Environment, Development and Sustainability (2006)
DOI 10.1007/s10668-005-9002-7

CDM PROJECTS UNDER THE KYOTO PROTOCOL: A METHODOLOGY FOR SUSTAINABILITY ASSESSMENT – EXPERIENCES FROM SOUTH AFRICA AND URUGUAY

RENAT HEUBERGER[1,*], ALAN BRENT[2], LUIS SANTOS[3], CHRISTOPH SUTTER[1] and DIETER IMBODEN[1]

[1]*Environmental Physics, Department of Environmental Sciences, ETH Zurich, 8092 Zurich, Switzerland*

[2]*Life Cycle Engineering, Department of Engineering and Technology Management, University of Pretoria, 0002, Pretoria, South Africa*

[3]*Climate Change Unit, Ministry of Housing, Territorial Regulation and Environment, Montevideo, Uruguay, (*author for correspondence, e-mail: _renat.heuberger@myclimate.org; tel.: +41-79-549-39-51; fax: +41-1-6321691)*

(Received 22 December 2003; Accepted 10 July 2005)

Abstract. Under the Clean Development Mechanism (CDM) of the Kyoto Protocol, industrialised countries may finance greenhouse gases mitigation projects in developing countries. The Kyoto Protocol explicitly requires that the CDM shall assist developing countries to achieve sustainable development. However, a clear definition of sustainability for CDM projects is still debatable. MATA-CDM (Multi-Attributive Assessment of CDM Projects) is an approach that facilitates a quantitative assessment of potential projects regarding their contribution to sustainable development. This paper presents applications of MATA-CDM in two different countries. In South Africa, the application was done mainly for academic and demonstrative purposes, whereas in Uruguay it was implemented together with the responsible Designated National Authority (DNA). The work in both countries included the selection of sustainability criteria and measurable indicators. Experts weighted the criteria using personal interviews and a multi-stakeholder workshop. This method was applied to three potential CDM projects in South Africa and one in Uruguay. Results show that under the conditions of this study, the MATA-CDM approach yet fails to yield a perfect quantitative overall sustainability assessment of CDM projects but that several findings could be useful to further develop the approach with the aim to translate the vague term *sustainable development* to a mainstream project level. Valuable experience was in particular collected with different stakeholder processes to perform criteria weighting.

Key words: Clean Development Mechanism, Kyoto protocol, multi-attributive utility theory, stakeholder process, sustainability assessment.

Abbreviations: AHP – Analytic Hierarchy Process; CDM – Clean Development Mechanism; DNA: – Designated National Authority; MATA-CDM: – Multi-Attributive Assessment of CDM Projects; MAUT: – Multi-Attributive Utility Theory; UCC: – Unidad de Cambio Climatico (Climate Change Unit); UNFCCC: – United Nations Framework Convention on Climate Change.

1. Introduction

1.1. CDM and Sustainable Development

Under the Clean Development Mechanism (CDM) of the Kyoto Protocol, the so-called Annex-1countries[1] have the possibility to achieve part of their binding greenhouse gas emission reduction targets by financing project activities, which result in emission reductions in developing countries. The Kyoto Protocol states: "the purpose of the Clean Development Mechanism shall be to assist Parties not included in Annex I in achieving sustainable development..."

'Sustainable Development' encompasses a broad concept. If a CDM project shall be assessed regarding its sustainability effects in the host (developing) country, the concept thereof has to be discussed on an operative level.

The host country has to give an approval for each CDM project through its Designated National Authority (DNA). The definition of criteria that lead to an approval or a rejection of a project proposal is the responsibility of the host countries. The Marrakech Accords state: "... it is the host Party's prerogative to confirm whether a clean development mechanism project activity assists it in achieving sustainable development" (UNFCCC, 2001).

In many host countries that participate in the Kyoto Process, investigations are underway to find an appropriate procedure to perform sustainability assessments and several approaches to assess CDM projects have been proposed. The international NGO Southsouthnorth (SSN) established a widely recognised Sustainable Development Tool, which consists of eligibility screens, additionality filters, sustainable development indicators and operationality indicators (Thorne et al., 2001). The IER (Institute for Energy Economics and the Rational Use of Energy) in Stuttgart, Germany, described a set of ranking methods to assess the contribution of CDM projects to Sustainable Development (Thomas et al., 2001). The South African Energy and Research Development Centre (EDRC) in Cape Town presented methodological considerations for climate mitigation projects (Hirst et al., 1998) and later proposed a set of sustainability criteria to be applied on CDM projects (Spalding-Fecher et al., 2002). In South Africa, the government has proposed a list of sustainability guidelines (Directorate of Global Climate Change and Ozone Layer Protection, 2002) and a simple list of sustainability criteria is, for example, presented in the Indonesian National Strategy Study (State Ministry for Environment, 2001).

