Development of a national strategy for adaptation to climate change adverse impacts in Cyprus

CYPADAPT

LIFE10 ENV/CY/000723

Report on the literature review on the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide

DELIVERABLE 4.1
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Disclaimer
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Abbreviations and Acronyms

AHP Analytical Hierarch Process
ELECTRE Elimination Et Choix Traduisant La Réalité (Elimination And Choice Expressing Reality).
CLIMACT Prio Climate Actions Prioritization
DSSs Decision Support Systems
GAHP Group Analytical Hierarchy Process
IVA Impact, Vulnerability and Adaptation
MAUT Multi Attribute Utility Theory
MCA Multi Criteria Analysis
MCDM Multi Criteria Decision Making
NACCC National Advisory Committee on Climate Change
NAPA National Adaptation Plan of Action
PROMETHEE Preference Ranking Organization Method For Enrichment Evaluations
SMART Simple Multi Attribute Rating Technique
TEAM Tool for Environmental Assessment and Management
Executive summary

Adaptation strategies are essential in order action to be taken on adverse effects of climate change. Through adaptation strategies climate change negative effects can be prevented or minimized. In order to develop an adaptation strategy, prioritization of all possible adaptation options is pre-required. Multi-criteria analysis (MCA) is proposed as the most appropriate method to accomplish decision making in the field of adaptation to climate change. MCA can accomplish handling of all available technical information and incorporation of different stakeholder views.

In the context of Action 4 of the CYPADAPT project a preliminary literature review on the state-of-the art multi-criteria analysis tools, used for the elaboration of adaptation plans worldwide, follows and selected series of MCA applications in adaptation strategies are presented. The aim of this review is:

- a comparison between different methods to take place while identification of advantages and disadvantages of different methods to be conducted.
- the most prominent multi-criteria analysis tools used in the field of adaptation planning to climate change to be identified and evaluated on the basis of criteria and weights used for the different adaptation options.
- the best applicable methodology to be selected in order an MCA software to be developed so as to prioritize a series of adaptation measures in Cyprus and form an adaptation strategy.

In order to collect the data for the preparation of this report significant research was elaborated, mainly comprising internet survey. The results have been structured as follows:

In the first chapter of Deliverable 4.1 is made a short description and comparison of cost-benefit analysis (CBA), cost effectiveness analysis (CEA), multi-criteria analysis (MCA) and expert judgment, as the most widely used methods in decision making. MCA is proposed as the most prominent method to accomplish prioritization of decisions in the frame of developing an adaptation strategy. In the second chapter key characteristics of the Multi Criteria Analysis are analyzed while categorization of the relevant methodologies is presented. In the third chapter an analytical description of the most prominent multi criteria analysis methods and assisting tools is made. In the fourth chapter a number of case studies of MCA applications in adaptation policy are presented. Special reference is made for the MCA methods and tools developed in National Adaptation plans of Least Developing Countries. Finally in the fifth chapter is made a short description of the key characteristics of the MCA tool that will be developed so as to prioritize proposed adaptation measures to climate change in Cyprus, in order to develop a national adaptation strategy.
1 Elaboration of strategy for adaptation to climate change (methods and tools)

1.1 Short review of efforts towards adaptation to climate change

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, to cooperatively consider what they could do to limit average global temperature increases and the resulting climate change, and to cope with whatever impacts were, by then, inevitable.

By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed countries to emission reduction targets. The Protocol’s first commitment period started in 2008 and ends in 2012. At COP17 in Durban, governments of the Parties to the Kyoto Protocol decided that a second commitment period, from 2013 onwards, would seamlessly follow the end of the first commitment period.

There are now 195 Parties to the Convention. Participation of Cyprus in the convention entered into force in 1998. Institutions involved in the international climate change negotiations are particularly the Conference of the Parties (COP), the subsidiary bodies (which advise the COP), and the COP Bureau (UNFCCC, 2002).

- The Kyoto Protocol was structured on the principles of the Convention. In short, the Kyoto Protocol commits industrialized countries to stabilize greenhouse gas emissions based on the principles of the Convention. The Convention itself only encourages countries to do so.

  KP, sets binding emission reduction targets for 37 industrialized countries and the European community in its first commitment period. Overall, these targets add up to an average five per cent emissions reduction compared to 1990 levels over the five-year period 2008 to 2012.

  Cyprus and Malta become EU members after the signature of the Kyoto protocol, but have not yet changed their status to become annex I/II/B states and thus have no commitment for emissions reduction. However, as EU members they are obliged to participate in the European Union Emissions Trading System (EU ETS) (UNFCCC, Kyoto).

- The Bali Road Map was adopted at the 13th Conference of the Parties and the 3rd Meeting of the Parties in December 2007 in Bali. The Bali Action Plan is divided into five main categories: shared vision, mitigation, adaptation, technology and financing. The shared vision refers to a long-term vision for action on climate change, including a long-term goal for for emission reductions. The AWG-LCA subsequently split the work streams into components under those five parts. The Bali Action Plan was highly ambitious. In terms of the time lines it spelled out, it may have been overly optimistic, and underestimated the complexity both of climate change as a problem and of crafting a global response to it (UNFCCC, Bali).
□ COP15 in Copenhagen advanced many key issues including (UNFCCC, Copenhagen):

- It raised climate change policy to the highest political level;
- It advanced the negotiations on the infrastructure needed for well-functioning, global climate change cooperation;
- It produced the Copenhagen Accord. It was not adopted by all governments, but it advanced a number of key issues; and
- It committed developed countries to $30 billion fast-start financing (in 2010-2012) for adaptation and mitigation in developing countries, with priority given to the least developed countries.

□ All of this momentum was built upon in Cancun in 2010, when governments drew up the Cancun Agreements, a set of significant decisions to respond to the long-term challenge of climate change collectively and comprehensively, now and over time.

The Cancun Agreements constituted a significant achievement for the UN climate process. They addressed the long-term challenge of climate change collectively and comprehensively over time, and took concrete action immediately to speed up the global response to it.

Cancun Agreements’ main objectives cover encouragement of the participation of all countries in reducing greenhouse gas emissions (mitigation), ensuring transparency of actions, mobilizing development and transfer of clean technology, set up of the Green climate fund to disburse $100 billion per year by 2020 to developing countries to assist them in mitigating climate change and adapting to its impacts, assistance of the particularly vulnerable people in the world to adapt to the inevitable impacts of climate change by taking a coordinated approach to adaptation, protection the world’s forests, which are a major repository of carbon and finally building up of the global capacity, especially in developing countries, to meet the overall challenge (UNFCCC, Cancun).

□ At COP17 in Durban, they reached agreement on a second commitment period on the Kyoto Protocol and on a pathway and deadlines to drawing up and committing to a new, post-2020 mitigation framework under the Convention (see section on Durban Platform for Enhanced Action). All industrialized countries and 48 developing countries also affirmed their pledges up to 2020 (UNFCCC, Durban).

□ At the UN Climate Change Conference in Doha in December 2012, Qatar (COP18/CMP8), governments have taken the next essential step in the global response to climate change. Countries have successfully launched a new commitment period under the Kyoto Protocol, agreed a firm timetable to adopt a universal climate agreement by 2015 and agreed a path to raise necessary ambition to respond to climate change. They also endorsed the completion of new institutions and agreed ways and means to deliver scaled-up climate finance and
technology to developing countries. The Doha round of talks mark the beginning of a transition to a new global climate change regime that will come into effect from 2020 and include within its ambit all countries (UNFCCC, Doha).

In 6th of December in Doha, Cyprus presented the project “Development of a National Strategy for Adaptation to Climate Change Adverse Impacts in Cyprus, CYPADAPT”, within which this deliverable is produced. The CYPADAPT main aim is to strengthen and increase Cyprus adaptive capacity to climate change impacts through the development of a National Adaptation Strategy.

The Department of Environment, Ministry of Agriculture, Natural Resources and Environment of Cyprus is the coordinator of the project, while the National Technical University of Athens and the National Observatory of Athens are project partners. The project is co-financed by the LIFE+ programme, the EU financial instrument for the environment.

1.2 Overview of methods accomplishing Adaptation Policy Assessment.

Assessment of adaptation measures is referring to the practice of identifying all possible options of adapting to climate change, and evaluating them in terms of various criteria. Those criteria can be availability, benefits, costs, effectiveness, efficiency and feasibility (IPCC 2007, Fourth Assessment Report). Assessment of adaptation measures presupposes assessment of climate change impacts on natural systems (e.g. water supplies, agricultural production) and human systems (e.g. economic activities, social well-being), in order to check their vulnerability to climate change (UNFCCC).

In the following part of this study is described the UNFCCC Compendium on methods and assisting tools to assess impacts and vulnerability, and be prepared for adaptation to climate change. The most prominent methods used for prioritization and selection of adaptation measures are presented. In specific these methods are cost-benefit analysis (CBA), cost effectiveness analysis (CEA) and multi-criteria analysis (MCA). Evaluation of the methods is presented in order to present adequacy of MCA technique in relevance with adaptation policy assessment.

1.2.1 Compendium on methods and tools to evaluate impacts, vulnerability and adaptation to climate change

To evaluate possible impacts of climate change, vulnerability of systems and adaptation to climate change the UNFCCC Compendium on methods and tools has been already designed. It is available to assist users in selecting the most appropriate methodology to assess impacts and vulnerability, and be prepared for adaptation to climate change. The Compendium was developed in 1999 and updated in 2003, 2005, 2008 and more recently in 2009. The compendium is available online:

All entries are searchable through three different filters: sector (e.g. agriculture, forestry, etc), theme (climate scenarios, impact assessment, etc), and type (e.g. guidance document, modelling tool etc) (UNFCCC).

Figure 1: Compendium of methods and tools used by potential users in selecting the most appropriate methodology for assessments of impacts and vulnerability, and preparing for adaptation to climate change.

In order to present the possible result of using this tool the following table is presented as example. The table presents all methods and tools used methods concerning “adaptation evaluation” for “all sectors” if as type “Risk screening and adaptation decision” is selected.

Table 1: Tools and methods available for every sector, when screening and adaptation decision support tool are chosen as type.

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<th>Method / Tool</th>
<th>Sector</th>
<th>Theme</th>
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<td>Aquarius</td>
<td>Water</td>
<td>Adaptation evaluation</td>
<td>Modeling tool</td>
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## Deliverable 4.1: Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide

### Method / Tool

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<td>Adaptation evaluation impact assessment</td>
<td>Risk screening and adaptation decision support tool</td>
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<tr>
<td>Climate change and Environmental Degradation Risk and Adaptation assessment (CEDRA) by Tearfund</td>
<td>Agriculture Terrestrial ecosystem</td>
<td>Adaptation evaluation impact assessment stakeholder engagement</td>
<td>Risk screening and adaptation decision support tool</td>
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<tr>
<td>CoastClim of Simulator of Climate Change Risks and Adaptation Initiatives (SimClim)</td>
<td>Coastal resources</td>
<td>Adaptation evaluation adaptation planning climate scenarios impact assessment sea level scenarios</td>
<td>Modeling tool Risk screening and adaptation decision support tool</td>
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<td>Water resources</td>
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<td>Risk screening and adaptation decision support tool</td>
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### Deliverable 4.1: Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide

#### 1.2.2 Methods for assessment and prioritization of climate change adaptation options (MCA, CBA, CEA)

In the previous table a list of methods and tools used in forming adaptation policy was presented. Prioritization of adaptation options follows compilation of a list with all the relevant possibilities. Thus some of the options can be rejected or postponed, while others are characterized as high priority options. Among the various methods the most widely used for this prioritization process are: cost-benefit analysis (CBA), cost effectiveness analysis (CEA), multi-criteria analysis (MCA) and expert judgment (UNFCCC). Information concerning these methods follows.

**Multi-Criteria Analysis**

Multi-Criteria Analysis is used to evaluate options based on a set of criteria. Stakeholder analysis and expert judgment provides identification of all possible decisions/ options. In the following relevant criteria are selected in order to prioritize alternative adaptation options. Through weights and scores the performance of each adaptation option is measured against criteria. This step in specific reflects the preferences of the decision makers. Finally the weighted sum of the different criteria is used to rank the different options (UNFCCC).

**Cost-Benefit Analysis**

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<td>frameworks Stakeholder engagement Vulnerability mapping</td>
<td>decision support tool</td>
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<td>UNDP Quality Standards for the Integration of Adaptation to Climate Change into Development Programming</td>
<td>Generic</td>
<td>Adaptation evaluation Adaptation planning Methodological frameworks</td>
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<td>Risk screening and adaptation decision support tool</td>
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<td>Water Evaluation and Planning System (WEAP)</td>
<td>Water resources</td>
<td>Adaptation evaluation Adaptation planning Impact assessment</td>
<td>Modeling tool Risk screening and adaptation decision support tool</td>
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Cost-Benefit Analysis focuses on the quantitative assessment of different adaptation options. CBA is a social-economic evaluation method based on welfare economics. In this method basically is developed an inventory of all the costs and benefits associated to the direct, indirect and external effects of an adaptation option. Wherever this is possible these effects are expressed in monetary terms, as well. Furthermore CBA makes use of the Net present Value. When the timing of the different cost and benefit elements and the discount rate is known, the net present value of these costs and benefits is determined. To sum up CBA’s objective is to gain insight into all benefits and costs for the society in a whole (UNFCCC).

Cost effectiveness analysis

Cost effectiveness analysis is a method that falls somewhere between CBA and MCA. As is the case with MCA, CEA can provide only the ranking result.

Expert judgment is a qualitative method used to support the prioritization of adaptation options in a project level.

To sum up, CBA appears to be the most objective method and can handle optimization, thus it may be proposed as the most desirable option. However, in cases of adaptation policy where important criteria (such as cultural or social barriers) cannot be accommodated, or benefits cannot be quantified and valued (such as the benefits of preserving biodiversity) CBA is not preferred. On the contrary in such cases MCA appears to provide better results.

In order to make this result evident in the following table the different techniques are briefly described, indicating possible cases where each method is most suitable (UNFCCC, Smith, 1997, Wigley, 1996, Duong, 1997, Goulder, 1999, Hamalainen, 1992, Jones, 1990, Pearman, 1989). For each method is provided the description, appropriate use, scope, key input and output, ease of use, level of precision, ability to address uncertainties and resources requirements.
### Table 2: Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change

<table>
<thead>
<tr>
<th>Description</th>
<th>Benefit-Cost Analysis</th>
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<tbody>
<tr>
<td>This approach uses a conceptual framework for analyzing an adaptation measure by identifying, quantifying, and monetizing the costs and benefits associated with the measure. Spreadsheet software is often used to facilitate analysis; however, the specific approaches used are highly dependent on the measure under consideration. This tool can be used to determine whether the benefits of the adaptation measure outweigh the costs, whether net benefits are maximized, and how the measure compares to other options.</td>
<td>Cost-effectiveness analysis takes a predetermined objective and seeks ways to accomplish it as inexpensively as possible. Unlike cost-benefit analysis, the level of the benefit is treated as an external given, and the objective of the analysis is to minimize the costs associated with the achievement of this specified objective.</td>
<td>MCA describes any structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives. In MCA, desirable objectives are specified and corresponding attributes or indicators are identified. The actual measurement of indicators need not be in monetary terms, but are often based on the quantitative analysis (through scoring, ranking and weighting) of a wide range of qualitative impact categories and criteria. Different environmental and social indicators may be developed side by side with economic costs and benefits. Explicit recognition is given to the fact that a variety of both monetary and nonmonetary objectives may influence policy decisions. MCA provides techniques for comparing and ranking different outcomes, even though a variety of indictors are used. MCA includes a range of related techniques, some of which follow this entry.</td>
<td></td>
</tr>
<tr>
<td>Benefit-Cost Analysis</td>
<td>Cost-Effectiveness</td>
<td>Multicriteria Analysis (MCA)</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td><strong>Appropriate Use</strong></td>
<td>A benefit-cost analysis is useful when the adaptation being considered is likely to involve significant expenditures of capital and labor. Benefit-cost analyses of adaptation responses often involve a high degree of uncertainty when quantifying nonmarket goods and services as well as when anticipating the direction and magnitude of climate change.</td>
<td>Cost-effectiveness on the adaptation side might be used when, under different climate change scenarios, a required minimum level of a public good or service (e.g., flood protection) is specified and the option to deliver this good at the lowest cost is sought. Also particularly applicable to those cases where the analyst may be unwilling or unable to monetize the most important policy impact. Cost-effectiveness is generally more applicable for individual project decisions that are applying decision rules or procedures which have already been determined in policy, strategic, or program decisions.</td>
<td>Multicriteria analysis or multi objective decision making is a type of decision analysis tool that is particularly applicable to cases where a single-criterion approach (such as cost-benefit analysis) fails short, especially where significant environmental and social impacts cannot be assigned monetary values. MCA allows decision makers to include a full range of social, environmental, technical, economic, and financial criteria.</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>All locations; all sectors; national or site-specific.</td>
<td>All regions. Can be difficult to apply to those sectors where the market does not apply a satisfactory measure of value for costs.</td>
<td>All regions, all sectors.</td>
</tr>
<tr>
<td><strong>Key Output</strong></td>
<td>A monetary comparison of the costs and benefits of a proposed adaptation measure.</td>
<td>Ranking of alternatives relative according to cost-effectiveness</td>
<td>A single most preferred option, ranked options, short list of options for further appraisal, or characterization of</td>
</tr>
</tbody>
</table>
1.2.3 Evaluation of different decision making methods in adaptation policy

Cost benefit analysis is used to handle optimization and prioritization. Furthermore CBA can also provide even an absolute yardstick. In this frame CBA allows a decision to be made on whether to implement a measure or not, independently of its ranking. Moreover the yardstick (that is for example IRR-internal rate of return or NPV-net present value) permits the comparison of adaptation measures in relevant sectors and is used to optimize measures. Nevertheless, the limitation in CBA method is that possible benefits and costs must be provided in pecuniary values while its basic purpose is economic efficiency.

On the contrary, Multi Criteria Analysis permits only ranking of all the alternative options. Furthermore, MCA provides as a result the evaluation of measures or interventions for which a great number of criteria are deemed as relevant. In addition, MCA can provide evaluation of measures when quantification and valuation in money terms and/or benefits is not possible. This is the reason why expert judgment plays an important role in this technique.
Cost Effectiveness Analysis (CEA) is a method located somewhere between Cost Benefit Analysis (CBA) and Multi Criteria Analysis (MCA). It is used mainly in costing of different options that can achieve the same objective. The way through which CEA can produce ranking is cost terms. Furthermore CEA can be used in cases with multiple objectives or criteria, but only if it is possible to weigh these objectives against each other.

It can be suggested that CBA is a technique superior to MCA, taking into account that CBA is a highly objective method and goes beyond simple ranking of activities, applied in a wide field. However, in cases that criteria, which cannot (easily) be used in CBA (such as institutional, sociological or cultural barriers), are important or in cases that benefits cannot be quantified and valued (such as preserving bio-diversity), it is suggested to resort to MCA.

In Figure 2 it is schematized the preferential order for using the various methodologies. Reference is made also to the Compendium of Decision Tools, which lists more methods than dealt in this study, including sector-specific tools. In all cases, however, the availability of data is the basic determinant of selecting a method (UNFCCC).
In this point it should be emphasized that implementation of the different methods is also enhanced by diverse socio-economic characteristics. This fact in correlation with the previous remarks leads to the conclusion that there is not a single, widely accepted method.

The UN advocated the multicriteria analysis (MCA) as a preferred method, for Least Developed Countries, in order to prioritize and select possible adaptation policies and measures. Nevertheless, no mutual agreement exists on which criteria would characterize an optimal climate change policy. Guidelines have been provided by the United Nations Energy Programme and analytical frameworks to give the ability to develop consistently the national greenhouse gases (GHGs) abatement scenarios, highlighting the significance of multi-criteria analysis (MCA) for ranking national alternatives and assessing policy portfolios. In the same direction, United Nations Framework on Climate Change Convention (UNFCCC, 2002) has stressed the need to apply MCA on specific occasions such as cases where costs and/or benefits are not possible to be quantified.

To sum up it is concluded that MCA is suitable when a significant number of criteria are thought to be relevant, and in cases that quantification and valuation in monetary terms can be possible. Thus MCA can be characterized as an efficient assessment technique for environmental planning able to consider numerous alternatives taking into consideration many different criteria, as well as different preferences of decision makers and relevant groups, even when they are conflicting. Result of such a procedure is not always unique. It is a compromised and commonly acceptable solution (Lahdelma et all, 2001).

**The case of Cyprus**

In the case of Cyprus a significant number of adaptation measures are proposed aiming at reinforcing the adaptive capacity of a great number of different sectors (water, soil, tourism, biodiversity, coastal areas, public health, forest, energy, infrastructure, fisheries). Those measures have to be analyzed, categorized and prioritized on the basis of their effectiveness, viability and their contribution to climate change adaptation. The number of criteria thought as relevant is significant since there are ten sectors to be evaluated and different preferences of decision makers and relevant groups exist. Furthermore quantification and valuation in monetary terms can be possible for many cases but not for all. In this frame MCA appears to be a useful tools for selecting measures to form an adaptation strategy to climate change for Cyprus.
2 Multi-criteria analysis decision making methods and application in adaptation policy

Multi-criteria analysis (MCA), in general, establishes preferences between various options by making reference to a set of objectives that the decision making body has already identified. MCA puts emphasis on the judgment of the decision making body, on providing objectives and criteria, on calculating relative weights and, to an extent, on judging the performance of each option against each fulfillment criterion.

MCA basis, in principle, is the objectives and personal choices of the decision making body along with criteria, weights and assessments of achieving each objective. Furthermore it should be emphasized that data such as observed prices can also be included in the baseline characteristics of MCA. In general, the criteria established in MCA are measurable. However, in simple cases the way of identifying objectives and criteria, alone, may provide adequate information for decision-makers (Department for Communities and Local Government, 2009).

The growing literature suggests that, there are many MCA techniques. The number of MCA techniques is still rising and there are several reasons for that such as:

- The variety of different types of decision that can fit to the broad circumstances of MCA
- the availability of time to undertake relevant analysis may vary
- the nature or amount of available data to support the analysis may vary
- the variety of analytical skills of those supporting the decision and
- the variety of requirements and administrative culture of organizations.

