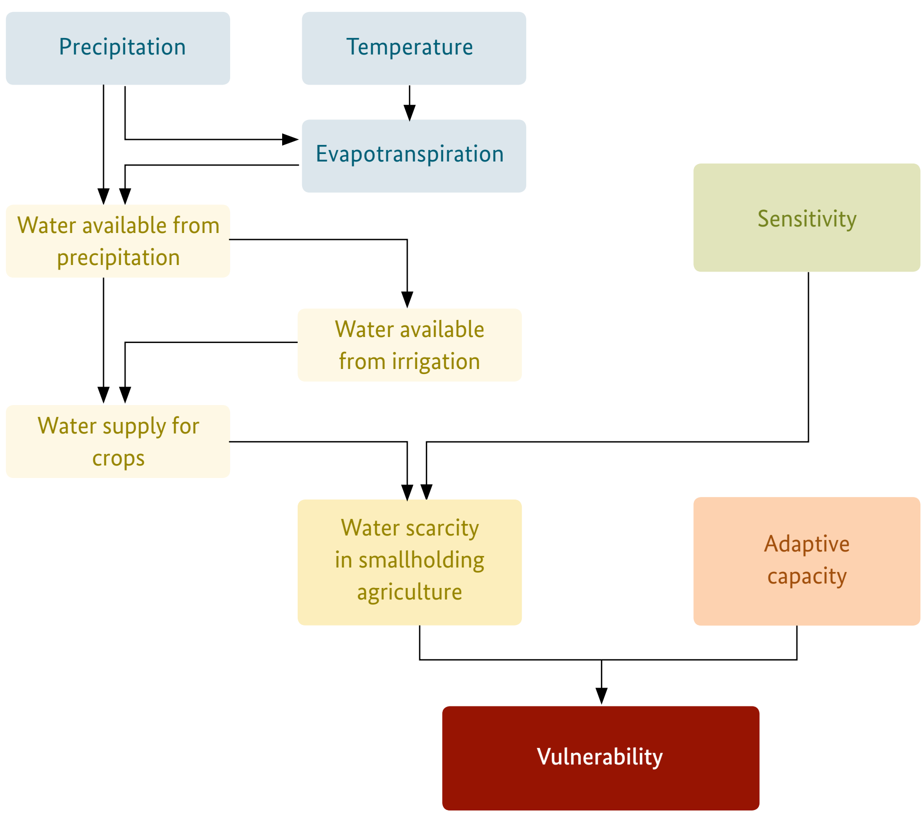
Step 2
Determine exposure

Start with your potential impact, then work from the bottom up by identifying related intermediate impacts that cause your potential impact until you have reached the climate signal(s) which represent the essential trigger(s).

Figure 12 is an example of an impact chain for the potential impact 'water scarcity in small-holding agriculture'.

As you can see, exposure factors usually follow a sequence which leads from readily measurable direct factors, such as temperature and precipitation, through to more complex, indirect factors such as evapotranspiration. The difference between exposure and impact is often opaque; as you see in the diagram, relatively direct impacts ('water supply for crops') lead to more indirect ones ('water scarcity in small-holding agriculture'). As a general rule, only those factors which are directly determined by climatic factors (such as 'water availability from precipitation') are understood as exposure. The others are 'intermediate impacts'.

Figure 12: Example for exposure factors for the impact 'Water scarcity in agriculture'



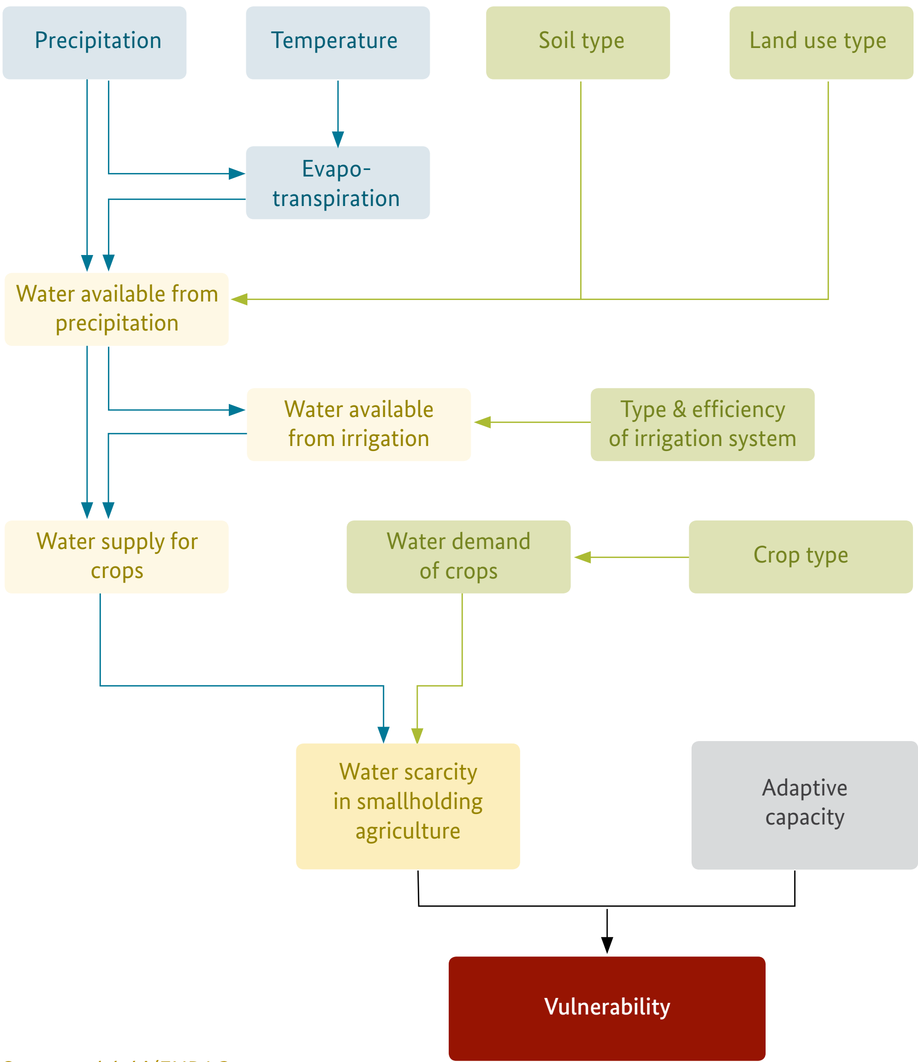
Source: adelphi/EURAC 2014.

With exposure factors and intermediate impacts identified, you now have a basis for determining relevant sensitivity factors.

Step 3
Determine sensitivity

Sensitivity factors can be approached much as you would approach exposure. The guiding question here is: what are the characteristics of the system which make it susceptible to adverse effects of the changing climate signal(s) identified in the previous step? That means that any intermediate impacts identified previously will also need to be taken into consideration.

Figure 13: Sensitivity factors for the impact 'Water scarcity in agriculture'



Source: adelphi/EURAC 2014.

While your aim in the first step was to link impact to climate signals, your task now is to identify attributes or properties that influence the *extent* of the impacts at the core of the impact chain. Figure 13 shows a practical example.

When specifying sensitivity, focus on the natural or physical characteristics of the system including existing infrastructure such as irrigation systems or water storage. When looking at the quantity of water available from precipitation, for example, think of questions like: is the permeability of the soil type an important factor here?

Many factors identified under 'sensitivity', such as soil type, tend to be static and are inherent in the system. Other factors might be altered through human activity. One example is preparing for decreasing rainfall by switching to crops which require less water. Another (albeit more costly) option would be to introduce terracing to reduce gradients. It is important not to confuse sensitivity and adaptive capacity factors. The ability or resources required to implement these measures are adaptive capacities, but once the measures are implemented you can count them as sensitivity factors.

Step 4
Determine adaptive capacity

Once you have determined key exposure and sensitivity factors, you can now move on to the identification of adaptive capacities of your system.

The key question for this step is: which capacities and resources within the system will allow to address climate change impacts? To structure your approach here, refer to the four dimensions of adaptive capacity from the Conceptual Framework (see Chapter II). Consider these guiding questions for each dimension of adaptive capacity:

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

In identifying adaptive capacities, consider aspects directly linked to the impact as well as more generic issues. The main thing is that the adaptive capacity factors identified explicitly contribute to reducing vulnerability.

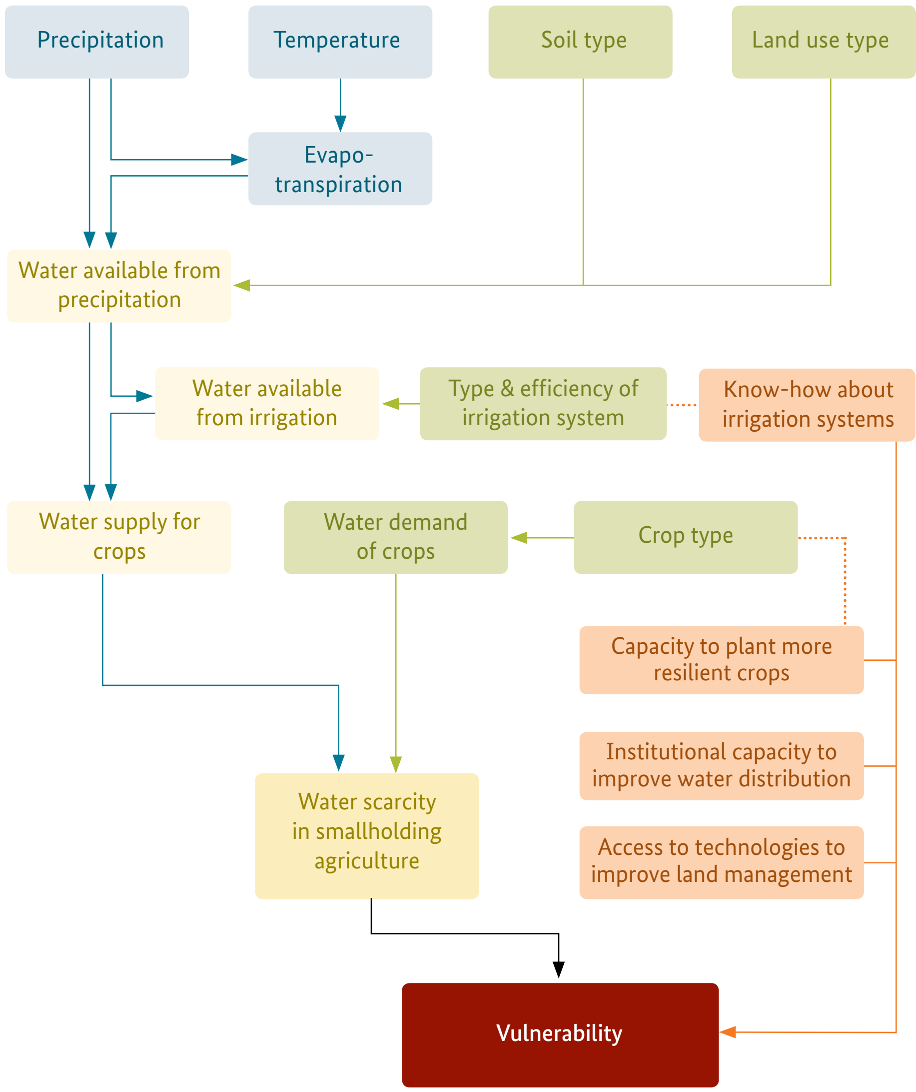
Figure 14 below shows how adaptive capacity can be added to the impact chain.

This impact chain now provides you with a comprehensive understanding of the different factors which influence vulnerability and how they relate to each other.

TIP

Once your impact chain is finished, look at the overall picture and check whether it includes all the major factors that influence vulnerability in your system.

Figure 14: Adaptive capacities for the impact 'Water scarcity in agriculture'

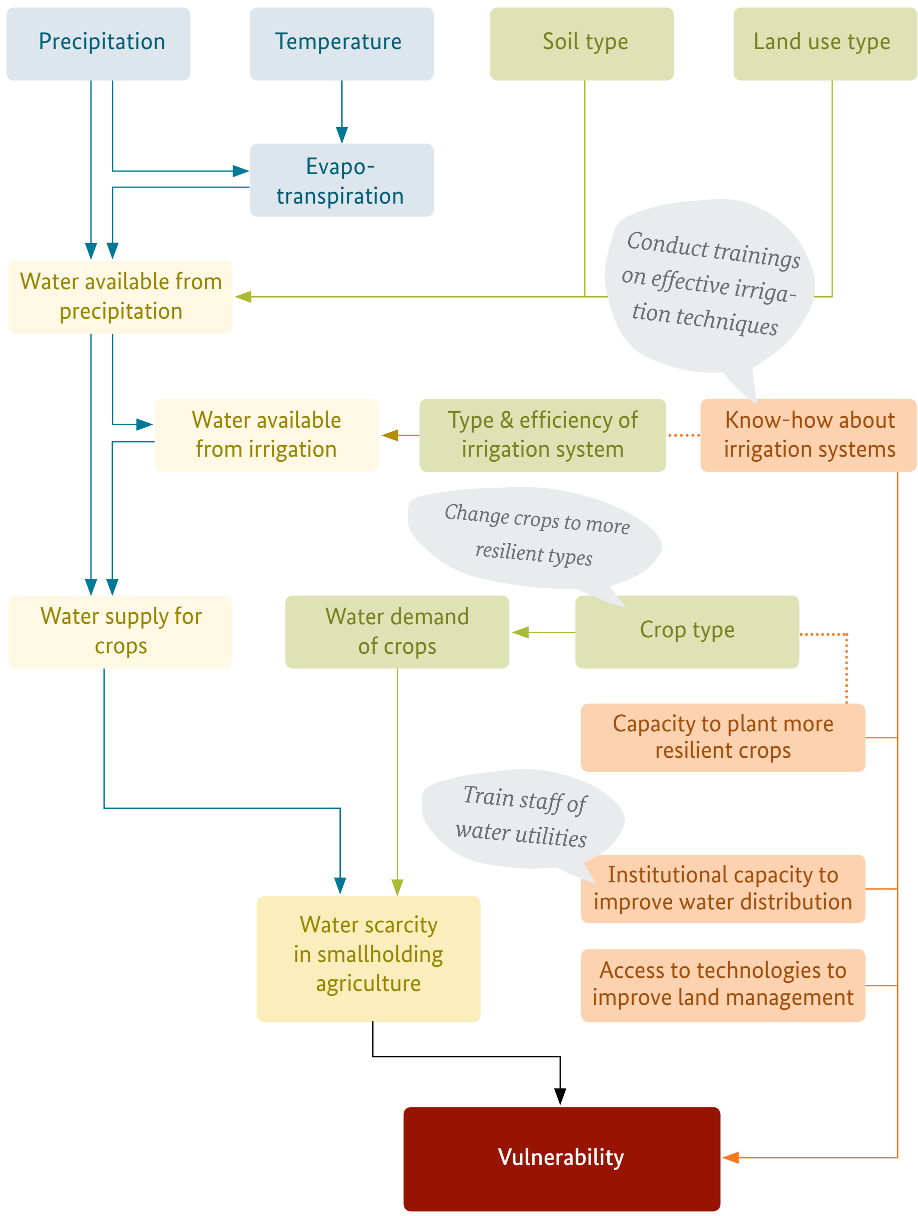


Source: adelphi/EURAC 2014.

Step 5
Brainstorm adaptation measures (optional)

Impact chains not only provide an understanding of vulnerability which can be operationalised, but can drive the initial brainstorming session on potential adaptation measures. We particularly recommend this exercise if your vulnerability assessment is designed to support the development and M&E of adapta-

Figure 15: Adaptation options for the impact 'Water scarcity in agriculture'

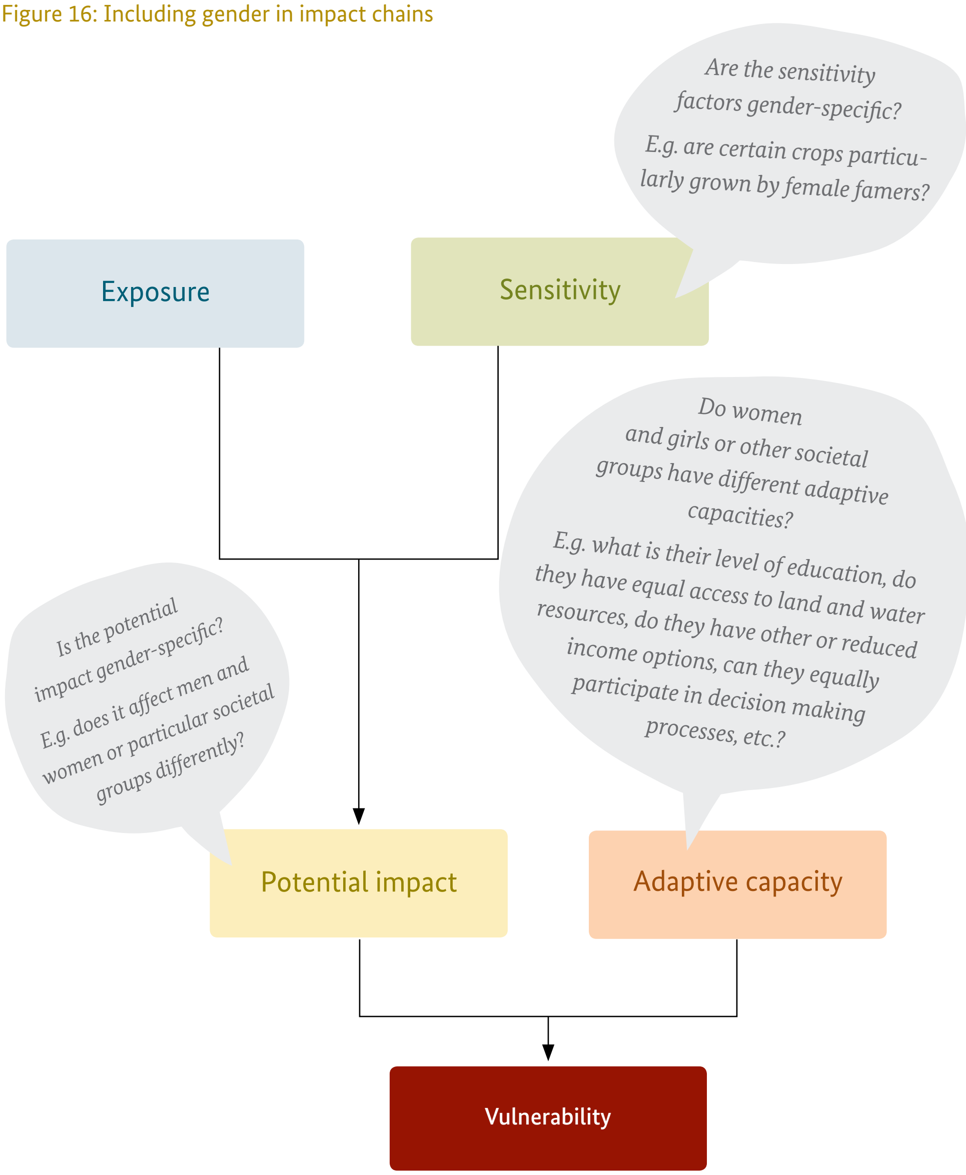


Source: adelphi/EURAC 2014.

tion interventions. The sensitivity and adaptive capacity factors identified serve as a starting point for brainstorming, facilitated by questions such as: what is the best way to tackle sensitivity factors and enhance adaptive capacities to moderate impact (i.e. formulating an adaptation hypothesis).

This is especially helpful where the vulnerability assessment is the starting point for adaptation measures, and can serve as a useful reality check. Feel encouraged discussing potential measures beyond the identified sensitivity and adaptive capacity factors. This might indicate that the understanding of the causal relationships of the components contributing to vulnerability is incomplete and that the impact chain requires additional elements.

Figure 16: Including gender in impact chains

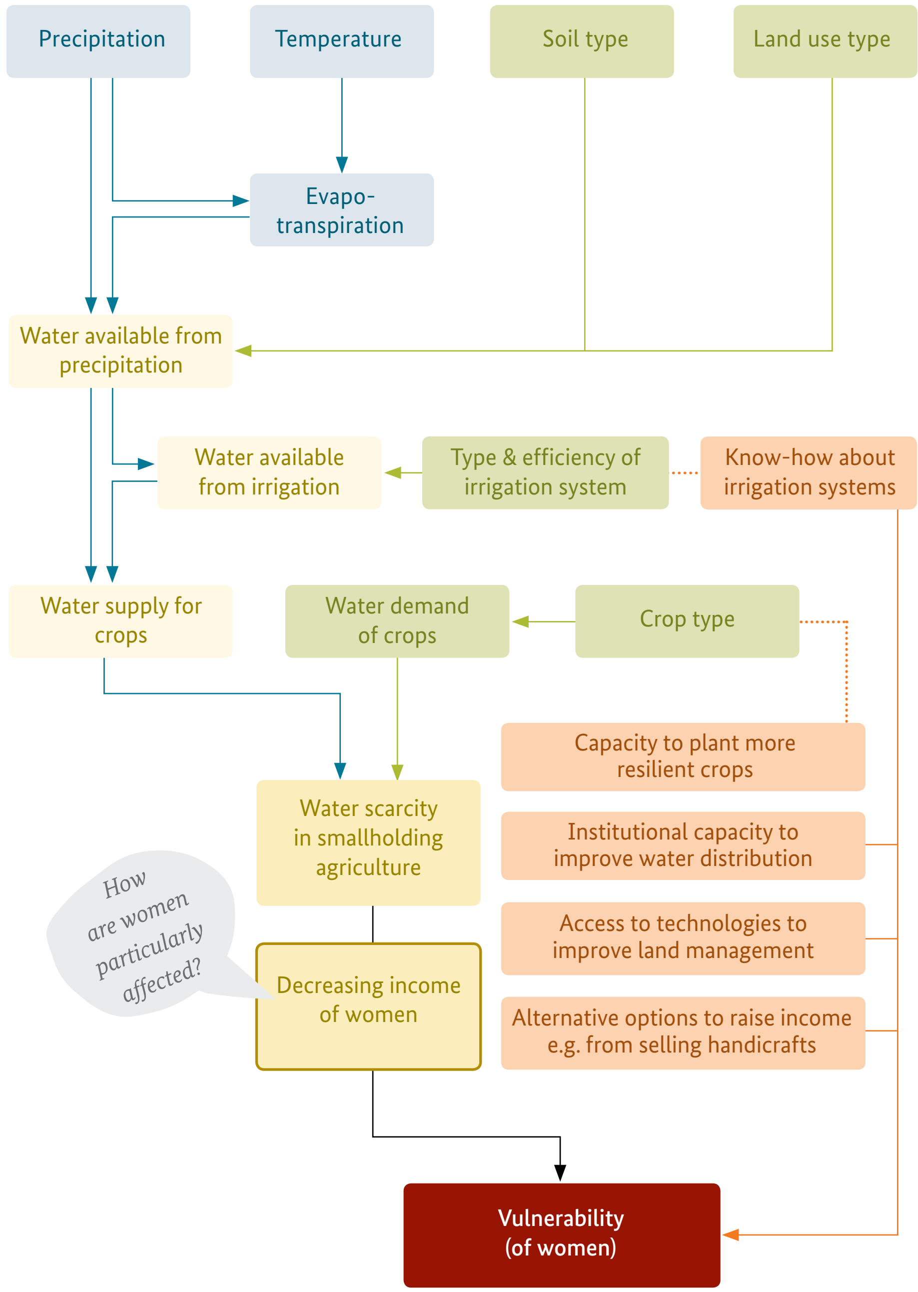


Source: adelphi/EURAC 2014.