If successfully applied, a *quantitative* project assessment can provide more transparency and validity in the CDM approval process than the qualitative application of guidelines. The proposed approach (MATA-CDM, Multi-Attributive Assessment of CDM Projects) has been designed to allow a quantitative assessment of CDM projects, using the elements of the Multi Attributive Utility Theory (MAUT) as its basis. In particular, it combines the establishment of measurable sustainability indicators (for criteria) together with a weighting procedure to identify the relative importance of the respective criteria.

1.2. Application of the Sustainability Assessment Methodology in South Africa and Uruguay

The MATA-CDM approach was developed at the Department of Environmental Physics of the ETH Zurich. Environmental Physics group. It was first applied in South Africa in cooperation with the University of Pretoria, PricewaterhouseCoopers and Department of Environmental Affairs and Tourism (DEAT). A set of sustainability criteria and indicators was selected, thereby using existing work as reference. From different professional sectors, 32 persons have weighted the sustainability criteria in interviews. A parallel mailed survey targeted at criteria weighting in the manufacturing sector (Brent et al., 2005). The criteria were finally applied to three potential CDM projects, i.e. to an energy efficient technology in the ferrochrome manufacturing industry, a methane recovery project at a landfill site and a methane recovery project at a wastewater treatment plant. Although the newly established DNA participated in the research, the application in South Africa was merely done for academic and demonstrative purposes.

After the application in South Africa, the acting DNA in Uruguay showed interest in this sustainability assessment methodology. ETHZ and the Climate Change Unit in Uruguay (UCC) jointly supported its implementation in order to facilitate the approval of CDM projects in Uruguay. The stakeholder process to select sustainability criteria in Uruguay started in January 2003 and culminated with a criteria-weighting workshop at the end of April 2003. The criteria were then applied on one potential CDM project, where electricity is generated from rice husks. With yearly 379.8 Mt emissions of CO_2-equivalents, South Africa is a potentially large player on the CDM market (NSS, 2002). In comparison, Uruguay's energy sector emits in the order of 5.4 Mt annually (INGEI, 1998 and MVOTMA, 2002).

This paper provides a brief overview of the methodology of the MATA-CDM approach in Section 2. In Section 3, the application of the methodology in South Africa and Uruguay is presented. The outcomes and lessons that have been learnt during the application of MATA-CDM are discussed in Section 4.

2. The methodology of the MATA-CDM approach

There is no standardised, generally accepted measure for sustainability. If the implementation of a new development project is to be assessed regarding "sustainability", the concept must be concretised, i.e. values have to be defined. The methodology that is followed through the MATA-CDM (Multi-Attributive Assessment of CDM Projects) approach yields a country-specific sustainability assessment of potential projects under the Clean Development Mechanism (CDM).

The methodology is based on the multi-attributive utility theory (MAUT). The MAUT is a known set of methods to analyse situations and perform an evaluation process. MAUT measures the attractiveness (utility), of each option within a set of alternatives. In decision support applications, it is normally used to identify one

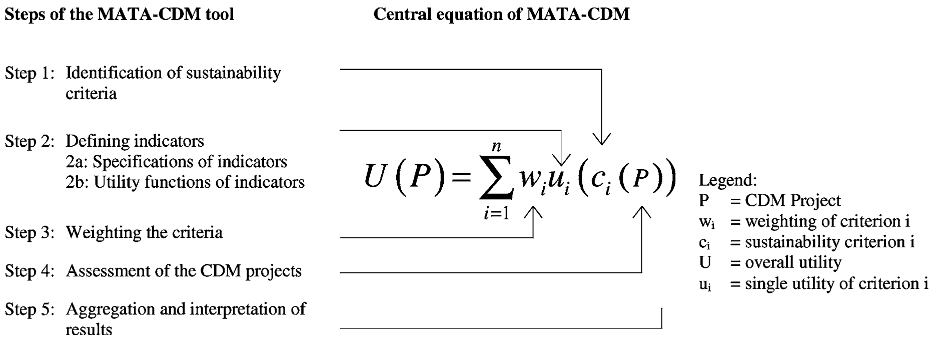

Figure 1. The five steps of MATA-CDM.

alternative that performs *best*. MAUT is, for example, documented in "embedded case study methods" (Scholz et al., 2002).