It is neither desirable nor necessary to provide information for all MCA methods. The reason is that some of those techniques are oriented towards issues which are unlikely to be encountered by decision makers; some others are complicated and in practice untested and others lack sound theoretical foundations. Nevertheless the main characteristics of the various MCA methods are common, at least for categories that share the main principles.
In general, MCA is based on the general MCDM problem. It evaluates m alternatives of decision, among n possible problem criteria measures, and for a number of decision makers or relevant parties. The aim of the MCDM problem is to determine which of the alternatives specified in the beginning could be chosen, and how the alternatives are ranked relatively (Zeleny 1982). In many situations, the alternatives that could be considered are infinite. The use of multi-objective programming methods to tackle these cases is far well-known.

All methods follow the same decision process and include (Wang et al., 2009)

- alternative solutions,
- different criteria,
- matrix of specific values for each criteria,
- weighting indicators for each criteria,
- an evaluation of each alternative solution in respect to other alternatives.

The criteria used most widely used in literatures for the selection of MCA techniques are:

- environmental consistency
- logical soundness
- transparency
- ease of use
- data requirements not inconsistent with the importance of the issue being considered adaptation policy
- realistic time and manpower resource requirements for the analysis
- process
- ability to provide an audit trail, and
- software availability, where needed.

**Categorization of the MCA methods**

Categorization of the MCA methods is made according to the initial assumptions, the type of input data, the adapted method of analysis and the output result. Outranking, distance, priority based and mixed methods can be applied in the various fileds. Methods can also be classified as deterministic, stochastic and fuzzy, from another point of view, while there are...
combinations of them keeping some of their major characteristics (Greening and Bernow, 2004).

Taking into consideration the type of decision model various a certain classification of the MCA methods is presented on Figure 3 (Pokharel and Chandrashekar, 1998; Hooman Mostofi Camare, 2011; Ramanathan and Ganesh, 1995).

Figure 3: MCDA families of methodologies

The above mentioned families of methodologies include outranking methods, value or utility based methods, programming methods and other methods. Outranking and value or utility based methods are the most prominent categories (Hooman Mostofi Camare, 2011).

1. **outranking methods:**

Outranking concept was proposed by Roy (1968). The basic idea is: Alternative Ai outranks Aj if on a great part of the criteria Ai performs at least as good as Aj (concordance condition), while its worse performance is still acceptable on the other criteria (non-discordance condition). For each pair, alternatives are determined. Whether one alternative outranks another, these pairwise outranking assessments are combined into a partial or complete ranking. Examples of outranking methods are Elimination Et CoixTraduisant la Realite (ELECTRE) family (Roy and Vincke, 1981; Vincke, 1992), the Preference Ranking OrganizationMethod for Enrichment Evaluation (PROMETHEE) I and II methods (Brans and Vincke, 1986), and Regime Method Analysis (Nijkamp et al., 1990)

2. **value or utility function-based methods:**

The utility or value function approach suggests transformation of criterion maps to a common scale. Value or utility presents a number that is attached to a possible decision outcome (or level of attribute). To each result is given a value or utility. This utility (value)
function converts the various levels for an attribute to a utility or value scores. Possible
decision outcomes are related to a scale that reflects relative preference of the decision
maker’s. A function of value or utility relates worth (usually on a scale basis of 0 to 1) to the
concerned attributes. In this ways the function is yielding expression of a standardized scale
value for each value of a range of attribute data. Examples of value or utility function-based
methods are the Multi-Attribute Utility Theory (MAUT) (Keeney and Raiffa, 1976), the Simple
Multi-Attribute Rated Technique (SMART) (vonWinterfeldt and Edwards, 1986), the Analytic
Hierarchy Process (AHP) (Saaty, 1980), and the most elementary multicriteria technique, the
Simple Additive Weighting (SAW).

3. Programming and Other methods are such as Flag Model (Nijkamp and Vreeker, 2000),
Novel Approach to Imprecise Assessment and Decision Environment (NAIADE) (Munda,
1995) and Stochastic Multiobjective Acceptability Analysis (SMAA) (Lahdelma et al., 1998).

Other categorizations are also suggested. For example by Belton and Stewart (2002) the
following categorization of MCDM methods, is suggested:

(a) optimization methods or value measurement methods;
(b) outranking methods;
(c) aspiration, goal or reference level models.

Furthermore, by Zopounidis and Doumpos (2002) are suggested the following categories:
- multi-objective/goal programming;
- multi-attribute utility theory methods (AHP, MAUT, MACBETH etc.);
- outranking methods (ELECTRE, PROMETHEE, ORESTE etc.);
- preference disaggregation methods (UTA, UTADIS, MHDIS);
- rough set theory methods

**Multi Criteria Analysis and application of the method in adaptation policy (criteria and
weights)**

In terms of adaptation to climate change Multi-criteria analysis (MCA) is able to allow the
assessment of various different adaptation options against a significant number of criteria.
Every criterion is given a relevant weighting. This weighting can result an overall score for
each adaptation option. The adaptation option with the highest score is most prominent to
be selected.
Furthermore, Multi-criteria analysis (MCA) allows the assessment of various different adaptation options when only partial data is already available and when cultural and ecological considerations are difficult to be quantified.

Moreover, efficiency of the MCA result relies on the (un)certainty of the information relevant to the selected criteria, the relative priorities given to criteria (weights, scores) and if the weights are commonly agreed by stakeholders. In order to check robustness of the result for changes in scores and/or weights sensitivity analysis must be used (UNFCCC).

In terms of adaptation to climate change five steps are taken in MCA assessment of adaptation options (UNFCCC) in summary:

1. Agree on the objective of adaptation and identify various potential adaptation options.

2. Agree on criteria of decision making: Description of each criterion is essential, including the unit and span of all possible scores. This would ensure that participants involved in the assessment process have a common understanding.

3. Score each adaptation option performance against each of the selected criteria. When this is completed, standardization is essential in case scores of the various criteria differ in units (e.g. monetary or qualitative values) or spans (e.g. 1 – 5 or 0 – 100). Transformation of the scores into similar units permits effective comparison of the criteria. A value function is used for standardization or a standardization procedure where scores lose their dimension and their measurement unit.

4. Weight assignment to criteria in order to reflect priorities. In specific if there are some criteria as more important than others and there are known priorities then different weights could be assigned in different criteria. In this way their relative importance is indicated.

5. Ranking of the options. In each option a total score can be calculated by multiplication of the scores. Scores have been previously standardized with their appropriate weight. Finally weight adjusted scores must be aggregated and compared.

MCA results in a ranked order of adaptation options and an appreciation of strengths and weaknesses of all the attributes of each of the options.
3 Analysis of the most prominent Multi Criteria Analysis (MCA) methods

A large number of MCA methods exist to rank, compare and/or select the most suitable policy options according to the chosen criteria (Zeleny, 1977). MCA methods are implemented with the use of supportive MCA tools. Thus, tools are the means through which the methods are applied. Application of algorithms in the evaluation phase is made through these tools, which are described as Decision Support Systems (DSSs). Some of the most indicative Multicriteria Decision Making (MCDM) tools used for decision making in adaptation policy to climate change are presented within the framework of this report. Summary of their key characteristics follow. Furthermore evaluation of the methods and presentation of their advantages and disadvantages is made. Finally in the following part of this report a comparison among the MCA methods is attempted while a presentation of selected case studies assist the comprehensive analysis of the MCA methods.

3.1 Electre

ELECTRE method (Elimination and Choice Translating Reality) belongs to the family of outranking methods. ELECTRE method finds outranking relations by using pairwise comparisons among alternatives under each criterion separately (Roy 1991). An outranking relation of $A_i \rightarrow A_j$ - shown as $A_i S A_j$ as well- implies that $A_i$ is preferred to $A_j$, if $A_i$ is at least as good as $A_j$, on a majority of criteria, and if it is not significantly worse on any other criteria (Roy 1991). In the ELECTRE method, even if the $A_i$ does not strictly dominate $A_j$ quantitatively, the decision maker may still decide that $A_i$ is preferred to $A_j$.

Physical or monetary values denoted as $g_k(A_i)$ and $g_k(A_j)$ are used for alternatives $A_i$ and $A_j$. Threshold levels are defined for the difference between $g_k(A_i)$ and $g_k(A_j)$.

The decision maker is able to support for different decisions that there is (Milani et al 2006):

- indifference between the two alternatives
- strong or weak preference of one over another
- no specific preference

Two sets of comparisons are required to establish an outranking relation between alternatives $A_i$ and $A_j$. The first is the one where $g_k(A_i)$ is superior to the $g_k(A_j)$ and the second is the one where $g_k(A_i)$ is not superior to the $g_k(A_j)$. Therefore, both the criteria that vote for $A_i S A_j$ and the ones that reject such dominance are separately studied by the ELECTRE method. Two are the tests on which the comparison sets are based, the concordance and discordance.

Concordance test allows verification on behalf of the decision maker that if $A_i$ is at least as good as $A_j$. The discordance test allows verification on behalf of the decision maker if there exists a major opposition to the outranking relation $A_i S A_j$ (Roy 1991; Milani et al 2006).
Electre method has a significant number of variations: ELECTRE I, ELECTRE II, III, and IV (Milani et al. 2006). The basic difference between ELECTRE I and II, for example, is that in the latter, we define two outranking relations and not one - the strong outranking and the weak outranking (Milani et al. 2006).

### 3.2 Promethee

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) is another example of outranking methodology. Brans et al. (1986), proposed the use of Promethee so as to solve problems with the following form:

$$\text{Max} \{ f_1(a), f_2(a), \ldots, f_k(a) | a \in A \}$$

where:
- \( f_i \) are criteria to be examined.
- \( A \) is a finite set of actions and \( i = 1, \ldots, K \) are the criteria to be examined.

A utility function is identified for each criterion so as to represent the preference on behalf of the decision maker, as far as evaluation criteria are regarded. Values are taken in this function between \((0, 1)\). It is not obligatory criteria to be in the same units since by defining a utility function; effects of different scales are eliminated.

In PROMETHEE, a preferably weighted index \((\mu)\) is defined. This index is calculated as follows:

$$\mu(a, b) = \frac{\sum_{i=1}^{K} W_i \cdot P_i(a, b)}{\sum_{i=1}^{K} W_i}$$

Index \((\mu)\) defines the preferable percentile of alternative “a” with respect to alternative “b” – after considering which the attributed weights to each criterion are.

The weights \((W_i)\) define the importance of each criterion.

Preference function \(\mu(\cdot)\) is defined by the decision maker.

It is also noted that:

- \(\mu(a, b) = 0\) defines a weak preference of \(a\) over \(b\) for all criteria
- \(\mu(a, b) = 1\) defines a strong preference of \(a\) over \(b\) for all criteria

Two outranking flows are defined by this method: leaving flow \((\emptyset^-)\) and entering flow \((\emptyset^+)\)
Deliverable 4.1: Literature review of the state-of-the art multi-criteria analysis tools used for the development of adaptation plans worldwide

\[
\phi^+(a) = \frac{\sum_{b=1}^{n} \mu(a,b)}{n-1}, \quad \phi^-(a) = \frac{\sum_{b=1}^{n} \mu(b,a)}{n-1},
\]

The better alternative is the one with the higher leaving flow and the lower entering flow (Brans et al. 1986).

\[\square\] D-Sight software is tool based on PROMETHEE methodology (Decision Sights, 2011).

3.3 Analytical Hierarchy Process (AHP)

Saaty (1980) has developed the Analytical Hierarchy Process (AHP). AHP is a widely used method for addressing decision making problems with multiple criteria and a mixture of qualitative and quantitative data inputs.

AHP method can be used efficiently by dividing the problem characteristics into sub-criteria in situations where criteria can be organized into a hierarchy this method. Operation researchers and decision scientists have used this method in the last decades particularly in the USA.

Four stages are involved in Analytical Hierarchy Process method:

- In the first stage the problem is decomposed into a hierarchy of more comprehensive sub problems.
- In second stage collections of trade-off data input is made by conducting pairwise comparisons among level problem hierarchy characteristics and problem alternatives.
- In the third stage estimation of relative weights of the hierarchy criteria is made.
- Finally, in fourth stage aggregation of criteria is made through combination of relative weights so as to perform an overall evaluation of all alternatives.

In general, AHP has number of significant advantages. For example, it is a relatively simple method for decision makers. Furthermore AHP includes collection of pairwise comparison data, especially in the subjective cases, that is an attractive aspect which involves directly the decision makers.

Software packages applied in AHP such as Expert Choice (2010) are used for applied decision making. The Expert Choice website (Expert Choice 2010) presents many examples of AHP and case studies on a wide range of multicriteria problems.

3.4 Group Analytical Hierarchy Process (AHP)

A common objective is strived usually from a group of decision makers rather than one. For example in political, social and economic issues the insight of a group of stakeholders must
be taken into account. In this frame a mechanism is required to capture collective insights into decision support system.

Decomposition of a complex problem into a problem hierarchy is allowed by AHP as already explained. With Group AHP structure of a complex system into a summary hierarchy is possible and then the solution can be identified and evaluated with respect to other factors of the problem. “This ability to structure a complex system into a summary hierarchy and then focus attention on individual decision components can amplify a group of decision making capabilities” (Dyer et al 1992).

Group AHP method allows the group member’s judgments about each facet of the decision problem to be captured. Subjective judgments on individual components of the decision problem are easily accommodated.

### 3.5 Multi-Attribute Utility Theory (MAUT)

Multi-Attribute Utility Theory (MAUT) is based on the preference of the decision-maker to determine the “utility” of various factors (Keeney and Raiffa, 1976). As a result utility curve for each factor is made available. The factor levels can be categorical, ordinal, or interval type values. Each alternative can be evaluated on each factor. The extraction of utility curves and summing of the factor utilities allows an overall score to be derived.

A major characteristic of MAUT is that it can be applied to multidimensional problems and widen the classic utility theory.

The basic steps of MAUT, as Sarkis and Sundarraj (2000) describe, are:

- identification of fundamental objective, sub-objectives and attributes of sub-objectives;
- assessment of attributes’ scores and weights;
- calculation of overall utility—most favourable choice—using weights and scores;
- sensitivity analysis to examine how a change in an attribute’s value or weight influence the overall utility.

MAUT’s objective is to model and represent the decision maker’s preferential system into a utility/value function \( U (a_j) \). The utility function is a non-linear function defined on the criteria space, such that:

\[
U (a_j) > U (a_k) \iff a_j > a_k \quad (a_j \text{ is preferred to } a_k)
\]

\[
U (a_j) = U (a_k) \iff a_j \sim a_k \quad (a_j \text{ is preferred to } a_k)
\]
The most commonly used form of the utility function is the additive one:

\[ U(a_j) = p_1u_1(g_{j1}) + \ldots + p_nu_n(g_{jn}) \]

Where:

- \( u_1; u_2; \ldots; u_n \) are the marginal utility functions corresponding to the evaluation criteria.

The process for extracting an additive utility function is accomplished via the collaboration between the researcher and the decision maker and involves the specification of the criteria trade-offs and the form of the marginal utility functions. The calculation of these parameters is accomplished via interactive procedures, e.g., the mid-point value technique suggested by Keeney and Raiffa (1976).

Every marginal utility function defines the utility (value) of the alternatives for each individual criterion \( g_i \). The parameters \( p_1; p_2; \ldots; p_n \) are constants standing for the trade-off that the decision maker is willing to obtain on a criterion, in order to gain one unit on criterion \( g_i \).

The utility/value can be defined by determination of single attribute utility functions followed by verification of preferential and utility independent conditions and derivation of multi-attribute utility functions.

Utility functions can be either additively separable or multiplicatively separable. The utility value is defined as follows:

\[ 1 + k \ u(x_1, x_2, \ldots, x_n) = \prod (1 + k_j u_j(x_j)) \quad j=1\ldots n \]

where:

- \( j \) is the index of attribute,
- \( k \) is overall scaling constant (greater than or equal to -1),
- \( k_j \) is the scaling constant for attribute \( j \),
- \( u(.) \) is the overall utility function operator,
- \( u_j(.) \) is the utility function operator for each attribute \( j \) (Pohekar and Ramachandran, 2004).
3.6 Simple Multi-Attribute Rating Technique (SMART)

SMART was originally described in 1977 by Edwards as the whole process of rating alternatives and weighting criteria and is a simpler form of MAUT.

The decision makers are asked to rank the importance of the changes in the criteria from the worst criteria levels to the best levels. Then 10 points are assigned to the least important criteria, and increasing number of points (without explicit upper limit) is assigned to the other criteria to address their importance relative to the least important criteria. The weight coefficients are calculated by normalizing the sum of the points to one.

Thus, the performance of an alternative “a” is calculated as:

\[ U_a = \frac{n \sum^j w_j r_{aj}}{\sum^n w_j} \]

where \( r_{aj} \) is the rating of alternative a under the jth attribute with a numerically comparable scale. This is the simplest form of the MAUT where scores are standardized to a 0-1 scale, where 0 representing the worst expected performance on a given criterion and 1 representing the best expected performance (Salminen, 1998; Olson, 2001).

3.7 Evaluation of Multicriteria Decision Making (MCDM) methods

Evaluation of advantages and disadvantages of the above analyzed MCA methods and their applications are presented in the following sections.

3.7.1 Advantages and disadvantages of MCA methods

ELECTRE advantages and disadvantages

Even when there are not clear preferences for one of the alternatives ELECTRE method can accomplish comparison of the alternatives. Compared with other methods that are sensitive to beliefs of decision makers ELECTRE is more reliable. Another positive aspect of the ELECTRE is that it can handle both quantitative and qualitative judgments.

On the other hand there is the point that ELECTRE cannot find the best alternative but just the most strong: “The ELECTRE method results in a system of binary outranking relations between the alternatives, and this system is not necessarily complete; the ELECTRE method is sometimes unable to identify the best alternative. It merely identifies a set of leading alternatives” (Triantaphyllou 2000). Finally a basic disadvantage of ELECTRE method is that it is a rather complex decision making method that requires a great variety of primary data.

PROMETHEE advantages and disadvantages
A major advantage of PROMETHEE method compared with other MCA methods is that it can finally provide an overall ranking of the different alternatives with respectively positive and negative outranking flows. PROMETHEE is expressing how an alternative is outranking or outranked by other alternatives submitted for evaluation. Moreover advantages of Promethee method include its ability to permit thorough sensitivity analysis and establishment of the highest allowable deviations from the original weights (Brans, 1996).

On the other hand a disadvantage resulting from PROMETHEE application is that it does not provide a specific method according to which the weights can be determined (Macharis et al., 2004a). As a result it does not provide a structuring possibility so in the case of significant number of criteria (more than seven), it may become very difficult for the decision maker to obtain a clear view of the problem and to evaluate the results (Macharis et al., 2004a).

**AHP advantages and disadvantages**

Applicability of AHP to the weighting of fuzzy criteria, along with solid ones, through ratio scales and scoring, constitutes one of its main advantages. In addition, by decomposing a problem or process in its components and combining them in a rational mode from the large, descending in regular steps, to the smaller, it is plausible to join via simple paired comparison judgments the lesser to the greater. The success of this method comes as a result of its simplicity and robustness (Vargas, 1990).

Furthermore the strength of AHP lies in its ability to handle both quantitative and qualitative judgements (Macharis et al., 2004), while it employs a consistency test that can screen out not consistent judgments. This characteristic turns the results as reliable (Kablan, 2004). In addition, the AHP method calculates the inconsistency index, as a ratio of the decision maker’s inconsistency and randomly generated index. Importance of this index for the decision maker is that it allows assuring the quality of judgment and efficiency of the final decision (Pohekar and Ramachandran, 2004).

However, a major disadvantage of the method is that the implemented pairwise comparisons may become so many that the uncertainty of the process is increasing significantly (Macharis et al., 2004). Furthermore, AHP has been criticized for its reliability based on the decision makers’ beliefs and preferences.

**MAUT advantages and disadvantages**

MAUT methods results in further knowledge and understanding of the problem for decision makers (parameters, criteria, etc). The method is considered as a rather complex method. It is true that it would be hardly preferred for example for solving energy planning problems. On the other hand despite its complexity as a decision making method, it is occasionally preferred so as to help decision makers to understand better the objective of the problem, the sub-objectives, the weights and scores and the sensitivity analysis.
SMART advantages and disadvantages

The SMART method is a simple, utility based method. It is preferred for simplified decision making problems. It has the ability to handle both quantitative and qualitative data. However for more complex problems other methods are more popular.

3.7.2 Application fields of MCA methods

MCA methods have been used by researchers, scientists, managers and social and political decision makers. A number of fields where MCA methods are applied are presented in the following.

In engineering and infrastructure investment studies researchers use widely the ELECTRE family multi-criteria methods. ELECTRE method is also used in environmental assessment as well as in multi-option problems within the environmental appraisal process. “The threshold values, values for noise, air, water impact criteria, as well as realistic values of indifference, preference and veto thresholds for various environmental criteria were determined through ELECTRE” (Figueira et al., 2004). Furthermore ELECTRE family methods applications are found in environmental impact assessment, environmental and energy planning, renewable energy sources’ problems, energy systems technology and waste management.

Environmental management is considered as the most popular topic in Promethee applications. A large amount of the papers are related to this topic. Environmental Management has covered several specific areas such as air quality, waste management, Life Cycle Assessment (LCA), Environmental Impact Assessment (EIA), and land-use planning. Business and Financial Management, focusing mainly on the key aspects of general management, performance measurement, portfolio management, and investment analysis are fields that Promethee finds application. In addition, PROMETHEE applications are related with the topic of Energy Management. Selecting and evaluating energy generation or exploitation alternatives was the main focus in this field.

Applications of Promethee in Hydrology and Water Management, devoted to the sustainable water resources planning, water management strategies assessment, and irrigation planning, are quite new in comparison with the other PROMETHEE applications. Chemistry in the field of evaluation and ranking of chemical material and samples in the experimental environments are another field of Promethee applications. Finally, Agriculture, Design, Medicine, Education, Sports, and Government constitute other application aspects of the PROMETHEE method.

A wide range of fields, has used AHP method. Varying from simple personal decisions to complex and capital intensive ones, AHP was used. Furthermore the AHP method has been successfully applied to environmental planning, energy design, social sciences, agriculture and marketing. Generally the AHP method is used in applications that a small number of criteria and decision makers are involved.
The applications of **MAUT method** concern, electric utility planning, renewable energy planning and environmental impact assessment problems.

Finally, the applications of **SMART method** concern in the majority of cases environmental impact assessment problems.

### 3.7.3 Comparison among MCA methods

The use of all major MCDA methods (utility based, outranking and AHP) has been significant over the last decade. Outranking methods (including PROMETHEE and ELECTRE) and utility based such as MAUT and AHP methods are considered of major importance (Linkov et al, 2004).

