

## Identifying Climate Vulnerability Exposure

Preliminary guidance for ACCCA teams

21<sup>st</sup> June 2007, Oxford

By the Stockholm Environment Institute

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This guidance sheet provides an approach to identify the key climatic hazards for a specific region and livelihood or economic activity. The outcomes of the process will allow the analyst:

- To identify measurable climate variables that can be obtained from climate information systems for the present and archives of global climate change models for relevant time periods in the future (Steps I to III)
- To identify climate variables and thresholds of concern that would be required in planning adaptation strategies and measures. This will prepare teams to work on construct climate envelopes that represent the range of available model outputs for potential future exposures to climate stresses (Step IV).
- To identify gaps in knowledge where additional sectoral and livelihood studies are required or may be available but not brought into the team's expertise, at the local to national and even regional level (in reflecting on the entire exercise, Step V).

## Introduction

In order to assess how climate change might impact certain livelihood groups, it is necessary to establish the degree and range of exposures of these groups to climate hazards. By ranking hazards according to their level of impact one is able to prioritise the key climate hazard(s) to address. The type of information needed about the climate hazard can be communicated to climate experts and climate modellers, who can then provide the current climate data and the range of future values, both directly relevant to vulnerability and exposure to hazards. This information can be used to plan adaptation options, by responding to the projected climate trends, whilst accounting for the degree of uncertainty associated with these projections.

### Step I: Selection of a target region, activity and vulnerable group

This step is already accomplished for ACCCA pilot actions as this was part of the concept note stage for getting the projects approved. Additional guidance on vulnerability mapping and targeting adaptation is now prepared as part of the collaboration on climate adaptation which is under development on the wikiADAPT site (contact: SEI Oxford, Anna Taylor SEI Oxford [annactaylor@gmail.com](mailto:annactaylor@gmail.com))

### Step II: Focus on key hazards or opportunities through a livelihood-exposure sensitivity matrix

A livelihood sensitivity matrix provides a starting point for determining which livelihoods are most vulnerable to different types of climatic hazards and the degree to which different livelihood activities are impacted by different climate hazards where:

- The rows correspond to exposure units such as resources, activities and livelihoods that may be exposed to and impacted by climate;
- The columns list climatic events, stresses or opportunities to which resources, activities and livelihoods may be exposed.
- The scores from the impact of climate hazards on livelihood activities can help to determine priorities in responding to hazards.

Additional material on completing this step is shown in Appendix A; a spreadsheet is available as a template for completing the matrix but hand-drawn exercises that follow a similar approach in a participatory manner are easier to work with. A variety of participatory methods are appropriate for use with vulnerable communities—some examples can be found on [www.VulnerabilityNet.org](http://www.VulnerabilityNet.org) in the document hotel, or contact the SEI.

### Step III: Defining climate variables to the stresses

Once the climate hazards of most concern are identified in the matrix columns, the climate variables associated with this hazard need to be specified, so that climate experts and modellers can assess whether the variables are available in existing data bases and climate

change scenarios. It should be noted that although climate information might be a focus on this approach, it is critical to incorporate information on the other stressors such as population pressures, poverty, and socio-economic conditions that livelihoods are exposed to, as this vulnerability information will determine the type of adaptation strategies that are possible and necessary.

Part of the process of gathering this information should be guided by those at risk of the hazard, the community 'at risk'. This should be targeted by sectors. Appendix B outlines the type of questions that could be asked about a specific climate hazard.

Once a hazard of concern is chosen for a particular livelihood(s) groups or activities, and the corresponding adaptation priority, it is necessary for the climate modellers to get answers to the following type of questions with a set of examples:

- What variables are critical such as precipitation for drought?
- What is their unit of measurement such as millimetres for precipitation or Celsius for temperature?
- What is the most important time period?
  - Averaging periods such as daily, monthly, or 10 days.
  - Average or time series such as WMO climate normals.
- What level of detail is needed such as station, gridded, or spatial average?
- Other important information needed such as the onset of the rainy season and/or amount of rainfall received in 10 day period.

These are *not* questions that should be directly asked of the community at risk but the formulation of the questions should be guided by those at risk of the hazard. That is, they should be formulated within the social and cultural framework applied in local decision making. These will be context specific and different for each community. See Appendix A for some examples of questions that can be asked of the community. It is then the role of the researcher and analyst to interpret and translate the answers to the questions into information that can be used by the climate modelling teams.

