Climate Change and Impact Research: the Mediterranean Environment

Integrated Project

Climate Change and Impact Research: the Mediterranean Environment

D13.2.2: Synopsis of toolkit

Project No. 036961 – CIRCE

Sixth Framework Programme
6.3 Global Change and Ecosystems

Start date of project: 01/04/07 Duration: 48 months
Due date of deliverable: 30/June/2008 Actual Submission date: 30/July/2008

Lead partner for deliverable:Stockholm Environment Institute
Author: Dr. Takeshi Takama, Dr. Richard Taylor, Dr. Sukaina Bharwani, Dr. Fernanda Zermoglio, Dr. Ruth Butterfield, Dr. Tom Downing

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the Consortium (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	

Document Release Sheet

Distribution:	All CIRCE consortium, or Work Package members, or Selected partners	

Table of Contents

1.Publishable Executive Summary

This interactive user guide and specification of a decision support tool for climate change adaptation was developed as the Circe deliverable D13.2.2 *Synopsis of toolkit*. Instead of a conventional paper, this deliverable is produced as an interactive web site within www.wikiADAPT.org, which is a part of previous deliverable D13.2.1. The rationale is that by producing the paper as an interactive web site, it will become a 'living document' which can be updated as knowledge and experience progresses updated through the Circe project or even beyond the project. The "living document" function in the wikiADAPT is directly accessible from this document through "[edit]" hyperlinks under headings. Other hyperlinks are either connected to some relevant pages of the wiki or appropriate external sites. This document details the concept of the toolkit, the currrent version and future development plan. Circe project members are encouraged to contribute the development of the toolkit as well as comment on the content.

The latest version of this document and the decision supporting toolkit will be found in the link below:

http://wikiadapt.org/index.php?title=Climate_Adaptation_Decision_explorer

Adaptation to climate change requires understanding of social processes. It means that we need to assess and respond to past climatic impacts, to increase adaptive capacity and resilience to multiple stresses, and to formulate plans and policies in ways which reduce the risk of adverse outcomes in the future. The Adaptation Decision Explorer (ADx) for climate change supports to screen potential adaptation options and guide decision makers to move appropriate directions of next decision making nodes

An essential component of support to adaptation planning is guidance and tools on how to choose among the many strategies and measures that are available to decision makers. We have developed a prototype tool consisting of a shell, through which users can access several engines to select adaptation options. Users choose an appropriate engine or several different engines - each one being an implementation of a type of approach/method. Engines are selected according to their fit to the the data, context, and objective of the users, and the combined results can also be compared via the shell, providing a more robust analytical approach. In some cases, more than one method will be selected as long as these methods satisfy a user's or ADx's criteria. Then, the user receives appropriate and potential options s/he should consider. As these options are analysed by multiple methods, which consider multiple criteria, the selected options are more robust.

There are four specific objectives to develop ADx:

- To screen decision options for climate adaptation from a given context
- To support evaluation of adaptation options under climate uncertainty with multiple decision approaches
- To connect to CCE to utilise climate information as well as map the results of the ensemble of approaches for vulnerable sectors and regions
- To identify and compare the advantages and disadvantages of different decision approaches and their applicability for different situations.

This document informs the readers how this tool can achieve these objectives with some hypothetical cases and examples. Its development plan, future mile stones, and potential partners are listed around the end of this document.

In addition to explaining the functionality and plan of ADx, this document is also written as a background document about decision making under uncertainties and "synopsis of decision making tools". One way to handle the uncertainties in decision making processes is to consider options, which do not lead to the consequence of bottleneck. This means that it is wiser to keep options as long as they satisfy required criteria although they may not produce the maximal benefit to their stakeholders under uncertainties -- a robust approach instead of optimal approach. This robust approach requires multiple criteria and they will be assessed in multiple appropriate methods or approaches. At the same time, it is important to reduce unnecessary uncertainties if possible. This concept is necessary to understand the philosophy and algorithms of ADx.

Although the deliverable was supposed to write the summary of existing decision making/supporting tools for climate change adaptation, there are already a number of projects and documents collected valuable information on the tools. Therefore, instead of reproducing the information, this deliverable summaries the documents of these projects and lists some key adaptation tools and approaches.

ADx will be developed continuously for at least the next 36 months and according to the workplan. The tool still needs a lot of incremental improvements. The connection with The Climate Change Explorer Tool CCE should help address visualisation issues and add other decision supporting functions. Also, more case examples and engines are required to promote the "learning by example" decision making approach. This improvement cannot be done solely by the internal development team; therefore, collaboration work with other research teams and the communities of potential users will be a key to the success of this tool development. The more popular the tool, the more successful the tool is. A virtuous circle will start from here.

2.Introduction

[edit]

Adaptation to climate change requires understanding of social processes. It means that we need to assess and respond to past climatic impacts, to increase adaptive capacity and resilience to multiple stresses, and to formulate plans and policies in ways which reduce the risk of adverse outcomes in the future. The first step is to gather the best available climate information to present and future climate hazards. This requires an understanding of present day risks, as well as trends in climate, and how both may change in years to come. The climate change explorer (CCE) handles these pieces of information and may map potential uncertainties. Then, we need the second step to screen potential adaptation options and guide decision makers to move appropriate directions of next decision making nodes. The Adaptation Decision Explorer (ADx) for climate change is one of the innovative tools of the weADAPT collaboration to support the second step. The philosophy of ADx is *there is no cure-all method to analyse everything: do not rely on only one approach!*. This concept is similar to the Climate Change Explorer (CCE), in its use of ensembles of future conditions.

An essential component of support to adaptation planning is guidance and tools on how to choose among the many strategies and measures that are available to decision makers. Supporting adaptation decision making is not as simple as 'use multi-criteria assessment' (as mandated in the NAPA guidance). We have developed a prototype tool consisting of a shell, through which users can access several engines to select adaptation options. Users choose an appropriate engine or several different engines - each one being an implementation of a type of approach/method. Engines are selected according to their fit to the the data, context, and objective of the users, and the combined results can also be compared via the shell, providing a more robust analytical approach.

One or several chosen engines receive input data from the shell and pass back preferred adaptation options to the shell. Therefore, the ADx needs a common but flexible data format. If a data format is specific to a particular engine, a user has to know which engine s/he needs to use beforehand. This violates the concept of ADx. At the same time, the data format should be flexible to accept new engines, which may require different input data. Therefore, the data format has to be anonymous to engines. The data format currently considering is XML as the component of data format could be extended as the tool is developed.

We are implementing existing six different methods as the first engines in the shell:

- Elimination by aspects and rule based decision making

- Data envelope decision analysis
- XLRM framework -- Robust Decision Making based on a RAND corporation approach.
- Bottom up synthesis approach
- Voting and ranking exercises possibly from Euro vision song contest approach.
- NAIDE multi-criteria analysis

These engines may be merged, expanded, or eliminated in the future. This documentation in wikiADAPT will address technical designs for each engine to identify appropriate grounds to use these tools, which will be implemented into the shell function eventually. The six engines have different characteristics to deal with adaptation cases and possibly require different input data, situation, and connection to the shell. For example, the input data for elimination by aspects is more qualitative and the engine will be directly written within the ADx. In contrast, the input data for NAIDE is quantitative and the engine is an external software application. The shell and the external application will communicate though batch processes.

2.1.Objectives

[edit]

The potential users of the ADx will be analysts or engineers working for decision makers such as doner agencies or policy makers. The decision analysis cycle between a decision maker and decision analysis is viewed as a blueprint for a carefully engineered conversation between two key participants, so that tight two-way communication is expected between the two (Holtzman, Kornman 1992). The ADx will help the analysts identify relevant information and consequently appropriate adaptation options to their decision makers. The relevant information can be selected according to similarities in situations, required methods, or merely their human networks. Therefore, the purpose of this tool is to support decision making processes related to adaptation to climate change for the policy maker, directory and indirectly. There are four specific objectives to develop ADx:

- To screen decision options for climate adaptation from a given context
- To support evaluation of adaptation options under climate uncertainty with multiple decision approaches
- To connect to CCE to utilise climate information as well as map the results of the ensemble of approaches for vulnerable sectors and regions
- To identify and compare the advantages and disadvantages of different decision approaches and their applicability for different situations.

It not possible to forecast all consequence of climate change and their impacts to the society; however, a computer aided tool such ADx can be still beneficial to decision makers if the tool helps them make decision, for example, by eliminating 'noisy' options. Climate change involves deep uncertainties and adaptation to climate change is a type of strategic (long term) decision making. In most cases, conventional approaches may not be applicable and need to use appropriate methods to handle particular types of uncertainties. Otherwise, it will improve creditability and will be safer to test the analysis in multiple analysis. These issues are discussed more in later sections.

One way to handle, the uncertainties of climate change is to use ensembles of recognised climate change information with The Climate Change Explorer Tool (CCE). There are volumes of climate data available from many sources around the world often of variable quality or of little use to decision-makers who do not have the time to track down data sources or the expertise to reformat, re-project and load them into appropriate analytical tools. Successful integration and dissemination is dependent on creating flexible and scalable frameworks that provide complex analysis tools for advanced users and deliver information to a wider audience in ways that will allow these users to evaluate how best they may be applied.

The future development of ADx will facilitate the bidirectional transfer of information mapped by the CCE tool. That is, the physical and social economic information as well as potential uncertainties from CCE are utilised in ADx as input data and the outputs from ADx can potentially visually displayed in 2 dimensional format or plots to compare with other factors and outcomes. In this way, the connection between CCE and ADx will support the fourth objective : identifying and comparing the advantages and disadvantages of different decision approaches.