Acknowledging gender and disadvantaged groups

To ensure that your assessment takes gender and disadvantaged groups into account, use the same approach applied in developing impact chains. But for each component in the impact chain, starting with the potential impact, consider

Figure 17: Gender-specific sub-impact and adaptive capacity (purple frame)



Source: adelphi/EURAC 2014.

whether there is a dimension specific to women or disadvantaged groups. This can be done for any individual factor of vulnerability except the biophysical components (exposure is biophysical, as is sensitivity, to an extent). Adaptive capacity, on the other hand, which represents societal and human dimensions, is where you are most likely to find specific factors determining vulnerability of women or disadvantaged groups.

Focussing on gender and disadvantaged groups usually adds another level of detail to your analysis. Consider a dedicated screening for these issues once an impact chain has been developed. This should focus on the following questions:

- Does the identified impact have a particular effect on women or disadvantaged groups?
- Are any of the factors in the impact chain specific to women or disadvantaged groups? What form does this effect take?
- Are there any additional factors that are specific to one gender or a particular societal group that should be included in the assessment?

Another way of including women and disadvantaged groups is to take a gender-neutral impact such as 'water scarcity in small-holding agriculture', and phrase it as, for example, 'water scarcity in small-holding agriculture conducted by women'.

You can also ask: if there is a specific impact, how does it particularly affect women and disadvantaged groups? Here, sub-impacts are identified and must be considered when elaborating on sensitivity as well as adaptive capacity.

! POTENTIAL PITFALLS

An impact chain should provide a good representation of the system under review. However, attempting to capture reality in all its detail and interconnections is one of the most frequent pitfalls when developing impact chains. An impact chain – just like any model – must reduce the complexity of the real world. The more complex your model, the more complex the assessment – and the more time and resources are required. Concentrate on the most relevant factors influencing vulnerability to keep your assessment feasible. Remember to make sure that the potential impacts identified are predominantly driven or aggravated by climate change as you are assessing vulnerability to climate change. For sensitivity, however, it is necessary to identify non-climatic factors (such as deforestation, available physical infrastructure) offering entry points for adaptation measures.

It is also important that you not (yet) restrict your impact chains for practical reasons, such as data availability. At this early stage of the assessment, a factor's relevance should be your sole criterion for integrating it into the impact chain. This will ideally result in a comprehensive picture of the vulnerability of your system with no significant factors omitted.

m3

GUIDELINES

m3

Module 3:

Identifying and selecting indicators

What will you learn in this module?

This module will show you how to select indicators for your assessment. It provides you with the criteria for deciding which indicators are suitable for quantifying the factors determining vulnerability identified in Module 2.

Key steps and questions addressed in this module:

Step 1
Selecting indicators for exposure and sensitivity

- How do I assess the exposure and sensitivity components of the impact chain?

Step 2
Selecting indicators for adaptive capacity

- How do I assess the adaptive capacity components of the impact chain?

Step 3
Check if your indicator is specific enough

- Are my indicators sufficently specific?

Step 4

Create a list of provisional indicators for each factor

- How do I generate a list of indicators with key information about content and data requirements?

What do you need to implement this module?

To select appropriate indicators for your vulnerability assessment, you need:

- The objectives of your vulnerability assessment which were determined in Module 1
- The impact chains developed in Module 2, which show how factors contribute to potential impacts

What are the outcomes of this module?

After completing Module 3, you will have:

- A provisional list of indicators representing all relevant factors of your impact chain and basic information about data issues

Which tools and information does the Annex provide?

In the Annex you will find:

- List of standard indicators including potential data sources (Annex 3, 4 and 5)
- Indicator fact sheet (Annex 6)

What are indicators used for?

In Module 2 you developed an impact chain and identified the relevant factors that intensify or mitigate climate change effects. Your task now is to quantify these identified factors. To do this, you will need to identify indicators that allow you to assess or measure these factors (see Box 7). An example of an indicator representing the factor 'access to information' is 'amount of households with TVs'. Alternative indicators might include 'households with radios' or 'households with internet access'.

Table 6 lists some examples of indicators used in assessments and their links to factors and vulnerability components. In Annex 3 you will find a more compre-

Table 6: Examples of factors and potential indicators

Vulnerability component	Factor	Possible indicators
Exposure	Precipitation	Average daily rainfall over 30 years [in mm]
		Average amount of days with snow-fall in the winter months (DJF) over the last 10 years
Sensitivity	Land use	Classified land cover map
	Topography	Slope gradient [in %]
Adaptive capacity	Poverty	GDP [in US$/year] for the year 2000
		Portion of household income spent for basic needs [in %] in the year 2000
		Proportion of population living below the national poverty line in 2000

Source: adelphi/EURAC 2014.

hensive list of indicators that are often used in vulnerability assessments concerned with rural areas. Moreover, Annex 3 also provides sample indicators used for the vulnerability assessment in Germany that is conducted by the 'Vulnerability Network' (see Introduction).

You will need to select at least one indicator for each relevant factor in your analysis. These indicator values will later be aggregated to vulnerability components (exposure, sensitivity and adaptive capacity) and thus contribute to the composite vulnerability score.

7 EXPERT

What are indicators and how are they used in the Vulnerability Sourcebook?

In general, indicators are parameters which provide information about specific states or conditions which are not directly measurable (after Meyer 2011). The purpose of applying indicators is to use this quantified information to compare against critical thresholds or previous measurements. This might be for M&E purposes, determined objectives or for other observations, such as a comparison of different communities (UNAIDS 2010). Indicators are used in a wide range of fields including chemistry, biology and economics (OECD 2008). They are also used extensively in assessing vulnerability in socio-ecological systems in the context of climate change. For these assessments, 'vulnerability' is usually broken down into more tangible components (in our approach these are 'exposure', 'sensitivity', and 'adaptive capacity'). Each component is made up of multiple factors (e.g. 'crop type' or 'irrigation system' for sensitivity). Indicators are selected to quantify each factor.

Indicators may be more or less direct in their relationship to the phenomenon they are intended to measure. An example of a direct indicator is 'rainfall amount' as an indicator for 'precipitation' or 'population density per unit' as an indicator for 'over-population'. Indirect – or proxy – indicators are used when direct measurements are unfeasible or inappropriate. Proxies are also applied where no data are available, or for highly complex parameters. A widely used example is 'GDP' as a proxy for 'poverty'. Proxy indicators can be useful for describing non-tangible factors but their validity, that is, their explanatory power in relation to the factor in question, must be verified and approved by users and stakeholders.

What makes a good indicator?

In practice, selecting indicators is an iterative process whereby a list of ideal choices is slowly thinned out, with indicators rejected where they are unfeasible or – in particular – where there are insufficient data to substantiate them. That is why the outcome of this module is a list of *provisional* indicators, which will be confirmed in Module 4.

A good indicator has the following characteristics:

- It is **valid and relevant**, i.e., it represents well the factor you want to assess
- It is **reliable** and credible and also allows for data acquisition in the future, which is particularly important for M&E
- It has a **precise meaning**, i.e. stakeholders agree on what the indicator is measuring in the context of the vulnerability assessment
- It is **clear in its direction**, i.e. an increase in value is unambiguously positive or negative with relation to the factor and vulnerability component
- It is **practical and affordable**, i.e., it comes from an accessible data source
- It is **appropriate**, i.e., the temporal and spatial resolution of the indicator is right for the vulnerability assessment

(after GIZ/WRI 2011 and CIDA 2004)

How to start identifying indicators?

First, pick one of the factors directly above your potential impact in the impact chain and work your way up to the top. We recommend concentrating on factors linked to exposure and sensitivity before focusing on adaptive capacity, while looking for measurable indicators which best describe or quantify the factor at hand.

Step 1
Selecting indicators for exposure and sensitivity

Let us start with the factors immediately above your potential impact, which most likely relate to exposure and sensitivity. If your potential impact is flooding, say, you may determine that it is caused by meteorological events such as heavy rainfall or snowmelt. Additionally, however, it may be influenced by sensitivity parameters such as soil sealing, vegetation, geology, and so forth. In many cases identifying relevant exposure indicators goes hand in hand with determining relevant sensitivity parameters. In selecting indicators you will need to consider the influence of both components. Ideally you will have physical models at your disposal (such as hydrological models in the example of flooding). It is more likely, however, that you will be reliant on past observations or expert opinion, or a combination of the two.

The further up the impact chain you go, the more likely that factors will relate to exposure or sensitivity. Indicators for exposure largely consist of directly measured (or modelled) climate parameters such as average temperature, amount and distribution of precipitation, or evapotranspiration data. For exposure factors you will need to specify the frequency of data values you require depending on the climate change impact in question. Average monthly rainfall data, for instance, may suffice as a measurement for water availability for crops. However to assess soil loss through erosion you will need hourly rainfall data. When quantifying extreme weather you might choose an indicator which describes the frequency and magnitude of events, such as 'number of days per year with a maximum temperature > 35°C'.

Sensitivity indicators are usually biophysical or physical; examples include type and density of vegetation cover, altitude and gradient of slopes, and irrigation systems in use. Unlike meteorological and socio-economic characteristics, these indicators – particularly topography parameters – tend to be more stable and constant.

As you consider indicators, it is a good idea to also consider potential data availability. This question will be discussed in more detail in Module 4.

TIP

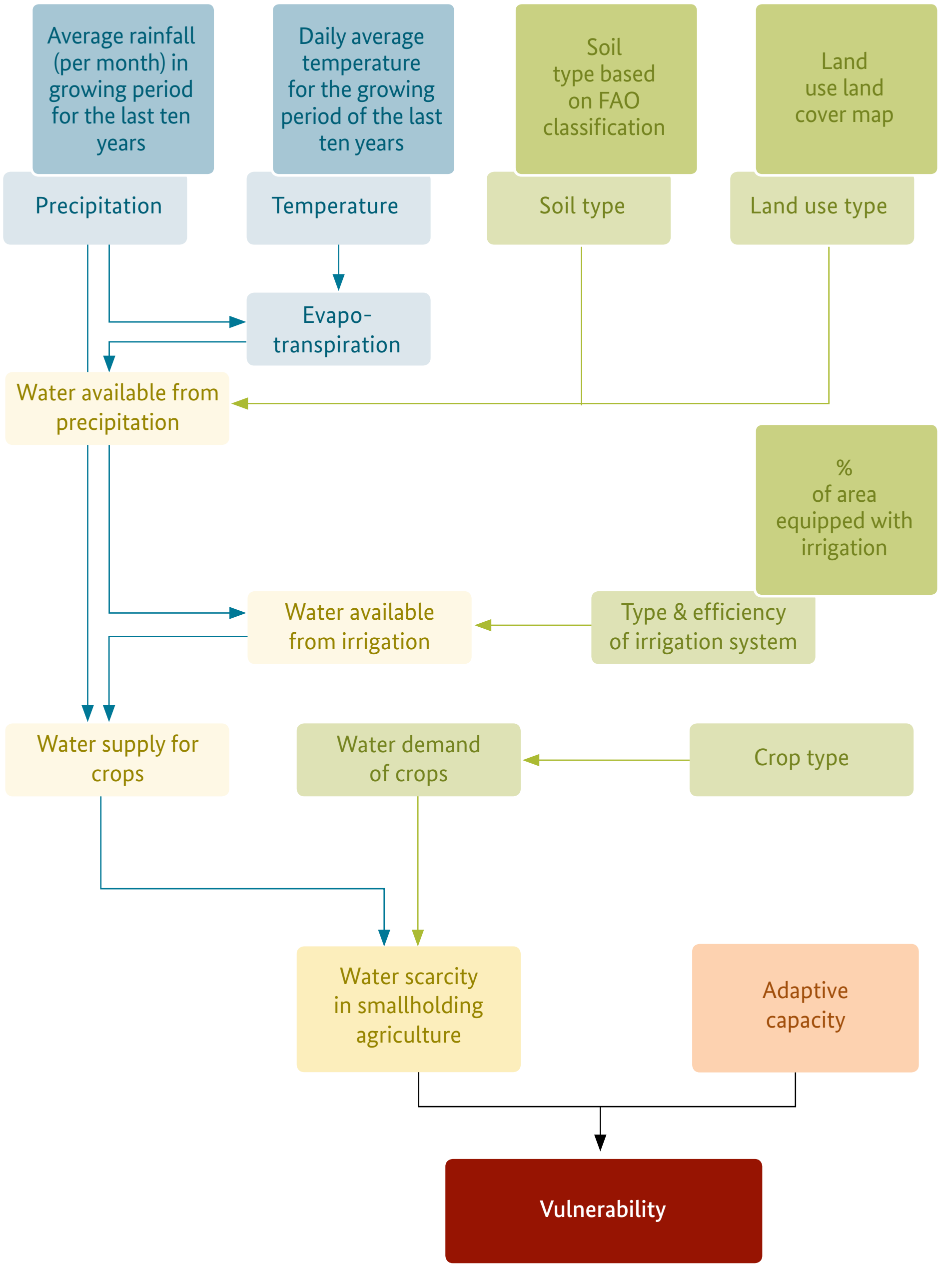
In your impact chain, particularly in the lower part, you may find indicators for a particular factor which also addresses and includes factors above it in the chain. For example, an indicator measuring evaporation will include the factor 'temperature' since this is a crucial element in evaporation. A separate temperature indicator would therefore be redundant and can be left out.

To illustrate this procedure, we return to the impact chain from Module 2 which led to the potential impact 'water scarcity in small-holding agriculture'. Above this potential impact we have two separate sub-chains, one leading to 'water supply for crops' and one leading to 'water demand of crops' (see Figure 18).

Water supply for crops

Consider the sub-chain 'water supply for crops'. Here the respective impact might be defined as the sum of water available from precipitation and irrigation. Let us concentrate first on water available from precipitation. Ideally, there would be existing calculation rules for your study area that provide you with relevant data.

Figure 18: Exposure and sensitivity indicators for the impact 'Water scarcity in agriculture'



Source: adelphi/EURAC 2014.

This could be a complex hydrological model or a simple function combining relevant input parameters. Where such calculation rules exist they would cover the preceding factors, meaning you would not need to find dedicated indicators for 'precipitation', 'temperature', 'evapotranspiration', 'soil type' or 'land cover type'. Without such a rule, however, you would need indicators for the exposure factor 'temperature' (e.g. daily average temperature for growing period over the last 10 years) and 'precipitation' (average monthly rainfall). You would also need indicators for the sensitivity factors 'soil type' (e.g. a map of soil types) and 'land use' (e.g. a land use map).

This leaves the factor 'water available from irrigation'. There may be measurements or model calculations available for irrigation, or alternatively a local expert might be able to estimate the amount of water from these systems. If this is unfeasible you might consider an indicator such as 'percentage of area under irrigation'.

Water demand of crops

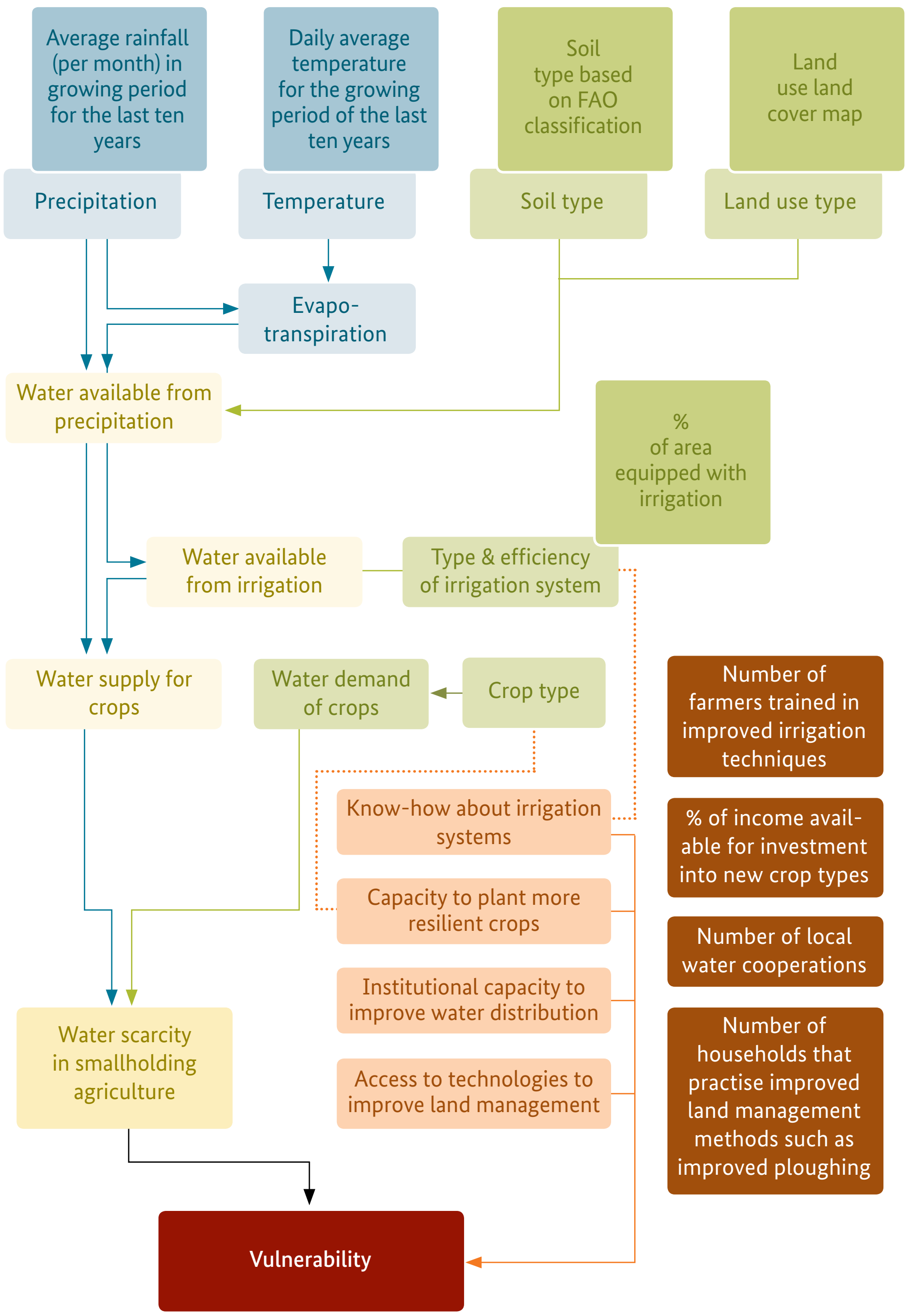
For the impact 'water demand of crops' a potential indicator might be 'water demand (in m^3) per growing period'. For many regions there are tables which estimate this value by crop type and temperature. In this case the whole chain is accounted for, meaning that the 'crop type' factor needs no further consideration.

Step 2
Selecting indicators for adaptive capacity

After you have specified indicators for exposure and sensitivity factors, your next step is to select at least one indicator per adaptive capacity factor (see Figure 19). For these factors, indicators are usually less direct and hence not so self-evident. For example, a factor such as 'willingness to implement adaption measures' is difficult to grasp or measure. One option in this case is to choose an indicator which reflects openness to innovation, such as the introduction of new crops better adapted to dry conditions.

As a consequence – and in contrast to exposure and sensitivity – it is often useful to select more than one indicator for adaptive capacity factors. The example list of indicators in Annex 4 illustrates this point. While the indicator 'classified land use map' suffices for the 'land use' factor, 'poverty' requires even more substantiation than the three listed indicators 'GDP', 'portion of household income spent for basic needs' and 'population living below the national poverty line in 2000'. In practice the number of indicators is often limited by data availability or resource constraints (time and budget). The number of indicators required to represent a particular factor varies from case to case and should be guided by topic-specific expertise.

Figure 19: Adaptive capacity indicators for the impact 'Water scarcity in agriculture'



Source: adelphi/EURAC 2014.

In any case and particular for the component of adaptive capacity, it is important to integrate local expertise and to find a consensus between the involved experts and stakeholders.