The aim of MATA-CDM is to assign a value to each project, which determines its *utility* in terms of a contribution to sustainable development of the host country. The utility U of a project P_i can be calculated with the central equation of MATA-CDM (Sutter, 2003). This equation is also the basis of the five steps that have to be conducted for the application of MATA-CDM.

The five steps that are applied through the MATA-CDM are shown in Figure 1. They are as follows:

1. *Identification of sustainability criteria*: The overall target of a "contribution to sustainable development in the host country" is divided into a hierarchical set of criteria (sub-targets).
2. *Defining indicators*: The criteria are associated with indicators, which can be applied on a project level. Indicators can either be quantitative or qualitative. The scales of these indicators, including maximum and minimum values, are identified.
3. *Weighting the criteria*: The criteria are weighted in order to determine their relative importance. The weighting can be performed as a stakeholder process.
4. *Assessment of the CDM projects*: The criteria are applied on CDM project proposals. The respective scorings of the projects can be displayed in a matrix.
5. *Aggregation and interpretation of results*: Results are aggregated and uncertainty is identified. Rules are defined, based on which the results lead to an approval or a rejection of the project proposal.

3. Application of MATA-CDM in South Africa and Uruguay

3.1. Identification of Sustainability Criteria

Much experience exists worldwide with sustainability assessments that measure the performance of a whole country or a region. To a lesser extent, assessments of the sustainability effects on a project level have been performed. Many authors have split the concept into a pre-defined set of criteria. Southsouthnorth (Thorne et al., 2001), Factor + Dasag (2001), the Institute for Energy Economics IER (Thomas et al., 2001), Spalding-Fecher et al. (2002) and the draft version of the Gold Standard (WWF, 2003) all referred to the classical division of sustainable development into the three pillars of social, environmental and economic aspects, which is in use since the establishment of the so-called Brundtland Report (WCED, 1987). The Indonesian National Strategy Study (State Ministry of Environment, 2001) used no classification, while Bossel (1999) and Villavicencio (2002) propose the concept of sustainability "orientors", dividing sustainable development into the aspects of Existence, Effectiveness, Freedom of Action, Security, Adaptability and Coexistence. Meadows (1998) proposes indicators for the categories Natural, Built, Human, and Social Capital and Well-being.

For the application in South Africa, a set of 12 sustainability criteria was derived from the mentioned literature and by expert interviews. This set of criteria was discussed and adjusted among over 100 experts on the Internet platform CDM-Connect (CDM-Connect, 2002). The set is shown in Table I. Brent et al. (2005) used a slightly modified set for their parallel survey in the South African manufacturing sector.

The Uruguayan Climate Change Unit used the same set as a starting point (UCC, 2003). Thereafter, a stakeholder consultation process was conducted to adjust the

TABLE I. Sustainability criteria used in South Africa and in Uruguay.

Criteria South Africa	Weight %	Criteria Uruguay, version April 2003	Weight %
Social Criteria			
Improved service availability	5.5	Employment generation	6.0
Equal distribution	12.6	Income of low resource population	5.2
Capacity development	7.1	Capacity development	5.0
Stakeholder participation	11.7	Technological self-sufficiency	5.0
		Impacts on the local population	5.6
Environmental Criteria			
Minerals/Energy resources	4.4	Use of renewable energies	7.0
Air quality	8.8	Air quality	5.9
Water resources	10.3	Water resources	7.7
Land resource	5.6	Land use	7.1
		Protection of biodiversity	6.2
		Energy efficiency	5.7
		Risk of environmental emergencies	5.7
Economic criteria			
Microeconomic efficiency	6.3	Microeconomic efficiency	6.8
Regional economy	5.0	Sustainability of pay balance	5.6
Employment Generation	15.1	Fiscal sustainability	4.5
Sustainable technology transfer	7.5	Economic efficiency	3.7
Political criteria			
		Citizen participation	4.6
		Participation of local authorities	3.4

The latter resulted from a stakeholder consultation process (NSS, 2003). Aggregated weights from AHP (South Africa) and from the workshop (Uruguay) are shown (see 4.2 for details).

criteria for specific circumstances of the country. Finally, the set was enlarged from 12 to 17 criteria. In particular, three environmental criteria were added, and the category of "political criteria" was introduced (see Table I).

3.2. Defining Indicators

It is crucial for the transparency of this sustainability assessment that each criterion is linked to a clearly defined indicator. An indicator measures to what extent a potentially eligible CDM project will meet the respective criterion. We distinguish three categories of indicators. They can be quantitative or qualitative in their assessment. Semi-quantitative indicators combine both quantitative and qualitative elements. Moreover, both types can either express an absolute value of the project, or they express a relative change to a reference scenario (baseline). In Table II, all indicators used in South Africa and Uruguay are categorised.