3.Backgrounds

[edit]

This section explains some important information related to ADx namely uncertainties in climate change and The Climate Change Explorer Tool (CCE). One way to handle the uncertainties in decision making processes is to consider options, which do not lead to the consequence of bottleneck. This means that it is wiser to keep options as long as they satisfy required criteria although they may not produce the maximal benefit to their stakeholders under uncertainties -- a robust approach instead of optimal approach. This robust approach requires multiple criteria and they will be assessed in multiple appropriate methods or approaches. At the same time, it is important to reduce unnecessary uncertainties if possible. The CCE will help clarify some uncertainties and the connection to The Climate Change Explorer Tool (CCE) will help to reduce uncertainties in the decision making processed in ADx.

3.1.Uncertainties in climate change

[edit]

Climate adaptation, over the course of decades and involving many levels of scales and decision making, requires analytical frameworks and concepts that define risk and uncertainty, that understand the emergence of system resilience from the exposure and behaviour of vulnerable groups, and that provide robust assessment leading to effective adaptation. Risk and uncertainty concepts and conditions have been analysed in several science communities. One of the most useful concepts, suggested early last century, is the famous distinction between risk and uncertainty (Knight 1921). Risk is the product of probability and utility of some future event based on experience -- you do not know for sure what will happen but you know the odds. In contrast, uncertainty is the structural and behavioural indeterminacy of the system -- you do not know the odds, nor even the outcomes. Risk is relatively easier to analyse with conventional probabilistic methods.

Moreover, uncertainties can be deeply unknown -- deep uncertainties and this can be defined as:

"*the condition where the decision maker does not knows and, or multiple decision makers cannot agree on, the system model, the priori probabilities for the uncertain parameters of the system model, an /or the value function.*" (Groves, Lempert 2007 p.422).

Then, surprising events will happen when people cannot predict these deeply uncertain events. This is a situation of facing deep uncertainties. For example, recent food crisis may have been "surprise" for a lot of people due to "deep uncertainty" and "complexity". The deep uncertainty in the current food crisis is trigger by a record-setting drought in Australia (source required). Australian agriculture suffers from the drought due to climate change. Then the amount of the world supply of food has decreased and there is details that pressure joined the production ground of other grain such as North America. Complexity may be, for instance, food demands in a new countries. The food demands connect with population explosion rapid growth economic in a new country, etc. There was no formula predicted when the food demands triggered the food crisis.

Another interpretation of uncertainties can be "unknowable information". There are three types of knowledges (Brewer 2005 p. 11), i.e. "known knowns":

1. Things we know we know
2. Things we know we do not know
3. Things we do not know we do not know

The second one is risk or uncertainty and third one is deeper uncertainty such as ignorance. So, as you see, uncertainty can arise from lack of knowledge, lack of data, or a limited understanding of the climate system. Sources of uncertainty that should be addressed, as they affect the results of the analysis relate to a specific case study. Uncertainty can be over the chance of a single event (for example crossing a threshold), recurrent events (the return period of a flood for example), discrete events (hurricane frequency) and complex events (for example the interplay of different factors that lead to drought). Many theoretical categorizations of uncertainty exist including uncertainty due to input parameters, scope of a model, limitation of a model, etc. (See more in CCE uncertainty). Therefore, it is extremely important to understand the range of uncertainty that exists, rather than just relying on one outcome chosen from many possibilities. This is the underlining reason why ADx as well as CCE consider multiple models and outcomes.

Moreover, the perception of uncertainties is often important than the uncertainties in the reality and visualised outputs from ADx will aid the user in making a decision based on her/his objectives to use the tool. It should be emphasised again that ADx will 'support' a user make a decision, but not 'make' the decision for her/him. Therefore, the users of ADx have to effectively interpret ADx inputs and outcomes as uncertainties will not be banished completely through the process of ADx. Some suggestions to deal with uncertainties are:

- Recognize that uncertainty is simply a part of all climate related science; therefore, any data and method/approach may not provide all of the answers, and acknowledging this will prevent over-interpretation of outputs. While some uncertainty is likely to decrease, others may not, for example the range of change in temperature for 2050 has changed very little since initial calculations were made over 20 years ago, so it is important to recognise the need to work with this uncertainty. Furthermore, some aspects of the climate and the most aspects of social systems may be too chaotic to say with certainty where within a range of possibilities the system may end.
- Take time to discuss these issues and their implications related to different projects, framing the issue in understandable ways.
- Take time to properly distinguish the differences between exogenous uncertainty, variability, policy levers, output measures, and relationships amongst them (See more in XLRM framework).
- Understand and precisely explain the types of uncertainty under discussion, especially signalling which uncertainties are most relevant for understanding a specific output or action and how those uncertainties could affect this.

3.1.1.Robustness

[edit]

Under the deep uncertainty, decision makers need to select robust options rather than best options, which works well for a particular prediction of future states. The success of these uncertain future states may need to be measured by multiple criteria to keep the decision maker's judgement robust. Rosenhead et al. (1972) suggested a concept of a robust decision making, which is still widely referred to in the area of decision making. Robustness is the flexibilities in decision making strategies against multiple future possibilities. This robustness concept distinguishes plans from decisions. A plan is a set of prospective decisions which designs a desired future and methods to bring it and decision is a commitment of resources to one of the prospective decisions (Rosenhead, Elton et al. 1972 p.418). In this concept, robustness is similar to the adaptive planning, adaptive resources management, and decision-pathway approach. The approach depicts a planning process as a series of decision nodes over time - a pathway of evaluation of risks, identifying options, choosing options, monitoring the outcome and then iterating the process at the next decision node. The approach also focuses on dealing with high levels of uncertainty and possible thresholds in the system being managed. Included in several chapters in the IPCC AR4, it is a more appropriate paradigm than optimal approaches that assume a high ability to predict future risks or outcomes of decisions.

In conventional planning language, Robust decision making process has to be flexible to unknown future states; therefore, instead of making the big plan, the process has a series of "small plans" and a decision maker makes a decision on the first plan and the rest of the chain of plans remain as plans. These remaining plans are open to revision as future states become more clear. In short, the Rosenhead (1972) defined robustness value as below:

ri = n(Si)/n(S),

where S is a subset of alternative choices which currently considered as good or acceptable and Si is a subset of S and attainable after the initial decision making. The robustness r is the proportion of decision sets, which can be used after the decision, so that as the number is higher, the decision maker is likely to have more options in the future or avoid the bottleneck of decision selections. This concept indicated that the robust decision making is not judged by only one uniformed measurement. For example, robust decision making can be judged by both the openness to the future as well as the successfulness of strategies. This means that inaction, which keeps the future options widest, does not necessarily prove to be a robust strategy if an inactive strategy is not also a successful one.

Using multiple methods or approaches will be useful to consider multiple future options and measurements of success as these are a limit what one approach can do. For example, Rayner (1998 p.30) suggested multiple dimension of measurements decision makers need to consider:

- Time scale such as short, medium, and long
- Spatial scale such as local, national, regional, and global
- Institutional level such as markets, governments, and civil society.

It will be an extreme case if a decision maker needs to consider adaptation options to fit all three dimensions, but it will be likely that s/he needs to consider more than one dimension to make her/his decision robust. Some analysis, such as GIS, is good at spatial analysis and another approach, such as text mining, performs well with contextualised institutional analysis. In this way, multiple methods in ADx can be viewed as the surrogates of multiple criteria. It should be emphasised that multiple methods, and in consequence multiple criteria approaches, should not be confused with finding a distribution from the outputs of models. ADx tells only the range, but not the likelihood of possible outputs.

3.2.Multiple methods/engines

[edit]

Decision making models can be categorised by many dimensions such as qualitative-quantitative, participatory, etc. One of the key category is probabilistic or non-probabilistic. Although, these two types of approaches use similar types of inputs such as 1) consistent, predetermined (risk), and uncertainties, the two types of models have different requirement, purposes, and trends due to the amount of input types they can handle (Figure 1).

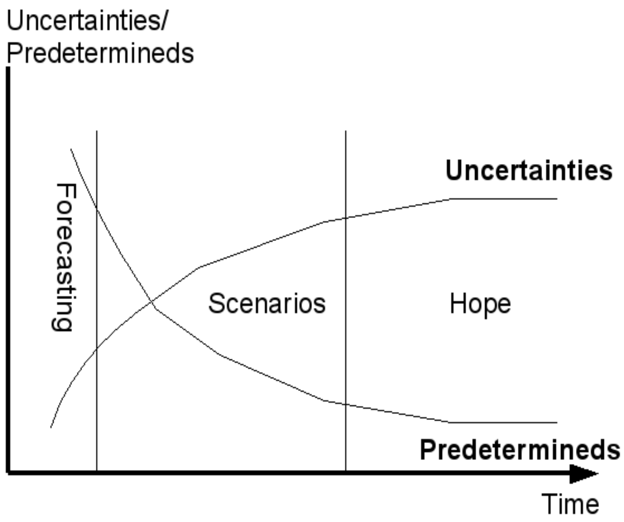


Figure 1: Forecasting, scenarios, and hope (Postma, Liebl 2005 p. 166)

Probability based decision making is generally used to predict future scenarios based on the information available at the present time. The likeliness is usually assigned to the alternative futures in the form of probability. If decision maker can set many probabilities or predetermined based on the frequencies in previous events or mathematical reasoning, e.g. a dice, the model will shows likelihoods of particular events in the future. However, this approach has severe weakness where probability is not possibly estimated by empirical studies. Strategic level adaptation planning to climate change is one of these situations. Climate change brings too much uncertainties for its strategic decision making processes; therefore, it is not possible to carry out a predictive decision making analysis unless many assumptions are included (Lempert, Nakicenovic et al. 2004 p. 2, Rayner, Malone 1998 p. 15).