Step 3
Check if your indicator is specific enough

Once you have identified the indicators for your assessment, take some time to assess whether they are sufficiently explicit. Indicators can be formulated in a very broad way, which can cause problems when it comes to identifying suitable data sets. For example, 'poverty level in the population' is not a sufficiently explicit indicator for measuring the factor 'poverty'. A better indicator would be 'percentage of households on income of less than 1 US$ per day'. This indicator provides you with a clear indication of what exactly you intend to measure. Your indicators should be explicit in two regards:

Spatial coverage and resolution

- What is the exact spatial extent (e.g. a community, a watershed, a country) which should be covered by your data?
- What spatial resolution should your data have? Do you require population density data at district or municipal level? Do you need run-off data for catchment areas at the first order, or the second, third, fourth?

Temporal coverage and time frame

- What time period will the data need to cover? How far will you be looking into the past/future? You may need meteorological data for the last 30 years, or climate projections for distant future (2021-2050).
- How frequently and at what intervals do you plan to repeat the vulnerability assessment for monitoring purposes?

When compiling your indicators, start considering the data which already exist for your assessment. You may decide on an indicator which has no suitable data to substantiate it whereas another indicator – with a slightly different name – may give you the data you need. This is an iterative and often time-consuming process: identifying an indicator, sourcing suitable data, reformulating the indicator, checking data quality and finding alternative sources where necessary (see Module 4).

m3

Step 4

Create a list of provisional indicators for each factor

At the end of Module 3 you will have identified at least one indicator per factor in the impact chain(s) developed in Module 2. The results of this work should be captured in a table or spread sheet, recording all potential indicators with any relevant additional information, particularly:

- A brief description of the indicator
- The factor and vulnerability component (exposure, sensitivity or adaptive capacity) the indicator represents
- A brief explanation outlining your reason for selecting this indicator
- The spatial coverage required for the indicator data
- The unit of measurement or spatial resolution required
- The temporal coverage required
- The required period for updating indicator values
- Potential data sources

These are the 'metadata' you need to collect for your indicator. In Module 4 you will be adding more information to this list. Annex 6 provides you with an indicator factsheet template to help you document relevant information.

POTENTIAL PITFALLS

Indicators are often formulated without regard for specific details, such as spatial and temporal coverage. Any content-specific information should be defined at this point in the vulnerability assessment. Experience shows that retrieving this information at a later stage can be very time-consuming.

Another frequent pitfall in indicator selection is underestimating the question of data availability. The best indicator is inoperable if there is no feasible way of acquiring required data. The paradox here is that you need to find out about data availability to select a possible indicator, but you can only determine availability for a limited number of potential indicators. The solution is to listen to expert opinion and examine previous studies to reduce the number of potential indicators at the start.

m4

Module 4:

Data acquisition and management

m4

What will you learn in this module?

This module shows you how to acquire, review and prepare data for your vulnerability assessment. This includes guidance on data collection, database construction and linking relevant data to your chosen indicators to allow analysis and modelling of vulnerability.

Key steps and questions addressed in this module:

Step 1
Gather your data

- What kind of data do you need?
- Who can provide the data?
- What alternatives are available if your preferred data sources prove unreliable?

Step 2
Data quality check

- Are the data in the format you expected? Are all the files legible and ready for further processing?
- Is the temporal and spatial coverage as planned?
- Is the value range of the data as expected?
- Are there any missing data values or ‘outliers’ in your data?
- Are the data in the right geographical projection?

m4

Step 3

Data management

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

What do you need to implement this module?

To gather and manage your data, you will need:

- Your list of proposed indicators from Module 3, including name, unit of measurement and potential data sources
- Knowledge of available resources (financial, but also skills, including data analysis/processing, leading surveys and workshops)
- Knowledge of available data sources in your country/region

What are the outcomes of this module?

After completing Module 4, you will have:

- A final indicator list
- A database containing all the data for further analysis in this assessment
- Complete indicator factsheets

Which tools and information does the Annex provide?

In the Annex you will find:

- Indicator fact sheet (Annex 6)

Moving from a preliminary to a final list of indicators

In Module 3 you developed a draft list of indicators and identified potential data sources to quantify your indicators. Your next steps are gathering the required data (Step 1), checking quality and preparing it for utilisation (Step 2) before documenting and storing the data in a suitable database (Step 3).

Throughout Steps 1 and 2 of this module you may find that the data you planned to use is either not available or has significant quality constraints. In this case you may need to return to Module 3 and revise your indicator framework. However, once you have collected, prepared, documented and stored your data, you will have your final indicator list and the data will be ready for further use.

Where do data come from?

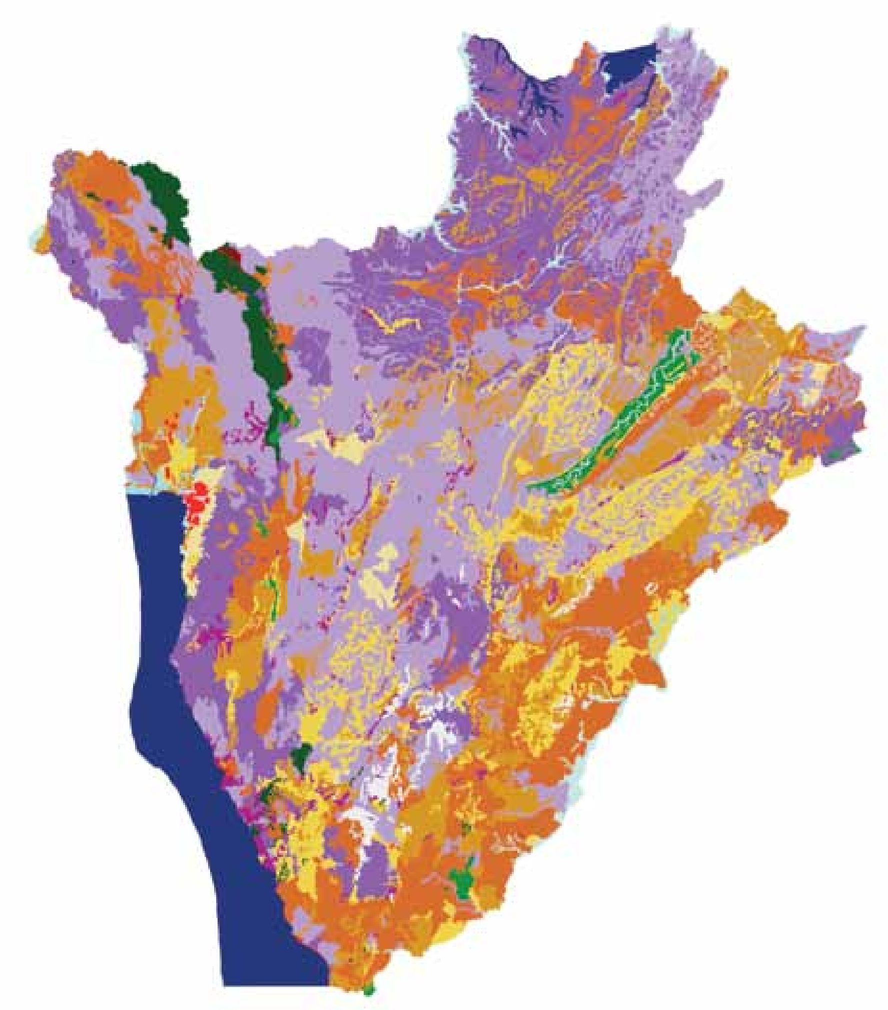
For this module, it is worth thinking more about how data are collected before finalising your list of indicators. The data you require to quantify your exposure, sensitivity and adaptive capacity indicators are likely to have been collected using different methodologies.

Here is a brief overview of the different ways your data may have been collected or generated:

- **Measurement:** Physical measurements are carried out for indicators such as air humidity, water runoff and soil moisture using thermometers, hygrometers, gauges and other instruments. Measurement also encompasses 'remote sensing' methods, such as analysis of satellite data to determine land use/ land cover (see Figure 20). Many assessments draw on data from measurements to quantify exposure and sensitivity indicators.

- **Censuses and surveys:** Data used to quantify adaptive capacity indicators (and to some extent sensitivity indicators) are largely provided by censuses, surveys and related approaches. They can provide information on household income, education and traditional irrigation techniques. As with physical measurements, the expertise required for this method of data acquisition– drafting questionnaires, conducting surveys, selecting representative samples, analysing statistical data – is very context-specific, but crucial for obtaining robust results. Socio-economic data obtained through censuses or surveys may further be aggregated – from community to province level, for example – and extrapolated before you incorporate it into your vulnerability assessment.

Figure 20: Example of a land cover map used in the Burundi vulnerability assessment

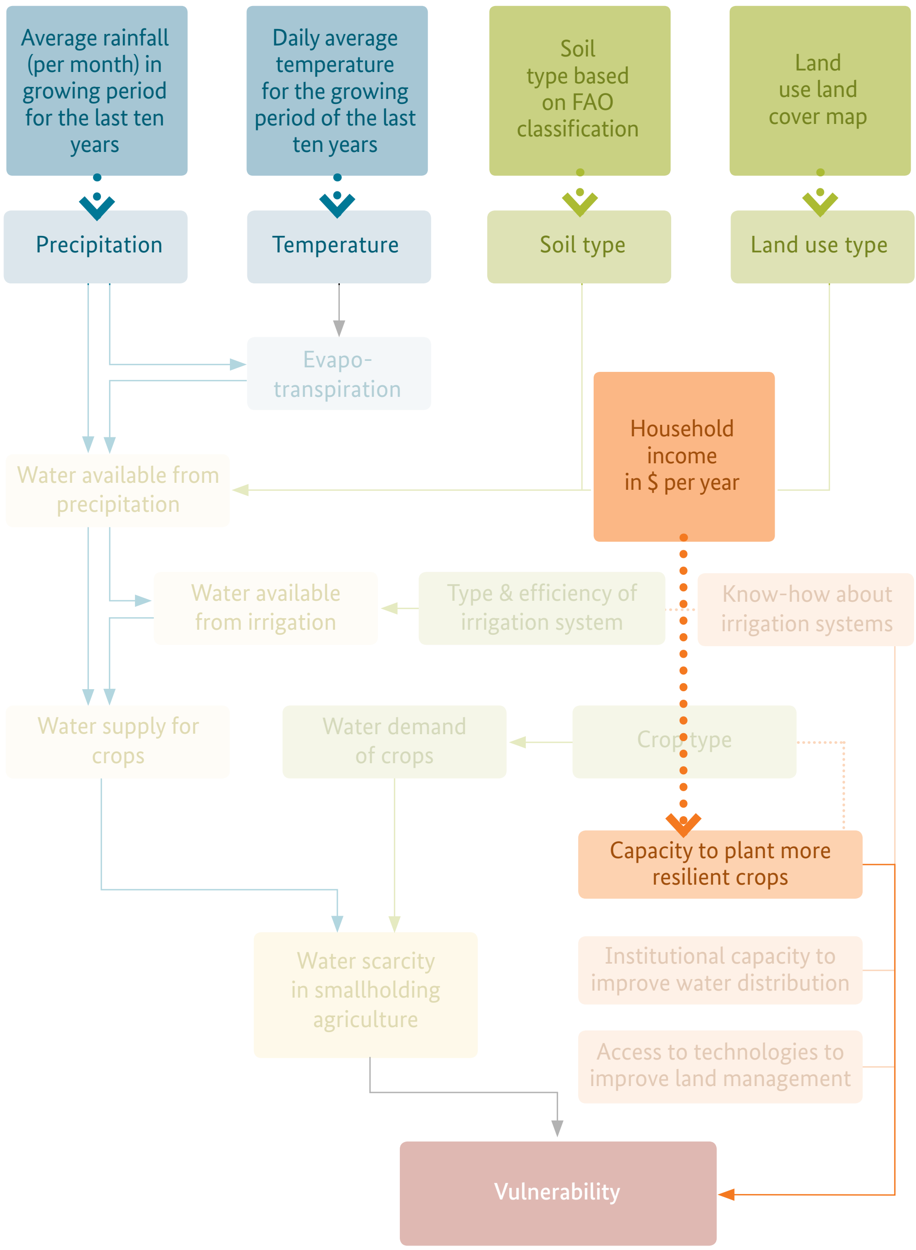


- Forest plantations and tree plantations
- Shrub crop
- Herbaceous crops
- Vegetated urban areas
- Forest
- Woodland
- Closed woody vegetation
- Open woody vegetation
- Thicket
- Shrubland
- Tree savannah
- Shrub savannah
- Grassland
- Sparse trees
- Sparse shrubs
- Sparse herbaceous vegetation
- Fields rice
- Closed swamp
- Open swamp
- Woody vegetation on flooded land
- Shrubs on flooded land
- Herbaceous vegetation on flooded land
- Artificial surfaces
- Bare soil
- Water bodies
- Snow

Source: AfriCover (FAO).

- **Modelling:** Data for your assessment may also come from models, such as climate, crop and hydrological models. These are complex calculation tools integrating a variety of indicators in order to represent the functional relationship of various input parameters in a simplified way (see Figure 21). Consequently models are often used in vulnerability assessments to estimate climate change exposure (e.g. change in temperature or precipitation) as well as potential future climate change impacts (e.g. runoff for a certain amount of precipitation, change in crop yields due to temperature change).

Figure 21: Example indicators from direct measurement (exposure and sensitivity) and surveys (adaptive capacity)

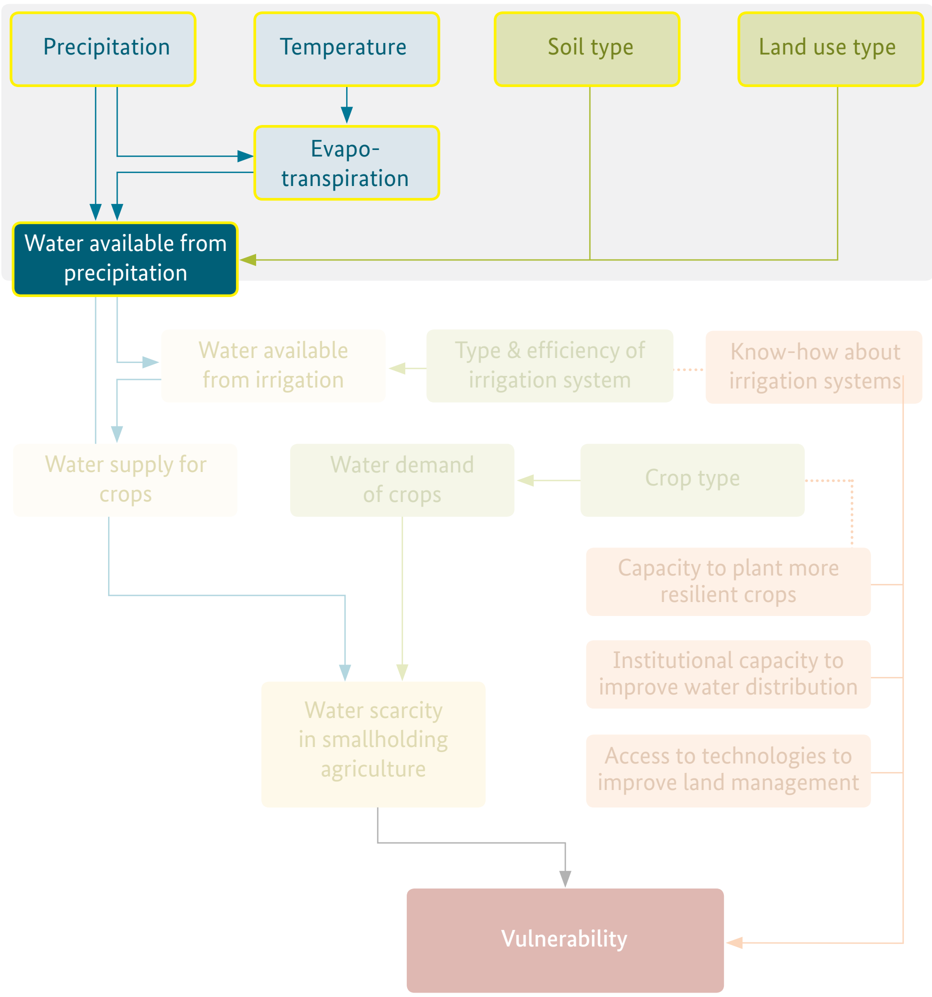


Source: adelphi/EURAC 2014.

The complexity of models means this is usually a time- and resource-intensive method of developing data, requiring the expertise of research centres, universities and private companies. Here, too, the quality of the model is highly dependent on the quality of the input data – which usually comes from measurements. The best flood inundation model, for instance, will not work without suitable elevation models and relevant meteorological data time series.

- **Expert judgement:** The methods detailed above may not be appropriate for every vulnerability assessment. Data may not be available in the required quantity or quality, or there may not be enough time to generate data specifically for the assessment. A very localised scope in an area with poor data availability may also present a challenge. In this case you may need to draw on the knowledge of local experts to quantify certain indicators. This could include questions like, has the rainy season in the region shifted over the past 20 years? By how many weeks?

Figure 22: Example of a modelled intermediate impact comprising further vulnerability factors



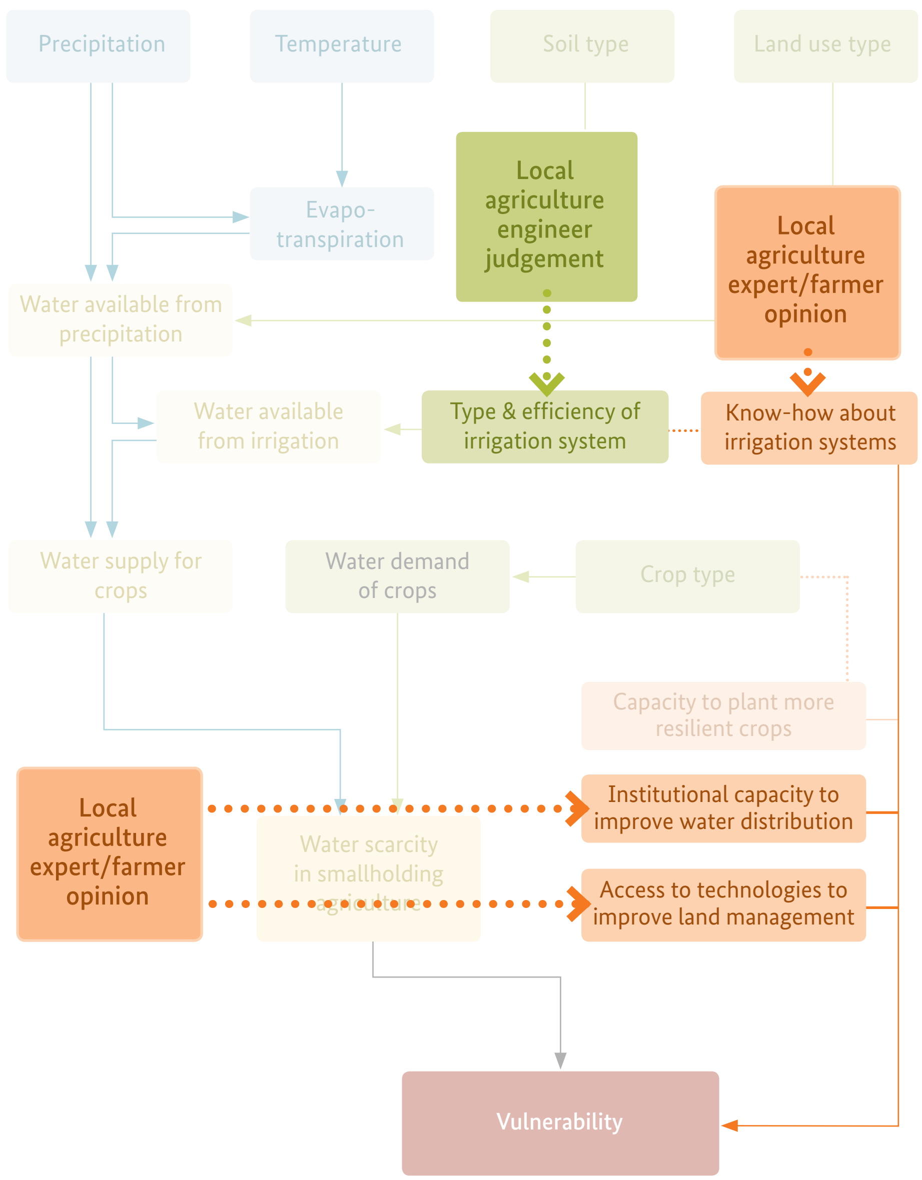
Source: adelphi/EURAC 2014.

And has rainfall increased or decreased during the rainy season? This could be used to quantify exposure indicators related to the amount and temporal distribution of precipitation.

Remember, however, that expert judgement is based on the experience and perception of respondents, and is thus subjective. Expert judgement might be captured in the form of participatory workshops or in interviews with selected experts and stakeholders.

We will return to these different methods of data collection as we guide you step by step through this module.

Figure 23: Example of a modelled intermediate impact comprising further vulnerability factors



Source: adelphi/EURAC 2014.

Step 1

Gather your data

Obtaining the data you need for your assessment can be as easy as downloading available census data or GIS maps from publicly accessible websites. However it can also be complicated, particularly when it comes to conducting surveys or processing large datasets such as Earth observation data. It all depends on the following closely related key questions:

- What kind of data do you need to quantify your indicator?
- Do the data already exist?
- If they are not available what can you commit in terms of time and other resources to generate them?

You may well find yourself in a situation where some data are readily available while other datasets are of poor quality or missing altogether, forcing you to find an alternative. Let us start with the first question:

What kind of data do you need to quantify your indicators?