The various MCA methods share a common mathematical basis such as values for alternatives assigned for a number of dimensions, weights multiplying and total scoring. In terms of how values are assigned and combined, the difference is made obvious. The reason is that processes have different information – and knowledge – requirements and the calculated scores have different mathematical properties and thus slightly different meanings.

- Outranking approaches such as PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) and ELECTRE (Elimination and Choice Expressing Reality) are methods that essentially involve holding of various “votes” across dimensions.
- AHP (Saaty, 1994), or the Analytic Hierarchy Process and its extension the Analytic Network Process (ANP) is a family of approaches that uses pairwise comparisons of criteria. AHP and ANP can function even with incomplete or inconsistent inputs, by using matrix algebra (involving either eigenvalue-based or similar calculation methods), to produce weights, overall scores, and measures of consistency (Ishizaka and Lusti, 2006). Like other MCDA approaches, AHP produces scores for each alternative; in some cases, it is theoretically possible for the alternatives to change order depending on how other aspects of the problem are structured, so these scores are not necessarily interpreted exactly the same as MAUT scores.
- “While MAUT allows greater flexibility in preference trade-off functions, if a linear MAUT model is used, transformation as applied in SMART yields precisely the same result. In MAUT, weights reflect both scale and importance. In SMART, scales are transformed to a common basis, so weights reflect importance. SMART does not request preference or indifference judgment among alternatives, as it is requested in most of MAUT derived methods” (Edward and Barron, 1994).
3.8 Presentation of selected case studies of MCA methods used in climate change adaptation policy

Climate change decisions involve a group of decision makers striving to reach a consensus on a common objective. Local people, governmental institutions, NGOs and commercial organizations are examples of different stakeholders involved in adaptation practices as a response to climate change impacts. Decomposition of adaptation to climate change problem into a problem hierarchy can be faced with MCA efficiently. Various MCA environmental applications exist in the literature and also a number of case studies that refer to elaboration of adaptation policy with the use of Electra, Promethee and AHP. A selected number of MCA environmental applications are mentioned in the following.

**ELECTRE**

An MCDM-based expert system was developed to tackle the interrelationships between the climate change and the adaptation policies in terms of water resources management in the Georgia Basin, Canada. A number of processes that were vulnerable to climate change were examined and adaptation policies to face impacts of temperature increase, precipitation-pattern variation and sea-level rise were comprehensively explicated and incorporated within the developed system. The ELECTRE III approach was selected for the specific MCDM analysis (Qin et al, 2008) for the prioritization of policy options and a relevant software tool was used. Its interface is presented in Figures 4 and 5. Prioritization of criteria weights is of particular importance in this case study.

In specific, the criteria that were identified through the study-configuration process were five. In order to implement the MCDM analysis, an overall priority or score to each criterion was given by the following equation:

\[
\text{Score}_i = \sum_{j=1}^{n} P_{ij} \cdot WP_j, \quad i = 1, 2, \ldots, m,
\]

Where:

- \( P_{ij} \) is percentile of respondents on criteria \( i \)
- \( WP_j \) is weighting preference for the \( j \)th alternative (\( j = 1, 2, \ldots, n \));
- \( m \) is number of criteria;
- \( n \) is number of alternatives.

More specifically, the final weight for each criterion can be determined as follows:
The results of the above scoring indicated that the most important criteria were efficiency and cost with weighting levels were 0.298 and 0.239, respectively. Implementation ability (weight = 0.197) and flexibility (weight = 0.146) followed while responsivity was considered to be the least important (weight = 0.118).

In the same application, specification of the weighting preferences of the users was made. This had direct impacts on the final weights. As a result:

- If users prefer relatively close weighting levels among different criteria, a smaller number can be chosen for each option
- If priorities of criteria are expected to be highly differentiated, larger numbers can be specified.

Indicatively the matrix of the ELECTRE III software tool is presented in the following. The row items represent various policy alternatives, the column items represent criteria, and the cells represent the scores of performances. Scores were derived from stakeholder survey, and the weighting preferences through applying similar arithmetic manipulations.

![Policy options and system performance](image)

Within the tool specification of the weighting preferences take place (Figure 5a). Weighting levels was zero to 10. In specific 10 was adopted for “very important”, 7.5 for “important”, 5 for “medium”, 2.5 for “unimportant”, and 0 for “negligible”.

Figure 5b also shows the outputs generated from the method. Ranking of actions can be seen in the upright corner of the figure. The “Act 5” was ranked as the best option and Actions 2, 3, and 6 were determined to be the least preferable choices.
PROMETHEE

Environmental Management is thought as the most popular topic in PROMETHEE applications. A great number of scientific papers deal with this topic. Environmental Management has covered a number of certain areas such as Waste Management, Life Cycle Assessment (LCA), Environmental Impact Assessment (EIA), and land-use planning. The following table presents a summary of the PROMETHEE papers addressed in the topic of Environmental Management to make evident the importance of this tool in decision making.

Table 3: The applied papers on the topic of “Environment Management”

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Specific area, Other tools/methodologies used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Rashdan et al. (1999)</td>
<td>Ranking and selecting environmental projects, The Nominal Group Technique</td>
</tr>
<tr>
<td>Ayoko et al. (2003)</td>
<td>Ranking organization compounds with fungicidal properties</td>
</tr>
<tr>
<td>Ayoko et al. (2004)</td>
<td>To select residential houses base on air quality criteria</td>
</tr>
<tr>
<td>Beynon and Wells (2008)</td>
<td>Ranking motor vehicles based on exhaust emissions, Uncertainty analysis</td>
</tr>
<tr>
<td>Briggs et al. (1990)</td>
<td>Nuclear waste management problem/ranking 27 actions</td>
</tr>
<tr>
<td>Carroll et al. (2004)</td>
<td>Ranking various soil types/wastewater treatment systems, Principal Component Analysis (PCA)</td>
</tr>
<tr>
<td>de Leeneer and Pastijn (2002)</td>
<td>To select land mine detection strategies</td>
</tr>
<tr>
<td>Delhaye et al. (1991)</td>
<td>Nuclear waste management problem</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Specific area, Other tools/methodologies used</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Diakoulaki et al. (2007)</td>
<td>To identify investment opportunities for the exploitation of the clean development mechanism</td>
</tr>
<tr>
<td>Geldermann et al. (2000)</td>
<td>Ranking sinter plants through Life Cycle Assessment (LCA), Fuzzy PROMETHEE</td>
</tr>
<tr>
<td>Geldermann and Rentz (2001)</td>
<td>Environmental assessment for sinter plants, Trapezoidal fuzzy intervals</td>
</tr>
<tr>
<td>Geldermann and Rentz (2005)</td>
<td>Ranking scenarios for the coating of PVC parts/LCA</td>
</tr>
<tr>
<td>Gilliams et al. (2005)</td>
<td>To choose among the afforestation strategies for a given class of agricultural land, Geographic Information System (GIS)/goal programming technique</td>
</tr>
<tr>
<td>Hokkanen and Salminen (1997)</td>
<td>The location problem of a waste treatment facility</td>
</tr>
<tr>
<td>Huth et al. (2005)</td>
<td>To evaluate tree-harvesting scenarios, Stochastic PROMETHEE</td>
</tr>
<tr>
<td>Kangas et al. (2001a)</td>
<td>Supporting strategic natural resources planning, Fuzzy method</td>
</tr>
<tr>
<td>Kangas et al. (2001b)</td>
<td>Ranking forestry strategies,</td>
</tr>
<tr>
<td>Kapepula et al. (2007)</td>
<td>Household solid waste management/ranking nine areas</td>
</tr>
<tr>
<td>Kiker et al. (2005)</td>
<td>Decision-making in environmental projects, A review paper on MCDA methods including PROMETHEE</td>
</tr>
<tr>
<td>Klauer et al. (2006)</td>
<td>Decisions for sustainable development, Decisions under uncertainty</td>
</tr>
<tr>
<td>Le Teno and Mareschal (1998)</td>
<td>To evaluate the environmental quality of building products through LCA, A new version of PROMETHEE with interval criteria/fuzzy theory</td>
</tr>
<tr>
<td>Le Teno (1999)</td>
<td>LCA, PCA/non-parametric bootstrapping</td>
</tr>
<tr>
<td>Linkov et al. (2006a)</td>
<td>Ranking contaminated sediment management technologies, A review on MCDA for sediment management</td>
</tr>
<tr>
<td>Linkov et al. (2006b)</td>
<td>Environmental risk assessment and decision-making strategies/The New York/New Jersey arbor as a case study, A review on MCDA applications for contaminated site management</td>
</tr>
<tr>
<td>Margeta et al. (1990)</td>
<td>Ranking wastewater disposal alternatives</td>
</tr>
<tr>
<td>Martin et al. (1999)</td>
<td>Land-use planning and management, GIS</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Specific area, Other tools/methodologies used</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Martin et al. (2003)</td>
<td>The environmental impact assessment (EIA)/ranking sites to build bus station, Fuzzy PROMETHEE I and II</td>
</tr>
<tr>
<td>Mavrotas et al. (2006a)</td>
<td>To evaluate strategies for reducing atmospheric pollutants</td>
</tr>
<tr>
<td>Mergias et al. (2007)</td>
<td>To select the best scheme for End-of-Life Vehicles (ELVs)</td>
</tr>
<tr>
<td>Moffett and Sarkar (2006)</td>
<td>Biodiversity conservation planning, A taxonomy of MCDM methods including PROMETHEE</td>
</tr>
<tr>
<td>Palma et al. (2007)</td>
<td>To evaluate performance of silvoarable agroforestry</td>
</tr>
<tr>
<td>Petras (1997)</td>
<td>Ranking the sites for radioactive waste disposal facilities</td>
</tr>
<tr>
<td>Queiruga et al. (2008)</td>
<td>Ranking the alternatives location for installation of recycling plants (to recycle waste electrical and electronic equipment)</td>
</tr>
<tr>
<td>Rogers et al. (2004)</td>
<td>Ranking contaminated sediment management technologies</td>
</tr>
<tr>
<td>Rousis et al. (2008)</td>
<td>Ranking alternative management systems for the waste from electrical and electronic equipment constitutes</td>
</tr>
<tr>
<td>Salminen et al. (1998)</td>
<td>To analyze four different real applications to environment problems in Finland</td>
</tr>
<tr>
<td>Settle et al. (2007)</td>
<td>Ranking the combined North Lakes and Cabbage tree samples to determine the water quality behaviour, PCA/Partial Least Squares (PLS)</td>
</tr>
<tr>
<td>Spengler et al. (1998)</td>
<td>Ranking recycling measures in the iron and steel making industry/LCA, KOSIMEUS: a simulation and decision support system model</td>
</tr>
<tr>
<td>Vaillancourt and Waaub (2002)</td>
<td>Ranking waste management facilities, Mixed integer linear programming</td>
</tr>
<tr>
<td>Vaillancourt and Waaub (2004)</td>
<td>Ranking regions or countries in order to allocate the greenhouse gases emission rights, A dynamic multi-criterion model</td>
</tr>
<tr>
<td>Vego et al. (2008)</td>
<td>Ranking solid waste management alternatives</td>
</tr>
<tr>
<td>Vuk et al. (1991)</td>
<td>The location problem for disposal of communal waste</td>
</tr>
<tr>
<td>Walther et al. (2008)</td>
<td>To evaluate municipalities for the installation of recycling facilities</td>
</tr>
</tbody>
</table>
AHP

The following case study illustrates the application of analytical hierarchy process in impact assessment of climate change on ecohydrology management (Yasin, A. Al-Zubi, 2009). In specific, with the use of AHP the expected result of climate change on ecohydrology is assessed with the use of space as a variable. Results indicated that impact on climate change on ecohydrology is significant at local level and in the long term. Compared with a stochastic model and results appear to be the same.

In order to establish priorities pairwise comparisons of all combinations of alternatives were used in a cluster relative to the parent cluster. These pairwise comparisons resulted local priorities of alternatives in a cluster or sub-cluster. The original Saaty Rating Scale of linguistic variables was used (Table 4).

Table 4: The pairwise comparison scale (Saaty, 1988)

<table>
<thead>
<tr>
<th>Intensity of Importance</th>
<th>Definition</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
<td>Two elements contribute equally to the objective</td>
</tr>
<tr>
<td>3</td>
<td>Moderate importance</td>
<td>Experience and judgment slightly favor one element over another</td>
</tr>
<tr>
<td>5</td>
<td>Strong importance</td>
<td>Experience and judgment strongly favor one element over another</td>
</tr>
<tr>
<td>7</td>
<td>Very strong importance</td>
<td>One element is favored very strongly over another; its dominance is demonstrated in practice</td>
</tr>
<tr>
<td>9</td>
<td>Extreme importance</td>
<td>The evidence favoring one element over another is of the highest possible order of affirmation</td>
</tr>
</tbody>
</table>

A hierarchy was constructed to assess the relative influence of spatial, in terms of local level, national level, regional level and temporal level (5 years, 10 years and 20 years), so as to detect possible climatic change impact on ecohydrology.

Three climate scenarios for each out of two cases were assessed.

- In the first case (1) climate change impact has been assumed to be most significant at the local level (more than national and regional).

- In the second case (2) climate change impact was considered to be more significant at a regional level and less in national and local.
In order to assign weights the percentage of change in recharge volumes (averagely and annually), in the various periods, were used as basis.

The two cases (Case 1, Case 2) were used as a tool to behold the tendency of temporal and climate variables with another interacting factor, in order to include space as a variable.

The hierarchy tree was developed after dividing the problem into different levels.

- The first level defined the goal (e.g. assessing the impact of climate change on ecohydrology).
- The second level outlines the locations at different levels; Local (Azraq Basin), National (Jordan) and Regional (Jordan, Egypt, Syria, Iraq and Lebanon).
- The third level represents the period of times selected to predict the change; 5, 10 and 20 years.
- The fourth level shows the different scenarios;
  - +2°C with 0% precipitation,
  - +2°C with -10% precipitation and
  - +2°C with -20% precipitation.

![Hierarchy Tree](image)

**Figure 6: Hierarchy for impact assessment of climate change on water resources**

The weights for these variables are determined based on the results of the climate change impact model described above. With the use of all climate and temporal variables, under various different periods, the priority weights are illustrated by the results of Case 1 and Case 2.

As AHP presents in Case 1 (Table 6), local impacts from climate change are more significant (and receive higher weights) than national or regional. Finally in Case 2 the results of the AHP assume that regional impacts from climate change are more significant than national or local and receive higher weights (Table 7).
To sum up the tree structure used to formulate an AHP problem provides a clear, organized and logical view of the climate response problem making it easy for decision makers to visualise and analyse the problem systematically at each level.
4 Multi Criteria Analysis in the field of climate change adaptation planning

In the following part of this report, after summarizing briefly the meaning of adaptation to climate change in a Global and European basis, a number of case studies of MCA application in adaptation policy are presented. MCA methods and assisting tools applied or developed in the selected cases were used so as to reinforce the adaptive capacity of various sectors in a country level, in a local level or in a city level. Specific reference is made in MCA methods developed in National Adaptation plans of Least Developing Countries. The following case studies are presented in order criteria and weights used in them to be analyzed. Results of this analysis may be used as a baseline for the development of an MCA software tool in the field of adaptation planning. This MCA tool may constitute a means for other countries as well so as to prioritize possible adaptation measures and form adaptation strategies.

Adaptation to climate change in a global basis

The significant importance of adaptation planning as a response strategy to climate change related issues is widely understood. Scientific community recognizes to an international level the great importance of forming an adaptation strategy to climate change as a way to tackle climate change related issues (Smit et al 2000).

Active and sustained engagement of stakeholders (Nairobi work programme) including national, regional, multilateral and international organizations, the public and private sectors (private sector initiative), civil society and other relevant stakeholders can ensure among else the success of adaptation policies to climate change.

Adaptation plans pose challenges which are relating primarily to the high complexity of the planning process. This complexity results from the different levels of vulnerability of social, economic and ecological systems, the various impacts of climate change, the large number of actors involved, the different levels of decision-making and the cross-sectoral relations and required interactions.

Nevertheless, a significant number of countries have already initiated the efforts of elaborating national adaptation plans and strategies with the aim of moving to a more coherent approach than current individual activities. That coherent approach aims in contributing to climate-resilient development, suggesting a rather long-term, continuous process. Therefore, most existing adaptation strategies and plans consist of various interrelated and often overlapping options and require periodic revision, allowing for the consideration of changing circumstances and the availability of new information and knowledge.

The common step of most of the countries that elaborated adaptation strategies was to assess initially climate risks. This assessment included thorough analysis of potential climate impacts and the underlying vulnerabilities of affected systems. It should be pointed that this risk assessment of climate change requires expert judgment that enhances effective evaluation.
Risk assessment, in order to address those risks that are considered urgent or that could result in unmanageable consequences in the future, after identification of risks requires risks ranking. This ranking can lead to the identification of prioritized adaptation actions. Furthermore within this process is required the involvement of various stakeholders and the distribution of adequate responsibilities. A monitoring and evaluation system must be developed and accompany the implementation process so that corrective measures can be undertaken as required.

According to IPCC (2007) adaptations practices differentiate along several dimensions:

- In a spatial scale: the Global (IAM, GEM) scale, the National (NAPAs) scale and the Local (appraisal of vulnerability and adaptation measures).
- In a sector level: agriculture, tourism, water resources, health etc.
- Depending on the type of action: technological, physical, investment, regulatory market etc
- Depending on the actor: national government, local government, NG, international donors, private sector, local communities and individuals etc
- In a climate zone scale: floodplains, dryland, Arctic, mountains etc.
- By income or development level of the system they are being implemented to: developed and least developed countries, middle income countries.

In specific, adaptation measures or options may vary. As an example, adaptation measures can be classified according to the considered sector. As an alternative, adaptation measures could be classified in the basis of timing, goal and motive of implementation. Adaptation could also include reactive or anticipatory actions, or could be planned as autonomous (UNFCCC, 2006 and TERI, IPCC, 2007).

Furthermore individual sectors affected by climate change require special adaptation measures. As an example, in agriculture, reduced precipitation and higher evapotranspiration rates would call for new irrigation practices. As a result a national policy framework which integrates traditional coping mechanisms along with new practices, is required when formulating new policies. This policy would emphasize, among else, on the importance of including climate change as a long term consideration.

Use of scarce water resources in a more efficient way is another adaptation measure. Further examples include building flood defenses, adapting building codes to future climate conditions and extreme weather events, raising the levels of dykes, developing drought-tolerant crops, setting aside land corridors to help species migrate and choosing tree species and forestry practices less vulnerable to storms and fires.

Actions that draw from various sectors require for a multi sectoral approach. In a way it is the same uproach as looking at a particular problem through different lenses. In other words the multi sectoral approach is an integrated measure which looks the objectives with a more
holistic manner. As an example, integrated management of water, river basins or coastal zones is referred. Linking adaptation to climate change, with management options identified in various conventions, could serve as a multi-sectoral approach.

**Europe**

EEA member countries are at different stages of preparing, developing and implementing national adaptation strategies. The development depends on the magnitude and nature of the observed impacts, assessments of current and future vulnerability and the capacity to adapt. All countries have also submitted information on their adaptation plans in their 5th National Communication to the United Nations Framework Convention on Climate Change due on 1 January 2010. In addition, some actions and measures are increasingly being taken at regional and local levels. More information is available at Deliverable 2.3, Action 2, CYPADAPT 2011 - LIFE10ENV/CY/000723.

*Figure 7: Mapping the adaptation strategy adopted in Europe*
4.1 Multi-criteria analysis methods applicable in adaptation measures worldwide

In the following part of this review short summaries of successful applications of MCA methods developed for the assessment of adaptation measures are presented. Results can be used as a baseline for future applications.

The following case studies are presented in country level, in a sector level and a city level. The first case study refers to the ranking of adaptation options for climate change in the Netherlands (Bruin et al. 2009). The second case study, which applies in sector level, refers to use of MCA method for prioritizing adaptation measures in the agricultural sector (Julius, et al., 2009). The third case study refers to the application of MCA at a city level. More specific it is presented a summary of development of an MCA method in the city of Dhaka in Bangladesh (Haque et all, 2010) for the assessment of different adaptation options.

**Country level case study: Climate change adaptation strategy in Netherlands**

MCA is thought to be a useful tool in order to assess climate change policy, especially when focused on adaptation and mitigation options. The following case study is of significant importance since it describes the various criteria, scoring and weighting process that can be used while developing and MCA methodology.

In specific, in Netherlands, was created by stakeholders a database with all the relevant adaptation options and effects of climate change for various sectors (agriculture, water, nature, transport, energy, infrastructure, health and tourism). Their assessment was made by various criteria described in the following.

In specific, evaluation criteria used for qualitative assessment of adaptation options were:

(1) The necessity of implementation, reflected by the importance of the option;

(2) Possibility to postpone the action for a later stage in comparison with the immediate need of adaptation option implementation, reflected by the urgency of the option;

(3) No-regret possibility. Those are options for which non-climate related benefits, for example improved air quality, will exceed implementation costs; they will be beneficial therefore independently of future climate change;

(4) Auxiliary benefit options, implemented to reduce vulnerability to climate-change, while producing also benefits that are irrelevant with climate change;

(5) Mitigation linkages, as options of adaptation will also induce a reduction of global emissions, and thus have a very high score on mitigation effect.
The different options were scored so as to be ranked. The scoring scale ranged from 1 to 5. One (1) indicated a low priority and five (5) indicated the highest priority. To make the scores robust enough and able to provide an overview, broadly, experts from many different sectors gave their input. Furthermore, validation of scores with external experts took place.

In specific, options of adaptation which scored ‘very high’ (5) included:

- Integrated water and nature management;
- Integrated management of coastal zone;
- Water storage and retention.

Categorization and ranking of promising and also feasible options of adaptation was carried out through a multi-level multi criteria analysis (MCA), based on expert judgment, that defined different weights for the criteria: 40 % for importance, 20 % for urgency, 15 % for no-regrets, 15 % for ancillary benefits and 10 % for mitigation effect to produce a weighted sum for every option. Top options were not affected by weights’ choices, since these on most criteria scored very high and high on the other.

Finally, in order to properly inform policymakers, the feasibility of the different options was assessed using three different criteria:

- Technical complication: technical difficulties which escort the accomplishment of the option;
- Social complication: involves the variety of values when the option will be accomplished, the changes which are important in the perceptions of stakeholders, the importance of their collaboration and so on; and
- Institutional complication: institutions that involved the higher level of relevant bureaucracy.

The above mentioned criteria and the scoring and weighting procedure are of significant importance when applying MCA in adaptation policy. They could be used as a baseline in the elaboration of adaptation policies worldwide.

