Capacity strengthening in climate change vulnerability and adaptation strategy assessments

Exercise 3
Multi-criteria analysis for the identification of national adaptation strategies

In collaboration with:

CIAT SEI UNITAR

Exercise 3: Multi-criteria analysis for the identification of national adaptation strategies

Objective: Based on available data and tools, conduct a multi-criteria analysis (MCA) to develop a national adaptation strategy for the most vulnerable groups and sectors to climate change. The challenge of this exercise is to identify and develop, albeit in a qualitative way, local and national adaptation options to natural disasters and climate change. The MCA must be done not only to analyze potential adaptation options but also to prioritize which options should be implemented first.

Note: Generally, vulnerability assessments, and the identification of adaptation strategies in particular, are often based on variables that are difficult to quantify. However this does not mean that the variables are any less important in the decision-making process. A MCA allows one to take into consideration all of the important parameters and variables, both quantitative and qualitative. MCA is a simple decision-making tool and not an optimization technique.

To keep in mind throughout the exercise:
MCA is a multi-step analysis based on the synthesis of already existing vulnerability studies. The results from this analysis will assist the decision-making process in choosing the best adaptation options and strategies. The purpose of this analysis is not to assess vulnerability anew, but to bridge the gap between existing scientific knowledge and the decision-making process based on available information. For each step, groups are reminded to refer to the tools previously outlined (cf. Module 2).

Step 1 – Decision-making context
The context in which decisions will be made should be clear. Is the purpose of the analysis to choose adaptation options that allow one to face the impacts of climate change? Does a desire exist, as is the case with the National Adaptation Programmes of Action (NAPA), to place the emphasis on the urgent and immediate needs to adapt to current climate variability and climate change? Depending on the framework selected, the first step of the analysis should be to characterize the potential and existing climatic impacts/risks and identify the most vulnerable resources, groups, activities, areas, etc to these risks. It is with respect to those risks and vulnerable groups, sectors, and so on, that one must take adaptation decisions. These decisions should be based, as much as possible, on the best available information.

To the extent possible, this step should be based on existing vulnerability studies and participatory exercises. In the NAPA context, a sensitivity matrix has been used to identify the resources, sectors and groups that are particularly vulnerable to climate risks.

Step 2 – Identification of potential adaptation options
Based on the results of the first step, it is possible to develop an initial list of potential adaptation options. These options should target the most vulnerable sectors, zones and groups based on the most important climate risks (present and/or future). They can be based on traditional adaptation options used in the country/region, experience within government technical services, results of national or regional research institutes as well as on information available at the international level. Since these adaptation options will be implemented by stakeholders, those stakeholders need to be involved at all stages of the process - discussion, development and approval of the options - which is the main argument for the use of participatory approaches. It is

necessary to have a rough idea of the potential constraints (social, technical, political or other) likely to limit the implementation of adaptation measures.

Step 3 – Criteria identification
One must identify and define the criteria to be used in the MCA to rank the options. The criteria selected can be of a diverse nature: they may be selected unilaterally or through a group discussion with the various stakeholders. The criteria should be relatively simple to use, especially if the analysis will be done in a participatory manner. This step is important, as the ranking of the options may change depending on the criteria selected.

Step 4 – Scoring of criteria per adaptation option
One must assign a score for each criterion selected and for each adaptation option being analyzed. To minimize ambiguity and subjectivity, scoring should be done based on a clearly understood and agreed upon scale. In this regard, a smaller scoring scale is easier to use and is less subjective than a larger scale (for instance, values of 55 to 80 could denote an important impact on a scale of 0 to 100, where 2 is the only value available on a scale of 1 to 3). The importance of a smaller scale is even greater when the analysis will be done in a participatory manner. On the other hand, there are some criteria, like costs and benefits, that can easily be expressed using precise units (monetary or others).