There is no one-size-fits-all solution, but most assessments will require either measured or modelled data for exposure and sensitivity indicators, and statistical data from censuses or surveys for adaptive capacity indicators. The scale of your assessment (e.g. 5x5 km, community-level, national level), the extent of the area covered (e.g. one or two communities, a whole country, an entire region) as well as the outputs you aim to produce (e.g. maps, diagrams) are crucial in deciding what data to look for.

If your vulnerability assessment focuses on the local level, for instance, national values for average household income will not be sufficiently specific. You would then need to determine whether there are subnational data available for the area under review.

Do the data already exist or do they have to be generated?

As a first step, we recommend that you first verify whether organisations at the local, national or international level provide statistics or maps for the data you require. Your draft indicator list developed in Module 3 should provide you with some ideas for relevant institutions to contact. The sheer number of institutions and experts you will need to contact to obtain your data often makes this one of the most time-consuming steps, especially as follow-up negotiation is often required.

Depending on the thematic scope of your study, your points of contact may include statistical offices, meteorological authorities and government departments covering forestry and the environment, to name just a few. 'National Spatial Data Infrastructures' (NSDI) are another key entry point for data acquisition. NSDIs have been established in many countries and will ideally offer standardized data, even where it is sourced from multiple institutions.

Box 8 provides you with some examples of regionally and globally available data sets.

TIP

When using data from different institutions, you should familiar yourself with their data sharing policies, which may be relatively open or more restrictive. Data acquisition may also require formal agreements with data providing bodies. Make sure that any property rights for the distribution and publication of data, or products derived therefrom, are respected.

What can you commit in terms of time and other resources for generating data?

In an ideal case you may find all the data you need to populate your indicator list from different institutions in the country or region under review. But if the data are not available or of insufficient quality, you may decide to collect data yourself as an alternative to choosing another indicator.

You will need to carefully assess the required costs and expertise needed for data collection to quantify particular indicators. Some basic rules apply here:

- For meaningful results, observation of biophysical indicators such as precipitation, temperature, run-off must be made over long periods – often over decades. The time and money required for this means it is almost certainly unfeasible for your vulnerability assessment. Luckily, however, most countries can provide such data. If you require highly localised data, expert judgement may be a worthwhile alternative.
- Data for socio-economic indicators such as average household income, average size of household and livelihood strategies can be captured in surveys. The

8 EXPERT

Using regionally or globally available data sets

Depending on the geographical scope of the area under review, regionally and globally available datasets may be relevant. A number of bodies (including AfriPop, CIESIN, DHS) facilitate access to information such as global population data, while the IPCC and research organisations (see Table below) perform a similar role with climatological data. You may need to involve external consultancies with specific knowledge and/or link up with national and international institutions already involved in implementing vulnerability assessments.

Table 7: Overview of selected available datasets useful for vulnerability assessments

Category	Data provider	Data elements	Link
Climate	CRU TS 3.1 (Climatic Research Unit)	Temp., precip., cloud cover, vapour, evap., etc.	http://www.cgiar-csi.org/data
	NOAA-NCDC: Global Summary of the Day	Temp., precip., cloud cover, vapour, evap., etc	http://gis.ncdc.noaa.gov/map/viewer/#app=clim&cfg=cdo&theme=daily&layers=0001&node=gis
	IPCC Data Distribution Centre	Observations & simulations	http://www.ipcc-data.org/
Land cover	globcover	Land use / land cover	http://due.esrin.esa.int/globcover/
Population	WorldPop	Population, demography, births, poverty, pregnancies, urban change	http://www.worldpop.org.uk/
	Gridded Population of the World (GPWv3)	Population counts, population density	http://sedac.ciesin.columbia.edu/gpw
Survey	DHS	Demographic and health surveys	http://www.measuredhs.com/data/available-datasets.cfm
Geographic data	Open Street Map	Baseline geographic data	http://openstreetmap.org/

Source: adelphi/EURAC 2014.

time and money required depend largely on the sample size. A representative survey may cover a whole country, or just a few communities (see Box 9). At the sub-national level, surveys can be an effective means of gathering information not captured by national institutions, such as perceptions around climate and environmental change. Be sure to involve a local expert who can help in drafting the survey, selecting a representative sample and analysing the resulting data (see Box 10).

9 EXPERT

Ensuring a representative sample

If you are collecting your own data based on a survey, it is vital that you make a representative sample selection. The term 'sampling' refers to methods of selecting a subset from a population (e.g. a specific number of households participating in a household survey) from which you can make inferences about the whole. Sampling facilitates data collection, and can be done in a representative way (probability sampling) or non-representative way (non-probability sampling). We however recommend you to apply methods for representative sampling. For example, at the community level the selection of individuals could be done by selecting every fifth, tenth, fiftieth, etc. person from a (complete) list or register of the community's inhabitants.

The most commonly used probability sampling method is simple random sampling, where individuals are chosen from the population at random, with every person having an equal chance of selection.

Further reading on sampling:

- Carletto, C. 1999: Constructing Samples for Characterizing Household Food Security and for Monitoring and Evaluating Food Security Interventions: Theoretical Concerns and Practical Guidelines. International Food Policy Research Institute Technical Guide #8, Washington D.C.: International Food Policy Research Institute (IFPRI). Retrieved 16.04.2014 from http://www.fao.org/docs/eims/upload/219147/tg08.pdf.
- World Food Programme 2004: Thematic Guidelines Sampling: Sampling Guidelines for Vulnerability Analysis. Rome: WFP. Retrieved 16.04.2014 from http://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp197270.pdf.
- United Nations Department of Economic and Social Affairs Statistics Division 2005: Household Sample Surveys in Developing and Transition Countries. In: Studies in Methods, Series F No. 96, New York: United Nations Publications, ISBN 92-1-161481-3. Retrieved 16.04.2014 from https://unstats.un.org/unsd/hhsurveys/pdf/Household_surveys.pdf.
- Andres, L. 2012: Designing and Doing Survey Research. SAGE Publications Ltd. Retrieved 17.04.2014 from http://www.sagepub.com/booksProdDesc.nav?prodId=Book234957.

10 PRACTICE

A representative household survey in Mozambique

During the application of the Vulnerability Sourcebook in Mozambique, vulnerability to natural disasters and food shortages was assessed in the two districts Mabote and Inhassaro. After a set of indicators was agreed, data availability was checked in an iterative process. This check revealed that a number of indicators – particularly adaptive capacity indicators – could not be quantified with readily available data. Project organisers consequently decided to implement a representative household survey. The table below show some of the adaptive capacity indicators and how they were addressed in the questionnaire.

Table 8: List of indicators covered by a household questionnaire in Mozambique.

Vulnerability component	Indicator	Unit	Question
Adaptive Capacity	Percentage of households saving crops	Per cent	Does your household save some of the crops you harvest to eat during a different time of the year?
	Percentage of households depending on subsistence farming	Per cent	How much of your food supplies come from your own personal farm (agricultural production and livestock)?
	Average distance to health facility	Per cent	How long does it take you to get to the nearest health facility using your normal means of transportation?
	Percentage of household members with a chronic disease	Per cent	How many members of your household suffer from chronic diseases?

Source: adelphi/EURAC 2014.

For each indicator in the list, the team formulated a question which was readily comprehensible and likely to prompt a clear answer. This list of questions was used to design the questionnaire. No longer structured in terms of vulnerability components, the questionnaire instead presented questions in an order which would be logical to the respondent. Grouping related questions, for example, helped respondents answer the questionnaire and thus improved data quality. The unit of measurement was also specified, such as average travel distance to nearest health facility, here assessed in minutes.

- Modelled data are both time- and resource-intensive and usually requires measured data as input. When it comes to national or supra-national assessments, however, it may be worth investing several months in developing regional climate or hydrological models. For meaningful results you will need to ensure that you can call on the required modelling skills.
- Where time and financial resources are limited, expert judgement can be a good, fast way of quantifying indicators that cannot otherwise be assessed. This is most often the case at a very local level – such as a village or community – which is rarely covered by detailed statistical data, and where the climatic and hydrological characteristics are too specific to be captured by modelling. This local knowledge – captured using participative methods as well as scoring and ranking – can be used to either complement or replace surveys. Remember, however, that information gathered in this way is always subjective. Moreover it is difficult to repeat and limited in precision and spatial distinction. A balanced selection of experts and stakeholders will increase your chances of obtaining meaningful results.

Once you have gathered your data from available data sources, you can move on to the next steps and assure the quality of your data. It may happen that this step will reveal major data quality issues leading you back to Step 1 of this module. In case you may decide to collect data on your own you should carefully consider the quality issues discussed in Step 2 while planning collecting your data.

Step 2
Data quality check

Data are vital to any vulnerability assessment and the quality of the results depends to a great extent on the quality of the data (or conversely, 'garbage in, garbage out'). Once you have gathered your data you will need to conduct a quality check. Ideally, you keep the quality criteria below already in mind while collecting data. In practice, however, you may first gather the data and then choose the most appropriate data set. For that purpose, use these questions as a guide:

Are the data in the format you expected? Are all the files legible and ready for further processing?

Data may be provided in different formats, such as Excel files or CSV, or the more complex formats used for climatology data (e.g. netCDF). Ensure that you are able to read and process the data. If not, the data provider may need to provide additional explanation of formats; alternatively you might require external expertise in converting data. If you choose to attempt this yourself there are conversion tools available on the internet. In a worst case scenario, where data are unreadable or cannot be processed, you may need to redefine your scope of assessment or find alternative indicators (Module 3).

Is the temporal and spatial coverage as planned?

Geographical coverage and timeframes may vary among different data sources, so determine whether they can be combined and compared. Where data are missing or inconsistent, find out whether you can source additional data from measurements, censuses or surveys. If not, you may need to modify the indicator framework and discard weak indicators.

Are there any missing values or 'outliers' in your data?

Data gaps are a recurring problem in the area of quantitative data (e.g. regions omitted from geographical data, time periods missing from time series data). You can try and close smaller gaps with interpolation, that is, finding existing data nearest to the gaps (in space or time) most likely to match the missing data. In your data 'outliers' may also turn up. These are values which are far outside the expected range; they may indicate an error in the data capture method. The OECD guidelines (OECD 2008) offer sound guidance on data imputation methods and dealing with outliers.

Are the data in the right geographical projection?

Different sources of spatial data may well use different coordinate systems and projections. This is an additional challenge when working on cross-border regions, and you should consider using a common geographic reference system for the case study region such as the UTM (Universal Transverse Mercator) reference system.

If your datasets fail this quality check – and you are unable to apply any of the remedies described above – you will need to consider another approach. This may be an alternative data source, a proxy, or an alternative indicator (e.g. distance to school instead of census data on education levels) or alternative means of data acquisition such as expert input. As a last resort you may need to modify the indicator list from Module 3. Modules 3 and 4 are closely linked and may involve iterative steps.

Step 3
Data management

Once datasets are collected (Step 1) and checked for quality (Step 2) they should be stored in a common database to avoid the risk of redundancy and data loss. This might range from a simple data collection in a structured set of folders to more complex databases (e.g. Excel spread sheets, geo-databases, Access databases, distributed web-based databases). You may need to transform different types of data into a common data format (see above), perhaps utilising export and transformation routines from multiple software products. If you are working with multiple partners and stakeholders you should ensure that they can all access the different datasets required for further analysis. Depending on the scope of your assessment you may also need to assign responsibilities for database management and maintenance.

The documentation of metadata is an important element in data management. Metadata are, simply, data about data, functioning much like a catalogue which provides data on the books in a library. It describes the content and characteristics of the different datasets and instructions for interpreting values. This includes where and when the data were obtained and analysed, the institution responsible for it and instructions for searching and other functions. There are international standards (such as ISO 19115 and the Dublin Core Standard) which provide guidance on structure and mandatory fields for metadata. Standardised metadata editors are also often included in GIS software products. Additionally, in Annex 6, you will find an indicator fact sheet which you can use to document your data and indicators. Although this is a time-consuming exercise, experience has shown the importance of documenting data, particularly when qualitative or quantitative questions regarding your data arise. Insufficient knowledge about data from third-party organisations can also lead to duplication of effort.

TIP

If you are planning to use your vulnerability assessment for M&E of adaptation (see Chapter IV), you may need to retrieve data after an interval of several years. Ensure that you store your data, including metadata, carefully and systematically – along with your assessment methodology and results – so that you can repeat your vulnerability assessment in the future.

POTENTIAL PITFALLS

Potential pitfalls within this module include poor data quality, lack of metadata documentation, limited access to data sources as well as the challenges associated with varying data formats. The quality of the vulnerability assessment results depends greatly on the input data, and you will need to find alternatives if data fail quality checks. This point demands particular attention as it will greatly influence the impact of the assessment.

It is also important that you invest sufficient human resources into proper documentation of metadata. Poor-quality documentation may result in data loss and missing results in the long term. Furthermore, transparency and credibility of your results may suffer.

m5

Module 5:

Normalisation of indicator data

m5

What will you learn in this module?

This module will show you how to transfer (normalise) your different indicator data sets into unit-less values with a common scale from 0 (optimal, no improvement necessary or possible) to 1 (critical, system no longer functions).

Key steps and questions addressed in this module:

Step 1
Determine scale of measurement

- What scales of measurement do my indicators use?
- Am I dealing with multiple scales?

Step 2
Normalise your indicator values

- How do I normalise metric data into values between 0 and 1?
- How do I normalise categorial data into values between 0 and 1?

What do you need to implement this module?

For normalisation and threshold definition, you will need:

- The factsheet for each indicator
- The indicator values
- Experts or sources to help you identify thresholds

What are the outcomes of this module?

After completing Module 5, you will have:

- Normalised data for each indicator in a standardised value range from 0 to 1 ready for aggregation

Which tools and information does the Annex provide?

In the Annex you will find:

- Examples of the evaluated indicators from a vulnerability assessment conducted in Burundi (Annex 7)

What is normalisation?

In the literature (e.g. OECD 2008), 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. Consider the different units used for measurement: US$/household, hospitals/1000 inhabitants, literacy rate percentage, soil type, land use – and many more. These different units mean that your indicators cannot be aggregated without normalisation. In the Vulnerability Sourcebook, we are using a standard value range from 0 to 1.

A second important aspect of normalisation is to get from numbers to a meaning by evaluating the criticalness of an indicator value. In the Vulnerability Sourcebook, we define '0' as 'optimal, no improvement necessary or possible' and '1' as 'critical, system no longer functions'. For instance, an annual precipitation of 600mm/year may be '0 – optimal', while a precipitation of 200 mm may be '1 – critical'

Step 1

Determine the scale of measurement

In order to normalise your datasets you first have to determine the scale of measurement for each indicator (see Box 11 for further explanation). The scale

Table 10: 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.

of measurement is determined by the phenomenon you observe and how you intend to describe it (soil type, population age in absolute numbers or grouped in classes, field size). It determines which mathematical operations can be applied to analyse a dataset – the higher the scale level, the more operations are possible. This is important for normalisation where you will apply different methods for indicators with categorical and metric scales (see Box 11).

11 EXPERT

Scales of measurement

Different phenomena are measured in different ways. To measure temperature you need a thermometer. Naturally a thermometer is of no use when it comes to measuring a person's attitude to the introduction of a new crop type. In this case a rating scale is appropriate, using values such as 'very open', 'somewhat reluctant' and so on. Although procedures for measurement differ in many ways, they can be classified into three fundamental categories, or 'scale types' (see Table 9) (Field 2009). The scale types of relevance to your vulnerability assessment are nominal, ordinal (jointly summarised as categorical) and metric:

- In a metric scale you have ordered, numerical values where the difference between two values is clearly defined and of the same interval. That means that the difference between 2 and 3 is the same as the difference between 54 and 55. Examples include temperature, yield in tons or income in US$. Metric scales are the highest level of measurement.
- An ordinal scale indicates that one given value is greater or lesser than another, but the interval between values is undefined or unknown. Examples of ordinal scales include school marks, education level, and rankings of suitability of soil types for certain crops.
- For a nominal scale you simply name or categorize your values. Examples include names, postal codes, crop types, irrigation types. Nominal scales represent the lowest level of measurement.

Table 9: Level of measurement

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

Source: adelphi/EURAC 2014.

m5

To choose the correct method for normalisation you will need to go through each of your indicators and determine whether nominal, ordinal or metric scales apply. Table 10 lists frequently used indicators and their scale types.

Step 2
Normalise your indicator values

Normalisation of metric indicator values
Min-max normalisation

Indicators measured using a metric scale are normalised by applying the min-max 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. The following formula is used to apply min-max:

Formula 1:

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

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

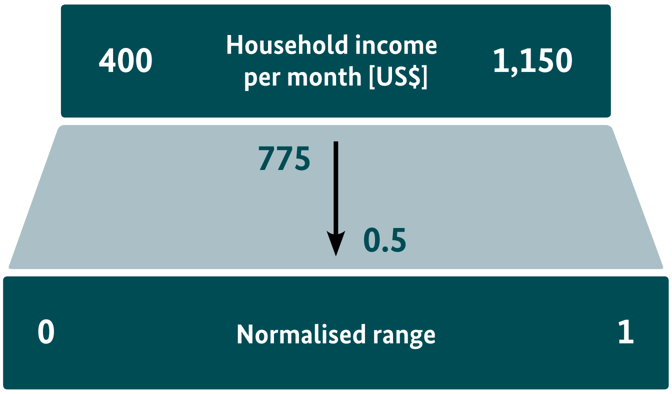
An example of a min-max normalisation for monthly household income is shown in Figure 24 and Table 11. Figure 24 visualises the range of values between the minimum of $400 and the maximum of $1,150 as expressed in a standardised range of 0 to 1. Table 10 shows the standardisation results after the dataset has been proportionally distributed to values between 0 and 1 according to the formula above.

As an example, the calculation for value no. 6 according to the formula used for min-max normalisation is:

Formula 2

$$\frac{620 - 400}{1150 - 400} = 0.29$$

Figure 24: Data transformation of household income data from $400 to $1,150 to a standard value range of 0 to 1



Source: adelphi/EURAC 2014.

Table 11: Example of min-max normalisation of household income (US$/month) - Values for 10 hypothetical households

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

Source: adelphi/EURAC 2014.

Check the 'direction' of the value range

The normalisation transformed the indicator values in metric scales to a standardised value range of 0 to 1. Next, you will need to check whether the indicator values increase in the right direction. That is, lower values should reflect positive conditions in terms of vulnerability and higher values more negative conditions.

For example, the indicator 'household income' is selected for the vulnerability assessment component 'adaptive capacity' to indicate whether there are sufficient financial resources to carry out adaptation measures. A higher household income represents a higher adaptive capacity and consequently lowers vulnerability. Therefore, the direction of the indicator's value range is negative: vulnerability increases as the indicator value decreases, and vice versa. So here the value range of the indicator, as shown in Table 11 above and in Table 12, should be inverted so that the lowest value is represented by the standardised value of 1 and the highest by the standardised value 0. To achieve this, simply subtract your value from 1 to determine the final standardised value (e.g. for a value of 0.29, apply calculation of 1-0.29, which returns a final standardised value of 0.71).

Table 12: Hypothetical example of a min-max normalisation of household income [US$/month] - Values for 10 households after inversion of values

Number	Household income [US$/month]	Normalised value	Value for the VA after inversion
1	1,150	1.00	0.00
2	1,009	0.81	0.19
3	949	0.73	0.27
4	780	0.51	0.49
5	775	0.5	0.5
6	620	0.29	0.71
7	570	0.23	0.77
8	490	0.12	0.88
9	410	0.01	0.99
10	400	0.00	1.00

Source: adelphi/EURAC 2014.

Building on Table 11, the new column in Table 12 shows final standardised values for the example indicator of household income after inversion of values as described above.

As an example, the formula for value no. 6 according to this calculation rule is:

Formula 3

$$\frac{620 - 400}{1150 - 400} = 0.29 \rightarrow 1 - 0.29 = 0.71$$

Define thresholds

Once you have verified the direction of your value range – and where necessary inverted it – there is one more point to consider: the issue of thresholds. When standardising your indicator values on a scale of 0 to 1, the value 0 is automatically allocated to the lowest number and the value 1 allocated to the highest. Even if you change the direction of this allocation, your indicator values will still occupy the full range from 0 to 1, i.e. from very positive (0) to very negative conditions (1). However, this default range will not always be what you are aiming at since your values may only represent a subset of this range.

Let us suppose you have monthly rainfall values for three communities of 51 mm, 52 mm and 53 mm. Following the default normalisation procedure, the values would be 0, 0.5 and 1 for these three communities, suggesting extremely positive, medium and extremely negative conditions respectively (Table 13).

Table 13: Example of default allocation of normalised values prior to application of appropriate thresholds

Monthly rainfall value [mm]	Values after automatic normalisation
51	0
52	0.5
53	1

Source: adelphi/EURAC 2014.

What if, however, you determine that 60 mm represents optimal rainfall conditions, while 25 mm is critically low? This means that your three values are actually near optimal. In this case you would introduce a new minimum and maximum representing negative and positive conditions. So your value range is no longer determined by the values you happen to have at hand (from 51 to 53 mm), but rather a range you determine yourself, ideally with the support of experts from the particular field (from 25 to 60 mm). With these new thresholds the normalised values are now allocated as shown in Table 14.

As an example, the calculation for the value 52 mm is then:

Formula 4

$$\frac{52 - 25}{60 - 25} = 0.77$$

This step should ensure that the indicator values in your vulnerability assessment are meaningful. When addressing thresholds you should apply a simple plausibility check for all datasets: does the range of normalized values for the indica-

Table 14: Example of automatic allocation of normalised values incorporating thresholds

Monthly rainfall value [mm]	Values after automatic normalisation *
25	0
51	0.74
52	0.77
53	0.8
60	1

Source: adelphi/EURAC 2014.

*(*Naturally, for the next steps the indicator values must be inverted to reflect the negative impact of low rainfall)*

tor provide a meaningful representation of high and low (positive and negative conditions) in terms of vulnerability? If not, you will need to define your own thresholds that represent this reality.