On the other hand, non probabilistic approaches focus on drawing the plausibility or possibility of future states. In other words, these approaches help to generate possible future scenarios for decision making processes (Postma, Liebl 2005). The scenario approaches are more torrent to uncertainties than predictive approaches. However, this approach is still has some limitations if users are try to "know" future through one of these approaches. Scenario approaches do not tell you, which decision you should take. Instead, these approaches only show possible future states and its potential ranges, and then, a decision maker has to make her/his decision on her/his own, i.e. the purpose of scenario approaches is different from that of predictive approaches. Moreover, there are "unknowable unknown information" (Type 3 of known knowns) and the type of information will not possible to find as it can be ignorant (Ansoff 1976). Therefore, if the situation has too many ignorant, even scenario approaches cannot contribute much on a decision making process.

There are some more shortcomings in scenario approach. The scenario approach cannot capture diverse view of future scenarios. Also, most scenario approaches including IPCC's SRES scenarios failed to suggest some distributions attached to scenarios. Although uncertainties like climate change are not possible to be presented as probabilities, but likelihoods will remain as a centre of discussion (Parson, Burkett et al. 2007). Therefore, to suggest decision makers all scenarios equally will be bring some confusion or debates (Groves, Lempert 2007 p. 74).

A forecasting model based on known probabilities is possible only if most factors are predetermineds (Figure x). A scenario approach can handle more uncertainty factors, but if a decision maker has to handle too many uncertainties and does not have many predetermineds, the approach will not be useful, either. Hence, it is extremely important not only to consider multiple methods, but also use appropriate methods to assess complex decision options for their purposes. ADx will help to select multiple appropriate methods or approaches to a particular decision making situation to adapt climate change. This issue is revisited in the section the later section [1].

3.3. Connection with The Climate Change Explorer Tool

[edit]

Adaptation to climate variability and change is a social process, of assessing and responding to present and future impacts, planning to reduce the risk of adverse outcomes, and increasing adaptive capacity and resilience in responding to multiple stresses. A key step is to make use of the best available science to identify conditions and risks-the present extent, condition and trends and how they may be exhibited in years to come-and their relevance for adaptation strategies and actions.

There are volumes of climate data available from various sources, often of little use to decision-makers who do not have the time to track down data sources or the expertise to reformat, re-project and load them into appropriate analytical tools. Successful integration and dissemination is dependent on creating flexible and scalable frameworks that provide complex analysis tools for advanced users and deliver information to a wider audience in ways that will allow these users to evaluate how best they may be applied.

The Climate Change Explorer (CCE) addresses these needs by packaging data access routines, guidance and customized analytical and visualization procedures that provide users a sound analytical foundation from which to explore climate variables relevant to their adaptation decisions. It is designed to simplify the tasks associated with the extraction, query and analysis of climate information, thereby allowing users to address issues of uncertainty in devising policy and strategies and in implementing actions. This approach makes crucial links between understanding vulnerability, monitoring climate dynamics and planning adaptation processes.

The Climate Change Explorer Tool is an overall system for the delivery of climate data, capacity building activities and knowledge sharing on the use and interpretation of climate information in adaptation efforts. The approach seeks to synthesize information from ensemble simulations in an envelope analysis to determine the potential distributions of future climate change. Its purpose is to provide information on the results from climate models, in ways that will allow the potential user of the information to evaluate how best it may be applied. By including uncertainty analysis (model skill, parameterizations and sensitivity) in the outputs, the approach provides guidance for prospective insurance mechanisms through a rolling re-assessment of these conditions based on emerging scientific findings on climate variability and change.

The purpose of the tool within the context of the decision explorer described hereing is to:

- Establish the envelope of future climatic conditions for (a) a chosen geographic domain and (b) for given climatic parameters that define exposure or are critical in planning adaptation and allow for provide guidance for prospective adaptation strategies through a rolling re-assessment of these conditions based on emerging scientific findings on climate variability and change.
- Guide users through issues of confidence in climate change related to geographical and temporal scale, robustness of climate modeling information.
- Set up the climatic futures for testing adaptation decision making.

Adaptation has been adopted as an international imperative and is included in the mandate of the United Nations Framework Convention on Climate Change (UNFCCC) and the Nairobi Work Programme (NWP). A particular change those tasked with the design and implementation of adaptation projects is in leveraging the best available data and synthesis tools to understand how the expected climatic changes will exacerbate or induce vulnerability. The Climate Change Explorer provides them with databases and user-drive methodologies to address these challenges, and represents an important contribution to the proper evaluation of adaptation options.

The identification of risk envelopes could be used to identify priority zones or activities, and would also be helpful in supporting a scientifically sound (rather than "climate proof") rationale for projects. Furthermore, the analysis of climate risk boundaries will add to a user-focused understanding of the needs of decision makers in terms of climate data, and will generate the information required to provide actionable suggestions to formulate viable policies. This is a particularly useful tool for such a purpose, since elucidating these boundaries will offer a way to measure how model parameters vary over time relative to different policies and to estimate the direct consequences of adaptation options.

It is expected that links to the decision explorer described in this document would be to support a **Probabilistic analysis of expected outcomes -** does the decision depend on the expected distribution of risks? Is there an outcome variable that is critical to the decision (cost-benefit ratio)?

Level of Analysis	Questions Addressed	Expected Outcomes
Probabilistic analysis of expected outcomes	• Is there a foreseeable problem that may be caused or exacerbated by climate change? • How will specific sectors (e.g. water, agriculture) be impacted by expected changes in climate? • How will atmospheric CO2 concentrations impact a specific group, sector, or area?	• Evaluating the expected future trends in likelihood, extent (identifying additional areas at risk due to climate change), and magnitude (additional impacts due to climate change under specified scenarios) of key climate variables • Examine the robustness of specific strategies against a range of climate futures, particularly those related to doubling CO2 concentrations • Understand the uncertainties and sensitivities of critical systems under a range of future conditions. • Make decisions that are robust against an uncertain future.

4.Current development of Adx

[edit]

The schematic diagram explains the overall pictures of ADx. As shown in the diagram (Figure 2), the main components are namely:

- Potential adaptation options: may be applicable to a situation a user is interested,
- Inputs: including climate information as well as socio-economic factors, vulnerability, etc. ,
- Shell: as a mechanism to select appropriate engines and present ouputs,
- Engines: as potential methods and approaches.

Potential adaptation options and input information are fed into the shell of ADx. The shell selects an appropriate engine or multiple engines if necessary. Then, the appropriate adaptation options, which match to the context of its user's case will be displayed and explored after they are selected by the selected engines. Potential adaptation options will be selected from existing early cases; otherwise, new options can be suggested by experts or stakeholders. Input information will including pre-dominants, exogenous uncertainties, policy levers of a target case (Lempert, Popper et al. 2003, Postma, Liebl 2005)and these are stored as XML for flexibility and future extension as it allows its users to define their own elements in the data structure.

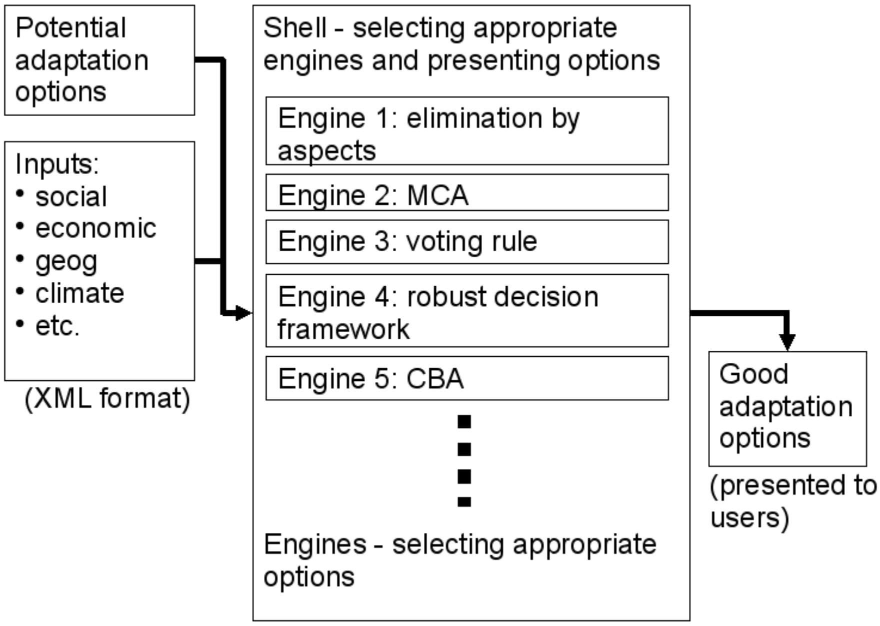


Figure 2: Schematic diagram of ADx.

The shell is the user face of ADx so that the shell read input information and pass it to appropriate engines for the data and present adaptation options in a way that a user can explore them. So, normally users do not need to know the functionalities of ADx underneath the shell. Engines will be modularised, so adding new engine or removing excising engines will not affect the overall functionalities of the ADx. In other words, additional engines will be included into ADx later as the tool is developed.