**Sector level case study: MCA Tool for Environmental Assessment and Management (TEAM)**

MCA is thought to be a useful tool in order to perform assessment of adaptation strategies. The following case study is of significant importance since it describes a decision support software system called the Tool for Environmental Assessment and Management (TEAM) that employs a multi-criteria approach for evaluating actions to address climate change.
impacts in the agricultural sector (Julius, 2009). Steps, attributes and evaluation procedures used in this case study can be used as a baseline for elaborating adaptation strategies.

The results of this case study revealed that the criterion considered of primary importance in developing agricultural policy was national security. Taking into consideration this result and the importance of domestic production relevant authorities may decide to change agricultural policy, or to continue with current practices.

In order to end up in using national security as a criterion for developing climate change adaptation policy in agricultural sector, the following steps were followed providing easy management of information:

- As a first step, the geographic region was identified, and the sector (e.g., water, agriculture, coastal zone) is characterized according to vulnerabilities to climate change.
- As a second step, the factors addressing the identified vulnerable system or resource were specified.
- As a third step, evaluation criteria were selected.
- As a fourth step, evaluation and scoring of the selected actions was performed.
- And in the final step, the upcoming results were assessed in order to promote consideration of the consequences of each action that was reviewed.

Five candidate strategies were developed by the relevant stakeholders: two strategies were about changing agricultural practices, two strategies were about switching to a new cultivar, and one strategy was to take no action.

Finally it is worth mentioning the seven attributes, which were selected to evaluate the candidate strategies. These are: up-front costs; long-term expected benefits; effectiveness and farm income (yield, price, and cost of production); technical/financing feasibility; distributional impact; and food security. Once the selection of strategies and evaluation criteria were chosen, each strategy was compared based on the above criteria.

**City level case study: Assessment of adaptation measures against flooding in the city of Dhaka, Bangladesh**

The following case study has been selected in order to demonstrates that when MCA analysis is used for prioritization of measures the upcoming results may be contradictory to the anticipated. Measures, thought to be of priority, come second in prioritization while others of less priority emerge in the first line.

In specific in Dhaka, the capital of Bangladesh, an eight step methodology was developed to perform the assessment of different adaptation measures to climate-related problems. According to experts, climate change posed risks to the Dhaka city are the flooding risk and the heat wave risk.
Those risks posed by climate change which are commonly addressed. Methodology, steps and criteria used to develop a policy to face these risks is of major importance and thus they are presented.

The following eight methodological steps were followed:

Step 1 (vulnerability assessment)

The most vulnerable types of capital assets to flooding have been identified through vulnerability assessment. The vulnerability assessment was performed based on exposure, sensitivity and adaptive capacity analysis.

Step 2 (Selection of potential adaptation options)

In the second phase selection of potential adaptation options was performed. Adaptation assessment was conducted through a specific methodology of (MCA) ‘Multi Criteria Analysis’ which used both the normative judgment and the technical expertise in an assessment process. This analytical method was assisted by a software tool, Excel based, named Climate Actions Prioritization (CLIMACT Prio) Decision Support Tool. It has been developed by the Institute for Housing and urban development Studies (IHS). CLIMACT Prio is a climate awareness, decision support and capacity building tool for assessment, prioritization and quick screening of climate change mitigation and adaptation measures at a local level.

Step 3 (Stakeholders’ criteria selection)

Taking into account the most significant considerations for the adaptation options, stakeholders selected criteria in a participatory manner, in the third step. These criteria, through a discussion, have been finalized by stakeholders. The following attributes were taken into account: Value relevance, operationality, reliability, measurability, decomposability, non-redundancy, minimum size, preferential independence, completeness and understandability.

Step 4 (Scoring of adaptation options)

In the fourth step experts scored each adaptation option based on their expertise.

Step 5 (Standardization of scores)

In the fifth step different units used to score the criteria, were standardized to a common scale with the use of the CLIMACT Prio software.

Step 6 (Stakeholders’ focus group discussion on weighting of criteria)

In the sixth step, that followed, weighting of criteria was done based on the degree of importance of each adaptation option.

Step 7 (Prioritization of options)
In the seventh step, adaptation options were prioritized based on the final weighted scores per option.

**Step 8 (Sensitivity Analysis)**

Sensitivity analysis was conducted.

Finally the ranking of the adaptation options was implemented. “The ranking resulted as the most effective protection of the water retention area, the enhancement of early warning systems and canal improvements” (Haque et al, 2010).

The measure resulting from this MCA ranking procedure is interesting to be commented since reducing flood vulnerability should be achieved mainly through construction and upgradation of drainage system according to common knowledge. But this has been proved to be a far less prioritized measure. Apparently if the drainage system is improved, it is expected to reduce flooding, but for a under developed country there are other factors that should also be considered.

“Construction and upgradation of the drainage system requires quite a high budget and also high technical capacity which is less available in the context. So, protection of the water retention area has proved to be relatively the most effective option for the study area for reducing vulnerability to flooding considering the relative importance of criteria along with the existing budget and capacity constraints. Uncertainty of stakeholders’ preferences has been incorporated by performing a sensitivity analysis” (Haque et al, 2010).

As a conclusion, by implementing MCA analysis of adaptation measures, stakeholders expertise and MCA methodology can prove that commonly accepted measures can be less prioritized than others due to economic, social or effectiveness reasons.

### 4.2 Multi-criteria analysis methods applicable in National Adaptation Plans of Actions (NAPAS)

Preparation of the climate change National Adaptation Plan of Action (NAPA) is a mechanism designed to assist the least developed countries to identify priority activities. Those prioritized activities can help less developed countries to meet their immediate needs and concerns related with adaptation to the adverse impacts of climate change.

In every adaptation attempt there are numerous criteria and indicators that must be considered as already mentioned in previous case studies. On the other hand climate change costs and their valuation in monetary terms are not possible in all cases. Therefore in a project, proposed to be implemented, view of local people must be taken into account and the most appropriate adaptation response is likely to be the one which is widely understandable and accessible to the greatest number of relevant participants in decision making.
The multicriteria analysis (MCA) has been advocated by the UN, taking the above mentioned rationale into account, as the preferred method for LDCs to prioritize and select adaptation policies and measures. This type of analysis is becoming increasingly popular in forming adaptation strategies as “it is considered to be more useful than traditional vulnerability management tools for structuring problems and decisions” (Willows and Connell, 2003).

Tools and techniques that can help to analyze both the risk and the uncertainty that climate change poses may prove more useful. In dealing with the challenges of climate change, the most difficult part in using traditional risk management tools lies in the fact that the level and types of risk uncertainty tend to be very different in comparison with more typical and better understood vulnerability. Once a vulnerability and hazards assessment has been carried out, NAPA will use the MCA to help rank preferences for adaptation activities and projects, as it is a particularly useful tool when many criteria are relevant to the decision-making process, and the valuation of costs and benefits is difficult due to inherent uncertainty. Therefore, some degree of subjective judgment is required.

Despite the fact that the NAPA guidelines do not include a rather formal process for ranking the relative risks importance, most of the NAPAs contain a sensitivity analysis carried out by the relevant NAPA team. Sensitivity analysis flags the activities that are sensitive particularly to climate change relying on location, current and future climate, and the proposed type of adaptation response. Stakeholder consultation determines the methods used for vulnerability assessments (through surveys, interviews, questionnaires) and participatory appraisals to modeling of resource allocations under different scenarios. These activities are subsequently deemed to be the most urgent priorities for adaptation action.

The participatory process involves the collaboration of local level, regional level, and national level stakeholders of representing vulnerable sectors. Also, as recommended by the NAPA guidelines, particular attention should be given to the highest affected by climate variability communities. In the majority of cases those are the local communities.

Irrespective of the GEF Agency involved in NAPA preparation (UNDP, UNEP, World Bank) in most countries NAPA preparation included the use of multi criteria analysis (MCA) as the method for adaptation action prioritization. Most countries that used MCA also examined the other prioritizing methods highlighted in LEG Annotated Guidelines for NAPA preparation – Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA) – as well as Multi-Criteria Analysis (MCA).

MCA was chosen due to a lack of the quantitative information required to be able to follow the other two methods. Most countries also used expert opinion and wide consultation processes for prioritization. Some countries chose their own methods rather than the methods recommended by the NAPA guidelines. For example, Samoa used a “consensus approach” which involved major stakeholders and community representatives engaging with communities through a series of country-wide consultation workshops to prioritize.
In Annex I all methods NAPAs used as tool are presented in a table of four columns. In the first column are presented the countries, in the second the methods used for prioritization, in the third the methods used for evidence, data and information collection. Finally in the fourth column reference is made in the NAPA team. A part of the table is presented in the following:

**Table 7: NAPA assessments**

<table>
<thead>
<tr>
<th>Country/ submission date</th>
<th>Methods used for prioritisation</th>
<th>Methods used for evidence, data and information collection</th>
<th>Composition of NAPA Teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>Expert opinion, Stakeholder consultation, Multiple criteria analysis</td>
<td>Secondary data review, expert opinion</td>
<td>National consultants, Government officials</td>
</tr>
<tr>
<td>Benin</td>
<td>Multiple Criteria Analysis Cost effective p64 Expert opinion p61 Consultation with the population and key stakeholders</td>
<td>meetings of groups, workshops of exchange, individual meetings, public consultations, interviews with key actors and local population to evaluate degree of vulnerability p73&amp;74 Review of secondary sources p72</td>
<td>Team constituted by the National Direction of project, the head of project and the secretary accountant. A National Committee of Coordination of Coordination was set up to give the orientation necessary for plan, as well as a Team of Multidisciplinary constituted of concerned national directions. Structures non governmental as well as UNDP to validate the results drawn in the development of the NAPA p74</td>
</tr>
<tr>
<td>Bhutan, May 2006</td>
<td>Multi-Criteria Analysis (MCA) technique in order to reach consensus on the selection of the top priority NAPA projects. A wide consultative process both at the national and regional levels. (Both senior and mid level RGOB officers representing a wide range of stakeholders took part in the numerous workshops).</td>
<td>Field visits (Four regional consultations were held in to gather evidence). Literature review on secondary sources.</td>
<td>Government (senior and mid level RGOB officers representing a wide range of stakeholders), National Consultants.</td>
</tr>
<tr>
<td>Suriname</td>
<td>Multiple Criteria Analysis 3 steps followed 3 criteria used to pre-select prioritized actions then four other criteria</td>
<td>Review and analysis of secondary sources and data p14 Exchange of information held with different administrative and political representatives.</td>
<td>Multidisciplinary Group of experts p20 comprised of representative from technical ministries and civil society</td>
</tr>
</tbody>
</table>

The NAPA MCA tools, in order to be a useful tool in deciding an adaptation strategy, should indicate stakeholders which adaptation activities and projects to undertake, and which process of ranking preferences to follow. There are several actions possibly suggested as the optimal response. However, those actions are also depending on the nature and extent of identified vulnerabilities. Generally, the prominent options tend to be the ones that ensure required adaptive capacity for the safe implementation of adaptation actions. As a result maximization of welfare over time will be accomplished.

Any MCA tool used is NAPAs should also take into account that the most desirable adaptation strategies are the ones that contribute to desired outcomes while improving the ability to adapt in the future. Those strategies accomplish maximization of benefits. Elements that compose adaptation strategies should ensure understanding of resources or time that adequate responses require, the state and accessibility of any required technologies, and the potential for conflict due to public or political resistance to the
proposed measures. Furthermore adaptation strategies and their subsequent funding allocation decisions is always a matter of governmental decision.

NAPA preparation guidelines suggest a set of criteria in order selection of priority adaptation activities and projects to be made, and a list of sectors and ecosystems to be examined. Locally driven criteria are used in order selection of priority adaptation activities to be made.

These criteria should include:

- Loss of life and livelihood
- Human health
- Food security and agriculture
- Water availability, quality, and accessibility
- Essential infrastructure
- Cultural heritage
- Biological diversity
- Land-use management and forestry
- Other environmental amenities

Furthermore the following criteria are applied so as to perform prioritization:

- Level or degree of adverse effects of climate change
- Poverty reduction so as to enhance adaptive capacity
- Synergy with other multilateral environmental agreements and
- Cost effectiveness.

Selected case studies of NAPAS that use MCA as tool to prioritize adaptation measures are presented below. Methodology, criteria, considerations, scoring scales, weighting scales etc used in these cases are summarized so as to be used as guidance in developing an MCA method that enhances elaboration of an adaptation strategy.

4.2.1 Bhutan case study: Assessing adaptation options using MCA

Bhutan assessed its vulnerability to climate change and possible adaptation options during the development of its National Adaptation Programme of Action (Bhutan NAPA, 2006). A task force team consisted by representatives from most important sectors, such as agriculture, biodiversity and forestry, natural disaster and infrastructure, health, and water resources, identified and ranked possible priority adaptation projects using MCA.
As a first step the NAPA team identified the most severe and likely climate related hazards and detected high risk groups:

(1) Hazards, such as increased Glacial Lake Outburst Floods (GLOF), landslides and flash-floods;

(2) Most vulnerable sectors, such as agriculture and hydropower;

(3) Most vulnerable communities, such as the rural poor;

In the second step the most prominent adaptation options were identified:

Seventeen adaptation options were suggested initially. Bhutan’s NAPA team, in the frame of the MCA analysis, utilized and adapted the four following criteria, recommended by the LDC Expert Group, in order to **create a second short list of nine adaptation options**:

- Convincing threats of climate and climate change/ level or degree of adverse effects of climate change;
- Risk level of not adapting;
- Other goals such as: overcoming poverty, enhancing adaptive capacity, or other environmental agreements;
- Demonstration of fiscal responsibility (or cost effectiveness);

In a third step, based on the following four criteria, the nine shortlisted options were **ranked**:

- Human life and health protected by the intervention;
- Arable land with associated water supply (for agriculture/ livestock) and productive forest (for forestry/forest products collection) saved by the intervention;
- Essential infrastructure saved by the intervention such as existing and projected hydropower plants, communication systems, industrial complexes, cultural and religious sites and main tourist attractions;
- Estimated project cost.

In the following step **scores** for the benefits of the different adaptation projects were given so as to be able to rank them. Adaptation projects were ranked on a scale from one (1) to five (5). Five (5) represented the greatest achievable benefit. Afterwards, the scores were standardized on a scale from zero (0) to one (1) to continue with the analysis and to allow costs to be included.

In the last level of the MCA technique weights were assigned. The task force team had decided to weigh the criteria in a different way, according to the needs of Bhutan and the
geographical scale of the projects. In specific the projects of national level were given greater weight than projects with local impact only. In the following table the standardized scores, the general and local weighing and the final ranks are presented.

Most of the prioritized adaption options have been already undertaken from most of the countries. However other options, such as developing a disaster management strategy, can be proposed for use in other countries as well.

Table 8: Standardized scores, general and local weighing and the final ranks

<table>
<thead>
<tr>
<th>Options</th>
<th>Estimated cost</th>
<th>Benefits saved</th>
<th>Ample land, water supply etc. saved</th>
<th>Essential infrastructure and manouvre saved</th>
<th>Summary of weighing</th>
<th>Initial rank</th>
<th>National (N)</th>
<th>Regional (R)</th>
<th>Local (L)</th>
<th>Adjusted ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Disaster Management: Food Security and Emergency Medicine</td>
<td>0.20</td>
<td>0.33</td>
<td>0.77</td>
<td>0.20</td>
<td></td>
<td></td>
<td>N</td>
<td>-15%</td>
<td>R : -0.0%</td>
<td>L -15%</td>
</tr>
<tr>
<td>(2) Landslide Management &amp; Flood Prevention</td>
<td>0.16</td>
<td>0.75</td>
<td>0.75</td>
<td>0.25</td>
<td>0.7795</td>
<td>2</td>
<td>R</td>
<td>-35%</td>
<td>-0.0%</td>
<td>-15%</td>
</tr>
<tr>
<td>(3) Rainwater Harvesting</td>
<td>0.36</td>
<td>0.75</td>
<td>0.50</td>
<td>0.20</td>
<td>0.4945</td>
<td>7</td>
<td>N</td>
<td>-30%</td>
<td>-0.0%</td>
<td>6</td>
</tr>
<tr>
<td>(4) Weather Forecasting System to Serve Farmers and Agriculture</td>
<td>0.81</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
<td>0.5934</td>
<td>5</td>
<td>N</td>
<td>-35%</td>
<td>-0.0%</td>
<td>3</td>
</tr>
<tr>
<td>(5) Artificial Lowering of Tharomhi Gisater Lela</td>
<td>0.25</td>
<td>0.75</td>
<td>0.75</td>
<td>0.25</td>
<td>0.7845</td>
<td>2</td>
<td>R</td>
<td>0%</td>
<td>1%</td>
<td>2</td>
</tr>
<tr>
<td>(6) Installation of Early Warning System on Piv Dhu Ruam</td>
<td>0.81</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25</td>
<td>0.6276</td>
<td>8</td>
<td>R</td>
<td>0%</td>
<td>1%</td>
<td>8</td>
</tr>
<tr>
<td>(7) Promote Community-based Forest Fire Management and Prevention</td>
<td>0.81</td>
<td>0.25</td>
<td>0.50</td>
<td>0.25</td>
<td>0.6295</td>
<td>9</td>
<td>R</td>
<td>0%</td>
<td>1%</td>
<td>9</td>
</tr>
<tr>
<td>(8) GLDF Hazard Zoning</td>
<td>0.08</td>
<td>0.75</td>
<td>0.25</td>
<td>0.25</td>
<td>0.3185</td>
<td>6</td>
<td>R</td>
<td>0%</td>
<td>1%</td>
<td>6</td>
</tr>
<tr>
<td>(9) Flood Protection of Downstream Industrial and Agricultural Area</td>
<td>1.00</td>
<td>0.75</td>
<td>0.75</td>
<td>0.25</td>
<td>0.7845</td>
<td>3</td>
<td>L</td>
<td>0%</td>
<td>1%</td>
<td>5</td>
</tr>
</tbody>
</table>

4.2.2 Burundi case study: Assessing adaptation options using MCA

Burundi, in a global basis, is among the poorest countries. Studies on the evaluation of adverse impacts of climate change on a number of sectors (Burundi NAPA, 2006) show that the rainfall periods of prolonged dryness will have serious consequences such as dryness, late rains, famine, deficit of water for various use, decreased livestock and agricultural production, loss of human lives and biodiversity, degradation of vegetable cover, bush fire, migration of population and cattle, drying up or lower level of dams and rivers and reduced hydropower energy.
Excess in rainfall can cause losses of habitats for species, rain erosion, destruction of infrastructures, losses of harvests, wood windfall, losses in human lives, landslide, eruptions of parasitic diseases, waterborne diseases and nutritional deficiency diseases, the blocking/silting of rivers and lakes, deterioration of water quality, floods of lowlands and marshes etc.

The objective of NAPA in Burundi (Burundi NAPA, 2006) is to produce a list of priority actions that are urgent and immediate and that contribute to the efforts of adaptation of the country to the adverse effects of climate change. The tools used towards this goal are Cost Benefit Analysis, Cost Effectiveness Analysis and Multi Criteria Analysis. However, due to the lack of quantitative information, the MCA which combines the CBA and CEA has been used.

Financially speaking, nevertheless, Burundi might face difficulties in mobilizing financial resources necessary to implement priority actions. Regarding the institutional aspect, the poor institutional capacity to implement NAPA activities could also represent a barrier to implementation. Unfortunately these are problems faced by most of the developing countries.

In the specific case study, fourteen options were proposed for adaptation. They have been weighted for criteria and prioritized. The criteria, in the MCA approach, were differentiated in two groups, i.e.:

- **Cost and**

- **Effectiveness** consisting of (a) *Climate-sensitive criteria* (Sustainable environmental management; Aptitude of adaptation, Prevention of climate risks) and (b) *Government objectives* (Fight against poverty, Food security, Women empowerment, Economic growth).

In the followings table absolute weightings and the relative weightings allotted to each criterion are presented.

**Table 9: Criteria and weighting in different adaptation measures**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Absolute weighting</th>
<th>Relative weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable environmental management</td>
<td>25</td>
<td>0.25</td>
</tr>
<tr>
<td>Cost</td>
<td>20</td>
<td>0.20</td>
</tr>
<tr>
<td>Aptitude of adaptation</td>
<td>15</td>
<td>0.15</td>
</tr>
<tr>
<td>Fight against poverty</td>
<td>14</td>
<td>0.14</td>
</tr>
<tr>
<td>Food security</td>
<td>10</td>
<td>0.10</td>
</tr>
<tr>
<td>Prevention of climate risks</td>
<td>10</td>
<td>0.10</td>
</tr>
<tr>
<td>Women empowerment</td>
<td>4</td>
<td>0.04</td>
</tr>
<tr>
<td>-Economic growth</td>
<td>2</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>1.00</strong></td>
</tr>
</tbody>
</table>

The resulting list of prioritization process follows:

1. Improve the seasonal early warning climate forecasts;
2. Preserve existing woodlots and reforest the stripped zones;

3. Reinforce the management of the existing protected areas and protect the threatened and vulnerable natural ecosystems;

4. Popularize rainwater harvesting techniques for agricultural or domestic use;

5. Set up erosion control mechanisms in sensitive areas;

6. Establish and protect strategic buffer zones in the floodplain of Lake Tanganyika and around the lakes of Bugesera;

7. Identify and popularize dryness resistant forest species;

8. Popularize short cycle and dryness resistant food crops;

9. Popularize the zero grazing techniques;

10. Identify and popularize the improved techniques of wood use and new renewable energies;

11. Control the river dynamics of watercourses and the torrents in Mumirwa, including the city of Bujumbura; Train and inform the decision makers and other partners, including the local communities, on the methods of adaptation to climate variability;

12. Identify and popularize the breeding of species adapted to local climate conditions;


Assessing Priority Options

Compare of every option against the criteria lead to the selected options of adaptation to climate change. The method of calculation was applied during this exercise of prioritization of the options. Thus it was made possible to define the type of important projects of adaptations to climate change. The result procedure is presented in the following table.

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies in other countries.