Step 5 – Standardization and ranking of options
If the criteria selected do not all use the same scoring scale, one must standardize the values in order to be able to compare the scores. Standardization can be on a 0 to 1, to a 0 to 100 scale. Standardization is done by linear interpolation.

Verify that all the criteria scores are in the same direction (i.e. that higher numbers represent a positive outcome and lower numbers represent less positive or negative outcomes or vice versa). For instance, when scoring for costs and benefits one must ensure that the option with the greatest benefits receives the highest positive score, while the option with the greatest costs receives the lowest score (as this is a negative attribute). All the scoring scales must be in the same direction (from negative to positive values).

Once scores are standardized, one can rank the options by their average score. Based on this first ranking and before beginning step 6, the group may decide to eliminate some of the options with the weakest scores. The group may then proceed to step 6 or redo the standardization based on the remaining options (and the corresponding new data range).

Many software programmes exist that can be used to conduct a MCA, such as *Hiview* or *Definite*. These programmes guide users through the various steps of a MCA and can present the results of the analysis in graphical format. However, it is also possible just to use an excel sheet to conduct the analysis as well.

Step 6 – Weighting of criteria
Until present the analysis has given the same weight to each of the criteria used (i.e. each criterion has a weight of 1). In this step, the group undertaking the analysis, in accordance with experts and stakeholders, must decide if any of the criteria should be given a higher or lower weight with respect to the others. Each case in which a criterion is given a weight other than 1 must be justified (for instance the criteria that relate to achieving the Millennium Development Goals or to reducing poverty may be

favoured). Weighting of criteria should be at the heart of group discussions, as it may change the ranking of some options.

The options that are selected as a result of this analysis could be used in further sensitivity analysis, instead of being immediately implemented as development projects. Furthermore, if the order of adaptation options changes as a result of modifying the criteria weights, the groups should analyze and discuss the results to ensure that everyone agrees on the ranking of priority adaptation options.

Step 7 – Development of project profiles for priority options

Groups should develop a summary of the highest ranking adaptation options from the results of Steps 5 & 6. This summary should enable the easy identification of the results of the MCA so as to facilitate the process of developing project profiles of adaptation measures for targeted groups/sectors.

For example, project profiles could include the following key elements:

1. Project goal/aim

What is the ultimate goal of the project? What would it like to achieve?

2. Immediate objectives

What are the specific objectives the project would like to achieve?

3. Expected results

What are the specific outcomes needed to meet the specific objectives of the project?

4. Estimated resource needs

Human and financial resources. Other resources.

NAPA INSPIRED MCA EXERCISE EXAMPLE

The National Adaptation Programme of Action (NAPA) process has been chosen to illustrate each of the steps of the exercise outlined above.

Step 1 – Decision-making context

The purpose of the NAPA process is to allow the Least Developed Countries (LDCs) to identify their urgent and immediate needs to adapt to current and projected adverse effects of climate change and to identify and prioritize adaptation options targeted to meeting those needs. In this framework, the first step in the analysis is to undertake an inventory of climate hazards and to identify which resources, sectors, geographical zones and populations are most vulnerable to those hazards. Table 1 below is an example of the most important climate hazards and the corresponding vulnerability of different sectors for a hypothetical country.

Note: Annotated guidelines for NAPA preparation are available online at: http://unfccc.int/files/cooperation_and_support/ldc/application/pdf/annguide.pdf
The guidebook, *A Selection of exercises and examples from the regional NAPA preparation workshops*, is also available online at: http://www.napa-pana.org/UserFiles/File/pdf/NAPA-Examples%20and%20Exercises-EN.pdf