One successful and similar example of this relationship between modularised engines and the shell is R programming language and environment. R is not only a programming language but also environment where you can load numerous packages to carry out various analytical studies. The user can submit and load packages, which allow specialized statistical techniques, graphical devices, as well as other functions. Notable packages are listed along with comments on the official R pages. Adding or removing packages does not affect fundamental functionalities of R environment, but adding extra packages enables users to use another types of analysis. Hence, the relationship between the shell and engines of ADx is similar to the relationship between the environment and packages of R. Having said that, one significant difference of ADx from R is that the environment of R does not select appropriate packages for your analysis, but ADx does.

4.1.Expert system to select appropriate adaptation engines in the Shell:

[edit]

We should not confuse this with Elimination by aspects as an engine. The approach can be similar, but the shell only select the engine/methods. Elimination by aspects as selection of options should be written in different places.

The selection of appropriate tools/approaches is multi attribute decision making as the selection should be decided based on its context such as the type of input data, users, geographical location, etc. The multi attribute decision making can be categories by rational/irrational and optimaised/unoptimised. The rational approach is based on the assumption of utility maximisation, and there are approaches do not assume it (von Neumann, Morgenstern 1947). If an approach is based on optimisation, its algorithm will try to find the absolute bast answer within given constraints.

As discussed above, climate change is a area of deep uncertainties, so that it is better to keep an approach as robust as possible. Selecting an absolute engine may be optimal and efficient if it works; however, it will be difficult to make sure the judgement by only one criteria such as maximising the utility. Therefore, the ADx does not at least assume rationality in the shell and will be more robust if we designed it as a non-optimal approach.

One of the promising approaches in this category is elimination by aspects. In the approach, a decision maker pays attention to some attributes one by one and rounds down choices that fall below the threshold about each attribute from the choices set (Tversky 1972). Therefore, the approach clearly includes more than one criteria to select option and is possible to deal with both concious and unconscious decision making processes. If ADx adopts an optimal approach, the chosen engine will be the last one remained in the process. If non-optimal approach is used, more than one engines can be chosen and they are chosen based on the some thresholds, i.e. multiple satisfactory measurements (Rosenhead, Elton et al. 1972). The latter approach is currently focused more in this version and will be the appropriate approach for the nature of study.

More specifically, accounting for differing socio-economic contextual variables would enable such a model to be more useful in its application. Differing goals of subsistence, income, technology and productivity requirements could be included using Gladwin's 'elimination by aspects' methodology. This would allow customisation to include the constraints of in the data format and purpose of the studies. Different adaptation decision making process in different geographic locations involve different sets of socio-economic and cultural constraints.

Therefore, the selection of engine will be established by presenting the user with a series of yes/no ('elimination by aspects') questions from a set of engines; these will be filtered to a smaller set based on the responses given and the expert system will produce an ordering of engines as a result. These could be linked to other relevant databases of shared experiences and expertise in climate adaptation. Then, the shell will run the engine(s) to produce adaptation option(s) as a result of ADx.

In addition, ADx will always keep the option of self-selection by a user. A wizard will allow a user to select engines and/or to accept recommendations based on user responses to series of questions. This may not be a recommended option in the future, but the wizard will give another degree of flexibility and will be useful to test ADx and engines.

4.1.1.Developing environment of the shell

[edit]

This section explains the technical aspects of the shell. ADx aims to support multiple operation systems such as Windows, Mac OS and Linux, or even we may develop its web-based application. Therefore, as the first prototype, we decided to develop the shell in the Java programming language and environment, which is independent from platforms such as hardware/operation system and possible to integrate into a web page displayed in a web browser.

The algorithm of elimination by aspects will be implemented by an expert system of Java Expert System Shell (Jess) or similar in the first version. The ADx will be used to analyse a specific case. The expert system of the ADx will then filter 'context-specific' in a specific case by using elimination by aspects. As Jess may have some licensing problem after ADx is launched officially and distributed to public openly and also the shell probably needs only a small subset of entire Jess functionalities, it will not necessary to use Jess to select engines. Therefore, the subset of Jess will be cloned in open-sourced language such as Lisp, Prolog, Scala, or implemented as a pure Java program.

4.2.Engines: methods and approaches to select appropriate adaptation options

[edit]

Most context will be written in the different pages, and will be put in Appendix when this is prepared as Circe deliverable.

Different engines have different characteristics to analyse adaptation cases. This section addresses the technical design of each approach to identify appropriate grounds to use these tools. We are trying six engines as listed and most likely we will start with an engine of rule based decision making and an engine of voting and Voting and ranking exercises.

- Elimination by aspects and rule based decision making
- Data envelope decision analysis
- XLRM framework -- Robust Decision Making based on a RAND corporation approach.
- Bottom up synthesis approach
- Voting and ranking exercises possibly from Euro vision song contest approach.
- NAIDE multi-criteria analysis

As mentioned above, each engine is modularised so that it will be possible to add extra engines or remove unnecessary in the future.

4.2.1.Some synopsis of adaptation tools done by external projects

[edit]

The selection of tools and guidances have been already documented in earlier projects and meetings, which are highly related to the concepts of climate change adaptation. Therefore, instead of repeating this process, this section summaries the documents of these projects and lists some key adaptation tools and approaches.

The four noteworthy documents were produced in earlier projects:

- Expert meeting on tools
- The Compendium of Adaptation Models for Climate Change: First Edition
- Tools for Assessing Vulnerability and Adaptation ? A Guide
- Advanced Tools for Sustainability Assessment

4.2.1.1.Expert meetings on Tools

[edit]

The Institute for Development Studies (IDS), together with the World Bank and the International Institute for Sustainable Development (IISD) has convened a series of meetings "to assess progress and fill crucial gaps around adaptation tools for development".

On 11-12 April 2007, in Geneva 40 participants met for a two day workshop to discuss and share adaptation tools for international development entitled: **Sharing Climate Adaptation Tools: Improving decision-making for development.**

The objective of the meeting was to take stock of the tools and methods available to improve decision-making with regards to climate variability and change. The workshop coupled hands-on demonstrations of tools along with informal presentations. A summary report was produced, which organized the tools according to: the intended audience, level of screening provided, spatial scale, training time, application time, main data type and whether economic analysis was included. These categories, which are summarized in detail in the meeting report, include:

- Broad information providers [www.weadapt.org weADAPT], PRECIS, ILRI-et al
- Computer-based decision tools - targeting project design (CRiSTAL, Adaptation Learning Mechanism (ALM), ADAPT, USAID Guidebook)
- Screening approaches to evaluate portfolios and justify design changes (ORCHID).

We (weADAPT) presented the platform, noting features such as open source/access, the use of existing climate information, pulling in climate envelopes, and developing the platform from prototypes. Following the meeting, SEI, ENDA, AWhere Inc and UNITAR met to review plans, in particular how the platform collaboration will support our existing projects including the CIRCE project. We are also in the process of preparing a guide to adaptation tools on the knowledge sharing platform known as wikiadapt.

On 28-29 April, 2008 in Paris a second workshop was convened hich built on findings of an initial workshop in Geneva in 2007 on Sharing Climate Adaptation Tools. The objectives of the workshop were to

- Compare, contrast and improve technical aspects of tools
- Improve collaboration and the ability of tools to match user needs
- Take stock and improve understanding of the demand for adaptation tools

A summary of these meetings was subsequently presented at a *side event at the recent UN Climate Change negotiations in Bonn*, chaired by Thomas Tanner from IDS. The side event aimed to showcase tools available, and encourage user-developer dialogues.

- Adaptation Metrics

4.2.1.2.The Compendium of Adaptation Models for Climate Change: First Edition

[edit]

This document is a compilation of 35 selected adaptation models for climate change. The Compendium is a contribution to the Nairobi Work Programme.

Model Inclusion and Categorization

In order to be included in the compendium, a model had to adhere to the following criteria:

- It is applied to **humans** adapting to clinate change
- It incorporated adaptation, even in a basic way
- It is based on climate variability/change
- Studies using the model can be replicated
- Output could be applied to policy

For a model to meet the Incorporated Adaptation requirement in the Compendium, it had to fit within one or more of the following categories:

- Simulates agent adaptation
- Policy/Decision Variable

- Statistical Downscaling
- Estimate cost water man
- Adaptation Assessment
- Assess/Evaluate adaptation options
- Emissions targets
- Adaptation module
- Links several IAMs
- Cost effective adaptations
- Induced/Evaluates adaptations
- Assess strenghs of adaptation

Models in the compendium were **classified based on their treatment of adaptation into two categories**:

- **Adaptation Centered Models (ACMs)** - explore a variety of adaptation options and allow for these options to be evaluated/manipulated, and according to the authors, represent a "more promising direction for future development".
- **Impact Centered Models (ICMs)** - measure the impacts of climate change and some gross measurements of adaptation. However, adaptation in these models is assumed to be a fixed parameter of measureable quantities, rather than a dynamic set of options.

Further classification and presentation of the model descriptions (which the author notes as having been "extracted from peer review literature, model authors and corresponding websites" was based on model **typology** which categorizes models based on:

- **sectors** (Agricultural (36%), Coastal (7%), Economic (43%), Forestry (0%), Human Health (0%), Hydrological (0%), Multi-sectoral), Economic (43%), Social (14%) and the
- **engines or parameters they employ** (Agent Based (5%), Behavioural (6%), Cost Benefit Analysis (5%), Evaluation (10%),Integrated Assessment Models (25%), Optimization (6%), Qualitative (7%), Quantitative (25%) or Simulation (11%)). Parentheses next to each of the above indicate the percentage of models in the compendium which fit these criteria.