#### Step IV: Link climate variables to planning adaptation

In order to guide the process of getting data, the following points need to be established for your pilot project:

- What climate information are needed, the details of which were guided by the questions above?
- What climate information exists and can be gathered, even if not from formal climate observing systems?
- What are the data limitations, degree of completeness and confidence in the data for the targeted region?

Data related to the climate hazard of concern that is provided by climatologists can then be used to guide the development of adaptation strategies. These should be appropriate to the livelihood typology and climate scenarios that were linked to the hazards specified as a

priority in the livelihoods sensitivity matrix exercise. However, it is important that the project team organizes a discussion about the uncertainty that is associated with the

different variables because in some cases, adaptation may have unintended consequences and these should be addressed before implementing strategies are developed.

For each of the hazards, it is also important to define values of concern, such as frequencies and critical limits that define extremes and/or thresholds. The values chosen will invariably be sector and region or location specific. Historical events might provide examples of where a certain threshold was exceeded and impacts recorded. One may choose to define these values by first identifying historical hazards such as droughts or floods. Once these are identified, defining critical values for related variables such as temperature or precipitation is a matter of comparing the differences for these variables and the historical record for these events. For example, when considering a drought on record, one define this drought by quantifying the number of days where little or no rainfall was received (the dry period) and then compare this number to the historical record's average dry period. Looking at the difference between these would permit the identification of the length or quantity of rainfall that define a drought period.

For example, in the European heat wave during 2003, temperatures were 6<sup>o</sup>C above the long-term mean for several days and as a result crop yields dropped significantly. In Italy, corn yields dropped 36%; and in France, fruits harvests declined by 25% and forage production by 30% (IPCC, 2007 <http://www.ipcc.ch/SPM6avr07.pdf>). This event resulted in numerous other impacts such as human temperature stress and numerous deaths. This type of information could provide useful baseline data of critical thresholds. In relation to the above example, it could help to provide evidence for the impact on crop yields when temperatures cross a certain threshold. In some cases, modelling approaches would help to determine what the actual threshold is.

The identification of the specific climate variables, and the location and time period relevant to the hazard is required in order to 'overlay' future climate conditions on current, or baseline vulnerability. It is not possible to predict future socio-economic and environmental vulnerability or the climate system at a local scale for the decades into the future that are of concern in climate change adaptation. However, it is important to gain a sense of the range of future conditions that a community might face, and consider whether this information warrants a different response, beyond what is planned at present.<sup>1</sup>

<sup>1</sup> The following additional guidance notes are in preparation: 1) Characterising future climate change from the perspective of current exposure, taking advantage of large ensembles of climate model scenarios (what we term "CCEERs" which stands for climate change exposure ensemble ranges); and 2) Tools for screening adaptation options against future climate conditions and the many other factors that drive adaptation planning, which will take into consideration different time horizons for planning and implementing urgent adaptation strategies by various stakeholders. This range will be represented in a multi-model analysis through the "Climate Change Exposure Ensemble Range" (CCEERs) module, currently under development by UCT, AWhere Inc and SEI (an outcome of the entire process, but see Step V). The module will synthesize information from ensemble simulations in an envelope analysis to determine the potential distributions of future climate change. Its purpose is to provide information on the results from climate models, in ways that will allow the potential user of the information to evaluate how best it may be applied.

## Step V: Reflecting on the uncertainties of exposure and context in narratives

As the exercise proceeds, it is helpful to document the state of knowledge, possibly with interviews with experts, developing narratives that tell the story behind the 'numbers' and similar reflections. Such techniques will help to communicate the findings to other experts, and with the communities affected as well. Methods for constructing narratives from interviews and drawing upon local knowledge should be explored if possible.

Although it is important to gather relevant climate data, it is vital to recognise two other key points. Firstly, that the climate scenarios have a high degree of uncertainty, so this can only be used for guiding planning rather than predicting the future climate. Secondly, it should be recognised that climate is one of many factors, including socio-economic, cultural and political factors that contribute to vulnerability. Therefore, planning adaptation strategies in response to climate as a single, isolated stress needs to be treated with caution. There are likely to be additional factors determining thresholds in different contexts which will make it hard to identify climate thresholds alone. It is therefore important to explore examples where climate and socio-economic variables are clearly inter-linked.