This 'manual' change of minimum or maximum values may have a significant influence on the results of your vulnerability assessment. Therefore, it should be applied with care, based on reliable literature or expert knowledge and ideally in agreement with your stakeholders and/or users.

Normalisation of categorical indicator values

Applying a five-class evaluation scheme

The min-max method applied to metric indicator values cannot be applied to categorical values. Instead, you will need to use a rating scale to normalise your data. By defining classes in negative or positive terms, you also give the indicator values a meaning applicable to the vulnerability assessment. We call this process the 'evaluation' of indicators.

The Vulnerability Sourcebook suggests a five-class system with the most positive conditions represented by the lowest class and the most negative represented by the highest class (see Table 15).

Table 15: The five-class scale for categorial indicators with class values and description

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

Source: adelphi/EURAC 2014.

Each of the indicator values for nominally scaled data, such as types of land cover, must be allocated to one of these classes. In doing so you are changing the measurement scale from nominal to ordinal. In the case of land cover classes you could allocate a level of 4 ('rather negative') to peat soil or 2 ('rather positive') to silty soil. However, this allocation depends on the meaning of the particular indicator within the respective impact chain. So if you use 'land cover' as an indicator in the impact chain 'risk of erosion', for example, a densely vegetated area will receive a low (positive) value since vegetated areas are usually less prone to erosion than bare soil. However if the same indicator is used within the impact chain 'malaria occurrence', densely vegetated areas may receive a high (negative) value since they provide a better habitat for mosquitos.

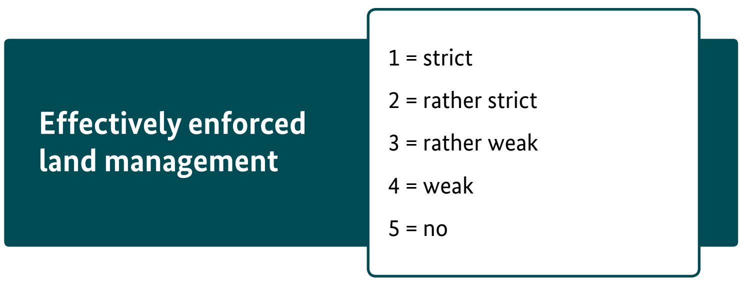
Another example would be an adaptive capacity indicator of 'effectively enforced land management'. In this case the classes might be labelled as shown in Figure 25 (from a vulnerability assessment study carried out in Pakistan).

You will need to allocate indicator values on the basis of the best knowledge available – be it from existing literature, local experts or any other reliable source. If you consult experts for this step you will need to thoroughly prepare a session in the form of an interview or workshop, providing relevant background material about your study (scope, purposes etc. – for an example see Box 12).

Transformation from five-class scheme into 0 to 1 scheme.

In preparation for the aggregation of indicator values form a categorical scheme values in Module 6 you will need to ensure that all indicator values are trans-

Figure 25: Example of the indicator 'Effectively enforced and land management'



Source: adelphi/EURAC 2014.

12 PRACTICE

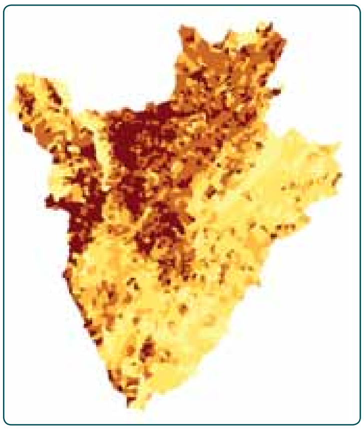
Evaluating data sets jointly with local experts in Burundi

The vulnerability assessment addressing water and soil resources in Burundi integrates different types of data, such as metric data covering population density, slope and household income as well as categorical data concerned with vegetation cover and soil type. To prepare these different indicators for aggregation, a workshop was conducted with a group of local experts who were tasked with evaluating the different data sets.

The experts were provided with the data for each indicator including its constituent categories, or the lowest and highest values (see example below and Annex 7). The group defined a common scale ranging from 1 (most positive conditions) to 5 (most negative). The experts were then asked how the indicator values relate to the potential impact selected for the vulnerability assessment, to which they assigned a value. For example, crops were evaluated according to their resistance to decreasing water availability. Bananas and manioc were considered highly resistant and were assigned to class 1. Rice, on the other hand, was evaluated as highly susceptible and assigned to class 5. At the end of evaluating each indicator, the group looked at all assigned values as a whole to check whether they were plausible and provided a coherent picture.

Figure 26: Example of a powerpoint: Evaluating the indicator 'Population density'

Which population density allows/ does not allow a sustainable land use?



Number of inhabitants/km²	Class
< 100	1
101 - 200	2
201 - 300	3
301 - 450	4
> 451	5

1 - allows sustainable land use / 5 - does not allow sustainable use

One lesson learned from this exercise: it is important that participants understand that each indicator should be considered in isolation. In this example, the group found it difficult to focus on individual indicators at first. Vegetation cover was therefore presented first as an 'easy' indicator, where sensitivity to decreasing water availability was clear.

m5

formed into the value range of 0 to 1. That is, you need to bring your classified values into this value range as shown in Table 16.

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

indicator values — categorical: Class No.	Class value within range of 0 to 1	Description	Indicator value range (0 to 1) metric: 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

Source: adelphi/EURAC 2014.

POTENTIAL PITFALLS

The difficult part of this module is the evaluation required to allocate classes to values or define minimum and maximum values when dealing with metric data. Successful decision-making in this instance is dependent on two things:

- an understanding of how the different steps of this approach lead to the vulnerability assessment, and
- local, context-specific knowledge in defining thresholds appropriately.

In most cases you will have to rely on the judgment of stakeholders in this evaluative step. Local experts may at first be reluctant to assign concrete numbers and classes. Experience shows that these values are more readily obtained in group sessions rather than individual consultation. When moderating these group discussions it is best to avoid getting bogged down in the question of whether or not the phenomenon at hand can be measured in numbers. Let the participants begin working on a 'test' case and you will usually find this overcomes mental barriers, leading to constructive discussions and agreement on concrete outcomes.

III

m6

IDELINES

Module 6:

Weighting and aggregating of indicators

What will you learn in this module?

This module explains the weighting of various indicators selected to describe the vulnerability components exposure, sensitivity and adaptive capacity. Weighting is applied if some of the indicators are considered to have a greater influence on a vulnerability component than others.

Module 6 also demonstrates how to aggregate individual indicators of the three vulnerability components. Aggregation is used to combine the information from different indicators into a composite indicator representing a single vulnerability component.

Key steps and questions addressed in this module:

Step 1
Weighting of indicators

- Are some indicators and vulnerability components more important than others?
- How are different weighting factors defined?
- Which methods can be used to define weights?
- How should weighting factors be applied?

Step 2
Aggregation of indicators

- How do I combine several indicators into a composite indicator representing a vulnerability component?
- How should indicators be aggregated?
- What are the pros and cons of a composite indicator?

What do you need to implement this module?

To weight and aggregate your indicators, you will need:

- Normalized indicators describing the vulnerability components exposure, sensitivity and adaptive capacity (Module 5).
- Input from stakeholders, experts or literature on how to weight indicators.

What are the outcomes of this module?

After completing Module 6, you will have:

- Weights (equal or unequal), assigned to each indicator
- Vulnerability components by aggregating individual indicators

Which tools and information does the Annex provide?

In the Annex you will find:

- An Excel template for aggregating indicators of exposure, sensitivity and adaptive capacity (Annex 8).

Step 1
Weighting indicators

In Module 3, suitable indicators were identified to describe the three vulnerability components. Typically, several indicators are used to describe exposure, sensitivity and adaptive capacity. However, these indicators do not necessarily have equal influence on the respective vulnerability component (see Box 13).

13 PRACTICE

Applying weighting during a stakeholder workshop in Pakistan

During an application of the Vulnerability Sourcebook in Pakistan (see figure 27), workshop participants identified the following factors that influence sensitivity towards soil erosion in two pilot regions:

- Deforestation on steep slopes
- Unsuitable cultivation of steep slopes
- Overgrazing of grassland
- Soil type

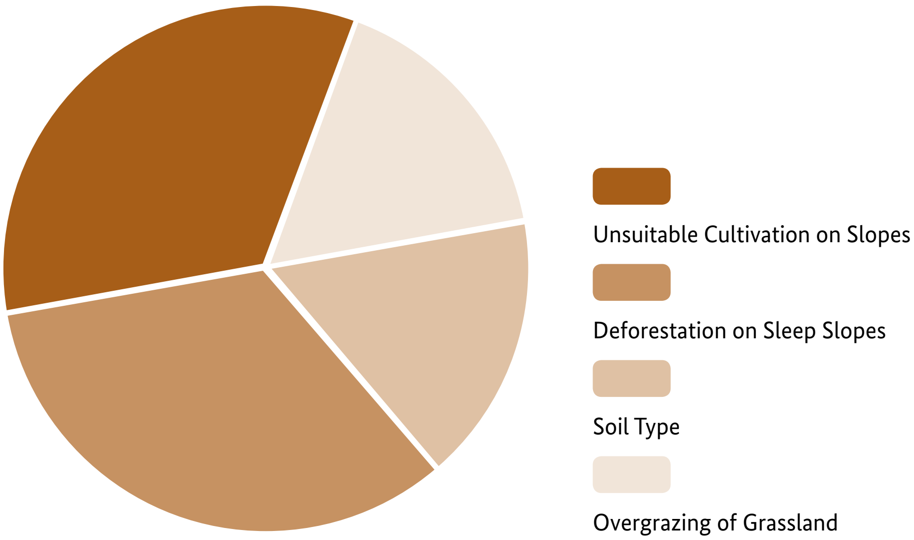
Figure 27: Participants of a stakeholder workshop in Islamabad, Pakistan

Source: adelphi/EURAC 2014.

Once these four factors were identified, workshop stakeholders agreed in an open discussion that 'deforestation' and 'unsuitable cultivation' were the dominant factors (twice as important) in erosion. This means that these two factors have a greater influence on sensitivity and thus should be assigned a greater weight in subsequent aggregation.

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. The different weights assigned to indicators can be derived from existing literature, stakeholder information or expert opinion (see also Box 14). Using the example from Pakistan, the weighting of the four different factors describing sensitivity to erosion might appear as shown in Figure 28 below, based on the assumption that 'deforestation' and 'unsuitable cultivation' are twice as important as 'overgrazing' and 'soil type':

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



Source: adelphi/EURAC 2014.

However, there might also be valid reasons for assigning equal weights to all indicators, such as a lack of information, consensus or resources for defining different weights. This might be the case, for instance, where a large number of indicators for the different vulnerability components make meaningful weights unfeasible (see also Box 14).

Procedures for assigning weights

The literature covers many different weighting techniques (OECD 2008). These techniques range from sophisticated **statistical procedures**, such as factor analysis and principal component analysis, to **participatory methods**, such as the budget allocation process (see Box 14). It should be noted that neither participatory nor statistical processes provide an 'objective' way of defining weights. Consequently weights should be regarded as value judgments (OECD 2008).

Since statistical procedures for deriving weights require substantial resources as well as sophisticated statistical knowledge within your vulnerability assessment implementation team, the Vulnerability Sourcebook views participatory approaches as a more practical way of applying weighting. The participatory process also introduces transparency to the subjective definition of weights, thus reducing potential sources of conflict and increasing acceptance of the vulnerability assessment results. Box 14 offers a practical example of how weights are defined in a participatory approach during an interactive workshop.

Where the vulnerability assessment is to be applied for M&E of adaptation (see Chapter IV), remember that weights must remain constant over time. Otherwise it is impossible to know whether changes in vulnerability components are due to wider changes in the system under review (e.g. development progress), the effect of implemented adaptation measures or differences in weighting.

14 EXPERT

Participatory methods for assigning weights

One method for assigning different weights using a participatory approach is the **'budget allocation approach'** (OECD 2008). Here workshop participants are issued with a 'budget' made up of a certain number of 'coins'. Each participant can spend his or her coins on those indicators he or she considers (more) important. This approach works best with a relatively small number of indicators (<12) to ensure that participants are not overwhelmed with 'budgeting' decisions, which can have a negative impact on results.

If participants are uncomfortable with the idea of 'play money', paper-based approaches can also be applied to weighting. For instance, stakeholders can be asked to rank different indicators in a questionnaire (see e.g. Below 2012).

Step 2
Aggregation of indicators

Once the different indicators of a vulnerability component have been evaluated and weighted, they are aggregated into the three vulnerability components exposure, sensitivity and adaptive capacity. In describing sensitivity to floods, for instance, indicators might include land use, population density and the number of industrial buildings in flood-prone areas. In a first step, these discrete (normalized) indicators must be aggregated into a composite indicator representing the sensitivity of the system in question.

15 EXPERT

On the use of composite indices

Composite indicators are increasingly popular in policy analysis for illustrating and communicating complex, multi-dimensional realities. The OECD (2008) defines a composite indicator as *'a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions (e.g. of a country) in a given area. When evaluated at regular intervals, an indicator can point out the direction of change across different units and through time.'* Policy makers and the general public often find it easier to comprehend a composite indicator than numerous discrete indicators (OECD 2008). The Vulnerability Sourcebook also uses a composite indicator approach for assessing different vulnerability components and overall vulnerability of a sector, population segment or region. The composite indicator of vulnerability is comprised of the vulnerability components exposure, sensitivity, potential impact and adaptive capacity.

While a highly aggregated composite indicator can help illustrate a complex and multi-dimensional problem, much of the underlying information remains invisible. However the extent to which components (or even individual indicators) contribute to the composite vulnerability indicator should be transparent throughout the vulnerability assessment (see Module 8). This is especially relevant when the vulnerability assessment is needed for identifying priority areas for adaptation. Should the vulnerability assessment reveal, for instance, that high sensitivity is resulting in high vulnerability, specific adaptation measures can be used to reduce this sensitivity. The information provided by individual indicators and vulnerability components can often be more useful in adaptation planning than the highly aggregated overall vulnerability indicator. Both individual and composite indicators for each vulnerability component should always be presented to decision-makers and other stakeholders alongside the vulnerability composite indicator.

Aggregation method

The literature covers various aggregation methods, each with their strengths and weaknesses (see Box 16). For aggregating individual indicators into composite indicators, the Vulnerability Sourcebook recommends a method called 'weighted arithmetic aggregation'. This is a common, simple and transparent aggregation procedure. Individual indicators are multiplied by their weights, summed and subsequently divided by the sum of their weights to calculate the composite indicator (CI) of a vulnerability component, as indicated in the following formula:

Formula 5:

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

...where *CI* is the composite indicator, e.g. sensitivity, *I* is an individual indicator of a vulnerability component, e.g. land use, and *w* is the weight assigned to the indicator.

If equal weighting applies, indicators are simply summed and divided by the number of indicators. Assigning a weight of 2 (or 3) to one or more indicators implies that these indicators are twice (or three times) more important than indicators which retain a weighting of 1.

To enable meaningful aggregation of individual indicators, remember that all indicators of the three vulnerability components must be aligned in the same way (see Module 5). This means that a low or high score represents a 'low' or 'high' value in terms of vulnerability (see Module 5). Figure 29 offers a schematic overview of the Vulnerability Sourcebook's approach to aggregating different indicators for vulnerability components.

TIP

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.

16

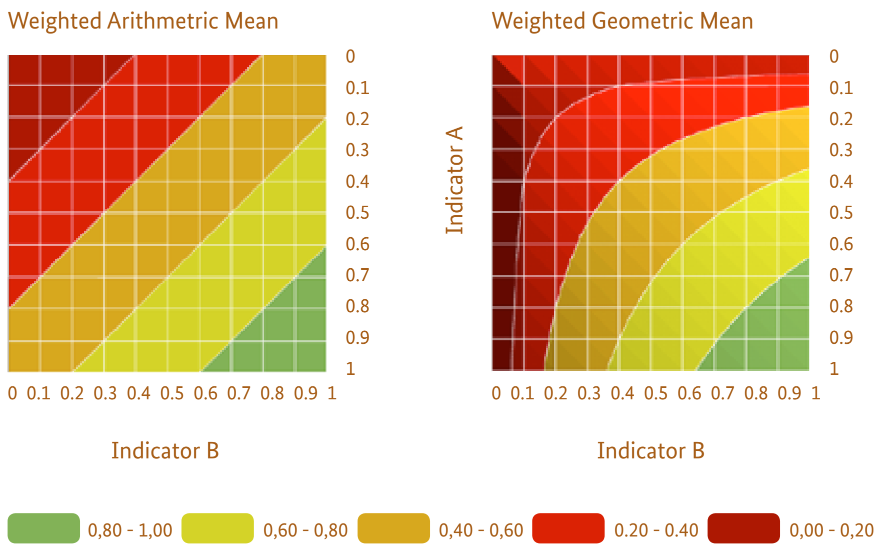
EXPERT

Aggregation methods

The literature covers various aggregation methods, each with their own strengths and weaknesses (OECD 2008). The method recommended in the Vulnerability Sourcebook is a common, simple and transparent method called **weighted arithmetic aggregation**, where weighted and normalized individual indicators add up to a composite indicator. This leads to what is known as 'full compensability' (OECD 2008), meaning that a high score for one indicator can offset a low score of another indicator. Using this aggregation approach, 'extreme' values are thus 'removed' on 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). This means that a very low score for one indicator can only partly offset a very high score of another indicator. While this can be a desirable effect in certain instances in a vulnerability assessment, the aggregation effects are more difficult to comprehend and sometimes counterintuitive due to a strong bias towards low values. Moreover, because individual indicators are multiplied by each other using geometric aggregation, zero values are not allowed because the calculated composite indicator would also be zero. Figure 30 offers a detailed illustration of the aggregation effects in each approach. It shows all possible results of aggregating two normalized indicators with a value range from 0 to 1. It exemplifies the effect of compensability of weighted arithmetic mean and the bias towards lower values for weighted geometric mean. For instance, aggregating two scores of 0.1 and 0.9 results in an average of 0.5 when applying weighted arithmetic mean, while it results in a value of 0.3 for weighted geometric mean (where weighting is equal).

Figure 30: Arithmetic and geometric Mean

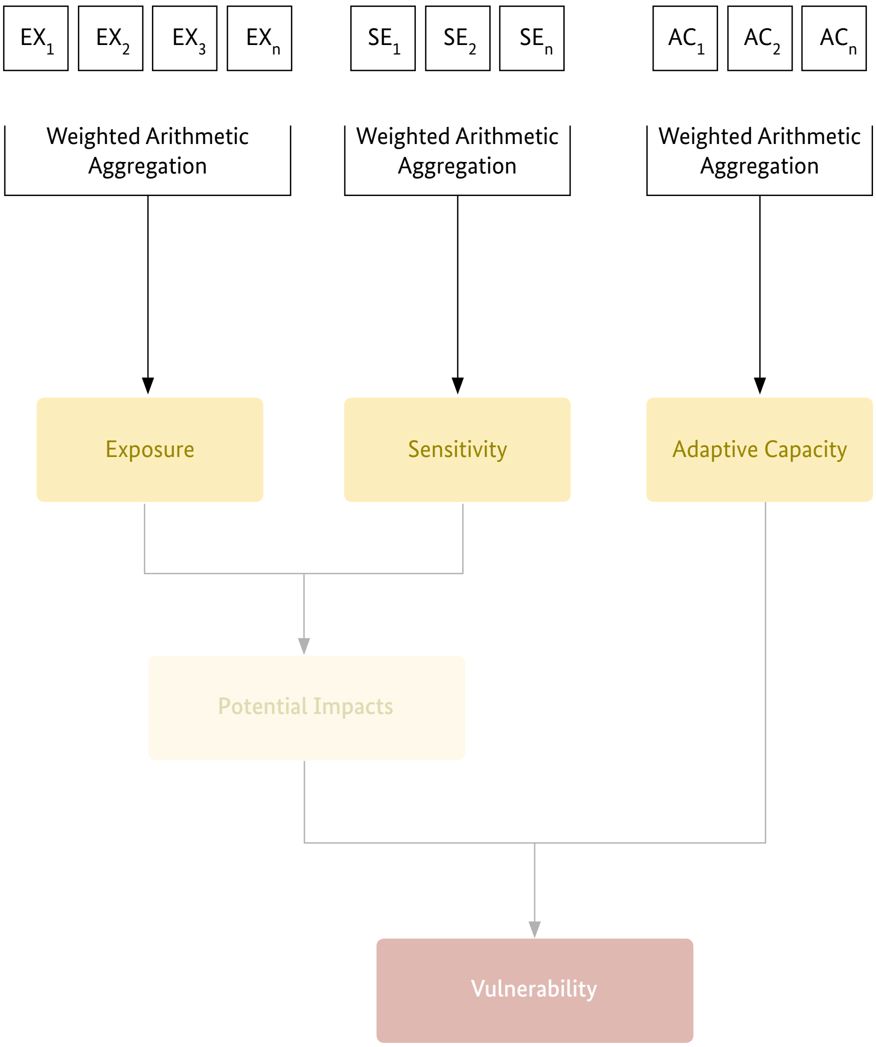


Source: adelphi/EURAC 2014.

POTENTIAL PITFALLS

A major pitfall in this module is not choosing appropriate weights. Weighting can have a major influence on your results and should be undertaken with care in a transparent process. Ensure you assign adequate time and resources to selecting and agreeing on suitable weights. A lack of transparency in weighting can cast doubt on the results of your vulnerability assessment.

Figure 29: The Vulnerability Sourcebook's approach to aggregating indicators for vulnerability components



Source: adelphi/EURAC 2014.

Another important pitfall in this module is the danger of aggregating indicators that are aligned differently. For meaningful aggregation results, make sure that all indicators are aligned in the same way: a low score represents a 'low' value and a high score a 'high' value in terms of vulnerability.