List of models included in the compendium:

- Agent Based Models(ABMs)
- Adaptation-Dynamic Integrated Model of Climate and the Economy(AD-Dice)
- Adaptation-Regional Integrated model of Climate and the Economy(AD-Rice)
- Automated Statistical Downscaling (ASD)
- Berg River Dynamic Spatial Equilibrium Model(modelBRDSEM)

- CALifornia Value Integrated Network(CALVIN)
- CanCLIM
- Canadian Regional Energy Model and Regional Energy Analysis Model(CanREM)
- Community Integrated Assessment Model(CIAM)
- Climate Impacts (CLIMPACTS)
- Climate Outlooks and Agent-Based Simulation of Adaptation in Africa(CLOUD)
- Complexity and Organized Behaviour Within Environmental Bounds (COBWEB)
- CRiSTAL Community-based Risk Screening - Adaptation and Livelihoods
- Dynamic Interactive Vulnerability Assessment(DIVA)
- Erosion Productivity Impact Calculator (EPIC)
- Evaluation of Strategies to Address Climate Change by Adapting to and Preventing Emissions(ESCAPE)
- Future Agricultural Resource Model-Adapt(FARM-Adapt)
- Framework for Uncertainty, Negotiation and Distribution (FUND2.9)
- Integrated Climate Assessment Model(ICAM2.5)
- Integrated Assessment of Climate Protection Strategies(ICLIPS)
- Integrated Model to Assess the Greenhouse Effect(IMAGE2)
- Information Society Integrated Systems(ISIS)
- Model for the Assessment of Greenhouse gas Induced Climate Change (MAGICC)
- Mini-Climate Assessment Model(MiniCAM 2.0)
- Model of Private Proactive Adaptation to Climate Change(MPPACC)
- Okanagan Sustainable Water Resources Mode (OSWRM)
- faculty/hopec.html Policy Analysis for the Greenhouse Effect (PAGE2002)
- RegIS2
- Ricardian
- SimCLIM
- Soil Water Atmosphere and Plant model-Water and Salinity Basin Model(SWAP)
- Tool to Assess Regional and Global Environmental and health Targets for Sustainability (TARGETS)
- Tool for Environmental Assessment and Management (TEAM)
- Urban Water Futures:A multivariate analysis of future residential water demand in the Okanagan Basin, British Columbia(UWF)

Availability - PDF copies of the compendium are available upon request from thea dickinson, and print copies from Don MacIver, Director - Adaptation and Impacts Research Division - Environment Canada.

4.2.1.3.Handbook of Current and Next Generation Vulnerability and Adaptation Assessment Tools

[edit]

The handbook/guide provides an assessment and critique of frequently used vulnerability and adaptation assessment (VA) tools so that users "are better informed and can take a more conscious decision in selecting appropriate tools for their use". It begins by outlining the charateristics that lend credibility, accuracy and stakeholder acceptance of a tool and use these in their assessment and description in subsequent chapters: credible, transparent, acceptable to stakeholders, relevant, accurate, measurable, reproducible analysis, comparable, cost-effective, flexible enough to adapt, able to identify trends, and readily understood.

Subsequent chapters provide an overview and assessment of strengths and weakness of available tools under three categories:

1. **Impact and vulnerability tools by sector** (Agriculture, Water Resources, Coastal Resources, Human Health, Forestry and Natural Ecosystems, Energy and Environment and Infrastructure and Industry)

1. **Adaptation policy assessment tools -** outlines platforms (Adaptation Policy Framework, NAPA), Decision Tools (Policy Exercises, Benefit Cost-Analysis, Cost-Effectiveness, MCA, Adaptation Decision Matrix (ADM)), and Stakeholder Approaches (networks, vulnerability indices, agent-based social simulations, Livelihood Sensitivity Matrix), (historical/geographical analogs,and Uncertainty and Risk Analysis.
2. **Integrated vulnerability and assessment tools** - PRIMES (Energy System Model), [Prospective Outlook on Long-term Energy Systems (Poles)], Externalities of Energy (Extreme),Integrated Assessment of Climate Protection Strategies), RICE and DICE, IGSM (The MIT Integrated Global System Model), .edu/group/MERGE/ MERGE, and MAGICC/SCENGEN (Model for the Assessment of Greenhouse-gas Induced Climate Change/ Regional Climate SCENario GENerator)

The final chapter of the manual outlines suggested components of an integrated vulnerability index.

Availability - Handbook of Current and Next Generation Vulnerability and Adaptation Assessment Tools, Amit Garg et al., Paper 8, BASIC Project, September 2007

4.2.1.4.Advanced Tools for Sustainability Assessment

[edit]

The project is about assessments tools used to assess a policy's contribution to sustainable development. The word 'tools' refers to all kinds of methods, analytical approaches, procedures and frameworks that can be used for the assessment of policy. Examples of tools are cost-benefit analysis tools, participatory tools, scenario tools, multi-criteria tools and models. SustainabilityA-Test is not an innovative research project in the sense that new tools have been developed. Instead, SustainabilityA-Test focussed on existing tools and created an inventory of tools, showing what can and cannot be done with them within an assessment.

Together with this report, an internet-based handbook is published, in which all information and other project deliverables can be found. This website is accessible via www.SustainabilityA-Test.net. This report is written as a scientific background report, explaining the methodology used to build the functions offered by the website.

This introductory chapter of the report explains the project's background and objectives, and methodology. It ends with an overview of the structure of the entire report.

4.3.Display multiple adaptation outputs in the Shell

[edit]

If the shell or a user chooses more than one engine to compare, the user get multiple adaptation options. Similarly, an engine may suggest multiple adaptation options in a nonoptimal algorithm if these options satisfy all criteria required by the algorithm. As the user identify adaptation options, he or she can explore decision making options. Any information might be useful to the user, but the real question is how to explore multiple options selected by different analytical methods and studies such as engines. For example, if two relevant studies by cost-benefit analysis and multi-criteria analysis choose the different sets of adaptation options and the number of adaptation options are too many to consider, a decision maker needs to make priority amongst the pre-selected options. Please bear in mind that "*ADx is decision support system, but not decision making system*". Therefore, we need some mechanism to explore potential adaptation options.

4.3.1.Example: Adapting to severe floods in Least Developing Countries

[edit]

We think a visual tool will be useful to make adaptation options comparable. Figure 3 shows an example of mapping potential adaptation options. The options can be displayed in ordinal and cardinal scales, e.g. cost to adapt is cardinal measurement, but any scale from awareness to action will be ordinal scale. Let's say this is about adaptation options for severe floods in the LDCs countries and a decision maker is from the Dakar city in Senegal and s/he pre-selects some existing adaptation options analysed for this situation. In this situation, the option 8 can be a "flood defence" and option 2 can be an "early warning system". So, this mapping exercise gives some useful information, i.e. a flood defence is more expensive and more action oriented option than an early warning system. If this set of information is not good enough to choose adaptation options, the decision maker can explore additional information and adaptation options.

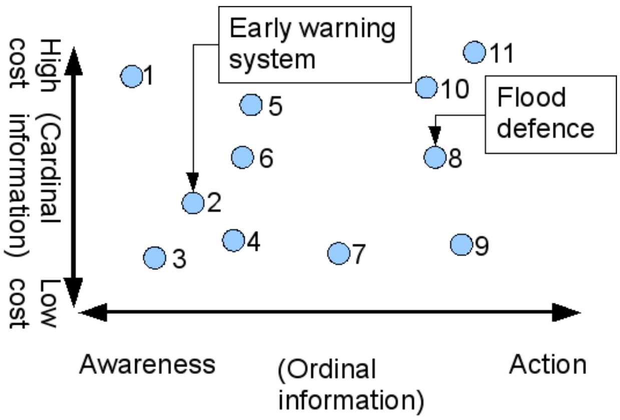


Figure 3: Example of mapping adaptation options in CADx.

4.3.1.1.Exploring by methods

[edit]

The decision-maker may ask an analyst categorise these options by methods s/he is interested in (Figure 4). For example, the option 1, 2, 3, and 4 were identified by multi-criteria analysis as good adaptation options in previous studies. Similarly, the option 2, 4, 5, and 6 were selected by cost-benefit analysis and the options 4, 6, 7, 8, and 9 were selected by participatory action research. If there is an existing guidance, it will narrow down options the decision maker needs to look at.

Some guidance on the choice of methods is available, for instance from the EC Sustainability A-Test project[1]. Although the shell choose cost-benefit analysis, the user may reduce the weight on the outcomes of the analysis and focus on the outcomes of participatory action research if s/he knows CBA is not appropriate at the stage of a project. Alternatively, if the decision-maker would like to select a most robust option, option 4 would be 'best' and option 10 and 11 would be 'worst' in this example.

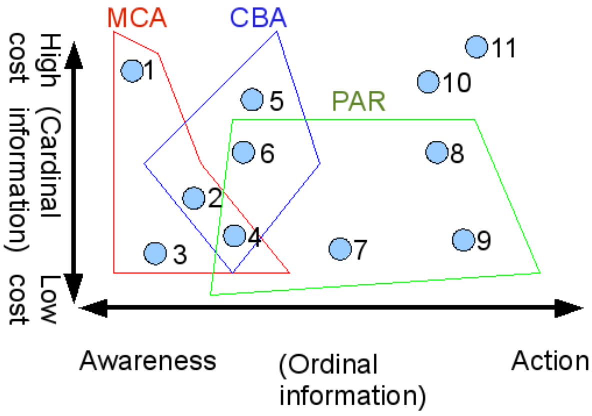


Figure 4: Exploring adaptation option by methods

4.3.1.2.Exploring by networking

[edit]
Alternatively, the decision maker may like to see what other people (city in this example) are doing (Figure 5). If s/he knows that a city like Chittagong in Bangladesh or Maputo in Mozambique has done something about adaptation to climate change and s/he always likes what that city does, why not just choose the same response? In this situation, the decision maker may put more weight on the option 5 and 6.