Table 1: Inventory of Current Climate Hazards

Hazard	*Vulnerability (by sector)*	*Economic impact*	*Loss of life*	*Duration*	*Spatial extent*	*Frequency*
Seasonal drought	*Agriculture (reduced yields, crop failure, capital loss, water availability)*	*1*	*1*	*1*	*2*	*3*
Dry spells	*Agriculture (crop loss, increased famine, rural migration, crop imports, water availability), Environmental (forest fires)*	*2*	*2*	*2*	*3*	*2*
Intense rain	*Agriculture (local flooding, reduced yields), human health (water pollution, disease), Infrastructure (damages to road infrastructure)*	*1*	*2*	*1*	*2*	*2*
Riverine flooding	*Agriculture (regional flooding, crop loss, rural migration), Infrastructure (damages to urban and road infrastructure, loss of access to markets), human health (disease, drinking water availability)*	*2*	*2*	*1*	*3*	*1*
Coastal storms	*Agriculture (crop loss, rural migration), Infrastructure (regional flooding, infrastructure damage), health (disease, drinking water availability), Environment (saltwater intrusion, coastal erosion)*	*3*	*3*	*1*	*3*	*1*
Sea-level rise	*Infrastructures (infrastructure damage, tourism revenue loss), Environment (saltwater intrusion, coastal erosion)*	*2*	*1*	*3*	*3*	*3*

Notes:
Economic impact ($ per person): 1 = $100; 2 = $1,000; 3 = more than $10,000
Loss of life (# of people): 1 = more than 100; 2 = more than 1,000; 3 = more than 10,000
Duration (days): 1 = 10; 2 = 100; 3 = over 1,000
Spatial extent (km^2): 1 = 1,000; 2 = 10,000; 3 = over 100,000
Frequency (annual probability): 1 = certain years; 2 = 1 in 3 years; 3 = annual

The next step is to construct a sensitivity matrix for the sectors, resources, zones and populations most vulnerable to the climate hazards. Table 2 below is a sensitivity matrix which gives an example of a sensitivity analysis of ecosystem goods and services, productive sectors/livelihoods and stakeholders to the climatic hazards in our hypothetical developing country.

Table 2: Sensitivity Matrix

	Climatic hazards						***Exposure Index*** *(Scale of 1-100)*
	Seasonal drought	*Dry spells*	*Intense rain*	*Riverine flooding*	*Coastal storms*	*Sea-level rise*	
Ecosystem goods and services							
Soil fertility	*1*	*2*	*1*	*1*	*2*	*3*	***33***
Water resources	*3*	*5*	*2*	*2*	*4*	*4*	***66***
Agro-biodiversity	*1*	*1*	*1*	*1*	*1*	*3*	***27***
Location of land	*1*	*3*	*2*	*3*	*5*	*3*	***56***
Productive sectors / livelihoods							
Agriculture	*2*	*5*	*3*	*3*	*5*	*3*	***70***
Livestock breeding	*2*	*4*	*2*	*2*	*4*	*2*	***53***
Forestry	*2*	*3*	*2*	*2*	*4*	*1*	***46***
Trade	*1*	*3*	*2*	*2*	*4*	*3*	***50***
Stakeholders / livelihoods							
Small landholders	*2*	*5*	*3*	*4*	*5*	*3*	***73***
Agricultural workers	*2*	*4*	*3*	*4*	*5*	*3*	***70***
Large landowners	*1*	*3*	*2*	*3*	*5*	*3*	***56***
Traders	*1*	*2*	*3*	*3*	*4*	*4*	***66***
Impact Index *(Scale of 1-100)*	***30***	***70***	***55***	***70***	***95***	***65***	

Notes: Each service, sector or population is given a score on a scale of 1 (lowest) to 5 (highest) to indicate its sensitivity to the climate hazard in question. The exposure index is calculated by adding up each of the scores the specific service, sector or population received for each of the climate hazards and dividing by 30 (the highest score possible), then multiplying by 100. In our example, agriculture has an exposure index of 70 (2+5+3+3+5+3 = 21/30 = 0.7 x 100 = 70).