It is equally important to check if results appear plausible, that a single indicator does not dominate a vulnerability component, for instance. This can be done by presenting aggregation results (e.g. in the form of maps) to experts or stakeholders that have a high expertise on the subject and area under review. If you conclude that weights need to be adjusted, the adjustment process must be as transparent as the initial weighting process.


LABORATORIO CLINICO

m7

Module 7:

Aggregating vulnerability components to vulnerability

What will you learn in this module?

This module shows you how to aggregate the vulnerability components exposure and sensitivity to a potential impact. It also explains how to combine the potential impact and adaptive capacity (AC) into a composite vulnerability indicator. Finally, Module 7 outlines how to aggregate several sub-vulnerabilities, for instance of several economic sectors.

Key steps and questions addressed in this module:

Step 1

Aggregation of exposure and sensitivity to potential impact

- How do I combine the two vulnerability components exposure and sensitivity to a potential impact?
- How do I apply weighted arithmetic aggregation?

Step 2

Aggregation of potential impact and adaptive capacity into vulnerability

- How should the two vulnerability components potential impact and adaptive capacity be combined to form a composite vulnerability indicator?

Step 3

Aggregation of several sub-vulnerabilities into an overall vulnerability

- How do I combine several sub-vulnerabilities into a single overall vulnerability?
- How useful is such a highly aggregated vulnerability value in identifying suitable adaptation measures, for instance?

What do you need to implement this module?

To aggregate your vulnerability components into a composite vulnerability indicator, you will need:

- Aggregated vulnerability components exposure, sensitivity and adaptive capacity (Module 6).
- Input from stakeholders, experts or literature if different vulnerability components are to be weighted.

What are the outcomes of this module?

After completing Module 7, you will have:

- The vulnerability value for your system.

Which tools and information does the Annex provide?

In the Annex you will find:

- An Excel template for aggregating vulnerability components into a composite vulnerability index (Annex 8).

Step 1

Aggregation of exposure and sensitivity to potential impact

Once you derived a composite indicator for the two vulnerability components exposure and sensitivity, these two components must be combined to form the vulnerability component potential impact. Weighted arithmetic aggregation is once more applied (see Module 6) to calculate the potential impact composite indicator, using the following formula:

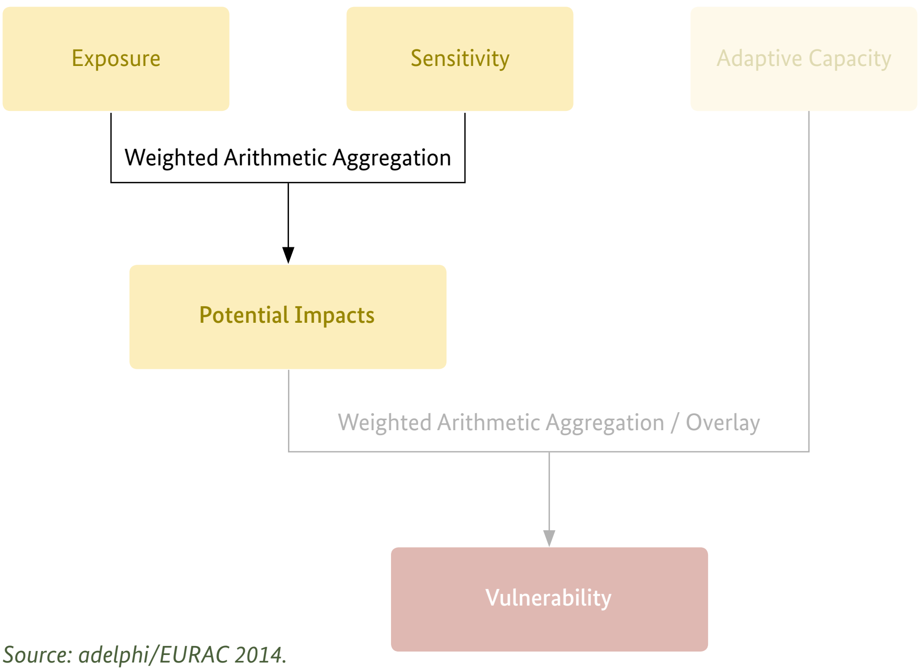
Formula 6:

$$PI = \frac{(EX + SE)}{2}$$

...where PI is the potential impact composite indicator, EX is the vulnerability component exposure, and SE is the vulnerability component sensitivity.

Figure 31 offers a schematic overview of the Vulnerability Sourcebook's approach to aggregating exposure and sensitivity to potential impact. An Excel template for this process is provided in Annex 8.

Figure 31: The Vulnerability Sourcebook's approach to aggregating the two vulnerability components exposure and sensitivity to potential impact.



Source: adelphi/EURAC 2014.

Step 2

Aggregation of potential impact and adaptive capacity into vulnerability

In a final step, the potential impact composite indicator is aggregated with adaptive capacity in order to arrive at a composite vulnerability indicator for the system under review. Here, again, weighted arithmetic aggregation is applied:

Formula 7:

$$V = \frac{(PI * w + AC * w)}{\sum_{n}^{1} w}$$

...where V is the composite vulnerability indicator, PI is the potential impact composite indicator, AC is the vulnerability component adaptive capacity, and *w* is the weight assigned to the vulnerability components (see below).

TIP

Check again that all vulnerability components are aligned correctly.

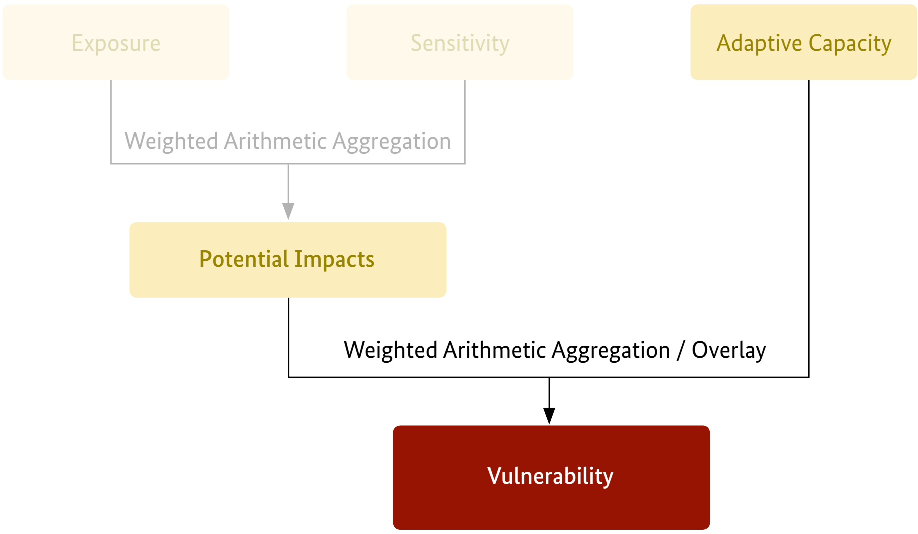
When aggregating potential impact and adaptive capacity, check again that all indicators and consequently all vulnerability components are aligned in the same way, as explained in Module 5: a low score represents a 'low' value and a high score a 'high' value in terms of vulnerability. This is especially important to consider when aggregating adaptive capacity: this is because contrary to exposure, sensitivity and potential impact, adaptive capacity, by definition, has a positive influence on vulnerability.

Weighting of potential impact

The fact that weighted arithmetic aggregation allows for (full) compensability (see Box 16) means that a high value for adaptive capacity has the potential to largely offset a high impact value. This results in low vulnerability despite high potential impact. This offsetting between impact and adaptive capacity will not always occur, especially if adaptive capacity is defined using generic factors such as income or educational status. Such generic adaptive capacities usually do not directly reduce the potential impact.

Therefore, the vulnerability component potential impact can be assigned a greater weight if aggregating a specific impact (e.g. mortality due to malaria) with a generic adaptive capacity (e.g. educational status). This means that a high generic adaptive capacity cannot completely offset a high impact. The level of the defined adaptive capacity - generic to directly influencing the potential impact (e.g. application of mosquito nets) - can indicate whether a larger weight for the potential impact component should be considered. Expert judgment or a participatory process, such as a stakeholder workshop (see Box 14), can help decide whether, and how, to distribute weights. Figure 32 provides a schematic overview of the Vulnerability Sourcebook's approach to aggregating potential impact and adaptive capacity to vulnerability.

Figure 32: The Vulnerability Sourcebook's approach to aggregating the two vulnerability components adaptive capacity and potential impact



Source: adelphi / EURAC 2014.

Visual overlay of potential impact and adaptive capacity

An explicit vulnerability value is not always required; identifying areas of high potential impact and low adaptive capacity (hotspots) may suffice. In this case, a visual overlay of potential impact and adaptive capacity on the map of a particular geographic area can be a useful solution (see e.g. Lung et al., 2013). Areas of high potential impact and low adaptive capacity can be highlighted graphically in a map summarizing these two values, using a geographical information system (GIS) (see Figure 34).

Making single indicators and vulnerability components visible

Remember that a highly aggregated vulnerability value may conceal important underlying factors influencing overall vulnerability (see Box 15). The influence

17 PRACTICE

Aggregating indicators and vulnerability components to assess vulnerability to soil erosion in two pilot areas in Pakistan

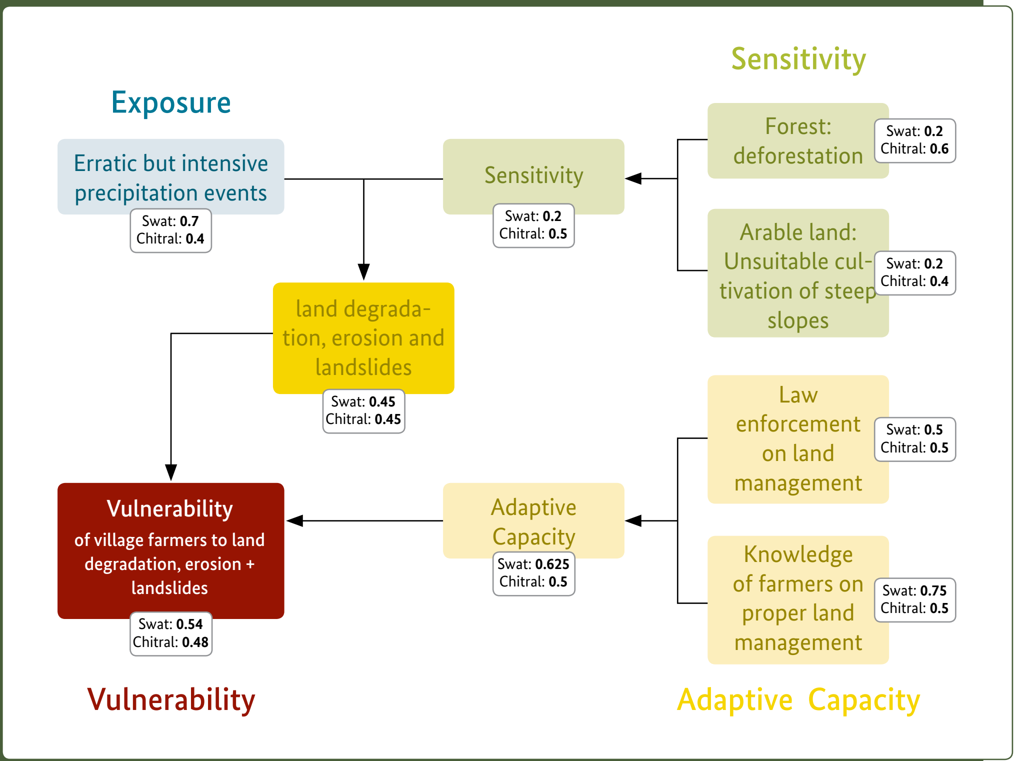
During an application of the Vulnerability Sourcebook in Pakistan, vulnerability to soil erosion was assessed in the two pilot districts Swat and Chitral. The impact chain describing vulnerability to soil erosion, which was developed during a one-and-a-half day stakeholder workshop, is depicted below (see Figure 33). Moreover, it shows:

- the values assigned by the participants to each indicator for the two pilot regions,
- the aggregated values for the vulnerability components, and
- the aggregated value for overall vulnerability for the two pilot regions.

Indicator values were assigned by the two vulnerability assessment implementation teams from Swat and Chitral on the basis of a group discussion. Each indicator value was then added to a board, which showed the impact chain and the respective indicators using sticky dots (see also documentation of the Pakistan case study in Annex 10).

For all aggregation steps, a weighted arithmetic mean was applied using equal weights.

Figure 33: Aggregation of indicators and vulnerability components for assessing vulnerability to soil erosion in two districts of Pakistan



Source: adelphi / EURAC 2014.

The assessment shows an identical potential impact value of 0.45 for both pilot regions. However closer scrutiny of the underlying sensitivity and exposure values reveals significant differences between the two regions. While Swat has higher exposure, Chitral is more sensitive to erratic rain. This once again highlights the importance of considering values of individual indicators and vulnerability components. In this example Swat has slightly higher overall vulnerability because of a lower adaptive capacity.

m7

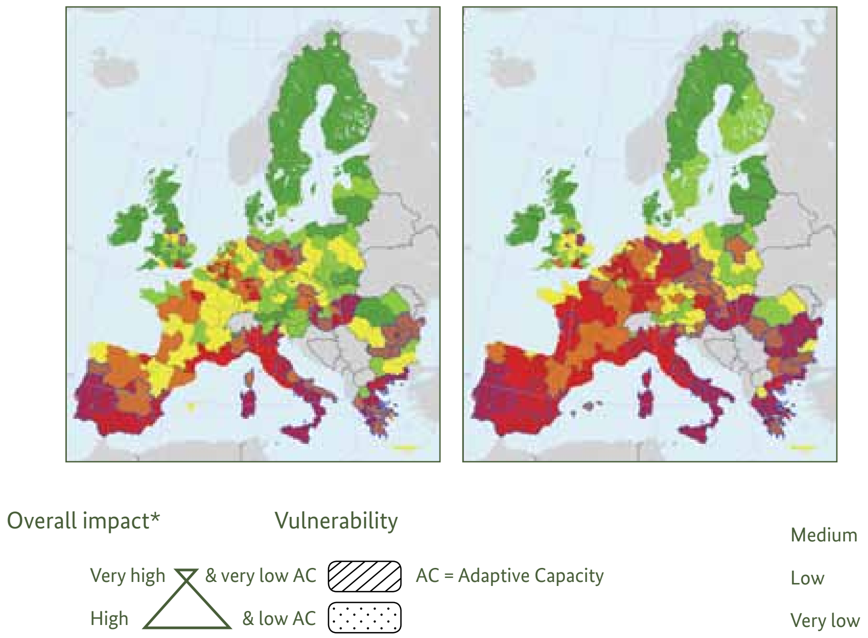
of indicators for vulnerability components (even single indicators) should always be transparent in the course of a vulnerability assessment. This can, for instance, be achieved by representing the influence of single indicators on vulnerability components using pie charts (see Module 8).

Step 3
Aggregation of several sub-vulnerabilities into an overall vulnerability

Vulnerability assessments are not necessarily limited to a single sector or region but can comprise several sub-vulnerabilities. This might be the case when examining different economic sectors or administrative regions within a larger area. These different sub-vulnerabilities can further be aggregated into an overall vulnerability value using the abovementioned approach (weighted arithmetic aggregation).

It is important to recall that such a value represents even higher aggregated information which might provide no information on the influence of the under-

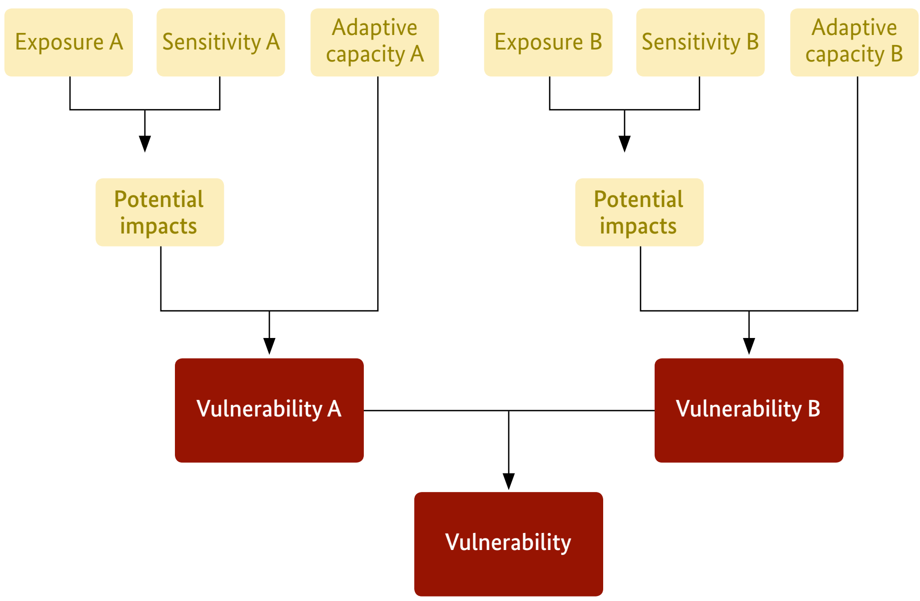
Figure 34: Vulnerability map representing vulnerable hotspots by an overlay of potential impact and adaptive capacity



Source: Reprint from Global Environmental Change – Human and Policy Dimensions, 23(2), Lung et al.: A multi-hazard regional level impact assessment for Europe combining indicators of climatic and non-climatic change, pages 522-536. Copyright (2013), with permission from Elsevier.

lying indicators and vulnerability components on this overall vulnerability value. Therefore, the intermediate results of the analysis should be included in any report describing the vulnerability assessment so as to make the best use of the underlying information. Indicators, vulnerability components or sub-vulnerabilities may well provide more useful information than this overall value when it comes to identifying priority areas for adaptation interventions (see Box 15). A schematic overview on aggregating several sub-vulnerabilities is provided in Figure 35.

Figure 35: The Vulnerability Sourcebook's approach to aggregating the two vulnerability components exposure and sensitivity to potential impact.



Source: adelphi/EURAC 2014.

POTENTIAL PITFALLS

The main pitfall in this module is the danger of aggregating vulnerability components that are aligned differently (see Module 5). For meaningful aggregation results, check again that all vulnerability components – and especially adaptive capacity - are aligned in the same way: a low score represents a 'low' value and a high score a 'high' value in terms of vulnerability.

If you use a visual overlay to identify areas of high potential impact and low adaptive capacity (hotspots) make sure that both data sets have identical map projections and a suitable resolution.

m8

GUIDELINES

m8

Module 8:

Presenting the outcomes of your vulnerability assessment

What will you learn in this module?

This module will show you how best to summarise and present the findings of your assessment.

For this task, you should keep both your objective and your target audience firmly in mind and ask yourself: What was the goal of your vulnerability assessment? Which outcomes are vital for subsequent tasks such as adaptation planning or strategy development? What is the best way to present your results to different target audiences? And who should present them?

Key steps and questions addressed in this module:

Step 1
Plan your vulnerability assessment report

- What did you learn from the assessment?
- Who is your target audience?
- What information should you include in your report?

Step 2
Describe your assessment

- What's the best way to structure your report?
- What processes will the vulnerability assessment support or feed into?
- What have you learnt which you consider to be crucial for this process?

Step 3
Illustrate your findings

- How should you illustrate your findings?
- How can you avoid misinterpretation?

What do you need to implement this module?

To present your vulnerability assessment results you will need:

- Outcomes from previous modules such as impact chains and assessment results
- Information on your target audience and the policy processes your vulnerability assessment will be supporting (Module 1)
- Standard Office software, and some specialist software (such as geographical information systems, or GIS) as required

What are the outcomes of this module?

After completing Module 8, you will have:

- A vulnerability assessment report, findings and method of presentation
- Visualisation of your findings

Which tools and information does the Annex provide you with?

In the Annex you will find:

- Sample structure of a vulnerability assessment report (Annex 9)
- Documentation of test applications Pakistan (Annex 10)
- Documentation of test applications Bolivia (Annex 11)

Step 1

Plan your vulnerability assessment report

There are numerous ways to present the outcomes of a vulnerability assessment. The most important means of presenting the results of your vulnerability assessment to an external audience is the vulnerability assessment report. This report should provide a clear description of the vulnerability assessment's objectives, the methods applied as well as the key findings. This should be a readily accessible document which gives your audience an overview, providing them with all the background information they need to interpret and comprehend your results.

Before compiling your report, take a moment to consider what you want to convey, and to whom.

What were the objectives of your assessment?

Vulnerability assessments are often designed to support and improve adaptation planning, with the overall objective of reducing vulnerability in the system under review. A vulnerability assessment can also help you substantiate your decision-making when it comes to selecting adaptation measures (see Module 1). Once measures are implemented, a small scale vulnerability assessment can help you document their impact (see Chapter IV). A thoroughly documented account of your successful adaptation activities can be useful when applying for (additional) funding.

Whatever your objective is, you should keep it in mind when writing your report. If you are, for instance, aiming at monitoring and evaluation of adaptation measures, it is absolutely essential to give a clear and extensive description of your methodology. This includes the steps and methods of your assessment as for example the number of experts that were interviewed, the selection criteria for the experts, where to retrieve the original data sources of the assessment and the detailed calculations. You or your contractors will need it when repeating the vulnerability assessment a few years later (see also Chapter IV). In other words, your report should target those who can support your on-going work, including policy makers, adaptation professionals and funding organisations.

What do you know about your target audience?

The content, style and language of your report should be appropriate to your audience. If your findings are targeted at external decision makers, it is essential that you consider their own objectives and the information – extent, level of detail – they need to achieve them. The skills and technical expertise of your target group should determine your vocabulary and the way you explain your concept. Use technical terms appropriate to your readership; provide a definition the first time an unfamiliar term appears in the text or refer readers to a glossary.