For example, activities carried out by the **Famine Early Warning Systems Network (FEWS NET)** (see: [www.fews.net](http://www.fews.net)) guide people in choosing different crop varieties suited to the expected climate of the season. This may be based on current and expected climate change exposure ensemble ranges (CCEERs-see footnote) as well as market trends and the degree of access to the seeds of suggested crop varieties. Therefore, although it is challenging to link socio-economic and climate data, it is also very important.

## Step VI: Monitoring exposure and updating the knowledge base

The exercise should be repeated, or at least revisited to ensure the knowledge base is kept current. Also, an important part of this process is that it will help climate modellers to know what information is of most relevance to users and they in turn will provide scenarios that are relevant to planning adaptation.

## Appendix A: Developing a livelihood-sensitivity matrix

This annex presents an example of a livelihood sensitivity matrix that can be used in several ways:

- To synthesize existing knowledge on climate vulnerability in a fairly rapid participatory exercise with stakeholders
- To provide a first-order vulnerability assessment based on expert judgment
- To integrate results from a variety of quantitative and qualitative methods

The matrix also illustrates some of the technical issues in the use of indicators of vulnerability to a range of climatic risks.

The analysis works best if focused on a particular region, ecosystem or resource. For instance, it might look at highland land use vulnerable to drought and floods or coastal zones susceptible to sea level rise and cyclones.

The first step is to list the livelihoods in the case study region. Then work backward to list the productive activities of these livelihoods and the ecosystem services that support those elements. Thus, the rows of the table are organised according in a hierarchy of the ecosystem services that are essential in productive activities, which are elements of common livelihoods. For example, a general relationship between climate and the soil water balance will affect a variety of crop and livestock production activities, which are the major components of some livelihoods.

More generally, the rows are the ‘units of exposure’—those elements in ecosystems, populations and economies that are subject to climatic hazards and trends. Analysts may wish to organise the rows differently—for instance concern for cross-cutting sectors such as infrastructure (roads, electricity, ports, and market facilities) may warrant adding a block on economic services to correspond to ecosystem services. The nature of the exposure elements should correspond to the broad framing of the vulnerable conditions.

The next step is to list the present climatic threats (or opportunities) and trends that are significant for the list of livelihoods (or exposure units). These climatic risks are the columns of the matrix. Some judgment is required to separate the continuum of weather and climate into distinct threats. For instance, drought is almost always a threat in some form for rural livelihoods. In the example below, episodes of drought over a year or more are separated from shorter dry spells during the year.

It is likely that some iteration and refinement will be warranted in rows and columns of the matrix. There are no hard and fast rules for separating ecosystems into services, people into livelihoods, or weather into climatic risks. Indeed, one of the purposes of the matrix is to show how thresholds of vulnerabilities differ between exposure units (and over time). The definition of drought risk is quite different for subsistence farmers and pastoralists.

How sensitive is each element of exposure to each climatic risk? Fill in the matrix by ranking each cell. A rapid, scoping exercise might use high, medium or low score. A five-point scale is probably sufficient for most analyses.

This is a first-cut of a rapid vulnerability assessment. What does it reveal about who is vulnerable? What are the gaps in knowledge? What indicators of vulnerability or adaptive capacity are generic to the matrix or specific for livelihoods and threats? For instance, crop-drought indicators (such as yield) are of different importance for semi-arid subsistence agriculture than for highland commercial farms. What is the range of adaptation options? Are these specific to livelihoods and threats or more generic? What institutions are relevant for implementing adaptation options for each livelihood?

Further use of the matrix might involve exploring ratings according to outcomes, or comparing different scenarios of future vulnerability and aggregating the matrix ratings into overall scores.

The rating of sensitivities depends on the outcome of exposure and hazard. For instance, sensitivity to mortality usually has a different rating for each hazard than exposure to loss of livelihood (e.g., economic impacts), or well-being (as a broader category including social and psychological stresses). In most cases, the initial ratings are related to a broad interpretation of economic assets. However, if the matrix is to be used analytically, it is necessary specify what the consequences or outcomes of the identified vulnerabilities. Most commonly, these include loss of life and loss of property (assets), but some stakeholders may be concerned with the full range of livelihood ‘capitals’ including social networks and psychological stress.