Table 10: Calculation and prioritization of options of adaptation projects to climate change

<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Options Selected</th>
<th>Cost ('000US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of seasonal early warning climate forecasts</td>
<td>Improve the seasonal early warning climate forecasts</td>
<td>500</td>
</tr>
<tr>
<td>Rehabilitation of degraded areas</td>
<td>Safeguard existing woodlots and reforest stripped areas</td>
<td>500</td>
</tr>
</tbody>
</table>
### Deliverable 4.1: Literature review of the state-of-the art multi-criteria analysis tools used for the development of adaptation plans worldwide

<table>
<thead>
<tr>
<th>Name of Project</th>
<th>Options Selected</th>
<th>Cost ('000US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify and popularise dryness resistant forest species</td>
<td><strong>Safeguarding of the natural environments</strong></td>
<td>200</td>
</tr>
<tr>
<td>Enhance the management of existing protected areas and transform into protected areas the natural ecosystems identified as threatened or vulnerable</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>Popularise the rainwater harvesting techniques for agricultural or domestic use</td>
<td><strong>Rainwater Valorisation</strong></td>
<td>600</td>
</tr>
<tr>
<td>Set up erosion control mechanisms in sensitive areas</td>
<td><strong>Erosion control in the region of Mumirwa</strong></td>
<td>200</td>
</tr>
<tr>
<td>Establish and protect strategic buffer zones in Lake Tanganyika floodplain and around the lakes of Bugesera</td>
<td><strong>Protection of buffer zones in Lake Tanganyika floodplain and around the lakes of Bugesera</strong></td>
<td>294</td>
</tr>
<tr>
<td>Popularise short cycle and dryness resistant food crops</td>
<td><strong>Popularisation of short cycle and dryness resistant food crops</strong></td>
<td>300</td>
</tr>
<tr>
<td>Popularise zero grazing techniques/Identify and popularise the breeding of species adapted to local climate conditions</td>
<td><strong>Zero grazing technique</strong></td>
<td>700</td>
</tr>
<tr>
<td>Identify and popularise improved techniques of use of wood and renewable new energies</td>
<td><strong>Capacity building to promote energy-wood saving techniques</strong></td>
<td>2000</td>
</tr>
<tr>
<td>Control the river dynamics of watercourses and torrents in Mumirwa, including the city of Bujumbura</td>
<td><strong>Stabilisation of river dynamics of watercourses and torrents in Mumirwa, including the city of Bujumbura</strong></td>
<td>2000</td>
</tr>
<tr>
<td>Train and inform decision makers and other actors, including local communities, on the methods of adaptation to climate variability</td>
<td><strong>Education on climate change adaptation</strong></td>
<td>500</td>
</tr>
<tr>
<td>Increase hydropower micro stations</td>
<td><strong>Increase hydropower micro stations</strong></td>
<td>500</td>
</tr>
</tbody>
</table>
4.2.3 Eritrea case study: Assessing adaptation options using MCA

Eritrea is a Least Developed Country situated in an arid and semi-arid region of Sahalian Africa. The country has low adaptive capacity relative to constraints in wealth, technology, education, institutions, information, infrastructure and social capital. Eritrea is highly vulnerable to climate variability, extreme weather events, and long-term climate change.

Regarding adaptation to climate change, Eritrea has special needs. Eritrea is particularly vulnerable with low-lying coastal regions, arid and semi-arid areas, areas liable to drought and desertification, areas with fragile ecosystems including mountainous ecosystems, and an economy highly dependent on consumption of fossil fuels and associated energy-intensive products. Climatic hazards such as temperature increases, reduced precipitation, chronic drought, flash flooding, heat stress, El Niño effects, and sea level rise are expected to adversely affect food security, water supply, public health, wildlife, coastal resources and fragile ecosystems are raising serious concerns in Eritrea about a changing climate. Citizens most likely to be affected are also those least able to cope. These include subsistence farmers, spate and irrigated well farmers, pastoralists, the rural poor, small-scale traders, urban and semi-urban poor, artisanal fishermen and island inhabitants. These groups are already finding it difficult to cope with increasing climatic variability. Women, children, and elderly people are particularly vulnerable.

Eritrea NAPA process (Eritrea NAPA, 2007) was planned in consistence with ongoing national strategies for sustainable development. The adaptation projects that were prioritized are closely linked with national strategy regarding poverty reduction, improving food security, disaster preparedness and prevention policy, and promoting sustainable development.

In the following is provided an overview of the process that was used to develop locally-driven evaluation criteria to rank potential adaptation options. Stakeholder consultations were taken into account. Specifically, a total of 102 specific adaptation projects were prioritized in the field of crops, livestock, forestry, water resource, coastal and marine environments and public health.

The criteria were ultimately used in the multi-criteria assessment of potential adaptation options using NAPAssess. NAPAssess is the tool for multicriteria assessment that integrates the various components of a multi-criteria assessment (i.e., scoring, weighting, standardization, and project ranking). More information about NAPAssess is available in the Sudan case study.

After standardization process, the weight assigned by stakeholders to each criterion was integrated into the analysis. A weighted score for each of the 102 potential adaptation projects was finally developed. Ranking of key adaptation needs and activities by sector is presented in the following tables.

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies in other countries.
Table 11: Ranking of key adaptation needs and activities by sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Key Adaptation Needs/Activities</th>
<th>ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Breeding Drought and Disease Resistant Crops</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Biological Soil and Water Conservation (use of vegetative contour hedges)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Construction of Diversion Structures to let in Rain Water into Spate Fields</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Construction of stone and earth bunds</td>
<td>4</td>
</tr>
<tr>
<td>Livestock</td>
<td>Introducing community based pilot projects to enhance existing production models, area and species specific in eastern and northwestern lowlands selecting suitable sheep and goat breeds.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Introducing community based pilot rangeland improvement and management in selected agro-ecological areas in the eastern and northwestern lowlands.</td>
<td>2</td>
</tr>
<tr>
<td>Forestry</td>
<td>Encourage afforestation and agroforestry through community forestry initiative</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Encourage natural regeneration through enclosures</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Encourage the use of improved wood stoves (Adhanat)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Conservation and management of the highland forest ecosystem</td>
<td>4</td>
</tr>
<tr>
<td>Water Resources</td>
<td>Groundwater Recharge for Irrigation Wells</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Introduction and expansion of irrigated agriculture especially spate irrigated agriculture (for crop and livestock production).</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Implement rural and urban water supply project by construction of new dams, ponds and wells.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Construction of livestock watering points</td>
<td>4</td>
</tr>
<tr>
<td>Marine &amp; Coastal zones</td>
<td>Strengthening formulation and development of integrated coastal zone management</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mangrove afforestation programs</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Establishing marine protected areas</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Constructing protection structures for the most vulnerable coastal infrastructure.</td>
<td>4</td>
</tr>
<tr>
<td>Public Health</td>
<td>Infant Young Child Feeding (IYCF) including supplementary feeding, therapeutic feeding (scurvy), and breast feeding.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Epidemic forecasting, early warning and response (Surveillance)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>GMP (Good Monitoring program) at community level including information, communication &amp; counseling, training and organization, and guidelines on feeding</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Integrated vector management including indoor residual spraying, insecticide-treated nets, and breeding site control.</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 12: Final list of priority adaptation projects for Eritrea

<table>
<thead>
<tr>
<th>Sector</th>
<th>Key Adaptation Needs/Activities</th>
<th>Final ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Breeding Drought and Disease Resistant Crops</td>
<td>1</td>
</tr>
<tr>
<td>Livestock</td>
<td>Introducing community based pilot rangeland improvement and management in selected agro-ecological areas in the eastern and northwestern lowlands rangelands.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Introducing community based pilot projects to intensify existing production models, area and species specific in eastern and northwestern lowlands selecting suitable sheep and goat breeds.</td>
<td>3</td>
</tr>
<tr>
<td>Forestry</td>
<td>Encourage afforestation and agroforestry through community forestry initiative</td>
<td>4</td>
</tr>
<tr>
<td>Water Resources</td>
<td>Groundwater Recharge for Irrigation Wells</td>
<td>5</td>
</tr>
</tbody>
</table>
4.2.4 Ethiopia case study: Assessing adaptation options using MCA

The Federal Democratic Republic of Ethiopia has already put in place policies, strategies and programs that enhance the adaptive capacity and reduce the vulnerability of the country to climate variability and change. Through the NAPA process, twenty priority project ideas were identified that address immediate climate change adaptation needs of the country. These projects broadly focus in the areas of human and institutional capacity building, improving natural resource management, enhancing irrigation agriculture and water harvesting, strengthening early warning systems and awareness raising (Ethiopia NAPA, 2006).

The following thirty seven potential adaptation options were proposed (identified) for further prioritization and ranking, with the use of a multi-criteria analysis tool. After prioritization process the selected options will be incorporated in the NAPA to address immediate adaptation needs.

1. Promoting drought/crop insurance program in Ethiopia
2. Realizing food security through multi-purpose large-scale water development project in Genale–Dawa Basin
3. Community Based Development and Commercialization of Non-timber Forest Products (Gum Arabic, Myrrah and Frank Incense)
4. Community Based Rehabilitation of Degraded Eco-Systems in Selected Parts of Ethiopia
5. Propagation and Commercial Scale Cultivation of Wild Essential Oil Crops
6. Establishment of Centre for Propagation and Commercialization of Traditional Herbal Medicinal Plants
7. Establishment of Acacia Woodland Nature Reserve in the Ethiopian Rift Valley System
8. Community Based Carbon Sequestration Project in the Rift Valley System of Ethiopia
9. Range Shift Cultivation of Selected Cash Crops in Drought Prone Areas
10. Establishment of National R&D Center for Climate Change
11. Development of an Incentive Scheme for Farmers (Hill-farming communities) to Reforest Hill Areas in the Northern Parts of Ethiopia
12. Participatory Approach to Rehabilitate Degraded Hills/Ecosystem in Northern Ethiopia
13. Institutional Re enforcement for Bio-diversity Conservation
14. Establishment of National Environmental Education Program
15. Reforestation for Fuel in the Highlands of Ethiopia
16. Regional Capacity Building for Monitoring and Inventorying of Biodiversity
17. Establishment of Potato-centered Small-sized Cottages
18. Reclamation of Bush Encroached Rangelands
19. Promotion of Legume-based Agroforestry Systems and Home-garden Agriculture
20. Development of New and Rehabilitation (upgrading) of the existing watering sites in Pastoral Areas
21. Aquaculture Development for Efficient Harvest of Commercial *Spirulina* Species in the Lakes of the Ethiopian Rift Valley System
22. Reorganization of drought Affected Communities
23. Stall feeding promotion and free range grazing restriction in selected regional states of Ethiopia
24. Promotion of on farm and homestead forestry and agroforestry practices in arid, semi-arid and dry-sub humid parts of Ethiopia
25. Undertake soil and water conservation practices for improved land husbandry in Afar, Somali and Gambella regional states and Diredawa city administration
26. Develop community seed bank and food storage facilities in Amhara, SNNPRS, Tigray, Oromia.
27. Capacity building for small scale irrigation planning and development in Afar, Gambella, Somali and SNNPRS.
28. Community based sustainable utilization and management of wet lands in selected wet lands in Ethiopia
29. Strengthening/enhancing drought and flood early warning systems in Ethiopia
30. Capacity building for climate change adaptation in Ethiopia at federal as well as regional levels
31. Public awareness program on climate change in Ethiopia at national as well as regional levels
32. Enhancing the use of water for agricultural purpose on small farms in arid and semi arid parts of Ethiopia
33. Community capacity building to initiate and implement environmental health program and or projects in the national regional states
34. Commercial level uses of some indigenous, wild edible fruits in selected arid and semi-arid areas of Ethiopia

35. Malaria containment program (MCP) in selected areas of Ethiopia

36. Institutional development; enhancement of research and development capacity of the national dry land research centers in Somali, Gambella, Benishangul-gumuz, low lands of Oromia, Amhara, Tigray, Afar and SNNPR.

37. Improving/enhancing the range land resources management practices in the pastoral areas of Ethiopia

Ethiopia’s NAPA team selected the MCA technique for the prioritization and selection of adaptation projects. In the following table the prioritized projects are presented. Relevant scores, ranking and estimated cost are also presented.

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.

Table 13: List of projects prioritized using Multi-Criteria Assessment (MCA)

<table>
<thead>
<tr>
<th>Title of Project</th>
<th>Average standard score</th>
<th>Rank</th>
<th>Estimated cost (Million USD)</th>
<th>Estimated project design cost (Million USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoting drought/crop insurance program in Ethiopia</td>
<td>1.00</td>
<td>1</td>
<td>8</td>
<td>0.1</td>
</tr>
<tr>
<td>Strengthening enhancing drought and flood early warning systems in Ethiopia</td>
<td>1.00</td>
<td>2</td>
<td>10</td>
<td>0.1</td>
</tr>
<tr>
<td>Development of small scale irrigation and water harvesting schemes in arid, semi-arid, and dry sub-humid areas of Ethiopia</td>
<td>0.99</td>
<td>3</td>
<td>30</td>
<td>0.5</td>
</tr>
<tr>
<td>Improving enhancing rangeland resource management practices in the pastoral areas of Ethiopia</td>
<td>0.95</td>
<td>4</td>
<td>2</td>
<td>0.05</td>
</tr>
<tr>
<td>Community based sustainable utilization and management of wet lands in selected parts of Ethiopia</td>
<td>0.95</td>
<td>5</td>
<td>2</td>
<td>0.05</td>
</tr>
<tr>
<td>Capacity building program for climate change adaptation in Ethiopia</td>
<td>0.85</td>
<td>6</td>
<td>3</td>
<td>0.1</td>
</tr>
<tr>
<td>Realizing food security through multi-purpose large-scale water development project in Genaale-Dawa Basin</td>
<td>0.80</td>
<td>7</td>
<td>700</td>
<td>2</td>
</tr>
<tr>
<td>Community Based Carbon Sequestration Project in the Rift Valley System of Ethiopia</td>
<td>0.78</td>
<td>8</td>
<td>1</td>
<td>0.05</td>
</tr>
<tr>
<td>Establishment of national research and development (R&amp;D) center for climate change</td>
<td>0.76</td>
<td>9</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Strengthening malaria containment program (MCP) in selected areas of Ethiopia</td>
<td>0.76</td>
<td>10</td>
<td>6</td>
<td>0.5</td>
</tr>
<tr>
<td>Promotion of on farm and homestead forestry and agro-forestry practices in arid, semi-arid and dry-sub humid parts of Ethiopia</td>
<td>0.76</td>
<td>11</td>
<td>5</td>
<td>0.1</td>
</tr>
<tr>
<td>Total cost</td>
<td>770</td>
<td>3.75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2.5 Gambia case study: Assessing adaptation options using MCA

Gambia is a small size country, were climate change and variability, in particular, placed tremendous pressure on natural resources and ecosystems. In The Gambia, three economic sectors (agriculture, fisheries and energy), two natural resources sectors (water, forest), one social sector (health) and coastal zones sector are selected for inclusion in the National Adaptation Programme of Action (NAPA) study (Gambia NAPA, 2007).

A menu of options was established through the Gambia’s NAPA thematic studies. Options were recognized individually and collectively as having the potential to offset some detrimental impacts of climate change. Those options were placed for multi-criteria analysis (MCA). Options were thus organised into sets of alternative adaptation measures (policies, programmes, project) that are assessed according to criteria: 1) economic; 2) environmental/ecological; 3) social/cultural/religious; 4) technical; and 5) political.

More specifically, the criteria used in MCA technique were:

- Cost effectiveness,
- Acceptability,
- Sustainability,
- Technical feasibility, Adaptability,
- Affordability,
- Environmental benefits/sustainability,
- Appropriate Technology,
- Reliability,
- Health and safety,
- Maximum abstraction rate,
- Species availability,
- Land suitability,
- Durability,
- Annual allowable cut,
- Employment opportunity,
- Crop yield,
- Coverage,
- Relevance,
- Accessibility,
- Fish catch,
- Regional cooperation,
- Illegal Unrecorded Unregulated (IUU) exploitation.

Those criteria, as further step, were clustered and summarized to highlight: 1) economic, 2) environmental, 3) social/cultural/religious, 4) technical, and 5) political aspects of
adaptation. Weights are assigned to individual criteria so as to ensure an adequate balance (in the judgment of participants/analysts) of these specific aspects within each context.

Criteria for the evaluation were suggested by technical experts with inputs both from local government representatives and extension/change agents. Evaluation criteria constitute the basis for multi-criteria analysis (MCA) of adaptation options/strategies. There was a two stages validation:

1) at policy making level (to ensure that national priorities are reflected in the NAPA) and

2) at local/community level (to ensure that social concerns and aspirations are adequately addressed).

Validation was made to check from policy makers’ and stakeholder perspectives how reasonable the results are.

In the following re-examination of adaptation options/strategies, in the context of national priorities and development plans, was implemented by policy-makers. In this way validation of different priority rankings in the economic and social sectors was accomplished. Shortcomings that emerged at this point in the validation exercise include also:

1) the absence of explanations/clarifications/commentaries for major differences, and

2) non pronouncement on the comparative weighting of sectors

It is very important to be pointed that there are major differences in the ranking process. The reason is that climate change has not the same definition necessarily on all policy makers’ minds, especially with the absence of guiding policy/governmental white paper on climate change and development.

On the technical side, expertise in MCA methodology is not sufficient, absence of feedback from stakeholders exists, and lack of data on key indicators may happen. Thus some of the differences are explained. In order to limit differences in ranking, some form of closure was attempted by joint ranking of adaptation options/strategies through the MCA exercise and public investment programmed perspectives (policy-makers).

Results are shown per sector in the following tables.
Table 14: Priority options in the agricultural sector (crop production sub-sector)

<table>
<thead>
<tr>
<th>Option</th>
<th>MCA Ranking</th>
<th>Policy Makers Ranking</th>
<th>Joint Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated agriculture</td>
<td>1 (0.688)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Suitable crop varieties</td>
<td>1 (0.688)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Erosion Control</td>
<td>3 (0.640)</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Micro-finance</td>
<td>7 (0.550)</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Crop diversification</td>
<td>8 (0.378)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Food Processing</td>
<td>8 (0.378)</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Notes: The figures in parentheses in the second column are standardized MCA scores

Table 15: Priority options in water resources management

<table>
<thead>
<tr>
<th>Option</th>
<th>MCA Ranking</th>
<th>Policy Makers Ranking</th>
<th>Joint Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing pumping policies</td>
<td>3 (0.560)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Improved drainage system</td>
<td>5 (0.435)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Relocation of boreholes</td>
<td>1 (0.655)</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Construction of protection dykes</td>
<td>2 (0.630)</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Water supply</td>
<td>9 (0.390)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Artificial recharge</td>
<td>6 (0.385)</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 16: Priority options in forest and woodland management

<table>
<thead>
<tr>
<th>Option</th>
<th>MCA Ranking</th>
<th>Policy Makers Ranking</th>
<th>Joint Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bushfire control</td>
<td>1 (0.760)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Reforestation</td>
<td>2 (0.642)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Propagation of fire resistant species</td>
<td>3 (0.550)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Public sensitisation</td>
<td>4 (0.490)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Expansion of protected areas</td>
<td>5 (0.483)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Services (eco-tourism)</td>
<td>6 (0.420)</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 17: Priority options in the coastal zone management

<table>
<thead>
<tr>
<th>Option</th>
<th>MCA Ranking</th>
<th>Policy Makers Ranking</th>
<th>Joint Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible zoning of reserve boundaries</td>
<td>1 (0.563)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Use of responsible fishing techniques</td>
<td>2 (0.500)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Revetment</td>
<td>2 (0.500)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Beach nourishment and stabilisation</td>
<td>4 (0.478)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Establishment/habilitation of protected wetland areas</td>
<td>5 (0.475)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Rice cultivation</td>
<td>6 (0.460)</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 18: Priority options in the fisheries sector

<table>
<thead>
<tr>
<th>Option</th>
<th>MCA Ranking</th>
<th>Policy Makers Ranking</th>
<th>Joint Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquaculture</td>
<td>1 (0.600)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Post harvest preservation</td>
<td>2 (0.500)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Fish imports</td>
<td>2 (0.500)</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Fishing gear restrictions</td>
<td>7 (0.315)</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Closed seasons</td>
<td>6 (0.320)</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Improved fishing infrastructure</td>
<td>9 (0.248)</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 19: Priority options in livestock production

<table>
<thead>
<tr>
<th>Option</th>
<th>MCA Ranking</th>
<th>Policy Makers Ranking</th>
<th>Joint Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rangeland regeneration</td>
<td>1 (0.870)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Establishment of intensive feed gardens</td>
<td>2 (0.867)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Improved animal watering</td>
<td>3 (0.775)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Stock size management</td>
<td>7 (0.600)</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Animal vaccination</td>
<td>10 (0.500)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Demarcation of range lands</td>
<td>5 (0.620)</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
Adaptation options in the various sectors were prioritized according to relative merit. Finally they were integrated into the following project concepts.

- Impairment of ecosystem goods and services
- Amplification of adverse effects of climate change by human factors
- Food security and sustainable livelihoods
- Poverty reduction and equity
- Technology acquisition, innovation, and diffusion
- Inadequate strategies for dealing with moving target (incremental effects of climate change).

A set of adaptive capacity building measures included also:

1. public awareness building on climate change, development, and livelihood issues;
2. enhancement of technical and managerial capacities of implementing agencies, beneficiaries (artisans, technicians, civil society organizations) and extension workers;
3. participatory planning and implementation;
4. provision, construction and upgrading of physical assets essential to the reduction of sectoral vulnerabilities;
5. introduction of new/alternative technologies and production methods; and
6. institutional re-alignments and mainstreaming of adaptation.

In this regard, adaptation measures overlap to a certain degree with the country’s flagship environmental management, disaster management and poverty reduction programs.

Both methodology (steps, criteria, ranking and weighting process etc) and selected options can be used as guidance in the setting of adaptation policies in other countries.

4.2.6 Lesotho case study: Assessing adaptation options using MCA

Lesotho faces severe environmental stresses mainly drought, land degradation, desertification and loss of biodiversity. Under climate change impacts these aforementioned stresses get more pronounced and hence counteract sustainable development attempts. Thus, climate change will have a range of negative impacts on the welfare of communities.

The key objectives of the Lesotho NAPA (Lesotho NAPA, 2007) took into account the following:

- Regions and communities vulnerable to climate change identification
- Assessment of climate change impact on community livelihoods
- Identification and prioritization of responsive adaptation activities for implementation in the vulnerable zones

Lesotho used in the NAPA process a Multi-Criteria Analysis technique so as to prioritize adaptation options. The methodology involved three steps:

- the identification of options,
- scoring of the options against selected criteria and
- weighting of the criteria.