MATA-CDM is able to aggregate quantitative indicators with different scales as well as qualitative indicators. Thereby, the performance of a project in each indicator is transformed into a so-called "utility". The scale ranges from -1 to $+1$, where an utmost satisfactory project would earn the maximum utility of $+1$ and a project with neither positive nor negative effects the medium utility of 0.

3.3. Weighting the Criteria

According to the specific conditions of a country or a region, the relative importance of each criterion will differ. To take these differences into account, the presented approach includes a weighting step, in which the relative importance of each criterion is identified.

In the MAUT, criteria are arranged in hierarchical levels and weighting is done on each level separately. Weighting starts at the lowest level, where (if available) sub-criteria are weighted against each other, and it ends on the highest level, where participants can weight the sustainability categories themselves. This concept can be infinitely extended, by splitting a sub-criterion again in a group of weighted

TABLE II. The indicators are categorised according to their scales. (SA): Criterion only used in South Africa. (Ur): Criterion only used in Uruguay.

Indicators	Quantitative	Semi-quantitative	Qualitative
Scale relative to baseline	Employment generation	Air quality	Capacity development
	Equal distribution	Water quality	Impacts on local population (Ur)
	Mineral/Energy resources	Land resources	
	Energy efficiency (Ur)	Service availability (SA)	
Absolute scale	Microeconomic efficiency	Regional economy (SA)	Stakeholder/Citizen participation
	Economic efficiency (Ur)		Sustainable technology transfer environment emergencies (Ur)
	Fiscal sustainability (Ur)		Biodiversity (Ur)
	Sustainability of pay balance (Ur)		Participation of local authorities (Ur)

sub-sub-criteria. Figure 2 illustrates this concept. The final weight w of a sub-criterion is calculated by:

$$w = w_c \cdot w_{ca} \cdot w_{cax} \cdots$$

where

w_c = the relative weight of the category c
w_{ca} = the relative weight of the criterion a in category c
w_{cax} = the relative weight of the sub-criterion x of criterion a in category c

In Uruguay, the criteria of ''water resources'' and ''land use'' had been divided into sub-criteria. Nevertheless, weighting was only done on category and criteria level to reduce the amount of work for the participants to perform the weighting steps. It is clear that sub-criteria must be included into the weighting system, if a substantial amount of criteria are further divided.

There are several methods to perform the criteria weighting. Some of them, which are suitable for sustainable development assessments of CDM projects, have been described in the SUSAC ranking methodologies (Thomas et al., 2001). In the application on South Africa and Uruguay, two methods were used that both provide quantitative results: Direct Weighting and the Analytic Hierarchy Process (AHP).

With the *Direct Weighting* method, the participants distribute percental weights to the criteria. The total of the distributed numbers must be 100 points. The participants are asked to normalise the values themselves, as the weights they can distribute must add up to a pre-defined total.

The *Analytic Hierarchy Process (AHP)* has been introduced by Saaty (1980 and 1986). Participants compare the criteria pair-wise. Each criterion is weighted relative to all other criteria of the same level, and the results are listed in a matrix. An algorithm based on the eigenvalue of this matrix can finally be used to calculate the relative weight of the criterion (Triantaphyllou, 2000).

In both Direct Weighting and AHP the evaluator can combine the individual judgements to calculate the combined preferences of a pre-defined group. Bolloju

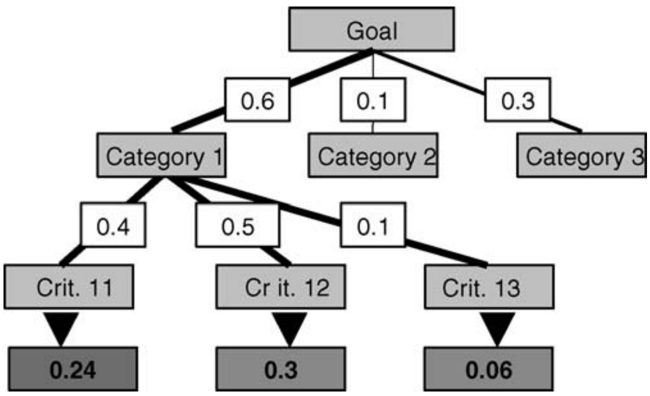

Figure 2. To calculate the weight of a criterion, all importance weights along the line up to the goal are multiplied.

(2001) shows that the arithmetical mean is an appropriate choice to calculate the combined values of different participants. To combine the values in AHP, it has been shown that it is better to use the calculated relative weights, rather than the pair-wise comparisons (Forman, 1998).