The impact index is only calculated for the stakeholders / livelihoods category. When assigning a score for this category one implicitly takes into consideration the impacts of the climate hazard has on the services or productive sectors related to the stakeholder, thus negating to the necessity to calculate the impact index for all categories. The index is calculated by adding all the scores a climate hazard has received for the stakeholder category, dividing by the total score possible (20) and multiplying by 100. For the impact index for seasonal drought on stakeholders, the calculation would be: 2+2+1+1 = 6/20 = 0.30 x 100 = 30.

The exposure index allows one to identify which elements of each category are the most vulnerable [agriculture (70), small landholders (73) and agricultural workers (70) have the

highest scores in our example], while the impact index allows one to identify the climate hazard that has the greatest impact on stakeholders [coastal storms (95), riverine flooding (70) and dry spells (70)].

However when analysing the impact index, it is prudent to keep in mind the frequency of occurrence of the various climate hazards. In our example, while coastal storms may have the highest impact index, they have a much lower frequency (once every 10-15 years for a big storm) then say seasonal droughts which occur each year.

Step 2 – Identification of potential adaptation options based on the sensitivity matrix

In our example, using the matrix above, the following adaptation options were identified: terrace rehabilitation, grain storage co-operatives, fodder improvement, use of drought resistant species, crop diversification, climate insurance, pasture restoration, water reservoirs, use of irrigation techniques, and slope and basin reforestation.

Step 3 - Criteria Identification

In our example, the criteria identified include: impact on agricultural-livestock production; increase in economic power of vulnerable populations, benefits and costs. Criteria selection is done in a participatory manner, thus while the NAPA guidelines suggest a number of criteria, others may be selected by the group.

Step 4 – Scoring of criteria per adaptation option

Table 3 below outlines the scores each adaptation option received for the various criteria.

Table 3: Criteria scoring for each adaptation option

Options	*Criteria*			
	Impact on agricultural-livestock production (Scale of 1 to 5)	*Increase in economic power of vulnerable population (%)*	*Benefits (Scale of 1 to 5)*	*Costs (in millions)*
1. Terrace rehabilitation	*3*	*3*	*5*	*10*
2. Grain storage co-operatives	*2*	*5*	*5*	*3*
3. Fodder improvement	*5*	*3*	*4*	*8*
4. Use of drought resistant species	*5*	*4*	*5*	*3*
5. Crop diversification	*5*	*4*	*5*	*12*
6. Climate insurance schemes	*3*	*5*	*5*	*50*
7. Pasture restoration	*5*	*3*	*4*	*30*
8. Water reservoirs	*1*	*5*	*5*	*100*
9. Irrigation techniques	*5*	*4*	*5*	*80*
10. Slope and basin reforestation	*2*	*3*	*5*	*10*

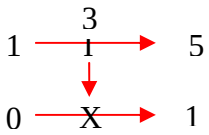
Note: Scale of 1 to 5: 1 = least important; 5 = most important

Step 5 – Standardization and ranking of options
Table 3 uses different scales and units to score the criteria: costs, percentages, and a numeric scale of 1-5. Criteria used in other exercises may also use other scales, e.g. different numeric scales (1-100) or a binary option (yes/no).

Example of how to standardize values: Choose the scale to which all values will be standardized. Here a scale of 0 to 1 is used; one could easily have used another scale.

The *impact on agricultural-livestock production* criterion uses a 1 to 5 scale.

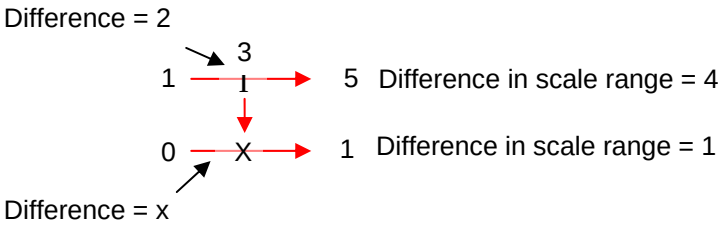
Let's say an option scored 3 on the 5 point scale.