The matrix is relatively easy to fill in for present conditions. In order to compile a matrix for future vulnerabilities, the analysts need to describe storylines that indicate how livelihoods might change (e.g., their reliance on different ecosystem services and activities, as well as their prevalence), how climate might change (there might be new hazards or trends become significant in the future) and how the sensitivities might change (for example with new technology). These are the typical concerns of building scenarios. The matrix provides an easy means to compare the results.

With some caution, it may be interesting to sum the rows, columns and overall matrix into aggregated indicators. A simple sum (divided by the maximum possible score) of the rows and columns yields relative scores for exposure and impacts. An aggregate score for the total exposure and impacts might be weighted by the probability of the different hazards occurring (for the exposure scores) or the prevalence of the livelihoods (for impacts scores). Analysts may wish to look at different scoring methods—for instance counting the number of high scores (for example those with a 4 or 5).

Note that aggregating matrices for different outcomes is not recommended—the justification for adding exposure to mortality to exposure to property loss raises concerns for equity that are beyond this simple technique (see guidance material on multi-criteria and benefit cost methods).

	Climatic risks						Exposure indices	
	Drought	Dry spells	Intense rain	Flood	Warm spells	... other	Exposure score	Weighted exposure index
<i>Frequency</i>	20	40	10	5	10		85	8.88
<b>Resources and Livelihoods</b>								
<b>Ecosystem services</b>								
Soil water balance	5	4	1	5	1		64	3.59
Water supply	5	2	2	4	1		56	2.71
Water quality	2	1	3	4	2		48	1.76
Non-farm wood fuels	3	1	1	2	1		32	1.53
Grazing and fodder	4	2	1	4	1		48	2.35
... others								
<b>Livelihood activities</b>								
Coarse grain production	5	4	2	3	1		60	3.59
Market crop production	5	3	2	2	1		52	3.06
Livestock production	4	3	1	3	1		48	2.76
Charcoal/wood fuel use	2	1	2	2	1		32	1.41
Craft sales	2	1	1	3	1		32	1.35
Rural casual labour	3	1	1	3	1		36	1.59
Non-farm permanent employment	2	1	1	3	1		32	1.35
... others								
<b>Livelihoods</b>								
	<i>Prevalence</i>							
Smallholder farmers	60	5	3	1	3	1	52	3.00
Emerging farmers	25	3	2	1	2	1	36	2.00
Ranchers	10	4	2	1	2	1	40	2.24
Market traders	5	3	1	1	4	1	40	1.65
...others								
<i>Impacts score</i>	100	75	40	20	55	20		
<i>Weighted impacts index</i>	<b>11.55</b>	4.30	2.55	1.00	2.70	1.00		<b>8.88</b>

*Notes:*

The example shown here is based on farming systems in southern Africa—these should not be taken as authoritative ratings, they are intended to show the technique rather than results from formal expert judgements.

- Exposure score: Sum of the columns for each row divided by the total possible score multiplied by 100 (25).
- Impacts score: Sum of the rows for each column divided by the total possible score multiplied by 100 (20). This is calculated only for the livelihoods—the preceding rows are elements of the livelihood scores and would result in double counting if added together.
- Weighted exposure index: This takes each cell in the row and multiplies it by the frequency for the climatic risk (shown at the top of the table), the sum of these weighted values is then divided by the sum of the frequencies. Note that the frequencies may not add to 100<sup>2</sup>.
- Weighted impact score: As above, the sumproduct of the cell values weighted according to the prevalence of the livelihood (shown in the left column of values). The sum of the prevalence of livelihoods should be 100, assuming they are discrete groups.

*Two aggregate values are shown:*

The sum of the weighted exposure scores for the livelihoods (8.88) and the sum of the weighted impact scores for the hazards (11.55) might be useful in comparing different regions or scenarios. Whilst they are useful for comparison, these scores should be used with caution as they have no explicit meaning in and of themselves.

*Source: Material prepared by SEI under the UNEP support project for the NAPA projects.*

<sup>2</sup> In Excel this is done using the sumproduct function.