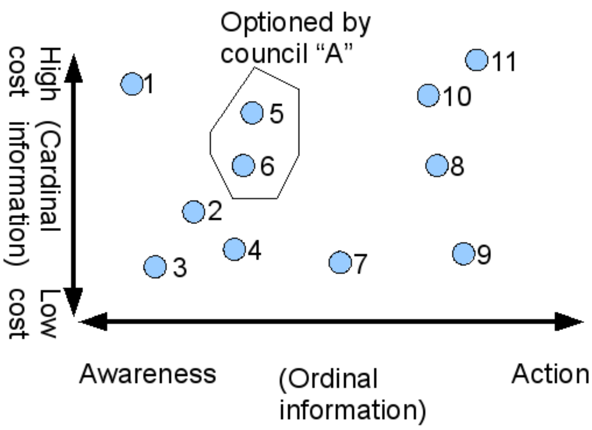


Figure 5: Exploring adaptation options by social network

4.4.Example of Tanzania

[edit]

As a real example of considered adaptation options an xml file was produced to test in the ADx. The adaptation options selected are for the agriculture sector from the National Adaptation Programme of Action preparation project which was completed in 2007 for Tanzania. Several sectors were identified as high priority and adaptation strategies were identified by sector through consultations. The following text is extracted from the NAPA document to give background to the process (see [2]).

The overall vision of Tanzania's NAPA is to identify immediate and urgent Climate Change Adaptation Actions that are robust enough to lead to long-term sustainable development in a changing climate. It will also identify climate change adaptation activities that most effectively reduce the risks that a changing climate poses to sustainable development.

The main objectives of NAPA are:

1. To identify and develop immediate and urgent NAPA activities to adapt to climate change and climate variability;
2. To protect life and livelihoods of the people, infrastructure, biodiversity and environment;
3. To mainstream adaptation activities into national and sectoral development policies and strategies, development goals, visions and objectives;
4. Increase public awareness to climate change impacts and adaptation activities in communities, civil society and government officials;
5. To assist communities to improve and sustain human and technological capacity for environmentally friendly exploitation of natural resources in a more sustainable way in a changing climate;
6. To complement national and community development activities which are hampered by adverse effects of climate change; and
7. To create a long-term sustainable livelihood and development activities at both community and national level in a changing climatic conditions.

The NAPA process was based on consultation with sectors and literature review. However a number of consultations were done at community level especially the farmers in some parts of the country mainly to verify and concretize the information from the sectors. In this regard, NAPA team members were able to obtain communities' perception and views regarding the adverse impacts of climate change on sustainable rural livelihoods and a range of coping and adaptation measures that have evolved through the use of indigenous knowledge and modern science and technology initiatives. In the final analysis, through this consultative process a large number of people participated in the development of this NAPA document and are aware of what the project intends to do and achieve for vulnerable rural communities.

The NAPA preparatory process involved the participation of many stakeholders. The multi-disciplinary team used participatory approaches to ensure that national plans and strategies are integrated in the document. This approach ensured that the NAPA document was developed in a transparent and participatory manner, a feature that would further ensure that the proposed activities are implemented and adopted by target vulnerable communities.

The following criteria were used in the process as the basis for the ranking priority adaptation options:

- Level or degree of adverse effects of climate change;
- Poverty reduction to enhance adaptive capacity;
- Cost effectiveness;
- Improvement of the livelihood of the rural communities;
- Vulnerable groups in the communities, e.g. the rural poor;
- Cost of the project;
- Complementality to national goals and objectives; and
- Locally driven criteria (country driven).

The overriding principle was the immediate and urgent needs that was disclosed and/or argued by stakeholders. These are of interest because they could be used as elements within the xml file descriptions of options.

Many sectors were addressed in the NAPA namely agriculture, livestock, forestry, water, coastal and marine resources,health, wildlife, industry, energy,wetlands and human settlement. We began by producing an xml file based only on the agriculture sector, so reproduced here is a some background on this sector in Tanzania and a table listing the vulnerabilities of the sector, existing adaptation activites and potential adaptation activities. It is from these potential activities that the xml file is based.

4.4.1.1.Agriculture sector

[edit]

Tanzania has about 88.6 million hectares of land suitable for agricultural production, including 60 million hectares of rangelands suitable for livestock grazing. Based on altitude, precipitation pattern, dependable growing seasons and average water holding capacity of the soils and physiographic features, Tanzania has 7 agro-ecological zones (Table 1).

Studies undertaken during INC indicate that increase in temperature by 2oC -4oC would alter the distribution of the agro ecological zones. Consequently, areas that used to grow perennial crops would be suitable for annual crops. In addition, global warming would tend to accelerate plant growth and hence reduce the length of growing seasons.

Among the vulnerability in the agricultural sector include decreased crop production of different crops exacerbated by climatic variability and unpredictability of seasonality, erosion of natural resource base and environmental degradation. The following list shows the percentage of decrease of two selected crops; maize and coffee:-

- maize: with increase in temperature and reduced rainfall as well as change in rainfall patterns, average yield will decrease by 33% country wide. Furthermore, yield of the same crop will decreases by up to 84% in the central regions, 22% in Northeastern highlands, 17% in the Lake Victoria region, and 10 - 15% in the Southern highland;

- Coffee and Cotton: As a result of temperature increase of 2-4 oC, coffee production is projected to increase by 18% in bimodal rainfall areas and 16% in unimodal rainfall areas.

Table 1: Summary of vulnerabilities and adaptation activities (existing & potential) of the agriculture sector

Sector	**Vulnerability**	**Existing Adaptation Activities**	**Potential Adaptation Activities**
Agricultur e **Sector**	• Unpredictable rainfall, uncertainty in cropping patterns • Shifting in agro-ecological zones • Prolonged dry spells beyond normal patterns • Increased weed competition with crops for moisture, nutrients and light • Ecological changes for pests and diseases • Decline of maize yields, the national food crop nationwide by 33% due to temperature	• Small scale irrigation • R&D on drought tolerant seed varieties • Agriculture extension activities • Diversification of agriculture: growing different types of crops on different land units • Water harvesting	• Alternative farming systems • Promote indigenous knowledge • Change planting dates in some agro ecological zones • Increase irrigation to boost maize production in selected areas • Drip irrigation for specific regions • Reduce reliance on maize as staple food by growing short-season

	rise; highest decline reported for Dodoma and Tabora • Cotton yields could decrease by 10%- 20% due to the impact of pests and diseases		and drought tolerant crops such as sorghum and millet • Shift crop farming to more appropriate agroecological zones • Change crop rotation practices • Integrated crop and pest management • Make better use of climate and weather data, weather forecasts, and other management tools • Create awareness on the negative effects of climate change • Sustainable water management to boost food crop production • Strengthen early warning system • Follow standard agronomic practices • Promotion of annual and short term crops

An excerpt from the xml file which was developed from this table for input into the ADx shell is shown below:

Screenshots of the shell display this information in a clear format.

4.5.ADx Version 1.0 user guide

[edit]

This user guide provides a walk-through of the Version 1.0 ADx tool, which is a prototype implementation of the ADx Shell, data input and output display steps. It provides a mock-up of the voting engine using information from the Tanzania NAPA case study (see above).