Policy makers favour concise, well-ordered presentations of the key insights and final results of a vulnerability assessment. Scientists and adaptation professionals, on the other hand, will often require a more detailed report, with additional information on your methods and key assumptions. No matter what your readership is, it is important that you include a summary. If you are addressing more than one target group, it makes sense to combine a detailed report with a short summary for policy makers, as seen, for instance, in the IPCC's global assessment reports (IPCC 2013).

Another important factor to think about: who will be presenting the outcomes of your vulnerability assessment? If you want to emphasise your methodology, a member of the implementation makes a good ambassador. But if the aim is to contribute your results to an on-going policy process, you might want to consider an influential stakeholder or decision maker associated with the assessment. Also remember to include the names or logos of assessment participants; this can improve the credibility and impact of your results.

What are your lessons learnt?

Often an assessment will produce not only the results you hoped for but will also turn up additional findings on topics, methods and methodological challenges. These additional results – 'lessons learnt' – are valuable! By describing them in a transparent way you can support others facing the same concerns while also helping your audience to understand your results.

Step 2

Describe your assessment

Once you have answered the above questions and established the key focus of your report, the next step is to structure it, keeping the four core sections in mind:

- Context and objectives
- Methodology and implementation
- Findings
- Conclusions and lessons learnt

An assessment report thus provides information on all the factors which have influenced your findings, defines underlying assumptions while supplying any additional information the reader needs to interpret the results. This is especially important in order to guarantee that the same methods can be used for repeated assessments.

Introduce your context and objectives

The beginning of your report should clearly state the context, objectives and the underlying assumptions. This includes in particular (addressed in Module 1):

- The context, in which the vulnerability assessment is conducted (for example as part of a specific program)
- Objectives and approach of the vulnerability assessment
- Institutions and key stakeholders or target groups involved
- The system and impact(s) under review, as well as the geographical scope and timeframe

A detailed report will also describe the resources and timeframe of the assessment to help the reader review assessment inputs and outputs in parallel.

Describe your methodology and how it was implemented

The next step is to outline the methods used in the vulnerability assessment (Modules 2 to 8) - this is key to your audience's interpretation of your findings. Using your vulnerability assessment for monitoring and evaluation, a brief summary of your methodology is not enough, as explained above. Here, an extensive description including indicator and data factsheets is needed. If this extended presentation of your methodology exceeds the level of detail your target audience is interested in, a separate document might be needed. The methodology chapter of your report should focus on:

- The assumed cause-effect relationships underlying the assessment, including the impact chains you have developed
- Selected factors and indicators and the method(s) you used in quantifying the
- Information on data quality, listing any data gaps and how you dealt with them
- The selection criteria for the stakeholders and experts (in case of an expert assessment)
- The number of experts that were consulted for the expert assessment including the sectors/geographic areas or professional background that were represented by the experts
- The weighting used and the process(es) by which it was determined (e.g. stakeholder process)
- The aggregation approach used for assessing vulnerability
- Information on data sources and calculations for future assessments in the case of M&E

Discuss your findings and outcomes

Now present the results of your assessment. This should be the main focus of the report, describing not just the findings but how they should be interpreted and what you have learnt about the vulnerability assessment method. This chapter should include:

- Values for individual indicators, the vulnerability components exposure, sensitivity, potential impact and adaptive capacity, as well as overall vulnerability
- Challenges and opportunities encountered at the various stages of the vulnerability assessment
- Lessons learnt

In this chapter you should also describe the uncertainties included in your assessment transparently and – if possible – quantify them. Knowing about the knowledge gaps on climate change and its impacts due to for example scale and model effects will foster your audience's understanding of your findings.

Think ahead

Bring your report to a close with conclusions for on-going or forthcoming (policy) processes, such as adaptation strategies and planning. What are the starting points for action? What obstacles need to be overcome? What knowledge gaps still remain? Here it is best to offer concrete recommendations for further assessments or adaptation measures.

Annex 9 provides you with a template for a vulnerability assessment report, but – as the above hopefully makes clear – the report should always consider the specific objectives of the vulnerability assessment, its target audience and their specific information needs. This will guide you in deciding which aspects to cover, and in what detail.

Step 3
Illustrate your findings

Illustrations attract the reader's attention and foster the comprehensibility of texts. Maps, diagrams and graphs are valuable and compelling tools for illustrating assessment findings. These elements represent high-level views of data, and while there is a danger of misinterpretation, when used with a sufficient description and/or legend in the context of a detailed report, they can aid understanding of outcomes.

Not every type of illustration will work in every context, so choosing the right type is crucial. By following some simple tips you can also enhance the readability of your graphic elements. For example, if you're using a scale, policy makers tend to find a value range of 0 to 1 less intuitive and persuasive than a range of 0 to 100.

Illustrating vulnerability using maps

Maps are the method of choice for geographical data and comparisons. They can have a wide range of content, styles and functions depending on available technology, resources, knowledge and the intention of the cartographer. Maps can be created using computer programmes such as geographic information systems (GIS) – specialist software for managing, analysing, and presenting geographical data. Simple hand-drawn maps are another alternative.

This approach predominates in data acquisition and participative processes, especially in defining past hazards and vulnerability hotspots on a small scale (such as a town or village). These 'subjective' maps say a lot about the ecological and social environment of those drawing them, and are a good way of involving local people in the vulnerability assessment (see Figure 36). When preparing such a participatory map, think about how to document the result, and how to include it in your report. Make sure you have camera at hand or use a poster for the mapping, which you can keep.

Figure 36: Photo of the mapping process of a hand-drawn subjective vulnerability map

Source: GIZ India/ASEM.

Enhancing the vulnerability assessment report with maps

Maps are particularly useful for presenting geographical comparisons, such as variation of vulnerabilities across regions. Maps for vulnerability assessment reports are normally produced using a GIS, since the analysis of spatial data is as important as the illustration. GIS programmes range from highly complex programmes with advanced functionality to simple, free open-source software. In any case, mapping requires substantial knowledge, time, and personnel resources. Maps offer various possibilities for illustration and can provide a wealth of (sometimes complex) information without excessive aggregation. To provide your audience with clear and comprehensible maps, comply with some formal requirements (also see further reading on this page):

- Insert a title and a description text into your map. This way, you can avoid misinterpretations when your map is examined independently from your report.
- Provide a scale, a north arrow and labels for key elements in your map to foster the regional understanding and highlight the relationship between two map elements.
- Name the source and the year of your data.
- Specify what you have mapped (e.g. land use classes) in a legend to avoid misunderstandings.
- Explain the map (as all other graphs, diagrams etc.) in the text body of your report with a reference to the respective object. This helps your reader to orient himself and to find information, which cannot be displayed in a map: i.e. the method you used to generate the findings which you have illustrated.

FURTHER READING on the use of maps, diagrams and graphs in vulnerability assessment reports

You will find more information on the use of visual designs in general and in vulnerability reports in the publications below.

For maps:

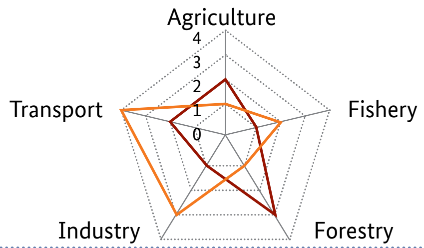
UNDP 2010: Mapping Climate Change Vulnerability and Impact Scenarios. A Guidebook for Sub-National Planners. New York: UNDP, Bureau for Development Policy. Retrieved 26.03.2014 from: *http://europeandcis.undp.org/uploads/public1/files/Mapping%20CC%20Vulnerability%20publication%20-%20November%202010.pdf*

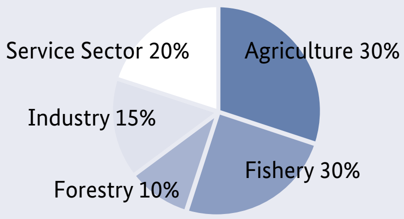
Cote, P. (n.a.): Effective Cartography, Elements of Cartographic Style. Harvard University Graduate School of Design, GIS Manual. Retrieved 16.04.2014 from *http://www.gsd.harvard.edu/gis/manual/style/*

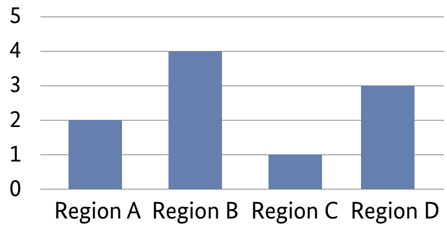
For diagrams and graphs:

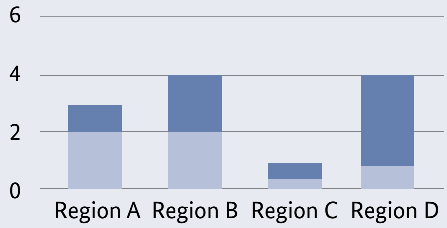
Balik (n.a.): Excel Chart Best Practices. Available online at: *http://www.academyfinancial.org/wp-content/uploads/2013/10/6B-Balik.pdf*

Table 17: Different chart types and how they can illustrate vulnerability assessment findings

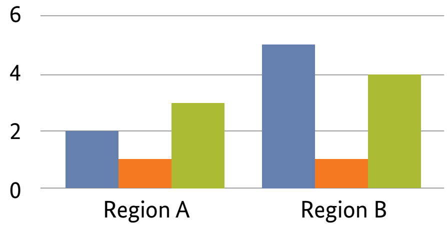
<table>
<tr><th>Chart type</th><th></th><th></th><th>Scope</th></tr>
<tr><td>Radar chart</td><td>


</td><td>Vulnerability value Region A
Vulnerability value Region B</td><td>• Illustration of complex (multi-dimensional) interrelations</td></tr>
<tr><td>Pie chart</td><td>


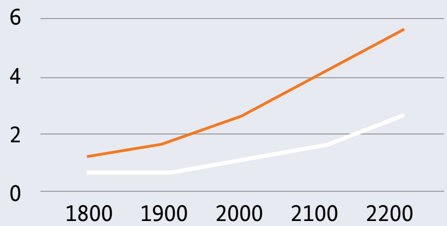
</td><td>Importance of sectors in Region A</td><td>• Illustration of percentage shares of a whole</td></tr>
<tr><td>Bar chart</td><td>


</td><td>Vulnerability value</td><td>• Illustration of the frequency with which a variable occurs in different categories
• Useful for ranking lists</td></tr>
<tr><td>Stacked bar chart</td><td>


</td><td>Potential Impact

Exposure
Sensitivity</td><td>• Comparison of summarised values
• Depiction of relative frequencies</td></tr>
<tr><td>Grouped bar chart</td><td>


</td><td>Vulnerability value

Agriculture
Fishery
Forestry</td><td>• Comparison of values in different categories</td></tr>
<tr><td>Line chart</td><td>


</td><td>Impact without adaptation
Impact with adaptation</td><td>• Illustration of time lines and trends
• Illustration of functional connections between two elements
• Comparison of different prospective trends</td></tr>
</table>

Source: adelphi/EURAC 2014.

Example of use in a VA	Tips for implementation
• Illustrating different components of a composite indicator • Illustrating vulnerability of sectors across different regions	• Ensure all categories have the same weighting. • Use five to seven axes for optimal clarity. • Use the same orientation for all axes (best value inside or outside the radar).
• Illustrating breakdown of a composite indicator • Comparing importance of individual vulnerability variables • Illustrating survey results (e.g. on adaptive capacity) • Describing the importance of sectors, crops, etc. in a region	• Provide percentages for each 'slice'.
• Comparing vulnerability (or one of its components) in different regions or sectors • Depicting a variable (such as literacy) in different regions	• Use the horizontal axis for categories, the vertical for values/frequency.
• Illustrating aggregated values such as potential impact, which is here broken down into exposure and sensitivity; or the overall vulnerability in different regions showing the three vulnerability components	• Do not include too many variables: the chart becomes more confusing the more each bar is subdivided.
• Comparing impact on or vulnerability of different sectors in different regions • Comparing different vulnerability components (sensitivity, adaptive capacity, etc.) in different sectors or regions	• Use readily distinguishable colours to help the reader comprehend the graph at a glance.
• Illustrating trends in climate signals or socio-economic variables over time • Illustrating change in vulnerability (or one of its components) over time	• This chart can be used for a large amount of data points on the horizontal axis. • This is a good choice for continuous data (where an infinite number of values is possible).

Microsoft 2013: Create charts in Excel 2007. Retrieved 16.04.2014 from *http://office.microsoft.com/en-us/excel-help/demo-create-charts-in-excel-2007-HA010200499.aspx?CTT=1*

Microsoft 2013: Present your data in a bar chart. Retrieved 16.04.2014 from *http://office.microsoft.com/en-us/excel-help/present-your-data-in-a-bar-chart-HA010218664.aspx*

Illustrating vulnerability using diagrams and graphs

Maps are just one way of illustrating your findings and making comparisons. You can also use various types of diagrams and graphs (see Table 17). When you're designing a chart, it is particularly important that you include any information the reader needs, indicating, for example, the data element represented by a given axis. You can do this either by including a legend in the chart itself or supplying a description next to the figure.

Table 17 provides examples of different charts and how they can be used to illustrate the findings of a vulnerability assessment.

POTENTIAL PITFALLS

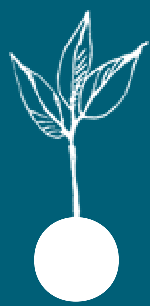
It can be difficult to formulate and present the findings of a complex and wide-ranging assessment in a way that is accessible and useful to outsiders. Therefore, it is even more important to have a clear and comprehensible structure and to come to the point. Set-up the structure of your report before writing and make sure it has a common thread.

During the course of a vulnerability assessment several assumptions and (normative) decisions are usually made. While they might be obvious for you, be aware that your target audience will need information on all assumptions made to be able to interpret your findings.

Remember the target audience when presenting your findings. A policy maker, for instance, may not need a detailed description of your methodology. Instead, he or she will be typically interested in clearly presented key findings.

When illustrating your findings, prevent misinterpretations by providing all the information required for reading maps and graphs correctly. Remember that some of your readers will look at the illustrations without reading the accompanying text, so include key information in legends and design elements.

IV



How to use your vulnerability assessment for monitoring and evaluation (M&E)

Now that you have completed the vulnerability assessment you have a wealth of information at your fingertips. It can help you identify regions, economic sectors and population segments that are especially vulnerable to climate impacts, while also aiding you in selecting suitable adaptation measures. What's more, it provides you with a baseline that can be used for M&E of vulnerability and adaptation as outlined in the Conceptual Framework.

While there is no pre-defined interval for repeating vulnerability assessments, aspects such as the duration or revision of the project or program or the expected time before the adaptation measure takes effect (and is therefore measurable) can be used for guidance. Table 18 provides general guidelines for repeating vulnerability assessment intervals for M&E. If you expect considerable changes in the system under review, shorter intervals can be advisable. For the test application in Pakistan, the vulnerability assessment shall be repeated at the end of the project life span of 3 to 5 years. In Norway, vulnerability and adaptation assessments at the national level are repeatedly conducted every 5 to 8 years and are linked to the timing of the global IPCC assessment reports. In the UK, changes in climate change vulnerability are reported biannually (GIZ 2013a).

Note that repeated vulnerability assessments require substantially less effort than the baseline vulnerability assessment. This is because the assessment framework and rules are already available: i.e. impact chains are developed, data sources are identified, contacts with data holding institutions are established and weighting procedures defined etc. (see also Box 18).

Table 18: General guidance on intervals to repeat vulnerability assessments for the purpose of M&E

Adaptation level	Interval
Project level	Every 3 – 5 years
Adaptation program or strategy	Every 5 – 10 years

Source: adelphi/EURAC 2014.

This chapter explains how you can use vulnerability assessments for general monitoring of changes in the level of vulnerability (Chapter IV.1) and the M&E of particular adaptation measures, programs or strategies (Chapter IV.2). Prerequisites and potential limitations in using vulnerability assessments for M&E are discussed in Chapter IV.3.

Applying vulnerability assessments for monitoring changes in vulnerability

By repeating vulnerability assessments you can monitor and evaluate the changes in the level of vulnerability over time at the three different levels of overall vulnerability, vulnerability components and individual indicators:

- Repeating a vulnerability assessment after a certain interval allows you to track changes in **overall vulnerability** in an economic sector, region or population segment – depending on the focus of your vulnerability assessment. This provides policy makers and project managers with vital information on intervention needs and hotspots as well as progress toward the long-term objective of an adaptation program or project, e.g. a reduction in climate change vulnerability (see also Chapter II). However such a highly aggregated value may conceal significant changes in underlying factors, so M&E must also consider changes in vulnerability components and individual indicators.
- Repeated assessments of vulnerability components and their indicators can help policy makers and project managers define priority areas for adaptation planning. The exposure component aids understanding of climate variability (short-term) and climate change (long-term) while sensitivity mainly offers data on changes to the bio-physical susceptibility of the system under review. Lastly, adaptive capacity reveals changes in a social system's ability to cope with the adverse effects of climate change, or to exploit its benefits. Changes in vulnerability components and indicators can occur due to the effect of adaptation interventions, development progress (or setbacks) and external influences such as conflicts or global trade policies affecting local living conditions. Since exposure (climate) covers longer time periods of ~30 years it will usually not be necessary to repeat its assessment, unless new information or improved projections become available (see Chapter IV.3).

Repeating several vulnerability assessments at the sub-national level can also provide important insights for adaptation planning at the national level. Such a comparison indicates in which part of the country vulnerability changes. When combining information from several (sub-national) vulnerability assessments, applying the standard approach of the Vulnerability Sourcebook for all vulnerability assessments facilitates comparability.

Applying vulnerability assessments for M&E of adaptation

As well as monitoring general vulnerability over time (Chapter IV.1), repeated vulnerability assessments can also contribute to the M&E of adaptation measures (for an introduction to adaptation M&E at the project level, please see GIZ 2013d). Adaptation aims at either reducing sensitivity, or increasing the adaptive capacity of the system under review. The objective here is to quantify the outcome of an adaptation program or measure on a system's sensitivity or adaptive capacity, and thus its vulnerability.

With the impact chains you developed in Module 2 you can monitor and evaluate the effect of an adaptation measure or program, according to the following logic:

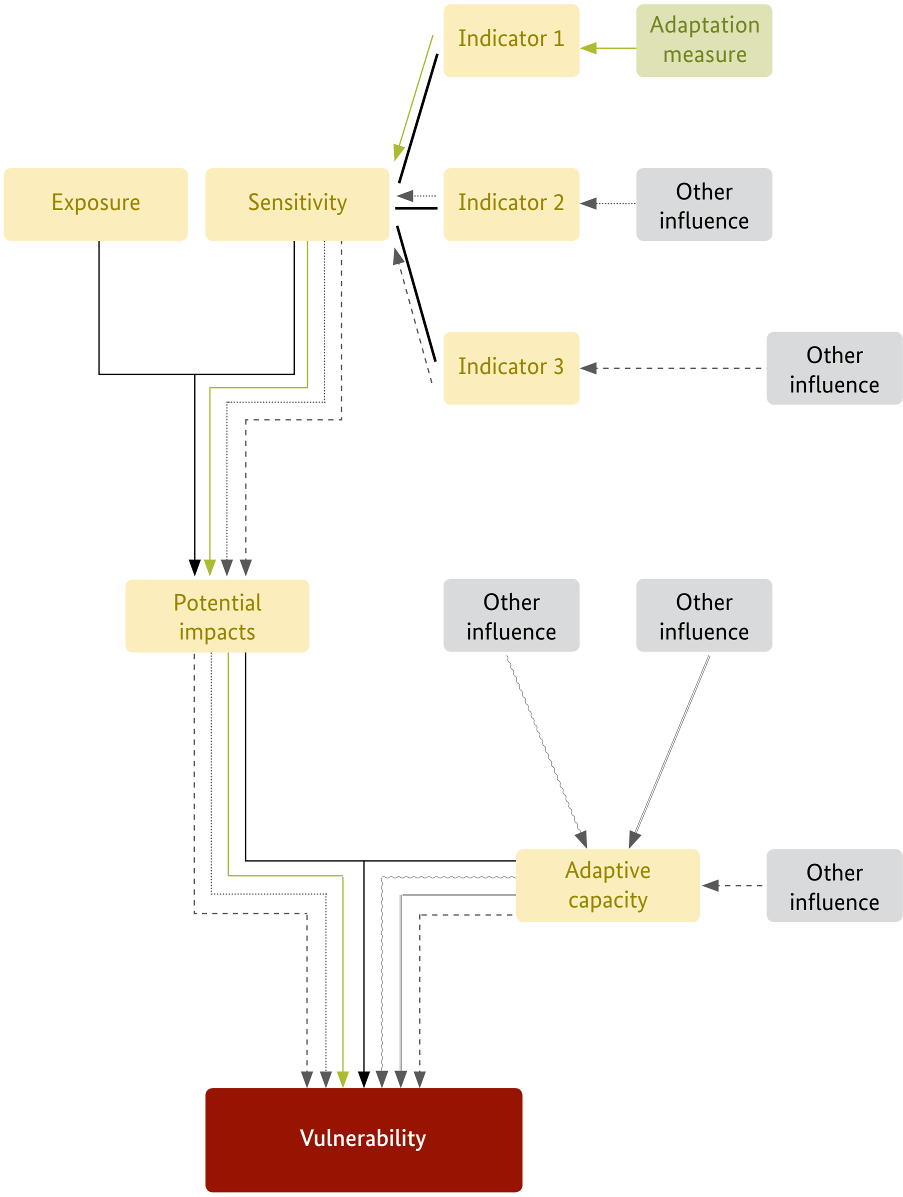
- The impact chain describes the vulnerability of your system and its cause/effect relationships (vulnerability hypothesis).
- You can use this description to identify suitable adaptation measures for reducing the system's sensitivity or increasing its adaptive capacity and to describe their desired outcome (adaptation hypothesis).
- Once the measure has been implemented, repeated vulnerability assessments can reveal whether the desired outcome has actually been achieved and to what extent.