To convert it to the standardized scale one must:

1. Calculate the difference between the highest and lowest number in the observed scale. In this case, the difference is **4** (i.e. 5-1 = 4).
2. Calculate the difference between the highest and lowest number in the standardized scale. In this case, the difference is **1** (i.e. 1-0 = 1).
3. Calculate the difference between the score (in our example, the value of 3) and the lowest end of the scale (i.e. 1). In this case, the difference is **2** (i.e. 3-1 = 2).

Thus we get something that looks like this:



Mathematically this is equivalent to:

$$\frac{4}{2} = \frac{1}{x}$$

To solve for x, we cross-multiply and divide:

$4x = 2*1$, therefore $x = 2/4$ or 0.5

Therefore a value of 3 on a 5 point scale corresponds to 0.5 on a 1 point scale. Intuitively we know this is correct because each number corresponds to the middle value on its respective scale.

The standardization calculation outlined above applies to cases where the standardized scale and the observed scale are in the same direction: this is not the case with the cost criterion. For this criterion, a higher score (cost) is less desirable than a lower score. We must ensure that when the scores are standardized those that cost more (have a higher observed score) receive a lower score than those that cost less (lower observed score); to do this we use what is called the 'inverse scoring' technique.

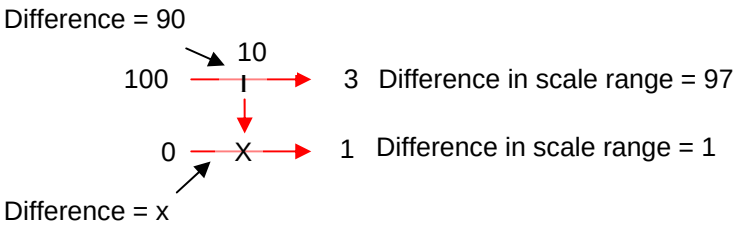
The cost criterion is not scored on the basis of a scale but represents the absolute number an option would cost. We must first, therefore, determine what the range of this absolute scale is. For table 3, we can see that the lowest cost an adaptation cost can have is 3 million, while the highest is 100 million, thus our scale is from 3 to 100. In our standardization we want to ensure that costs closer to 3 million get a higher score, while costs closer to 100 get a lower score:

Observed costs scale 100 ← 3
Standardized scale 0 ← 1

Like in the other standardization example we must determine the number of units of variation in each scale. For the observed scale this equals 97 (100-3) and for the standardized scale 1 (1-0).

Observed costs scale 100 ← 3 → 97 units
Standardized scale 0 ← 1 → 1 unit

Then we must determine the difference between our observed score and the lower end of the scale. For option 1 – Terrace rehabilitation, the cost score is 10 million. The difference between this value and the lower end of the scale is 90 (100-10).



Solving for x, we get 90/x = 97/1 or x = 90/97 = 0.93.

For option 2 – Grain storage co-operatives, the cost score is 3 million. The difference between this value and the lower end of the scale is 97 (100-3). Solving for x, we get 97/x = 97/1 therefore x = 1. Intuitively this makes sense because 3 is the lowest possible score on the cost scale so it should relate to the highest possible score on the standardized scale.

After all of the scores have been standardized, we can rank them by determining the average score for each option. The option with the highest score is first, the second highest second, and so on.

To calculate the average score of an option simply add up all of the individual scores it received from each criterion and divide by the total number of criteria (in this case 4).

For option 1 – Terrace rehabilitation, the calculation is: 0.5+0+1+0.93 = 2.43/4 = 0.61.