## Appendix B: Examples of eliciting key climatic variables and thresholds

These questions help to ensure that the exposed groups provide their perception of how the climate hazard is impacting them. This information will not directly indicate what is needed from the climate modellers; rather, it will guide the adaptation researchers in determining the type of information needed, as informed by the community. For example, a key informant might say that there have been more frequent droughts recently. The researcher can simply try to enquire as to how the drought has affected them in their day to day lives. This may require further probing and exploration of potentially many different ways in which the hazard (in this case, drought) may manifest itself within the community. The impact may be in many different areas, from agricultural to economic and social spheres. The researcher could also consult a local expert on the nature of drought in the identified region. It is the role of the researcher, as a conduit, to then translate this fuzzy context-specific information into more technical variables which can be used by the climate modellers. We, as researchers should not expect the community at risk to be able to provide us with this information directly. Therefore, we need to make sure we are asking the ‘right questions’ and these questions should also be derived from our informants’ own decision-making framework.

### Exercise:

Having identified key hazards and vulnerable groups, we need to elicit the following climate information using the following open-ended questions. The table below uses drought as the example of the climate hazard that must be addressed most urgently:

Type of climate information	Example Questions	Example Response	Type of climate parameter being accessed
HOW? (Climate parameter)	<i>How does drought affect you?</i>	<i>It has been increasingly dry and I have been getting lower yields</i>  <i>Increase in weed species, decrease in medicinal plants</i>	Precipitation Temperature? Evapotranspiration? (needs to be explored by experts)
WHAT? (More detail on above or other climate parameters)	<i>What is the weather like when you have a drought?</i>	<i>It is serious when there is no rain for months but high temperatures make the drought worse</i>	Number of days with no precipitation plus temperatures data
WHERE? (Location)	<i>How far does the impact of the drought stretch?</i>	<i>All of our country is badly impacted by drought</i>	Geographical range
	<i>Is it the weather locally that causes the problem or is it weather in other areas (upper catchments etc?)</i>	<i>If the rain doesn't fall in the highlands during specific months we will suffer drought</i>	Geographical range (and seasonality)
WHEN? (Seasonality)	<i>During what periods of the year do you experience dryness?</i>	<i>It is hard on our crops if it is dry in October – November.</i>	Season
	<i>Have you noticed an increase in dryness in your lifetime?</i>	<i>There used to be drought when we were young but now it is for longer periods</i>	Frequency and long-term trends
	<i>How long can your crop survive without rain?</i>	<i>Days/ weeks with precipitation &lt; ∞ mm</i>	Precipitation threshold in mm

Type of climate information that might be needed for integrating climate change information into decision making

- Daily T max
- Daily T min
- Precipitation totals (daily, weekly or monthly)
- Daily, weekly or monthly max precipitation
- Daily, weekly or monthly min precipitation
- Length dry spells
- No days precipitation  $< x$  mm

Examples of the type of climate variables that might be needed to assess potential degree of climate hazard

Drought	evapotranspiration, dry spells (number of days $< x$ mm)
Winds	wind speed – maximum daily wind speed
Heat wave	number of days $T_{max} > x^{\circ}C$
Flash floods	hourly or daily precipitation $> x$ mm; annual max daily precipitation; decadal cycles
Waterlogging	soil water deficit, precipitation
Landslide	soil moisture; accumulative daily rainfall
Riverine flood	number of rainy days consecutively
Cold spells	number of days $T < x^{\circ}C$
Air quality/pollution	diurnal temp cycle, cloud top pressure
Soil desiccation	evapotranspiration
Fire	onset of rainy season; 5 consecutive dry months with $T_{max} > x^{\circ}C$

## Appendix C: Additional Resources

IPCC AR4 Chapter 8: Climate Models and their Evaluation - [http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1\\_Pub\\_Ch08.pdf](http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Pub_Ch08.pdf)

IPCC AR4 Chapter 10: Global Climate Projections - [http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1\\_Pub\\_Ch10.pdf](http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Pub_Ch10.pdf)

IPCC AR4 Chapter 11: Regional Climate Projections - [http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1\\_Pub\\_Ch11.pdf](http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Pub_Ch11.pdf)

NAPA Guidance Note – Linking Vulnerability to Climate Change - <http://www.napa-pana.org/UserFiles/File/pdf/Technical%20Sheets%20-%20Feb%202007%20versions/Technical%20Support%20to%20Facilitate%20Step%20%20of%20the%20NAPA%20Process.pdf>