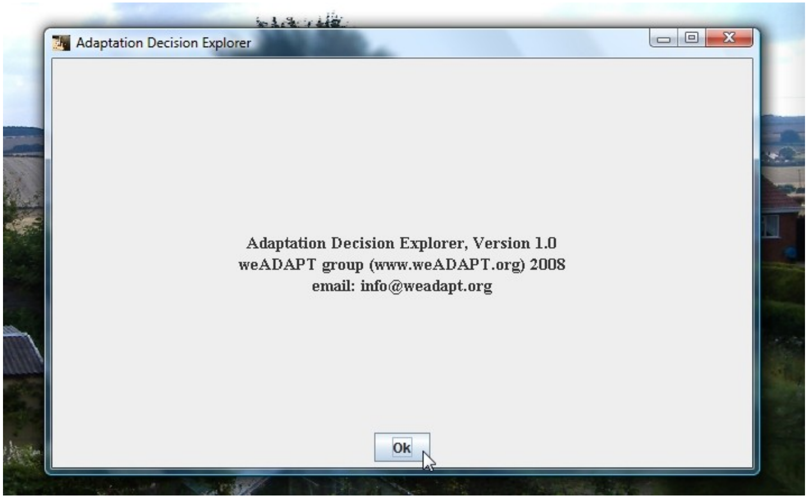
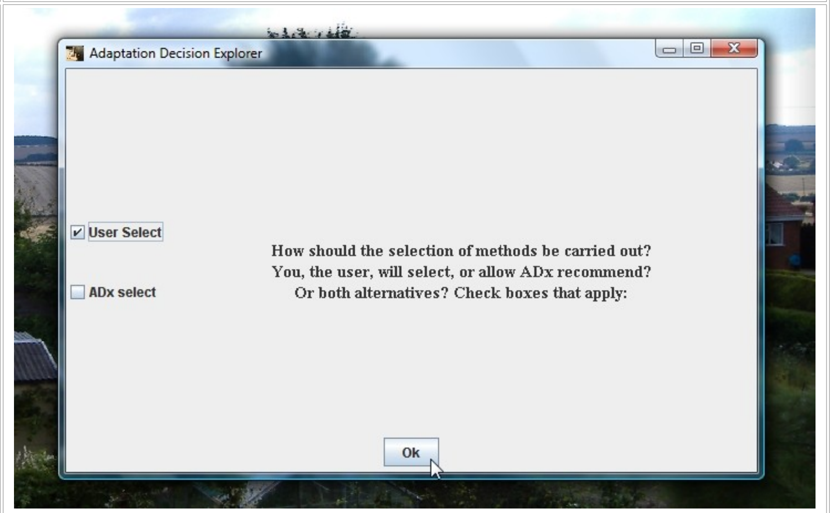
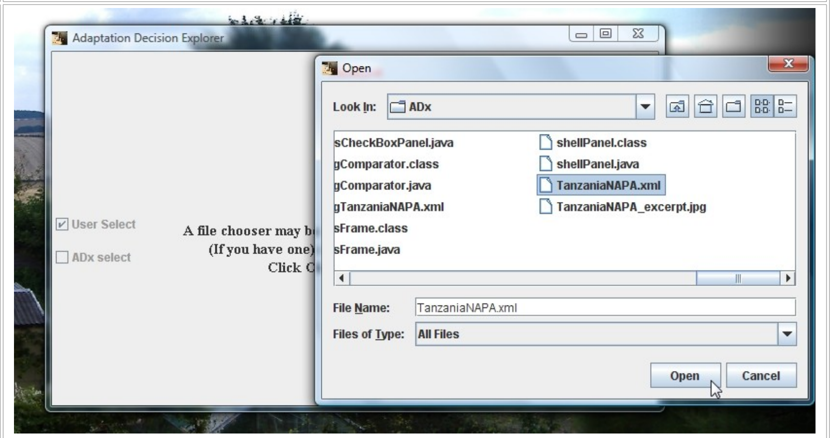
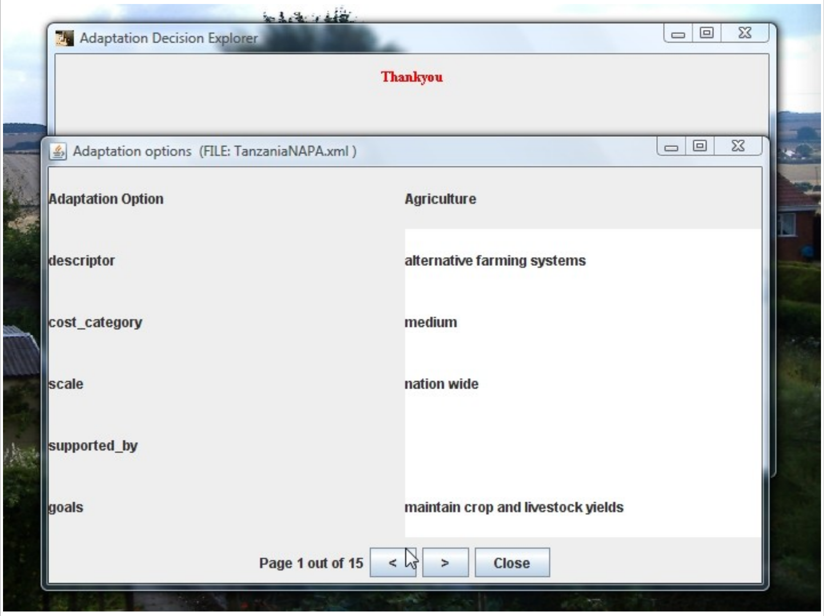
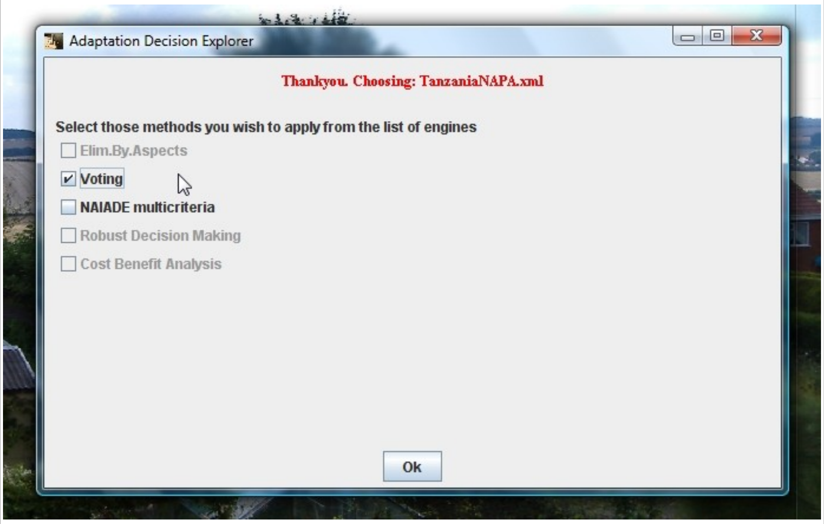


Figure 2 illustrates alternative methods by which the decision making engines may be selected. ADx auto-selection of methods is not implemented yet and user selection is limited to the "Voting" engine and to NAIADE engine.

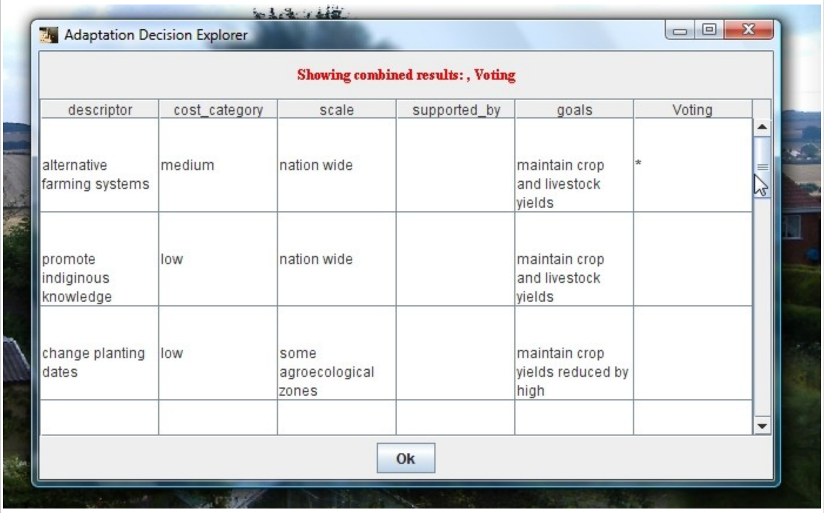


There is a file chooser enabled for selection of the input XML data. Selecting the file TanzaniaNAPA.xml and clicking "Open" will start the parsing of the XML which is recorded in a Java Document model.



This step opens a browser/explorer frame on the input XML data. On the bottom panel the left and right buttons allow the user to flip through the options of the NAPA. The information cannot, however, be edited in this implementation of the tool.	
User selection of engines is done with check boxes. Unavailable engines are greyed out. Selecting the "Voting" engine for the TanzaniaNAPA test case will start the mock-voting and display the results of the ranking exercise carried out in the NAPA case. Ticking the NAIADE check box will also start this engine in an external process (provided that it is installed in C:\Program Files).	
Final screen shows the combined results. The table allows comparison of options. Rows are adaptation options and the user can scroll to view these. It also allows comparison of the analytical engines used. Columns	

on the right of the table show engine results where a '*' indicates a preferred option (e.g. on the far right column under the "Voting" engine heading, the option "alternative farming systems" is a preferred one).



4.6.Development team

[edit]

Current implementation team members and their roles are:

Takeshi Takama
: PI, lead conceptual designer

Richard Taylor
: Implementing ADx concept into a Java software

Sukaina Bharwani
: Designing algorithms of ADx shell and engines

Fernanda Zermoglio
: Connection to Climate Change Explorer and climate uncertainties

Ruth Butterfield
: Testing a few case studies

The unique structure of the team will enhance the conceptualisation and development productivity of ADx and complement each others' skills to meet the requirements of the tool development. Takeshi Takama has worked various decision making related projects and he is familiar with numerous qualitative and quantitative decision making tools and approaches. For example, his PhD research included conceptual decision making and adaptation models as well as programming them as empirical models in Java, Perl, and R. Also, he worked model validation issues in a EU project namely CAVES. Richard Taylor is a serious computational modeller as well as a researcher in cognitive and environmental science. He has developed several Java models in large EU projects such as NeWater and ADAM. One of Sukaina Bharwani's specialisation is

Knets, which uses elimination by aspects. She is one of active developers of the tool and has tested the tool in several projects including her own PhD project. Fernanda Zermoglio is one of the original developers of The Climate Change Explorer Tool and another user friendly GIS tool namely AWhere. She examines not only physical uncertainties of climate change, but also social uncertainties such as vulnerabilities of local stakeholders. Ruth Butterfield has worked climate change and policy research in developing countries with several decision making/supporting tools namely The Climate Change Explorer Tool, Water Evaluation and Planning (WEAP), AWhere, etc. She is also involved in the development of matrix based decision making approaches related to ADx namely adaptation matrix and vulnerability matrix.

5.Future development of ADx

[edit]

The ADx described above is the first version and the tool will be continuously developed. There are types of development: 1) incremental improvement of each function and 2) replacement of some key functions.

Functions should be incrementally improved are:

- User friendly interface like CCE
- Linkage to CCE
- Number of engines and case examples

Good use interface is a key criterion to attract wider communities. ADx will connect CCE in the future and it will be easier for users to use the tools if both tools have the same (similar) interface. A linkage to CCE enable ADx to access to various accountable social and physical information especially ones related to climate change and vulnerability. Also, the connection will give an opportunity for ADx to map adaptation options in geographical space and compare them with other factors. It means that the connection between CCE and ADx will support time-line analysis as well as spatial analysis. One stunning future of CCE is a good graphic user interface and data visualisation. In fact, the visualisation of climate impacts becomes popular so the future will be a crucial attribute to ADx as well to attract many more users (e.g. 1, 2).