Table 4: Standardized scores and initial ranking of potential adaptation options

Options	*Criteria*				
	Impact on agricultural-livestock production (Scale of 1 to 5)	*Increase in economic power of vulnerable population (%)*	*Benefits (Scale of 1 to 5)*	*Costs (in millions)*	*Average score (and ranking)*
1. Terrace rehabilitation	*0.5*	*0*	*1*	*0.93*	*0.61 (8)*
2. Grain storage co-operatives	*0.25*	*1*	*1*	*1*	*0.81 (3)*
3. Fodder improvement	*1*	*0*	*0.75*	*0.95*	*0.68 (5)*
4. Use of drought resistant species	*1*	*0.5*	*1*	*1*	*0.88 (1)*
5. Crop diversification	*1*	*0.5*	*1*	*0.91*	*0.85 (2)*
6. Climate insurance	*0.5*	*1*	*1*	*0.52*	*0.76 (4)*
7. Pasture restoration	*1*	*0*	*0.75*	*0.72*	*0.62 (7)*
8. Water reservoirs	*0*	*1*	*1*	*0*	*0.5 (10)*
9. Irrigation techniques	*1*	*0.5*	*1*	*0.21*	*0.68 (5)*
10. Slope and basin reforestation	*0.25*	*0*	*1*	*0.93*	*0.55 (9)*

Step 6 – Weighing of criteria

In the following example, criteria 1 & 4 (impact on agricultural-livestock production and costs) are given a greater weight than the other two criteria. Thus, the absolute weight of criteria 1 & 4 is two (twice as important) and the weight of criteria 2 & 3 remains at one. The relative weight of these dominant criteria becomes 0.333 (2/6) against 0.167 (1/6) for the two remaining criteria (2 and 3). To calculate the relative weight, one must simply divide the absolute weight by the total of absolute weights. The sum of the relative weights must always equal to 1.

To recalculate the scores, multiply the original standardized score by the relative weight. Thus for option 1, the new score for the impact on agricultural-livestock production criterion is 0.5 x 0.333 = 0.167

Once all the scores have been recalculated using the new weighting system, add up the criteria scores and determine the new ranking of the options. There is no need to calculate the average of the new criteria scores as they have already been put on a scale of 1 by multiplying them by the relative weight.

Table 5: Second Ranking

Options	*Criteria*				
	Impact on agricultural-livestock production (Scale of 1 to 5)	*Increase in economic power of vulnerable population (%)*	*Benefits (Scale of 1 to 5)*	*Costs (in millions)*	*Total score (and second ranking)*
Absolute weight	***2***	***1***	***1***	***2***	***∑= 6***
Relative weight	***0,333***	***0,167***	***0,167***	***0,333***	***∑= 1***
1. Terrace rehabilitation	*0.167*	*0*	*0.167*	*0.310*	*0.664 (8)*
2. Grain storage co-operatives	*0.083*	*0.167*	*0.167*	*0.333*	*0.75 (3)*
3. Fodder improvement	*0.333*	*0*	*0.083*	*0.316*	*0.732 (4)*
4. Use of drought resistant species	*0.333*	*0.083*	*0.167*	*0.333*	*0.916 (1)*
5. Crop diversification	*0.333*	*0.083*	*0.167*	*0.303*	*0.866 (2)*
6. Climate insurance	*0.167*	*0.167*	*0.167*	*0.173*	*0.674 (5)*
7. Pasture restoration	*0.333*	*0*	*0.083*	*0.240*	*0.656 (6)*
8. Water reservoirs	*0*	*0.167*	*0.167*	*0*	*0.334 (10)*
9. Irrigation techniques	*0.333*	*0.083*	*0.167*	*0.070*	*0.653 (7)*
10. Slope and basin reforestation	*0.083*	*0*	*0.167*	*0.310*	*0.56 (9)*

NB: Note that the rank of the top adaptation options (top 3) and the lowest ranked options (last 3) did not change between the two rankings in Tables 4 & 5; only options originally ranked 4th to 7th changed position. This demonstrates that our results are robust. In fact, if the top options are really the best then their position in the ranking should not change significantly if we tweak the criteria or weightings used to assess them.