Prioritization criteria, selected as the most appropriate for Lesotho’s needs were:

- Impact on Vulnerable Groups and Resources
- Impact on the Economic Growth Rate of the Vulnerable Communities
- Impact on poverty reduction
- MEA synergies
- Employment Creation
- Prospects for Sustainability
The above criteria were selected according to the key challenges the country faces in its development needs (environment degradation, unemployment, poverty, gender equity and HIV) as well as the policies and programs put in place to combat the challenges.

The resulting adaptation options in the NAPA process are outlined below in their order of priority:

- **Option 1**: Improve Resilience of Livestock Production Systems Under Extreme Climatic Conditions in Various Livelihood Zones in Lesotho
- **Option 2**: Promoting Sustainable Crop Based Livelihood Systems in Foothills, Lowlands and Senqu River Valley
- **Option 3**: Capacity Building and Policy Reform to Integrate Climate Change in Sectoral Development Plans
- **Option 4**: Improvement of an Early Warning System Against Climate Induced Disasters and Hazards
- **Option 5**: Securing Village Water Supply for Communities in the Southern Lowlands
- **Option 6**: Management and Reclamation of Degraded and Eroded Land in the Flood Prone Areas (Pilot Project for Western Lowlands)
- **Option 7**: Conservation and Rehabilitation of Degraded Wetlands in the Mountain Areas of Lesotho
- **Option 8**: Improvement of Community Food Security Through the Promotion of Food Processing and Preservation Technologies
- **Option 9**: Strengthening and stabilizing eco-tourism based rural livelihoods
- **Option 10**: Promote Wind, Solar and Biogas Energy Use as a Supplement to Hydropower Energy
- **Option 11**: Stabilizing Community Livelihoods which are Adversely Affected by Climate Change Through Improvement of Small Scale Industries

Both methodology (steps, criteria, ranking and weighting process etc) and selected options can be used as guidance in the setting of adaptation policies.

### 4.2.7 Liberia case study: Assessing adaptation options using MCA

Prioritizing adaptation projects involved two major steps in the Liberia NAPA process (Liberia NAPA, 2008). In the first step, a number of evaluation criteria were locally determined through the stakeholder consultation process. In the second step, through a scoring, weighting, and ranking process – part of a multicriteria assessment process - a discrete set of prioritized adaptation projects were developed.
Five criteria emerged from stakeholders’ consultations. These criteria represent a mix of both quantitative and qualitative indicators supported by the range of stakeholders assembled and are the following:

- Impact on vulnerable groups and resources (qualitative; scale from 1 to 5);
- Impact on economic growth rate of poor people (quantitative; expressed in percentage terms);
- Losses avoided by people (quantitative; expressed in physical units per capita per year);
- Synergy with multilateral environmental agreements to which Liberia is a signatory (qualitative; scale from 1 to 10); and
- Cost (quantitative; expressed in cost per million units);

Once the evaluation criteria were fully identified, each of the twenty eight (28) adaptation projects that had been proposed by the stakeholders, was assigned a raw score for each of the proposed criteria. A set of the eight (8) highest prioritized projects in each vulnerable sector emerged, as briefly summarized below:

- Agriculture: Integrated crop/livestock farming;
- Forestry and wetlands: switching from fossil fuel based to biomass based energy products;
- Fisheries: promoting sustainable fishing practices;
- Energy: Promoting energy efficiency and conservation;
- Water: Awareness and sensitization about the importance of water resource management;
- Coastal zones: development of an integrated coastal zone management plan
- Meteorological: rebuilding the national meteorological monitoring network; and
- Public health: use of insecticide treated materials (ITMs), ranked first under the health sector.

The top three projects were identified in the context of further stakeholder consultations.

- Top priority project: Enhancing resilience to increasing rainfall variability through the diversification of crop cultivation and small ruminants rearing (agriculture);
- Second highest priority project: Enhance adaptive capacity through the rebuilding of the national hydro-meteorological monitoring system and improved networking for the measurement of climatic parameters;
Third highest priority project: Reducing the vulnerability of coastal urban areas (Monrovia, Buchanan) to erosion, floods, siltation and degraded landscapes.

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.

4.2.8 Malawi case study: Assessing adaptation options using MCA

Malawi has developed its National Adaptation Programs of Action (NAPA) by evaluating the effects of climate change in eight major sectors of economic development (agriculture, energy, water, human health, fisheries, wildlife, forestry and gender), and by using multi-criteria analysis ranked the identified activities. Results provided a list of fifteen (15) urgent and immediate priority needs for adaptation (Malawi NAPA, 2006).

In specific, public and private sector organizations were involved in a consultative process, including NGOs and civil society. In the eight sectors thirty-one adaptation options were identified and addressed the most eager adaptation needs, with a highlight on most vulnerable rural communities in Malawi. This final list was further analyzed and ranked using multi criteria analysis. The result was a limited list of fifteen adaptation options of key priority. These options were further ranked and prioritized in terms of eagerness, and categorized in the levels of high, medium and low.

These prioritized options are the following:

1) Sustaining life and livelihoods for the most vulnerable communities,
2) Enhancing food security and developing community based storage systems for seed and food,
3) Improving crop production through the use of appropriate technologies,
4) Increasing resilience of food production systems to erratic rains by promoting sustainable dimba production of maize and vegetables in dambos, wetlands and along river valleys,
5) Targeting afforestation and re-afforestation programmes to control siltation and the provision of fuel wood, and for their benefits, such as sources of alternative cash income,
6) Improving energy access and security in rural areas (e.g., through extension of the rural electrification programme, energy-efficient stoves and development of ethanol-based stoves),
7) Improving nutrition among rural communities (e.g., through the promotion of fish farming, rearing of small ruminants and nutritional supplements for children and the sick),
8) Disseminating bed nets in high incidence malaria areas,
9) Developing food and water reserves for disaster preparedness and response,
10) Developing community based wildlife ranching and a breeding programme for Nyala
11) Developing and implementing strategies for drought preparedness, flood zoning and mitigation works,
12) Developing technologies to mitigate climate change,
13) Providing standby power generation facilities,
14) Managing forest fires in collaboration with communities, and
15) Developing small dams, and other storage facilities, to mitigate flooding, to harvest water and to initiate community based fish farming and breeding.

The list of the proposed projects is the following:

(a) Improving community resilience to climate change through the development of sustainable rural livelihoods,
(b) Restoring forests in the Upper and Lower Shire Valleys catchments to reduce siltation and associated water flow problems,
(c) Improving agricultural production under erratic rains and changing climatic conditions,
(d) Improving Malawi’s preparedness to cope with droughts and floods, and
(e) Improving climate monitoring to enhance Malawi’s early warning capability and decision making and sustainable utilization of Lake Malawi and lakeshore areas resources.

Analytically

Malawi needed to implement the proposed projects urgently so as to enable vulnerable rural communities and groups in targeted areas. Thus it will be able to adapt to the adverse impacts of climate change. A total of forty-four adaptation options were proposed from the eight sectors. However the estimated budget for these priority projects to be implemented in Malawi was very high. In this frame prioritization had to take place.

In order to prioritize the projects Malawi’s NAPA chose a methodology for scoring options against the criteria. The criteria used in prioritizing priority activities were:

<table>
<thead>
<tr>
<th>Criteria for prioritization</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Technical feasibility,</td>
<td></td>
</tr>
<tr>
<td>(b) Economic growth (income levels of communities or target groups),</td>
<td></td>
</tr>
<tr>
<td>(c) Synergies (with ongoing policies, programmes and multilateral environmental agreements),</td>
<td></td>
</tr>
<tr>
<td>(d) Magnitude of impact of the option on vulnerable groups,</td>
<td></td>
</tr>
<tr>
<td>(e) Cost of the project,</td>
<td></td>
</tr>
</tbody>
</table>
In every sector was submitted a maximum of four highest-ranking adaptation options in order multi-criteria analysis (MCA) to take place. The resulting was a list of 31 scored adaptation options. Afterwards, scores were standardized. The standardized scores fall between zero (0) and one (1). For every option, an average score was obtained by summing up and averaging the score in every row.

NAPA Document Preparation Team reached an agreement on the weighting factor for every criterion in relevance with its importance. Appropriate factors were used to weight the standardized scores in each column. The scores in a row were added afterwards and further ranking was attempted so as options to be prioritized. No attention was given to the lowest adaptation options leaving the top ones.

Adaptation activities of priority were assessed also in the context of their urgency, and the need for immediate action as a further step.

Urgency ranking was made according to the criteria recommended by LEG, as listed below:

a) Costs, in terms of human impact (and loss of life) that would increase if the option is not addressed immediately,

b) Likelihood of irreversible change and damage,

c) Imminence of threat on critical components of development and livelihood,

d) Removal of triggers for environmental, social and economic deterioration and degradation, and

e) Enhancement of system properties (such as coping ability) to improve threshold of adverse effects.

In total seven multi criteria prioritization processes took place. In the following table final outlay of results of multi-criteria analysis simulations are presented:
Five urgent activities were finally identified, based on the previous table prioritization. Those activities were developed into project concepts or activities. They are presented in order of priority as follows:

(a) Improving community resilience to climate change through the development of sustainable rural livelihoods

b) Restoring forests in the Upper, Middle and Lower Shire Valleys catchments to reduce siltation and the associated water flow problems

(c) Improving agricultural production under erratic rains and changing climatic conditions
(d) Improving Malawi’s preparedness to cope with droughts and floods

e) Improving climate monitoring to enhance Malawi’s early warning capability and decision making and sustainable utilization of Lake Malawi and lakeshore areas resources

This case study is of particular importance since successive MCA analysis take place. Both methodology (steps, criteria, ranking and weighting process etc) and selected options can be used as guidance in the setting of adaptation policies in other countries.

4.2.9 Rwanda case study: Assessing adaptation options using MCA

Experts carried out studies concerning vulnerability of key sectors of Rwanda economy and identified also climate change adaptation options per key sector (Rwanda NAPA, 2006). NAPA team prepared an initiative list with 40 options from the six most vulnerable sectors. Sectors are those of agriculture and animal husbandry, water resources, lands, forestry and health. After use of MCA analysis on these possible options, another list comprising twenty options, taking into consideration the necessity to implement integrated and transversal projects within these sectors, was prepared.

These twenty adaptation options integrate into local dynamics or become integrated into the national development programs:

1) Promotion of non-rain-fed agriculture;

2) Increase agricultural techniques;

3) Introduction of species resistant to drought in arid and semi-arid zones;

4) Introduction of precocious varieties in arid and semi-arid zones;

5) Protection of basin sides in mountainous zones;

6) Promote stocking techniques of agricultural products after harvesting;

7) Reinforce early warning and rapid intervention systems;

8) Reinforce animal husbandry in permanent stalling;

9) Promote veterinary and phytosanitary services;

10) Develop alternative sources of wood energy;

11) Rational utilisation of wood energy;

12) Preparation and implementation of forestry development plan;

13) Preparation and implementation of land development plan;

14) Integrated water resources management (IWRM including rainwater);
15) Promotion of non-agricultural activities;
16) Increase the rate access of drinking water;
17) Favor access of the public to medical insurance services;
18) Prevent and fight against vectors of water-borne diseases;
19) Integration of NAPA in policies and national development plans;
20) Facilitate accessibility to health services

After taking into account national priorities and trying to keep the process of analysis both easy and manageable, eleven priority options have been submitted for multi-criteria analysis. Urgent and immediate needs were also considered.

The criteria used were:
- Impact on vulnerable groups and resources,
- The contribution to sustainable development (Socio-cultural, ecological and economic),
- The synergy with MEA (Multilateral Environment Agreement),
- Risks reduction,
- Cost-efficiency (financing).

Measure by scale was preferred by the expert team after taking into consideration the lack of exact data on the real values.

Standardization of criteria was made with the use of a scale from zero (0) to one (1) with increasing values for benefits and decreasing values for disadvantages (costs). This process allowed calculation of average notes for all criteria. The first classification of Multicriteria Analysis (MCA1) is presented in the following table:
As a result of the previous step it can be concluded that the same value has been given to five criteria. In order to have the highest priority options, the expert team as a next step found useful to give some criteria more consideration due to their importance in comparison with others.

In this second ranking process more than three marks are attributed to options that have an impact on groups and vulnerable resources. Options with contribution to sustainable development and reduction of risks got two marks and finally options characterized with synergy of MEA, and efficiency cost got the last note of one mark only.

The relative part in every criterion was given by dividing the standardized note of every criterion by nine (which is the sum amount of marks). As a result the weighted index of every option is acquired by summing products of the relative balance of criteria and that of the first standardization option.
A second Multicriteria Analysis (MCA 2) classification emerged different from the previous one. This classification is linked mainly with primordial value of the impact of options on the groups and vulnerable resources and on the contribution to sustainable development, according to the consensus of the expert team.

Table 25: MCA 2 classification with the weighed index of each option

<table>
<thead>
<tr>
<th>Nº</th>
<th>OPTIONS</th>
<th>Standardized Option Value / Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Impact on vulnerable groups and resources</td>
</tr>
<tr>
<td>----</td>
<td>--------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Promotion of non rain-fed agriculture</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Intensive agricultural intensifier</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Varieties resistant to drought</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>GEIE, Integrated water resource management</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Training and certification of agricultural products</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Information (means of early warning and rapid intervention)</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Development of energy source: alternative to firewood</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Preparation and implementation of land development plan</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Access to health facilities and fight against waterborne diseases</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Promotion of non agricultural activities of income generating clusters</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Preparation and implementation of forestry development plan</td>
<td>0</td>
</tr>
</tbody>
</table>

After having a comparison of the two kind of classifications, it appears that there are some options that keep the same positions or successive positions.
As a result six priority policies were selected from NAPA in Rwanda, after considering existing interventions of the government and taking into account the local dynamics, existing national development programs and experiences of other countries which had to face similar vulnerability problems. In order these priorities to be implemented projects must be prepared for funding and implementation.

Priority n° 1: Integrated water resources management (IWRM)

Priority n° 2: Set up information systems of hydro agrometeorologic early warning system and rapid intervention

Priority n° 3: Promotion of income generating activities

Priority n° 4: Promotion of intensive agriculture and animal husbandry

Priority n° 5: Introduction of varieties resisting to environmental conditions

Priority n° 6: Development of energy sources alternative to firewood

Both methodology (steps, criteria, ranking and weighting process etc) and selected options can be used as guidance in the setting of adaptation policies.

4.2.10 Sierra Leone case study: Assessing adaptation options using MCA

The Sierra Leone NAPA Team used the Multi-Criteria Analysis (MCA) to score all possible options and criteria (Sierra Leone NAPA, 2006) in order to form an adaptation policy to climate change.
The following criteria were used in the MCA technique:

- Impact on vulnerable groups and resources
- Impact on economic growth rate of poor people
- Losses avoided by poor people
- MEA synergies
- Cost-effectiveness

NAPA experts used scoring scales in adaptation measures:

- 1 - 5 for impact on vulnerable groups and resources; 1% - 5% for impact on economic growth rate of poor people;
- 50 - 500 for losses avoided by poor people;
- 0 - 10 for MEA synergies; and from
- 1 - 100 for cost.

As a second step standardization of scores had to be made by application of Linear Interpolation. All of the 5 country-driven criteria were of equal importance.

After implementation of the procedure and based on the ranked adaptation options the multi-criteria analysis simulations had as a result three (3) priority activities from each sector with the exception of the Meteorological Sector. Those priorities were identified for urgent and immediate adaptation.

Priorities are described are by sector in the following:

**Agriculture Sector**

1. Development of irrigation and land drainage system for agriculture;
2. Development and implementation of agricultural land-use and land cover management;
3. Promotion of swamp land farming.

**Forestry Sector**

4. Promoting the use of renewable energy (solar energy) and improve energy efficiency and conservation by retrofitting existing and future structures;
5. Establishing forest reserves, protected Areas and National Park/Sanctuaries and
6. Management and protection of forests reserves and catchments areas including wetlands and reduce dependence on firewood and charcoal by using liquid fuel (LPG) and bio fuels (ethanol/methane/oils).

**Water/Hydrology Sector**
7. Improve water research, monitoring and management;
8. Improvement of the efficiency of existing water supply systems in both urban rural areas;
9. Promote rain water harvesting and develop an integrated management system for fresh water bodies.

Coastal Zone

10. Develop an Integrated Coastal Zone Management Plan;
11. Rehabilitate degraded coastal habitats;
12. Develop and enact appropriate policies and regulations relevant to the development of coastal communities, urban growth planning, and wetland preservation.

Fisheries Sector

13. Promote sustainable fishing practices and develop aquaculture;
14. Improve weather forecasting and develop marine meteorological services;
15. Preserve and restore essential habitats; promote conservation and environmental education.

Health Sector

1. Increase the use of insecticide treated materials (ITMs) as a key strategy in malaria control;
2. Support HIV/AIDS prevention activities;
3. Develop appropriate sanitation programs.

Meteorology Sector

1. Establishment on National Early Warning System;
2. Improve research and weather forecasting capabilities and rehabilitate national weather stations as well as educate meteorological department personnel to forecast and inform about particular dangerous or extreme events;
3. Raise public awareness and mainstream gender perspectives into climate change issues;
4. Foster cooperation with International Conventions and Programmes.

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.
4.2.11 Sudan case study: Assessing adaptation options using MCA

The Sudan NAPA process is studying the most prominent adaptation options within agriculture, food security, water resources and human health in the frame of a stakeholder-driven effort (Sudan NAPA, 2006). Five ecological zones in Sudan are analyzed. Those zones are desert areas, semi-desert areas, woodland savanna (clay) areas, woodland savanna (sand) areas and flood-prone regions.

The Sudan NAPA process used the NAPAssess model as a part of the Sudan NAPA effort. This NAPAssess model uses multi-criteria assessment techniques to identify the highest priority climate change adaptation projects, measures and policies. It has been designed to reflect key stakeholder concerns and thoughts. The aim of the NAPAssess tool was to be used within any country that aims in a NAPA process. Sudan NAPA team has used this tool currently within the frame of organizing a skeleton of stakeholder input. It was also used within stakeholder consultations as a way of determining a prioritized set of adaptation options that best meet stakeholders’ evaluation criteria (Sudan NAPA, 2006).

Model Overview

NAPAssess tool was designed to provide guidance and a step-by-step reference point for the basic activities in the NAPA process. Those activities were determined by the guidelines developed by the LDC Expert Group (LEG) (from synergy assessment, to stakeholder engagement, to project prioritization, to project portfolio development). Secondly, NAPAssess tool aimed to record, store and access output from each of the activities. In this regard, NAPAssess can also be very helpful as a platform for sharing project information with stakeholders, and in turn, for storing data from the stakeholder-driven activities (vulnerability assessment and scope of adaptation choices). Finally, NAPAssess tool may be used to conduct multi-criteria assessment in a basic, straightforward way. NAPAssess streamlines the MCA process by housing all relevant project information on a single platform and supporting a clear, user-friendly process for weighting project selection criteria.

NAPAssess is an open-source Excel program that consists of a series of built-in macros and equipped with numerous help functions. It also includes a place to store notes or comments. To undertake the multicriteria assessment process in a stakeholder setting, one has to choose the option “Analysis” from the menu. Within this option, the tool is organized into 7 separate “modules” as illustrated in Figure 5. Navigation through the multicriteria analysis process is made by clicking the items on the menu, as briefly described below.
A prioritized set of adaptation initiatives was developed by this module that integrates all the information developed by far. This was actually the final stage of the multicriteria assessment process. "Prioritization" was the process of ranking these scores. The adaptation initiative that received the score of the highest degree was ranked first (i.e., has the highest priority). On the other hand, the adaptation initiative that received the score with the lowest degree was ranked as last.

Prioritization results are presented in NAPAssess within two types. The first type can give the total score for each adaptation initiative. For the low, central, and high estimates, it includes the total weighted score relative to each criterion and each adaptation initiative.

The second type provides the list of adaptation measures prioritized. The prioritized list varies depending on estimation type (low, central, high). Nevertheless, regardless of estimation type, the rangeland rehabilitation option is the highest priority adaptation initiative and the water point development initiative is the lowest. The priority of the other three initiatives depends highly on the type of estimate used.

It is very important to be highlighted the dynamic role of this tool. In specific, as new information becomes available, information in each of the previous modules can be updated. With every part of new information entered, the model can re-calculate total scores and provide new prioritization of adaptation initiatives.

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.
4.2.12 Timor Leste case study: Assessing adaptation options using MCA

In the national process of consultation on Timor Leste (Timor Leste NAPA, 2006) a list of activities was identified, including potential measures of adaptation in relation with the needs of each key sector.

Possible adaptation measures were listed in two categories. The first category was related with basic investments and policy planning, and the second was related with capacity building, awareness raising and other cross-cutting measures. With the aim of prioritization, the NAPA team decided that the main focus would be on adaptation measures connected with basic investments and planning needs of policy. Nevertheless, raising of awareness and building capacity elements, which is a cross cutting and recurrent need, would be included in every final concept.

Table 28: Proposed key adaptation options per sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Proposed key adaptation options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agroforestry, Agriculture and Livestock</td>
<td>Develop integrated sustainable land management promoting fixed/permanent agriculture, reduce burning, reduce erosion, and increase soil fertility.</td>
</tr>
<tr>
<td></td>
<td>Develop integrated agro-forestry and watershed management including climate change dimension.</td>
</tr>
<tr>
<td></td>
<td>Improve planning and legal framework for sustainable and balanced food for livestock production under climate change conditions.</td>
</tr>
<tr>
<td>Water Availability, Accessibility and Quality</td>
<td>Build climate consideration and environmentally friendly infrastructure to protect water sources (springs, streams, wells, etc) in order to provide safe water supply during climate change extreme event periods.</td>
</tr>
<tr>
<td></td>
<td>Create/enhance water harvesting model, water distribution system and management system at all levels to avoid water shortages caused by climate change.</td>
</tr>
<tr>
<td></td>
<td>Control of quantity of water use by industry, and water pollution control standardization (medium) including coffee processing waste management in a climate change context.</td>
</tr>
<tr>
<td>Sector</td>
<td>Proposed key adaptation options</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Terrestrial, Freshwater and Marine Ecosystems and Biodiversity. | Education and awareness - conduct a pilot demonstration of sustainable agriculture and sustainable forest management that increases resilience and reduces climate-related impacts of shifting cultivation and unsustainable upland farming practices.  
National legislation – strengthening implementation of forest laws and regulations to reduce illegal logging and burning and to strengthen customary law; as well as ownership by local communities.  
Reforestation of degraded lands with fuel-wood plantations; rehabilitate degraded land and soils and reduce deforestation by providing sustainable fuel-wood source. |
| Human Health                                | Strengthen SISCA (Integrated Community Health Services) especially on climate change related health issues and diseases.  
Strengthen integrated early warning system in community on airborne and vector-borne diseases and epidemics.  
Review existing guidance and standards issued by the Minister of Health on respiratory, airborne and vector-borne diseases to take climate change into consideration. |
| Human Settlement and Infrastructure         | Viability study and pilot project to lay underground cables and other equipment exposed to climate change.  
Review existing laws, regulations and standards to enhance Climate Change (CC)-resilient infrastructure.  
Pass new legislation to strengthen and guarantee national regulations on quality of materials, building codes and practices and law enforcement.  
Protect offshore infrastructure against strong wave damage that impacts the distribution of gas and oil, and reduce accidents and destruction of offshore oil and gas infrastructure; including: i) early warning system equipment; ii) data information to show occurrences; iii) equipment protection. |
Sector | Proposed key adaptation options
--- | ---
Disaster Management | Physical infrastructure - civil engineering and natural vegetation methods to prevent landslides in hill sites, roads and river banks.
 | Establish early warning systems in areas identified as vulnerable to risks of disasters such as floods and storms.
 | Enhance government strategies on responding to drought exacerbated by climate change.