Attributing the effect of adaptation measures

When monitoring and evaluating adaptation it can often be difficult to directly link changes in the value of an indicator or vulnerability component to the implementation of a particular measure. To make this causal relationship explicit it is important that you define indicators which capture the effect of planned adaptation measures into the vulnerability assessment framework right from the beginning. For instance, the effect of a training program on land management could be captured by an indicator 'number of suitable management techniques applied in a community' (see Annex 10). Remember that changes to an indicator or vulnerability component can also be influenced by other factors within and outside the assessment framework, including wider socio-economic developments.

Figure 37 illustrates the challenge of **attributing changes to specific measures or programs** (e.g. malaria prevention program) using an adaptation measure (e.g. campaign to cover water-storage systems to reduce breeding) that directly influences one of three sensitivity indicators (Indicator 1: e.g. ratio of covered / uncovered water storage systems). The effect of this measure is still evident at this level, whereas sensitivity indicator 2 (e.g. budget of local health clinics) changes due to other influences (e.g. global financial crisis). This makes it difficult to clearly identify the effect of an adaptation measure at the level of the vulnerability component sensitivity and even more so at higher levels of aggregation, where the number of internal (e.g. change in age structure) and external influences (e.g. progress in malaria drugs) increases. This again highlights the importance to also analyse individual indicators and vulnerability components and not only overall vulnerability.

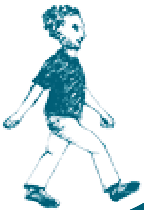
Figure 37: Influence of an adaptation measure and other influences on vulnerability and its components



Source: adelphi/EURAC 2014.

This so-called ‘attribution gap’ is a challenge for all M&E systems for adaptation. Unless an indicator cannot directly capture the outcome of a measure, addressing this gap would require additional context analyses that are not yet part of the VA framework. These might take the form of existing tools and indicators that are available for M&E from various sectors and disciplines, including cost-benefit analyses, environmental impact assessments and evaluation approaches in the field of disaster risk reduction (GIZ 2013a).

One approach to attribute the outcome of an adaptation measure is the use of so-called control-groups (counterfactual). Following this approach, adaptation effectiveness is typically assessed by comparing changes in the level of vulnerability of those who implemented an adaptation measure against those who did not. If the same vulnerability assessment framework is employed (e.g. for different communities), this approach could also be used to compare the effectiveness of different adaptation measures across groups. This would allow drawing conclusions which adaptation measure reduced vulnerability to a larger or lesser extent or which did not reduce vulnerability at all.



18 PRACTICE

Repeated vulnerability assessment to evaluate adaptation measures, the case study Chullcu Mayu, Cochabamba – Bolivia.

In a case study in Bolivia, the Vulnerability Sourcebook's approach to M&E of adaptation was applied. The village of Chullcu Mayu is located in a dry highland in Bolivia. In 2008, an innovative irrigation system was installed, along with the introduction of new crop types and capacity building measures (see Annex 11 for more details). One of the objectives of the case study was to assess the effect of those measures towards reducing vulnerability. Therefore, vulnerability was assessed before and after the introduction of these measures.

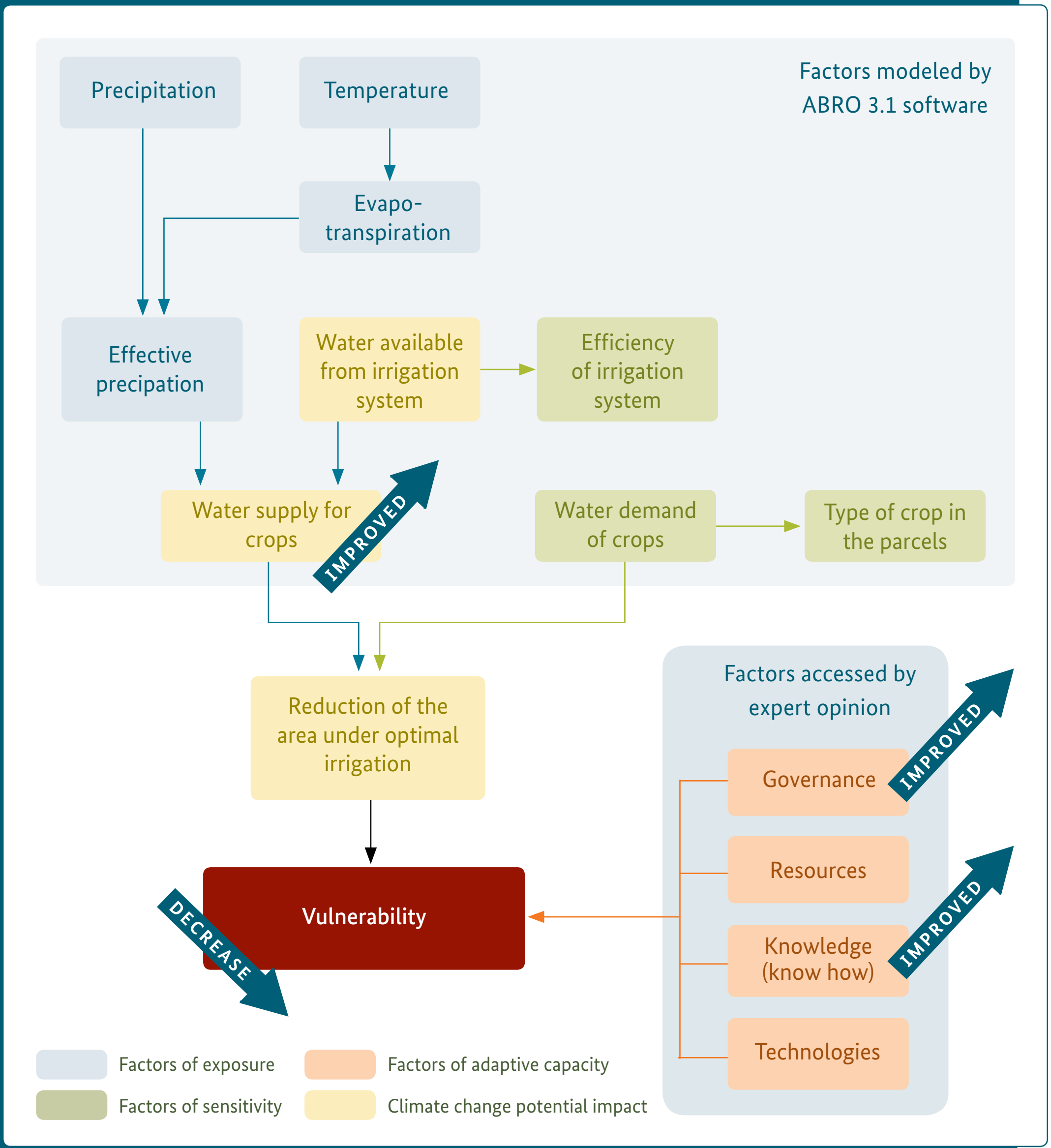
The measures influenced several indicators (see Figure 38):

- water supply was increased (sensitivity) due to the irrigation system (model result)
- farmers' irrigation organization was improved (adaptive capacity) through capacity building (expert opinion)
- know-how about crop management was improved (adaptive capacity) through capacity building (expert opinion)

Given the short time frame of six years, exposure remained unchained. The repeated vulnerability assessment could show that the implemented measures significantly improved respective indicators, vulnerability components and consequently reduced the vulnerability value from 0.77 to 0.26 (See Figure 38 and Table 19).

The application of the Vulnerability Sourcebook for M&E in Bolivia demonstrated that repeated vulnerability assessments can make an important contribution to assess the effectiveness of adaptation measures. It also showed that the vulnerability assessment could be repeated at reasonable effort for the purpose of M&E, since the assessment framework, models and data were already at hand. For a future monitoring, the factors mentioned above should be monitored regularly, i.e. every 3-5 years, to understand if the success gained in the first 6 years could be sustained.

Figure 38: Effect of adaptation measure on vulnerability and its sub-components in the Bolivia test case



Source: adelphi/EURAC 2014.

Table 19: Repeated assessment of impact, adaptive capacity and vulnerability of small farm holders against insufficient water supply

Impact	Adaptive capacity	Vulnerability	
0.92	0.63	0.77	before measures
0.17	0.35	0.25	after measures

Source: adelphi/EURAC 2014.

A challenge with this approach is that all other factors possibly influencing vulnerability (e.g. differences in income and geographic area) need to be controlled for to ensure that differences between groups are caused by the adaptation measure. This can be achieved by assigning individuals or groups of individuals randomly to the treatment (with adaptation measure) and the control group (Duflo et al. 2006). Moreover, you would need to apply statistical techniques to scientifically prove that change occurred due to the adaptation measure. This might not always be necessary or feasible in the course of a vulnerability assessment. Usually, repeating vulnerability assessments for M&E will suffice in most contexts. If you decide to apply statistical tests, keep in mind that you need a sufficiently large sample size to get robust results.

Defining the purpose of your M&E system

A proper understanding of attribution can also help you define the goal of your M&E system:

- If you can relate the effect of an adaptation measure directly to one or more of your indicators, you can use your vulnerability assessment (or parts thereof) for the M&E of adaptation. This applies mostly to vulnerability assessments at the project level with a specific focus and manageable time frame (3-5 years).
- If attribution is difficult or impossible, you can use your vulnerability assessment for the M&E of vulnerability over time. This applies mostly to vulnerability assessments at a regional or national level (e.g. NAPs) or those with a broader focus and/or longer time frame (more than 5 years).

Prerequisites and potential limitations in applying vulnerability assessments for M&E of vulnerability and adaptation

The following prerequisites and potential limitations must be taken into account during the set-up of your baseline vulnerability assessment, as well as any repetitions:

- **Carefully document the entire vulnerability assessment in writing, and keep a copy (preferably electronic) of all data used and their meta-data (see Module 4).** Only by careful documentation and data archiving will you (or someone else) be able to repeat the same vulnerability assessment approach at a later stage. This is particularly important if parties external to your adaptation initiative or programme (like a university institute or consulting company) are employed to conduct the vulnerability assessment. This is because there is always a risk that you will need to employ someone else if you wish to repeat the analysis at a later stage. Provision for documentation and data archiving must be made in the terms of reference, and must be budgeted for.

- **Ensure reliability of indicators:** Module 3 introduced general criteria for selecting indicators. When developing your baseline assessment for M&E, it is important that your indicators are reliable, i.e. that you will be able to use them for comparison in the future as well. As Module 3 also indicates, not all methods for quantifying indicators are equally reliable. For instance, standardized measurements of climate parameters, official statistical bureau data and representative household surveys are more objective than expert interviews. And if you do use participatory techniques or expert interviews, it is important that you approach a representative selection of stakeholders (UNDP 2008).
- **Describe procedures for quantifying indicators:** To improve the reliability of indicators it is important that you document the procedures used for quantifying them in your vulnerability assessment report, especially if you use a participatory approach (Module 4). Procedures may include such factors as selection and number of interviewees, guiding questions and evaluation procedures. This information can, for instance, be included in the indicator factsheet (see Annex 6) or in the vulnerability assessment documentation.
- **Keep assessment rules constant:** When repeating the vulnerability assessment, make sure that rules regarding threshold definition (Module 5), weighting of indicators and vulnerability components (Module 6) as well as aggregation (Modules 6, 7) remain constant. Otherwise it becomes impossible to determine the root cause of changes in vulnerability (see also Module 6).
- **Integrate new insights:** When repeating your vulnerability assessment after a certain period, you may find that your assessment framework (or parts thereof) needs to be revised if, for example, new climate data (exposure) becomes available, data for sensitivity or adaptive capacity indicators is discontinued or a cause/effect relationship is called into question. If you decide to revise your assessment framework the prerequisite 'keep assessment rules constant' no longer applies and the baseline assessment must be revised as well before using the revised framework for M&E. While this is relatively easy when integrating improved (climate) data, it becomes more difficult if the impact chain – and consequently weighting – needs to be re-considered. If a lack of resources or some other factor prevents you from revising and repeating the initial assessment, neither overall vulnerability nor revised elements of the assessment framework can be monitored and evaluated. Where assessment rules for vulnerability components or individual indicators remain unchanged they can still be used for M&E.

Glossary

Adaptation: is '(…) a process of adjusting to actual and expected climatic changes, or to the effects of climate change on social and ecological systems. Adaptation aims to moderate harm to human well-being associated with those changes, and to exploit potentially beneficial opportunities' (GIZ/WRI 2011, p.11). Adaption comprises different activities that are tailored to fit the specifics of its target groups, sectors and places.

Adaptive capacity: refers to 'the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences' (Parry et al. 2007). It is used to describe the various socio-economic, structural, institutional and technological abilities of a human system to produce adaptation measures.

Adaptation hypothesis: describes how and to what extent an adaptation measure or program is assumed to influence overall vulnerability, vulnerability components or individual indicators.

Aggregation: is the process of combining different data from different measurements into a composite indicator. The process of aggregation requires the normalisation and (if applicable) weighing of the data to avoid distortion effects when aggregating the several factors (OECD 2007).

Attribution gap: Even if an effect of an adaptation measure has been observed and measured, one should not deduce from this that the result came about through the project alone. And even if the direct effect (outcome) can be clearly attributed to an intervention, this does not prove that this contributes to an overarching goal (impact). This state of affairs is known as the 'attribution gap' (Zewo 2011). For a complex concept as vulnerability the attribution gap is relatively wide, since manifold social and natural factors influence the potential impact and the adaptive capacity and, therefore, the vulnerability of system.

Baseline: 'the baseline (or reference) is the state against which change is measured. It might be a 'current baseline', in which case it represents observable, present-day conditions. It might also be a 'future baseline', which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines' (IPCC 2007b).

Categorical data: categorical data are made up of distinct (non-overlapping) entities/categories. An example for categorical data is gender (male/female) or land use/land cover. Categorical data can be ordinal (ordered/intervals undefined) such as education level or nominal (no order) such as crop type.

Climate change: 'refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes' (IPCC 2007c).

Climate model: 'a numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for all or some of its known properties. The climate system can be represented by models of varying complexity, that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parametrisations are involved. […] Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal and interannual climate predictions' (IPCC 2007c).

Climate variability: 'refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability)' (IPCC 2007c).

Composite indicator: a composite indicator (also called index) is a complex indicator, composed by combining several (weighted) individual indicators. Composite Indicators are able to measure multi-dimensional concepts (vulnerability against climate change effects) which cannot be captured by a single indicator. The methodology of its composition should entail the details of the theoretic framework or definition upon whereas indicators have been selected, weighted and combined to reflect the structure or dimension of the phenomena being measured (OECD 2007).

Disaster risk reduction: this concept was established in the 1970s and highlights the socio-economic and political origin of disasters. A disaster risk is not only caused by the probability of a physical hazard, but also by the wider social, political, economic and natural environment in which the hazard will occur (Mercer 2010).

Ecosystem: 'the interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond' (IPCC 2007b).

Ensembles: are the combined use of different climate forecast models that attempts to quantify the amount of uncertainty in a projection by generating an ensemble of multiple forecasts. Every climate model has its own design and set of assumptions. To achieve a higher level of projection stability, the results of several models are averaged and employed in different climate scenarios.

Expert opinion method: Assessment of vulnerability components/indicators on an ordinal scale by stakeholders with a high degree of knowledge on the system at stake (e.g. local project officers, agricultural extension officers, experienced farmers and alike).

Exposure: refers to the character, magnitude, and rate of change and variation in the climate (IPCC 2001). Typical exposure factors include temperature, precipitation, evapotranspiration and climatic water balance, as well as extreme events such as heavy rain and drought.

Extreme weather event: 'an event that is rare at a particular place and time of year. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally' (IPCC 2007c).

Impact chains: they permit the structuring of cause - effect relationships between drivers and/or inhibitors affecting the vulnerability of a system (see: sensitivity, exposure, adaptive capacity). 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.

Impact: is determined by the climate signals, to which a system is exposed and its sensitivity. Potential impacts would be realized if the system had no potential to adjust or if no adaptation measures were taken.

Implementation plan: this document pinpoints the key findings from the different steps of the vulnerability assessment approach. It contains and accumulates the cornerstones of the assessment, i.e. its objectives, context, scope, partners and resources involved, methodology as well as further on the sharing of tasks between the different actors and a detailed time plan for the implementation of the vulnerability assessment. The vulnerability assessment implementation plan is the central tool for communicating responsibilities and progress of the assessment to all involved partners and stakeholders.

Indicator: Measurable characteristic or variable which helps to describe a situation that exists and to track changes or trends – i.e. progress – over a period of time (GIZ 2013).

Intergovernmental Panel on Climate Change (IPCC): is perceived as the leading international body for the assessment of climate change. In the 23 years since its founding, it has become a key framework for the exchange of scientific dialogue on climate change within the scientific community as well as across the science and policy arenas (Edenhofer and Seyboth 2013).

Metric scale: a *metric* scale consists of ordered, numerical values where the difference between two values is clearly defined and of the same interval. This means that the difference between 2 and 3 is the same as the difference between 54 and 55. Examples include temperature, yield in tons or income in US$. Metric scales are the highest level of measurement.

Mitigation: 'an anthropogenic intervention to reduce the anthropogenic forcings of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks' (IPCC 2007b).

Model: 'models are structured imitations of a system's attributes and mechanisms to mimic appearance or functioning of systems, for example, the climate, the economy of a country, or a crop. Mathematical models assemble (many) variables and relations (often in a computer code) to simulate system functioning and performance for variations in parameters and inputs' (SREX IPCC 2012).

Monitoring & evaluation: Is the systematic collection of data to allow stakeholders to check whether an initiative is on track (monitoring) and to measure the impact or effectiveness of an intervention in achieving set objectives (evaluation) (GIZ 2013c). M&E faces challenges in terms of attribution and causality, as complex phenomena make it difficult to assign a precise and testable connection between measures taken, other influencing factors or a general development and the results observed. Common method includes the comparison of a baseline vulnerability assessment vs. a repeated vulnerability assessment (GIZ 2013c).

National Adaptation Plan (NAP): 'national adaptation plans (NAPs) are means of identifying medium- and long-term adaptation needs and developing and implementing strategies and programmes to address those needs. It is a continuous, progressive and iterative process to formulate and implement NAPs which follows a country-driven, gender-sensitive, participatory and fully transparent approach' (UNFCC NAP).

Nominal scale: a nominal indicates distinct entities or categories. Examples include names, postal codes, crop types, irrigation types. Nominal scales represent the lowest level of measurement.

Normalization: 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 (OECD 2008). Normalisation is a prerequisite for aggregating individual indicators measured in different scales to a composite indicator.

Ordinal scale: indicates that one given value is greater or lesser than another, but the interval between values is undefined or unknown. Examples of ordinal scales include school marks, education level, and rankings of suitability of soil types for certain crops.

Participatory/bottom-up approaches: their participatory nature leads to outputs that reflect many different voices, perceptions and experiences. This requires an ability to synthesise and identify priorities for action. Qualitative approaches are often more in depth and able to consider local specificities but do not yield comparable results.

Potential impact: are climate change related events that may/potentially affect the assessed area. Direction, extend and scale are predominantly determined by the factors Exposure and Sensitivity.

Proxy: a proxy indicator is an indirect measure or sign that approximates or represents a phenomenon that cannot be measured directly. Proxies are also applied where no data is available, or for highly complex parameters. A widely used example is 'GDP' as a proxy for 'poverty'.

Quantitative / top-down approaches: such methodologies include complex modelling, projections and/or statistical models requiring access to data, software and knowledge of methodologies that involve training. Therefore, quantitative or top-down approaches are in general quite cost-intensive. However, the outputs from such sophisticated assessments are more likely to be understandable to and accepted by policy and decision makers (Hinkel et al. 2010, Schipper et al. 2010). Besides, quantitative assessments allow often a better comparability of assessment results.

Sensitivity: Sensitivity determines the degree to which a system is adversely or beneficially affected by a given climate change exposure (IPCC 2007b). Sensitivity is typically shaped by natural and/or physical attributes of the system including topography, the capacity of different soil types to resist erosion, land cover type. But it also refers to human activities which affect the physical constitution of a system, such as tillage systems, water management, resource depletion and population pressure. As most systems have been adapted to the current climate (e.g. construction of dams and dikes, irrigation systems), sensitivity already includes historic and recent adaptation.

Stakeholder: 'a person or an organisation that has a legitimate interest in a project or entity, or would be affected by a particular action or policy' (IPCC 2007c).

United Nations Framework Convention on Climate Change (UNFCCC): 'the Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. It contains commitments for all Parties. Under the Convention, Parties included in Annex 1 (all OECD countries and countries with economies in transition) aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The convention entered in force in March 1994' (IPCC 2007c).

Vulnerability: the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC 2007b).

Vulnerability analyses/assessments: is the practice of identifying, measuring and ranking vulnerabilities of a system. They are usually applied to inform decision-makers and to support processes of adaptation. Measures in the context of policy-making and for specific sectors and sub-systems aim to enhance the ability to resist or avoid harmful consequences of climate change.

Vulnerability hotspots: regions, populations and sectors with particularly high vulnerability.

Vulnerability hypothesis: Describes the factors and their cause-effect relationships that determine the vulnerability of the system under review. In the Vulnerability Sourcebook, these factors are structured along the vulnerability components exposure, sensitivity, potential impact and adaptive capacity.

Weighting: is the process of attaching a numerical modification (weight) to an indicator to emphasize the importance of this indicator against other indicators (OECD 2007). Weighting (i.e. adding a multiplier or divisor to the respective factor) is used to enhance or reduce the influence of that factor in its interaction within the composite indicator.

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