As ADx has more publicly available case examples, users will have more opportunities to learn from the examples. This is one of recommended approaches to make decision on social and environmental management issues (Lee 1999). If we have a series of case studies on adaptation to climate change, these become 'learning examples' where the decision makers and stakeholders explore processes of adaptation through questioning and browsing early cases (See more in Learning by example). The current format of XML probably needs to be revised to improve expandability, scalability, flexibility, and trustability as ADx collects more examples.

If we need to consider beyond the incremental improvement, i.e. the replacement of key function, the first option may be the alternation of the shell algorithm. Currently, we uses elimination by aspects to select appropriate engines, which are suitable for a particular situation of adaptation, and this approach is simple enough to select "good enough" engines, i.e. Keep it simple, stupid (Axelrod 1997). The elimination by aspects was started to explain an empirical phenomenon of multiple attribute choice, which could not explained by conventional approaches such as similarity effects (Tversky 1972); however, this approach cannot explain another choice effect such as attraction effect.

There has been more development in this field. A good approach is considered the one, which can explain empirical non-rational effects such as similarity effect, attraction effect, and compromise effect. Tversky and Simonson proposed a context-dependent advantage model, but this does not explain similarity effect (Tversky, Simonson 1993). Wedel proposed a dominance valuing model, which explained empirical results best amongst other proposal models (Wedell 1991). In the model, a decision maker changes his/her way of making decision based on contexts, i.e. the decision maker does not utilise all available information because of complex trade off, self-justification, etc. More recently, Roe, et. al proposed a multialternative decision field theory, which explains the all three effects (Roe, Busemeyer et al. 2001); however, this approach also has problem between empirical results and subjective decision making probabilities.

Hence, at this moment, there is no concrete alternative to elimination by aspects. This approach is probability a good enough approach as the shell of ADx. We will incrementally improve the algorithm of the shell and if it is necessary we will consider the alternative algorithms as there is a space to improve the approach of the shell.

5.1.Future mile stones and potential partnerships

[edit]

ADx is a collaboration effort to develop a software. This is not only because of case examples and list of engines, but also the the planning of future development. It is always wise to consult potential key users and to integrate their wealth of experiences to make a useful and usable product. As these collaborations take shape, much depends on clear leadership (specific people with resources, planning and reporting frameworks, shared work spaces, etc.). We would like to adept at matching strategy with resources with outcomes. Always a challenge, even more so if decision making is competitive for resources and stalled by extensive negotiations. Having said that, those 'on the ground' need will be necessary to produce a good tool.

We have contacted other potential partners and some partners may involve the development of ADx. This is still tentative schedule, but a long term versions of ADx based on potential partnerships are:

- ADx Light (next 6-12 month) -- developed by internal SEI team and some informal collaboration with external expert including the CCE team,
- ADx Gold (next 24 month) -- based on a partnership with Rand
- ADx Platinum (next 36 month)-- based on Google engagement with IIED, CLACC and others,
- ADx Titanium (next 36 month)-- might achieved with say ENDA, CIFOR and UCT integrating their wealth of experience

All this does require coordination of a technical nature and a long-term commitment through the project resources to recruit and train the very best staff to work on these challenging issues.

In these future versions, we are aiming to use the data reported to weADAPT. The potential testing cases will be:

- Mali Conditions and Trends- an assessment of vulnerability and climate change
- Nepal baseline vulnerability assessment and social indices.

The table below summarises the development plan of ADx Light (next 6-12 months). All development plans are ordinated by SEI Oxford; however, each case study partners has a responsibility and control on their case studies. Most software development will be done by SEI Oxford and they have responsibility to communicate with case study partners to check its usability and reflection to the reality and demands.

		Version 1.0 (End of July)	Version 1.5 (End of December)
Shell • To be developed in Java • Wizard to allow user to select engines and/or to accept recommendations based on user responses to series of questions		GUI will illustrate the concept using few buttons and radio buttons to select implemented engines. Unavailable engines will be listed but greyed out.	To prototype the filtering of methods to produce recommendations. Shell will prompt the user for information and will invoke 'elimination by aspects' or other expert system.
Engines (internal) • can programmatically access these engines	Eurovision based voting	JAVA program may be implemented in early version	
	Elimination by aspects	JESS/Scala or other program to be implemented by M. Fischer* how will data structuring be handled?	Explore alternatives to JESS for rule-based programming or implement procedurally in Java to avoid distribution issues.

		• Seminars tba	
Engines (external) • can launch from Java in a separate process and wait for response	NAIADE	Will start NAIADE	
	Robust decision-making		Engine based on RAND approach to be implemented
	Cost Benefit Analysis		Not scheduled to be implemented at the moment
Data		XML file format is preferred as input to shell. XML is parsed and then displayed in explorer. Output can also be produced in XML.	Other formats may be introduced and shell should be able to translate formats. Will be able to accept user input in text fields and record
Examples		Tanzania NAPA example shows adaptation options in agriculture. Findings include a ranking of options. This could be used in mock output in lieu of analysis by engines	Will be able to accept user input to shell and, e.g., add new adaptation options. In this way users will record their own reflections.
Documentation		Tool refers users to wikiADAPT	Incorporate menubar to bring up documentation on each engine.

6.Conclusion

[edit]

In summary, ADx first chooses appropriate methods to analyse and screen climate change adaptation options. In some cases, more than one method will be selected as long as these methods satisfy a user's or ADx's criteria. Then, the user receives appropriate and potential options s/he should consider. As these options are analysed by multiple methods, which consider multiple criteria, the selected options are more robust. Having said that, the selected options can be still too many to seriously consider. In this situation, ADx will help the user to make priorities by a visualised interface etc.

ADx will be developed continuously at least next 36 months. The tool still needs a lot of incremental improvements. The connection with The Climate Change Explorer Tool CCE should help visualisation issue and add other decision supporting functions. Also, more case examples and engines are required to promote the "learning by example" decision making approach. This improvement cannot be done solely by the internal development team; therefore, collaboration work with other research teams and the communities of potential users will be a key to the success of this tool development. The more popular the tool, the more success the tool is. A virtuous circle will start from here.

7.References

[edit]

ANSOFF, H.I., 1976. Managing Surprise and Discontinuity–Strategic Response to Weak Signals. *Zeitschrift für betriebswirtschaftliche Forschung,* **28**(1/76), pp. 129-152.

AXELROD, R., 1997. The Complexity of Cooperation. Princeton, NJ: Princeton University Press.

BREWER, J.D., 2005. Risk Perception & Strategic Decision Making: General Insights, a New Framework, and Specific Application to Electricity Generation Using Nuclear Energy.

GROVES, D.G. and LEMPERT, R.J., 2007. A new analytic method for finding policy-relevant scenarios. *Global Environmental Change,* **17**(1), pp. 73-85.

HOLTZMAN, S. and KORNMAN, K.S., 1992. Decision analysis for periodontal therapy. *Journal of dental education,* **56**(12), pp. 844-862.

KNIGHT, F.H., 1921. Risk, Uncertainty, and Profit. Boston, MA: Houghton Mifflin.

LEE, K.N., 1999. Appraising adaptive management. *Conservation Ecology,* **3**(2), pp. 3.

LEMPERT, R., NAKICENOVIC, N., SAREWITZ, D. and SCHLESINGER, M., 2004. Characterizing Climate-Change Uncertainties for Decision-Makers. An Editorial Essay. *Climatic Change,* **65**(1), pp. 1-9.

LEMPERT, R.J., POPPER, S.W. and BANKES, S.C., 2003. Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis. RAND Corporation.

PARSON, E.A., BURKETT, V., FISHER-VANDEN, K., KEITH, D.W., MEARNS, L.O., PITCHER, H.M., ROSENZWEIG, C.E. and WEBSTER, M.D., 2007. Global-Change Scenarios: Their Development and Use, Synthesis and Assessment Product 2.1 b. *Washington, DC: US Climate Change Science Program, July,* **10**.

POSTMA, T.J.B.M. and LIEBL, F., 2005. How to improve scenario analysis as a strategic management tool? *Technological Forecasting and Social Change,* **72**(2), pp. 161-173.

RAYNER, S. and MALONE, E., 1998. Ten suggestions for policymakers. *Human Choice and Climate Change,* **4**, pp. 109–138.

ROE, R.M., BUSEMEYER, J.R. and TOWNSEND, J.T., 2001. Multialternative decision field theory: A dynamic connectionist model of decision making. *Psychological review,* **108**(2), pp. 370-392.

ROSENHEAD, J., ELTON, M. and GUPTA, S.K., 1972. Robustness and Optimality as Criteria for Strategic Decisions. *Operational Research Quarterly (1970-1977),* **23**(4), pp. 413-431.

TVERSKY, A., 1972. Elimination by Aspects: A Theory of Choice. *Psychological Review,* **70**, pp. 281-299.

TVERSKY, A. and SIMONSON, I., 1993. Context-dependent preferences. *Management Science,* **39**(10), pp. 1179-1189.

VON NEUMANN, J. and MORGENSTERN, O., 1947. Theory of Games and Economic Behavior. *Princeton, NJ: Princeton,* .

WEDELL, D.H., 1991. Distinguishing among models of contextually induced preference reversals. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* **17**(4), pp. 767-778.