Selection, prioritization and ranking of adaptation measures process are following four basic steps:

1. Selection of criteria
2. Consolidation of the proposed adaptation measures to form 8 priority projects,
3. Priority options were analyzed against the criteria and awarded scores of 1 for low fulfillment of the criterion, 2 for medium and 3 for high. As the criteria were not weighted the scores were simply added,
4. Based on the final scores every project received they were ranked in priority order.

The resulting ranked adaptation options after the addition of the scoring exercise by the Sector Working Groups is presented in the following table. The two categories are representing food security and water resource management. They were scored equally and therefore were ranked first with a) and then with b). Furthermore, “Health issues” were also scored equally with the “Disasters concept” and are also marked as a) and b).

**Table 29: Ranked key adaptation options**

<table>
<thead>
<tr>
<th>Proposed adaptation options articulated into a programmatic approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.a</strong></td>
</tr>
<tr>
<td>Develop integrated agroforestry and watershed management including climate change dimension.</td>
</tr>
<tr>
<td>Develop integrated, sustainable land management to promote fixed/permanent agriculture, prevent burning, erosion control and soil rehabilitation.</td>
</tr>
<tr>
<td>1b</td>
</tr>
<tr>
<td>----</td>
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<td></td>
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<tr>
<td>2a</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>2b</td>
</tr>
</tbody>
</table>
of disasters such as floods and storms.

3

Maintain and rehabilitate mangrove ecosystems and conduct awareness raising to protect coastal ecosystems from impacts of sea level rise and other climate change impacts.

Include ecosystem management in national planning to develop sustainable, ongoing programme, nurseries and community awareness.

4

Improve planning and legal framework for sustainable and balanced food for livestock production under climate change conditions.

5

Review existing laws, regulations and standards and enhance climate change-resilient infrastructure - pass new legislation to strengthen and guarantee national development and to regulate the quality of materials, building codes and practices, and law enforcement.

6

Protect offshore infrastructure against strong wave damage that impacts the distribution of gas and oil, and reduce accidents and destruction of offshore oil and gas infrastructure; including: i) early warning system equipment; ii) data information to show occurrences; iii) equipment protection.

Based on this ranking, project profiles were developed to reflect the overall outcomes of each integrated project. Following table presents the Priority Adaptation Options.

Table 30: Priority Adaptation Options

<table>
<thead>
<tr>
<th>Rank</th>
<th>AdaptationOptions</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Food Security: Reduce vulnerability of farmers and pastoralists to increased drought</td>
<td>Develop integrated agroforestry and watershed management including climate change dimensions.</td>
</tr>
<tr>
<td>Rank</td>
<td>Adaptation Options</td>
<td>Activities</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>and flood events by improving their capacity to plan for and respond to future climatic conditions and improve national food production.</td>
<td>Based on existing national action plans on sustainable land management, implement integrated, sustainable land management promoting fixed/permanent agriculture, reduced burning, reduced erosion, and increased soil fertility.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reforestation of degraded land to prevent landslides and provide a sustainable fuel wood source in priority areas with high vulnerability to climate-related risks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improve physical infrastructure/civil engineering and natural vegetation methods to prevent landslides in hill sites, roads and river banks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Education and awareness and conduct a pilot demonstration on sustainable agriculture and forest management that increases resilience and reduces climate-related impacts of shifting cultivation and unsustainable upland farming practices.</td>
</tr>
<tr>
<td>2</td>
<td>Water Resources: Promote Integrated Water Resource Management (IWRM) to guarantee water access for food production, sanitary uses, ecosystems and industry development.</td>
<td>Build climate proofed and environmentally sustainable infrastructure to protect water sources (springs, streams, wells, etc.) in order to provide safewater supplies during climate change extreme event periods.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enhance government and community strategies to respond to drought exacerbated by climate change.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Create and enhance water harvesting model (capture and storage), water distribution system and management system at all levels to avoid water shortages due to climate change.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control of quantity of water use by industry, and water pollution control standardization including coffee processing waste management in a climate change context.</td>
</tr>
</tbody>
</table>
### Human Health: Enhance capacity of the health sector to anticipate and respond to changes in distribution of endemic and epidemic climate-sensitive diseases, and reduce vulnerability of the population to infection in areas at risk from expansion of climate-related diseases.

- Strengthen SISCA (Integrated Community Health Services) especially on health issues related to climate change related diseases.
- Strengthen integrated early warning system (EWS) at community level in relation to airborne and vector borne diseases and epidemics with disease surveillance.
- Review existing guidance and standard issues by Minister of Health on respiratory, airborne and vector diseases to take climate change into consideration.

### Natural Disasters: Improve institutional and staff capacity in the disaster sector in relation to climate change induced disasters.

- Establish early warning systems in areas identified as vulnerable to disasters such as floods and storms.
- Integrate of climate risk information into traditional disaster risk reduction and management.

### Forests, Biodiversity and Coastal Ecosystems Resilience:

- Maintain mangrove plantations and promote awareness raising to protect coastal ecosystems from impacts of sea level rise.
- Include ecosystem management in national planning to develop sustainable, ongoing programme, nurseries and community awareness development - 1st year assessment, 2nd year plan, 3rd year implementation and maintenance.

### Livestock Production:

- Improve planning and legal framework for promoting sustainable and balanced food for livestock production under increased climate variability and climate change conditions.

### Physical Infrastructure: Improve regulations and standards for climate-resilient infrastructure.

- Review existing laws, regulations and standards to enhance CC-resilience of critical infrastructure.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Adaptation Options</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pass new legislation to strengthen and guarantee national development through improved regulation of the quality of materials, adapted building codes and practices and law enforcement.</td>
</tr>
<tr>
<td>8.</td>
<td>Oil and Gas Production: Strengthen and protect valuable offshore oil and gas infrastructure against climate change impacts.</td>
<td>Protect offshore infrastructure against strong wave damage that impacts the distribution of gas and oil, and reduce accidents and destruction of offshore oil and gas infrastructure; including: i) early warning system equipment; ii) data information to show occurrences; iii) equipment protection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National Institutional Capacity Development for Climate Change:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strengthen the mandate of the cross-sectoral national climate change team to improve coordination and engagement.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Establish a Climate Change Unit with necessary staffing and budget to engage in and support national policy development and programming activities.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capacity development support for key non-governmental institutions in low emissions and climate resilient development planning, including national NGOs and research/educational institutions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Develop a national climate change strategy and action plan.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Promote sub-national capacity development for improved adaptation planning and implementation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strengthen national hydro-meteorological department to collect, compile, analyze and disseminate climate-related data.</td>
</tr>
</tbody>
</table>

Deliverable 4.1: Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide | 2013
Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies in other countries.

4.2.13 Vanuatu case study: Assessing adaptation options using MCA

Experts carried out surveys on the vulnerability to climate change in key sectors of Vanuatu economy. Furthermore, a number of projects were implemented currently that would help on elimination of this vulnerability. Sectors such as water, coastal zone resources, agriculture and health are affected already under current climatic conditions. Potential climate change in the future will further deteriorate currently observed or experienced impacts to those sectors (Vanuatu NAPA, 2006).

Expert team proposed a series of possible adaptation options. In the framework of the NAPA process, priority strategies for adaptation were selected, with the use of ranking criteria that were identified specifically for Vanuatu. Towards this purpose the Multi Criteria Analysis was used.

National Advisory Committee on Climate Change (NACCC) undertook these projects with the help of its technical core group. A series of adaptation strategies were suggested for various sectors and different Vanuatu regions. Stakeholders went over this list, and rationalized them. As a result the following adaptation strategies emerged, presented with no priority order.

1. Rainwater harvesting
2. Desalination & other alternative water sources
3. Water management policies/ programs
4. More resilient crop species including traditional varieties
5. Agriculture & food security (preservation/processing/marketing, modern& traditional practices including bartering)
6. Agricultural land use planning and management (modern & traditional practices, early warning including traditional systems)
7. Community based marine resource management programs (modern &traditional, aqua-culture)
8. Alternative fisheries (Fish Aggregating Devices (FAD) to promote pelagic fishing and deep water fisheries)
9. Mainstream climate change considerations into infrastructure design and planning (modern & traditional, EIA)
10. Relocation of vulnerable settlements and infrastructure

11. Develop Integrated Coastal Zone Management (ICZM), including mangroves & coastal flora management plan.

12. Sustainable land use management and planning

13. Vector & water borne disease activities (modern & traditional)

14. Enhance meteorological observations network nationwide (terrestrial & ocean) & develop early warning system using contemporary and traditional techniques

15. Sustainable Livestock farming and management

16. Alternative sources of energy

17. Energy conservation and efficiency programs

18. Sustainable forestry management

19. Sustainable tourism

The following core issues were relevant to all suggested options. Thus they should be an integral part of all proposed projects:

- Awareness raising at all levels (communities to policy makers)
- Capacity building including institutional capacity
- Research and development
- Promotion of appropriate traditional knowledge and practices
- Technology Transfer
- Education and training
- Mainstreaming climate change issues
- Biodiversity issues are essential considerations in all issues relevant to marine terrestrial, forestry, land and agriculture

A set of locally driven criteria should be chosen in order to prioritize measures, as the NAPA guidelines specify (UNFCCC Decision 28/CP.7):

- Degree of adverse effects to climate changes
- Degree of poverty reduction
- Synergies with MEAs
- Cost effectiveness

A wide discussion concerning adequacy and relevancy of criteria to Vanuatu was made from stakeholders. As a result the following criteria were adopted as more relevant to their unique situation:

i. Impact on livelihood 
ii. Impact on economy
iii. Impact on environment and biodiversity
iv. Severity of CC Issues/Sensitivity of sector/degree of adverse effects
v. Synergies with other MEAs
vi. Cost – Capital, Operations and Maintenance

Furthermore, stakeholders also agreed that the options should be ranked on a 0 to 10 scale (with the reverse range, 10 to 0 for costs). As a result, adaptation strategies were ranked in the following descending order:

1. Agriculture & food security (preservation/processing/marketing, modern & traditional practices, bartering)
2. More resilient crop species including traditional varieties
3. Land use planning and management (modern & traditional agricultural practices, early warning including traditional systems)
4. Water management policies/programs (including rainwater harvesting)
5. Sustainable forestry management
6. Community based marine resource management programs (modern & traditional/aqua-culture)
7. Mainstream climate change considerations into infrastructure design and planning (modern & traditional, EIA)
8. Sustainable Livestock farming and management
9. Develop Integrated Coastal Zone Management (ICZM) programs, including mangroves & coastal flora management plan.
10. Sustainable tourism
11. Vector & water borne disease activities (modern & traditional)
Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.

### 4.2.14 Yemen case study: Assessing adaptation options using MCA

Key vulnerable sectors of Yemen (i.e., water, agriculture, coastal zones) were examined in the frame of the NAPA process. The development of a broad vision for adaptation emerged (Yemen NAPA, 2005). Key activities were identified during the NAPA process and they are summarized in the following table.

**Table 31: Key sectoral activities identified during the NAPA process**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Adaptation activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Rainwater harvesting through various techniques including traditional methods.</td>
</tr>
<tr>
<td></td>
<td>Water conservation through reuse of treated waste water and grey water from mosques, and irrigation saving techniques.</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation and maintenance of mountainous terraces.</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Promotion of research on drought resistant and heat- and salinity-tolerant crops.</td>
</tr>
<tr>
<td></td>
<td>Develop and implement sustainable land management strategies to combat desertification and land degradation</td>
</tr>
<tr>
<td></td>
<td>Planting and re-planting of mangroves and palms for adaptation to sea level rise.</td>
</tr>
<tr>
<td>Coastal Zones</td>
<td>Sustainable management of fisheries resources.</td>
</tr>
<tr>
<td></td>
<td>Develop and implement Integrated Coastal Zone Management Programmes.</td>
</tr>
<tr>
<td>Cross Sectoral</td>
<td>Develop and implement an awareness raising programme on adaptation to the potential impacts of climate change on vulnerable sectors</td>
</tr>
<tr>
<td></td>
<td>Incorporate Climate Change and adaptation into school education.</td>
</tr>
<tr>
<td></td>
<td>Develop and implement programs to improve Yemen’s preparedness to cope with extreme weather events.</td>
</tr>
<tr>
<td></td>
<td>Establishment and Maintaining of Climate Change Database.</td>
</tr>
</tbody>
</table>

In the second step, through a scoring, weighting, and ranking process – that constitute the basic procedures of multicriteria analysis - a discrete set of prioritized adaptation projects were developed for each priority sector and for each of the ecological zones.

After the consultation process a final set of evaluation criteria was chosen by stakeholders:

- Contribution to Sustainable Development;
- Yemen NAPA process included two major steps with the purpose to prioritize possible adaptation projects. In the first step stakeholders should determine through a consultation process a set of evaluation criteria.
- Livelihood security of Local Communities;
- Poverty reduction to enhance adaptive capacity;
Deliverable 4.1: Literature review of the state-of-the art multi-criteria analysis tools used for the development of adaptation plans worldwide

- Synergy with other multilateral environmental agreements; and
- Cost-effectiveness

In the following step two stakeholder groups, a local and a national, assigned scores to the options in a participatory process based on a series of workshops that took place. In the local stakeholders process a consensus approach was used to prioritize options, followed by a more rigorous application of multi-criteria assessment at the provincial and national level.

Standardization of scores followed and weighting according to a set of locally-driven weights, that were assigned to each criterion. As a result, the initial ninety five (95) options were narrowed down to a set of twenty two (22) options. It is important to note that these are the highest priority projects relative to the complete set of ninety five (95) options. However, they are unranked relative to each other. All potential adaptation projects appear below, un-prioritized.

Table 32: Summary of adaptation options un-prioritized

<table>
<thead>
<tr>
<th>Un-prioritized adaptation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainwater harvesting through various techniques including traditional methods.</td>
</tr>
<tr>
<td>Develop and implement disaster preparedness and recovery programs, including forecasting, early warning systems and rapid response strategies to cope with extreme weather events.</td>
</tr>
<tr>
<td>Encourage and expand desalination for drinking water using renewable energy sources, especially on Yemeni islands and coastal areas, where water is unavailable or vulnerable to seawater intrusion.</td>
</tr>
<tr>
<td>Develop and implement awareness raising programme on adaptation to the potential impacts of climate change on vulnerable sectors.</td>
</tr>
<tr>
<td>Promote modern and more efficient irrigation technologies to increase use efficiency</td>
</tr>
<tr>
<td>Improve crop management programs by changing sowing date, crop density, tillage practices, fertilizer levels, growing season for crop, and enhancing crop specific characteristics (harvest index, photosynthetic efficiency). Make use of accumulated experience by farmers, by collecting and documenting local knowledge as a means to mitigate the impacts of drought.</td>
</tr>
<tr>
<td>Design and implement watershed management and terrace-rehabilitation programs</td>
</tr>
</tbody>
</table>
Un-prioritized adaptation measures

- Restore and preserve mountain forests to reduce soil erosion and peak-flows from intense precipitation events
- Disseminate flow and flood guidance for stations at main wadis
- Support alternatives sources for fuel-wood to control woodcutting and preserve plant cover e.g. promote liquefied petroleum gas (LPG) for cooking and solar energy applications for drying, heating, and lighting.
- Conduct studies and research on the following urgent topics:
  - Development of agriculture manuals for the different zones of Yemen that include
  - Sowing dates
  - New sowing dates
  - Utilization of flow-water in the wadis
  - Climate and other agriculture-related databases
  - Introduce and expand drought tolerant, and heat- and salinity-resistant crops
- To compensate water shortage, increase reuse of treated waste water from mosques for irrigation
- Establish a 'National Research Center’ to undertake research on climate change and adaptation issues
- Develop and implement Integrated Coastal Zone Management programmes
- Expand green-belts for coastal areas in main land and islands by planting and replanting mangroves and palms; establish and maintain nurseries that provide cultivars and other materials
- Develop and implement sustainable land management strategies to combat desertification and land degradation
- Establish a database for all climate change related issues including adaptation activities.
- Design and implement training and education programmes for use of efficient, environment friendly fishing techniques and equipment
- Increase soft protection (e.g., beach nourishment and wetland construction and restoration), and building stone walls to protect from storm surges
- Construct coastal defense and walls for coastal areas vulnerable to erosion
- Improve and activate marine fishing regulatory laws, and engage relevant stakeholders and local communities in monitoring the implementation of
Deliverable 4.1: Literature review of the state-of-the art multi-criteria analysis tools used for the development of adaptation plans worldwide 2013

Un-prioritized adaptation measures

valid fishing laws
Incorporate climate change and adaptation issues into school curriculum

After subjecting previous measures to the five evaluation criteria, a final ranked set of twelve high priority adaptation activities were developed. The following table represents the most compelling adaptation options for Yemen, in order of priority.

Table 33: Prioritized adaptation measures

<table>
<thead>
<tr>
<th>Prioritized adaptation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop and implement Integrated Coastal Zone Management programmes</td>
</tr>
<tr>
<td>2. Water conservation through reuse of treated waste water and grey water from mosques, and irrigation saving techniques.</td>
</tr>
<tr>
<td>3. Develop and implement an awareness raising programme on adaptation to the potential impacts of climate change.</td>
</tr>
<tr>
<td>4. Establish and maintain database for climate change and adaptation</td>
</tr>
<tr>
<td>5. Planting and re-planting of mangroves and palms for adaptation to projected sea level rise</td>
</tr>
<tr>
<td>6. Develop and implement programs to improve Yemen’s preparedness to cope with extreme weather events</td>
</tr>
<tr>
<td>7. Rainwater harvesting through various techniques including traditional methods.</td>
</tr>
<tr>
<td>8. Rehabilitation and maintenance of mountainous terraces.</td>
</tr>
<tr>
<td>9. Promotion of research on drought resistant and heat- and salinity-tolerant crops.</td>
</tr>
<tr>
<td>10. Design and implement sustainable land management strategies to combat desertification and land degradation</td>
</tr>
<tr>
<td>11. Sustainable management of fisheries resources.</td>
</tr>
<tr>
<td>12. Incorporation of climate change and adaptation to school education</td>
</tr>
</tbody>
</table>
Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.

4.2.15 Zambia case study: Assessing adaptation options using MCA

Impacts of climate change such as climate variability, extreme weather events and other changes in climate variables (e.g. temperature, precipitation) have been affecting Zambia over the last several decades. The sectors that are mainly affected are those of food and agriculture, water and energy, human health and natural resources. NAPA team suggested adaptation measures for the various sectors and the targeted vulnerable communities and areas. However available amount of resources will not be able to address all the options. Thus, further scrutiny and screening of the options was necessary to shorten the list through priority targeting (Zambia NAPA, 2007).

With the use of Multi-criteria analysis (MCA) procedure a set of criteria was agreed to screen potential options. A combination of Rating and Normal Ranking approaches was used in the procedure. Economic, environmental and social principles of sustainable development goals were the basis for the rating approach so as to give appropriate weighting. Indicators related to each of these principles were identified in a further step in relation to the indicators agreed upon earlier. The NAPA Working Group recommended and used the following weighting for the main principles:

- Economic 33.3%
- Environmental 33.3%
- Social 33.3%

Weighting of indicators under the economic, environmental and social principles, used a scale of 1 to 9, where:

1 = Weakly important;
3 = Less Important;
5 = Moderately Important,
7 = More Important; and
5 = Extremely Important in terms of its impact or contribution.

The list of projects NAPA team in Zambia prioritized, with the use of MCA method, follows:

- Strengthening of early warning systems to improve services to preparedness and adaptation to climate change in all the sectors (agriculture, health, natural resource, and energy)
4.1 Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide

- Promotion of alternatives sources of livelihoods
- Adaptation of the Effects of Drought in the context of Climate Change in Agro-Ecological Region of Zambia
- Management of critical habitats
- Promote natural regeneration of indigenous forests
- Adaptation of land use practices (crops, fish, and livestock) in light of climate change
- Maintenance and provision of water infrastructure to communities to reduce Human-Wildlife Conflict
- Eradication of Invasive Alien Species
- Capacity building for improved environmental health in rural areas
- Climate-proofing sanitation in urban areas

Both methodology (steps, criteria, ranking process etc) and selected options can be used as guidance in the setting of adaptation policies.

4.3 Key characteristics of the selected MCA applications

In the above presented case studies of MCA prioritization application there are similarities in methodology, criteria, weights, considerations etc. In most cases this prioritization applications was completed with the use of an MCA tool. The identified common characteristics of the worldwide case studies can be used as a baseline in the development of an MCA method. This method with the use of a relevant tool will allow planning of an effective adaptation strategy. Thus they are presented in summary in the following.

The initial step in the above mentioned case studies was, in most of the cases, the identification of regions and sectors vulnerable to climate change. This identification helped in the configuration of climate change adaptation options. Those options are illustrated as adaptation projects that cannot be accomplished simultaneously due to economic and technical factors. Thus the prioritization of the projects was accomplished with the use of an MCA tool that prioritized options according to certain criteria. Those criteria were cost effectiveness, acceptability, sustainability, technical feasibility, adaptability, affordability, environmental benefits/sustainability, appropriate technology, reliability, health and safety, durability, accessibility etc.

In the following each adaptation option performance was scored by stakeholders against each of the selected criteria with the use of the MCA tool. These scores of the various criteria may differ in units (e.g. monetary or qualitative values) or spans (e.g. 1 – 5 or 0 – 100). Furthermore weighting is attributed in each principle or indicator using a scale e.g. 1 – 10 or 0 %-100%, (e.g 1 is “Weakly important” and 10 is “Extremely Important”). Finally
standardization of the criteria is made with the use of a scale (e.g. from zero to one). Successive MCA analysis may take place.

The above mentioned steps and characteristics may be valuable indicators in development of the MCA tool that will be used for the elaboration of the adaptation strategy to climate change in Cyprus and in other countries as well.
5 Climate change adaptation plan with the use of CYPADAPT MCA tool

The ability of any employed adaptation strategy or option to offset adverse impacts of climate change will depend upon the efficiency of implementation, the region and sector under consideration, and the rate and magnitude of future climate change. In the frame of the CYPADAPT project the current and future vulnerability of Cyprus to climate change has been analyzed and the alternative adaptation options possible to be applied have been recorded and categorized. The CYPADAPT multi-criteria analysis (MCA) tool will accomplish prioritization of the adaptation measures. The prioritized measures will be the baseline for the elaboration of an adaptation plan for Cyprus.

In the following part of the current study after summarizing in short the current and future vulnerability of Cyprus to climate change, that consist the first step in adaptation policy decision making, a description of the CYPADAPT MCA tool follows.

5.1 Climate change adaptation plan in Cyprus

In the framework of the Cypadapt project a climate change impact, vulnerability and adaptation (IVA) assessment for the case of Cyprus was performed. The methodology followed is structured upon the observed or expected climate change impacts in Cyprus as well as in the wider Mediterranean region and further elaborates on each impact.

The selection of the policy areas that have been taken into consideration in the IVA assessment where based on the categorization of policy areas for integrating adaptation, as these were identified in the European Commission’s White Paper entitled “Adapting to climate change: Towards a European framework for action”. These policy areas where further categorized according to the specific characteristics of Cyprus, as illustrated in the following figure.
Overall, 56 future climate change impacts have been identified in the selected policy areas of Cyprus, from which 15 have been evaluated as key priorities for future adaptation action. In the following table the identified future climate change impacts in Cyprus as well as the future key vulnerability are presented.

Table 34: Impacts of climate change in the selected policy areas of Cyprus for the future situation

<table>
<thead>
<tr>
<th>Sector</th>
<th>Impacts</th>
<th>Key vulnerabilities</th>
<th>Prioritization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water resources</td>
<td>Water availability for domestic water supply in mountain areas</td>
<td>★</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Water availability for domestic water supply in urban areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water availability for irrigation in mountain areas</td>
<td>★</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Water availability for irrigation in plain &amp; coastal areas</td>
<td>★</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Water quality of surface water bodies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water quality of groundwater bodies</td>
<td>★</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Droughts</td>
<td>★</td>
<td>(3)</td>
</tr>
<tr>
<td>Sector</td>
<td>Impacts</td>
<td>Key vulnerabilities</td>
<td>Prioritization</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Floods in urban areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floods in mountain areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crop yield alterations</td>
<td></td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>Soil fertility alterations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase in pests and diseases*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Damages to crops from extreme weather events</td>
<td></td>
<td>(6)</td>
</tr>
<tr>
<td></td>
<td>Alterations in livestock productivity*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase in costs for livestock catering *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forests</td>
<td>Dieback of tree species, insect attacks and diseases</td>
<td></td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Fires</td>
<td></td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Forest growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisheries and aquaculture</td>
<td>Quantity and diversity of fishstocks*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fishstock physical environment*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs implications for fishermen*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coastal zones</td>
<td>Coastal erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coastal storm flooding and inundation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Degradation of coastal ecosystems *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Distribution of plant species in terrestrial ecosystems</td>
<td></td>
<td>(5)</td>
</tr>
<tr>
<td></td>
<td>Distribution of animal species in terrestrial ecosystems</td>
<td></td>
<td>(5)</td>
</tr>
<tr>
<td></td>
<td>Freshwater biodiversity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Marine biodiversity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soils</td>
<td>Soil erosion (by wind and/or rain water)</td>
<td></td>
<td>(6)</td>
</tr>
<tr>
<td></td>
<td>Soil salinization – Sodification</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soil contamination</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Desertification</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Energy</td>
<td>Landslides</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Renewable energy yield</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A significant number of adaptation measures are proposed aiming at reinforcing the adaptive capacity of a great number of different sectors (water, soil, tourism, biodiversity, coastal areas, public health, forest, energy, infrastructure, fisheries). In Deliverable 2.3 of the CYPADAPT project adaptation measures are presented per sector. Those measures have to be analyzed, categorized and prioritized on the basis of their effectiveness, viability and their contribution to climate change adaptation.

The number of criteria thought as relevant is significant since there are ten sectors to be evaluated and different preferences of decision makers and relevant groups exist. Furthermore quantification and valuation in monetary terms can be possible for many cases.
but not for all. In this frame MCA appears to be a useful tools for the prioritization of measures and development of an adaptation strategy to climate change in Cyprus.

5.2 CYPADAPT MCA tool used for the development of a climate change adaptation plan in Cyprus

After the vulnerability of Cyprus to climate change has been summarized the alternative adaptation options have to be prioritized in order the adaptation plan for Cyprus to be elaborated. As a result a tool for the prioritization of the adaptation measures is required. This tool has to be based on objectives, measures, criteria, weights and scores that measure or value the performance of each adaptation option against the criteria. Stakeholders participation in this process is of paramount importance. Furthermore this tool should be able to have a dynamic profile that will incorporate new data and preferential information.

As already mentioned due to socio-economic parameters that affect adaptation to climate change there is not a single, widely accepted method, in order to prioritize and select possible adaptation policies and measures. Nevertheless UN advocated the multi-criteria analysis (MCA) as a preferred method, at least for Least Developed Countries without specifying which criteria would characterize an optimal climate change policy.

In selecting a particular MCA approach among the various MCA methods, most of which were analyzed in the third chapter of this study, it is important to consider the complexity of the decision in terms of scientific, social, and technical factors, as well as understanding the requirements and the level of available knowledge. Moreover the availability of specific expertise and software tools consist an additional reason for the method and tool selection. (Figueira et al., 2005 and Belton and Stewart, 2002).

As described by Al –Zu‘bi, Analytical Hierarchy Process uses Multi Criteria Analysis (MCA) so as to enhance decisions through a process that provides structural clarity, communication and synthesis. The field of adaptation to climate change consists a complicated field with many intrusive parameters. “The ability of AHP to decompose a complex problem into a hierarchical structure of homogeneous clusters, coupled with its ability to capture, measure and synthesize individual preferences of qualitative and quantitative attributes into ratio scale weights, make this method appropriate in establishing climate change response priorities and subsequently allocating resources to chosen priorities” (Hwang & Syamsuddin, 2010).

Furthermore applicability of AHP to the weighting of criteria through ratio scales and scoring, constitutes one of its main advantages. AHP’s success comes as a result of its simplicity and robustness (Vargas, 1990). Moreover the strength of AHP lies in its ability to handle both quantitative and qualitative judgments (Macharis et al., 2004), while it employs a consistency test that can screen out not consistent judgments. This characteristic turns the results as reliable (Kablan, 2004).
In this frame and due to the fact that costs and/or benefits are not possible to be quantified for all proposed adaptation measures in Cyprus, Analytical Hierarchy Process was selected as a baseline method for the development of the CYPADAPT MCA tool.

The structure of the CYPADAPT MCA tool has been based on objectives, alternative measures/options/interventions, criteria (or attributes), scores that measure or value the performance of each adaptation option against the criteria, and weights (applied to criteria). This baseline parameters have emerged from worldwide applications and scientific review, presented in the previous chapters. Scores shall be entered in various ways by stakeholders such as: monetary and non-monetary data, qualitative data, various rating scales, and direct assignment of a percentage contribution to an objective or criterion. In the following, the scores will be normalized or standardized to make them comparable. In specific the structure of the software constitutes from:

- Introduction (general info – instructions)
- Input of Stakeholder’s details
- Selection of Adaptation Measures per Sector
- Selection of General Evaluation Criteria
- Weighting of the Criteria
- Rating / Ranking / Scoring of the Adaptation Measures
- Scenario selection

Evaluation Criteria which are used in the CYPADAPT MCA tool are the following:

I. Efficiency of the Measure
II. Environmental Friendliness
III. Supporting the Prevention of Climate Impacts
IV. Urgency for Implementing the Measure
V. Usefulness of Implementation Irrespective of Climate Change (No-regret characteristics of the measure)
VI. Technical Viability (in terms of installation, operation, maintenance, expertise etc)
VII. Economic Viability
VIII. Social Acceptance

For the selection of those criteria MCA applications in adaptation strategy, presented in Chapter 4, have been taken into account.

As already mentioned, each adaptation measure performance will be scored by stakeholders against each of those criteria. Scoring will use the following scales:
The first scale is a rating scale, where each measure will be scored against each criterion on a scale from 0 to 100.

Where:

- 80 < excellent ≤ 100,
- 60 < very good ≤ 80,
- 40 < good ≤ 60,
- 20 < Low ≤ 40,
- 0 ≤ Very Low ≤ 20

The second scale is a ranking scale (1-n). A ranking order should be given in the measures that have the same rating grade, with 1 being the most preferable and n being the least preferable measure (where n is the number of rated measures with the same grade).

This scale will help in eliminating prioritized options. In this way the basic disadvantage of AHP method, which is that the implemented pairwise comparisons may become so many that the uncertainty of the process will increase significantly, will be faced.

The final scoring is optional. Each adaptation measure if this is possible will be scored by stakeholders in terms of cost or will be characterized (e.g. Very expensive/ expensive/ not expensive etc.)

As a first step for the optimization of the software tool and for the selection of the most appropriate set of adaptation options for the case of Cyprus, questionnaires have been prepared and distributed to relevant stakeholders in Cyprus. In particular, the aim of the questionnaire was the evaluation of the criteria and weights used into the multi-criteria analysis for the selection of the adaptation measures as well as the evaluation of the adaptation measures. A round of visits and meetings with the stakeholders has been scheduled. Questionnaires will have the following form.
Table 35: Questionnaire for the scoring of adaptation measure to climate change per sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Evaluation Criteria</th>
<th>I.</th>
<th>II.</th>
<th>III.</th>
<th>IV.</th>
<th>V.</th>
<th>VI.</th>
<th>VII.</th>
<th>VIII.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TEC 1</td>
<td>ENV 1</td>
<td>ENV 2</td>
<td>TEC 2</td>
<td>TEC 3</td>
<td>TEC 4</td>
<td>EC 1</td>
<td>SOC 1</td>
</tr>
<tr>
<td></td>
<td>Efficiency of the Measure</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Environmental Friendliness</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Supporting the Prevention of Climate Impacts</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Urgency for Implementing the measure</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Usefulness of Implementation Irrespective of Climate Change (No-regret characteristics of the measure)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Technical Viability</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Economic Viability</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
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<tr>
<td></td>
<td>Social Acceptance</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
</tr>
<tr>
<td></td>
<td>Adaptation Measures</td>
<td>C (number/description)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C (number/description)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C (number/description)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C (number/description)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
<td>B (RANKING 1-n)</td>
<td>A (RATING 0-100)</td>
</tr>
</tbody>
</table>
Conclusions

Multi-criteria analysis (MCA) is proposed as the most appropriate method to accomplish decision making in the field of adaptation to climate change. MCA can accomplish handling of all available technical information and incorporation of different stakeholder views.

In the current Deliverable of the CYPADAPT project a preliminary literature review on the state-of-the art multi-criteria analysis tools used for the elaboration of adaptation plans worldwide was conducted and selected series of MCA applications in adaptation strategies were presented.

Finally the most appropriate MCA method for prioritizing adaptation measure so as to plan an adaptation strategy to climate change was selected to be the Analytical Hierarchy process. The interface of the CYPADAPT MCA tool will be available in the site of the CYPADAPT project (http://uest.ntua.gr/cypadapt/).
References

1. Anika Nasra Haque, Stelios Grafakos and Marijk Huijsman, Assessment of adaptation measures against flooding in the city of Dhaka, Bangladesh, Institute for housing and urban development studies Rotterdam/Netherlands, Num 25/2010


Deliverable 4.1: Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide

Adaptation Plan of Action to climate change “NAPA”.


32. Integrating Climate Change Adaptation into Development Co-operation


34. Ismail E., Nagmedlin G., Fernandes M., Dougherty B., NAPAssess: A Decision Support Tool for Use in the Sudan NAPA Process


42. Lesotho’s national adaptation programme of action (NAPA) on climate change, 2007.


44. Liberia, 2008, National Adaptation Plan of Action to climate change “NAPA”


51. Nijkamp P., Rietveld P., 1983, Qualitative discrete multiple criteria choice models in regional planning, Regional Science and Urban Economics 13, pp.77.10


60. Republic of Malawi, Ministry of Mines, Natural Resources and Environment, 2006, National Adaptation Plan of Action to climate change “NAPA”

61. Republic of Rwanda, 2006, National Adaptation Plan of Action to climate change “NAPA”


63. Republic of Yemen, 2005, Environment Protection Authority, National Adaptation Plan of Action to climate change “NAPA”

64. Republic of Zambia, 2007, Ministry of Tourism, Environment and Natural Resources, Formulation of the National adaptation programme of action on climate change.


67. Roy, B., 1968, "Classement et choix en présence de points de vue multiple (la méthode electre).”, RAIRO, 2, 57-75.


75. State of Eritrea, 2007, National Adaptation Plan of Action to climate change “NAPA”

76. The federal democratic republic of Ethiopia, Ministry of water resources, 2007, National Adaptation Plan of Action to climate change “NAPA”


81. UNFCCC. The Cancun Agreements-Introduction. Internet article available at: http:// cancun.unfccc.int/index.php%20title


86. United Nations Framework Convention on Climate Change. Available at: http:// unfccc.int/adaptation/items/7006.php#Stakeholder


90. United Nations Framework Convention on Climate Change: Methodologies and Tools to Evaluate Climate Change Impacts and Adaptation

91. United Nations Framework Convention on Climate Change: Methodologies and Tools to Evaluate Climate Change Impacts and Adaptation

92. United Nations Framework Convention on Climate Change: Nairobi Work Programme
Available at:

93. United Nations Framework Convention on Climate Change: Nairobi Work Programme. Internet article available at:
http:// unfccc.int/resource/docs/publications/pub_nwp_costs_benefits_adaptation.pdf

FCCC/INFORMAL/84. Available at:
http:// unfccc.int/resource/docs/convkp/conveng.pdf


### Annex I

#### Table 36: NAPA assessments

<table>
<thead>
<tr>
<th>Country/Annex</th>
<th>Methods used for prioritisation</th>
<th>Methods used for evidence, data and information collection</th>
<th>Composition of NAPA teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>Expert opinion, Stakeholder consultation, Multiple criteria analysis</td>
<td>Secondary data review, expert opinion</td>
<td>National consultants, Government officials</td>
</tr>
<tr>
<td>Senegal</td>
<td>Cost effective P54 Expert opinion P51 Consultation with the population and key stakeholders P74</td>
<td>Meetings of group, from workshops of exchange, individual meetings, public consultations, interviews with key actors and local population to evaluate degree of vulnerability P76 &amp; P74 Review of secondary sources P72</td>
<td>Team constituted by the National Director of project, the head of project and the secretariat accountant. A National Committee of Coordination of Coordination was set up to give the orientation necessary for plan, as well as a Team of Multidisciplinary constituted of concerned national directors, (structures non governmental as well as UNDP to validate the results drawn in the development of the NAPA P74)</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Multi-Criteria Analysis (MCA) technique in order to reach consensus on the selection of the top priority NAPA projects. A wide consultative process both at the national and regional levels. (Joint senior and mid level RIOB officers representing a wide range of stakeholders took part in the numerous workshops.</td>
<td>Field visits (four regional consultations were held in to gather evidence). Literature review on secondary sources.</td>
<td>Government (senior and mid level RIOB officers representing a wide range of stakeholders). National Consultants.</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>Multi-Criteria Analysis (MCA) technique in order to reach consensus on the selection of the top priority NAPA projects. A wide consultative process both at the national and regional levels. (Joint senior and mid level RIOB officers representing a wide range of stakeholders took part in the numerous workshops.</td>
<td>Review and analysis of secondary sources and data P54 Exchange of information held with different administrative and political representatives.</td>
<td>Multidisciplinary Group of experts P54 Comprised of representative from technical ministries and civil society</td>
</tr>
</tbody>
</table>
Deliverable 4.1: Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>Activity Options</th>
<th>Analysis Methods</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central African Republic</td>
<td>Identification of activity options through public consultation then multi-criteria analysis used to prioritize activities p45-49</td>
<td>Review of previous studies on environmental issues (CC) Local and regional consultations with the local population p21</td>
<td>Group of multidisciplinary experts from sectors affected by climate change and/or have interest in environmental issues, NGOs, Civil Society local communities and partners, international organizations and private sector p8 &amp; p21</td>
</tr>
<tr>
<td>Comoros November 2006</td>
<td>The multi-criteria analysis has been used, in order to highly specify the order of priority in the ranking of options. This method includes variables as well as non-monetary and qualitative</td>
<td>Government, National consultants</td>
<td></td>
</tr>
<tr>
<td>Democratic Republic of Congo</td>
<td>MCA [p29]</td>
<td>Review of secondary sources Participatory evaluation of vulnerability Public consultation p56 Field visit to capture the reality of climate change and collect opinions of target groups Survey p15</td>
<td>National committee to direct project composed of general secretary of environment, secretary general from planning, energy and budget ministry, sustainable development director from ministry of environment National coordinator of project, multidisciplinary technical team and experts from different ministries; national committee of climate change and other partners (p51) p90</td>
</tr>
<tr>
<td>Djibouti</td>
<td>MCA p46</td>
<td>Review of secondary data Regional, sectorial, and national workshops and consultations held to collect information and data on the causes of vulnerability of sectors and target groups p46</td>
<td>Ad hoc group involving various key sectors including political decision makers Group of experts and consultants (national and international) and participants from civil society, women and youth groups and key partners and decision makers on national level standard Pilot group from the different sectors such as Agriculture, Forestry, Health, Water, Livestock, Economy, Meteorology etc. p7</td>
</tr>
<tr>
<td>Eritrea</td>
<td>Cost-effective analysis, expert</td>
<td>a high-level expert group, literature review</td>
<td>Government officials, national and</td>
</tr>
<tr>
<td>Deliverable 4.1: Literature review of the state-of-the-art multi-criteria analysis tools used for the development of adaptation plans worldwide</td>
<td>2013</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>May 2007</th>
<th>Review of secondary data &amp; consultations held in 12 target regions with representatives from the authorities, public administrations, traditional authorities, NGOs, groupings of the peasants, and the society.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Lao People’s Democratic Republic</th>
<th>May 2009</th>
<th>Literature review, dedicated radio and TV programmes</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Madagascar</th>
<th>MCA p.22</th>
<th>Multidisciplinary team comprised of civil society and administrative p.59</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maldives</th>
<th>March 2006</th>
<th>Literature review, dedicated radio and TV programmes</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Malawi</th>
<th>See case study for more details</th>
<th>Secondary data review, expert opinion, field visits</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mali</th>
<th>See case study for more details</th>
<th>Review of secondary sources National consultations with key stakeholders and local consultations at regional level to gather information on vulnerability and adaptation issues p.89 Multidisciplinary team of experts p.86</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mauritania</th>
<th>Literature review, expert opinions</th>
<th>National consultations, government officials</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mozambique</th>
<th>Literature review of the relevant documentation on the sector, synthesis in the form of a report on the vulnerability and adaptation of the sector to climate variability, establishment of an inventory of the existing adaptation options, literature review.</th>
<th>National consultations, government officials</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Nepal</th>
<th>Literature review, expert opinions</th>
<th>Government officials, national consultants</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Nigeria</th>
<th>Literature review, expert opinions</th>
<th>Government officials, national consultants</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2006</td>
<td>This is the multi-criteria analysis (MCA) tool.</td>
<td>Substantive literature review, expert views, interviews, questionnaires</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Rwanda May 2007</td>
<td>The ranking of the projects in Table 5 was decided in account of a consensus approach rather than using the multi-criteria analysis (MCA) method or any of the methods outlined in the annexed guidelines for the preparation of the NAPA. Country-wide consultation process.</td>
<td>Literature review, expert views, interviews, questionnaires</td>
</tr>
<tr>
<td>Senegal December 2005</td>
<td>Consultation with local population at all regions to identify priority options. Then, MCA was used to prioritise options in 2011.</td>
<td>Consultation and review of secondary studies on the implementation of the NAPA in 2011, survey and research undertaken to gather information on various issues such as the vulnerability of various sectors and identifying adaptation mechanisms and priority activities.</td>
</tr>
<tr>
<td>Sierra Leone November 2007</td>
<td>Multi-criteria analysis</td>
<td>Public meetings, personal discussions, administration of questionnaires, literature review, expert views</td>
</tr>
<tr>
<td>Solomon Islands December 2008</td>
<td>Multi-criteria analysis, multi-stakeholder consultation</td>
<td>Literature review secondary sources, face-to-face group sessions</td>
</tr>
<tr>
<td>Sudan</td>
<td>Multiple criteria analysis within sub-regions</td>
<td>Secondary data review, expert opinion, sub-regional surveys etc</td>
</tr>
<tr>
<td>Tanzania September 2007</td>
<td>Cost benefit analysis (although little evidence in NAPA report)</td>
<td>Public consultation (using interviews and questionnaires, literature review)</td>
</tr>
<tr>
<td>Togo</td>
<td>Simpex qualitative and parametric analysis of the collected data/ information. This approach has a strong advantage in that it is participatory. Therefore, Togo took this approach for the analysis, prioritisation and ranking of identified interventions.</td>
<td>Participatory rural appraisal (PRA) approach was used for collection of data/ information from communities of selected districts, literature review for secondary data/ information, surveys and participatory rural appraisal (PRA), analysis and consultations</td>
</tr>
<tr>
<td>Vanuatu December 2007</td>
<td>Multi-Criteria Analysis (MCA) was used as it was considered the most appropriate method for assessing NAPA adaptation options in Vanuatu.</td>
<td>Existing information including data collected from NAPA rapid vulnerability and assessments (VARA) and information generated from three national climate change conference were utilized to carry out further consultations in order to enable the completion of the NAPA document</td>
</tr>
<tr>
<td>Yemen April 2009</td>
<td>Consultation process, multi-criteria assessment</td>
<td>Literature review, expert views</td>
</tr>
<tr>
<td>Zambia October 2007</td>
<td>Multi-Criteria Analysis (MCA)</td>
<td>Expert view, literature review</td>
</tr>
</tbody>
</table>