Personal interviews in South Africa

The primary target-group for this application were individuals, who are involved in the CDM mechanism. In addition, a selected group of teachers at an elementary school in a township near Pretoria (the capital) completed questionnaires. Both Direct Weighting and AHP were used in the interviews. To reach a balance between people from different sectors, we distinguished the participants according to their field of activity: Government (7 participants), business (consisting of industry and services, 6), NGOs (9), university (6), as well as a group from a township (4). Of the 32 questionnaires, 26 were completed in face-to-face interviews. Of the 32 persons who participated in the survey, 8 had to be excluded, because the internal inconsistency in their answers proved to be too high. It is an advantage of AHP that internal inconsistency of the answers can be quantified by calculating a consistency ratio of individuals (Saaty, 1987). Using AHP, the participants in the survey gave the highest priority in the social category to "capacity development" with 32%. The environmental sub-criterion "local water quality" was highest in its category with 38%. In the economic category "employment generation" was clearly shown (42%) to be the most important sub-criterion. Direct Weighting resulted in the same ranking of criteria. However, the weights were closer together. This fact is illustrated in Figure 1, where the weighting values of the environmental sub-criteria are compared. The aggregated weights from the AHP survey are shown in Table 1. The overall most important criterion was "employment generation" with 15% of the total aggregated weight.

Mailed questionnaire in South Africa

Parallel to the interviews the University of Pretoria performed criteria weighting using AHP (Brent et al., 2005). Thereby questionnaires were mailed to financial directors and managing directors in the manufacturing sector. The 56 returned questionnaires were used for calculation. Within the social category, "capacity development" was shown to be the most important with 38%, within the environmental category, "water quality" scored highest with 42%, and the economic category was dominated by the "macroeconomic growth potential" sub-criterion with 34%. As the social and the economic criteria varied slightly, a direct comparison of the overall weight values of the sub-criteria with the face-to-face interviews is only possible for the environmental sub-criteria (see Figure 1). The individual priorities of the participants of the survey were not obtained for the three main categories.

Weighting workshop in Uruguay

Criteria weighting in Uruguay was done within a multi-stakeholder workshop organised by the Designated National Authority (DNA). 36 representatives from different professional sectors weighted in three groups according to the Delphi

System, in which each category of criteria is weighted twice with an open discussion between the two rounds of weighting. In Uruguay, "employment generation" was indicated to be the most important social sub-criterion, "water quality" scored highest of the environmental sub-criteria (all environmental criteria were very close together), the most important economic criterion was "microeconomic efficiency", and "citizen participation" was the more important of the two political criteria. With 7.7% "Water quality" was the most important overall aggregated criterion (all aggregated weights are shown in Table 1).

There is evidence that the explicitness with which participants express their preferences to some extent depends on the weighting method. In the study, four different weighting methods have been used. To illustrate this fact, Figure 3 shows the relative weights of the environmental criteria "water", "air", "land" and "resources", which were common in the four surveys. To make the Uruguayan set comparable to the South African, these four criteria have been aggregated to 100%, while the three remaining criteria have been neglected in Figure 3. Participants expressed their preferences clearer in pair-wise comparisons (AHP) compared to the Direct Weighting method, where trade-offs between the criteria are more obvious. Also, participants seem to weight more evenly if an interview partner or even a working group is present.

Uncertainty analysis in weighting

In the case of Uruguay, a panel of experts has weighted the criteria. If it is assumed that the weighting panel is representative for the whole population (e.g. it is democratically elected or constituted after defined rules that ensure representation of all major stakeholders), the final weights can simply be calculated as the average weights of all representatives. This was not the case in Uruguay, where the panel of experts was merely selected by invitation of UCC. In contrast, if the participants of the weighting panel are selected randomly, as was partly the case for the face-to-face interviews in South Africa, the panel represents an estimate of the 'true' population. The smaller the sub-sample relative to the whole population, the larger is the uncertainty of this estimate. Then the application of weights is only justified, if the mean weights assigned by the participants, i.e. the estimates of the 'true' values, are significantly different from the 'equal weight hypothesis'.

3.4. Assessment of the CDM Projects

The described assessment method was applied to three potential CDM project proposals in South Africa. The method is supposed to be applied to all future CDM projects in Uruguay before approval. So far it has been tested and applied to one potential project.

SA Project 1 – energy efficient tunnel kiln for a ferrochrome production facility

Compared to the widely used traditional technology (pelletrising sintering), the production of chrome can be made more energy efficient by reducing the ore in a tunnel kiln. The significant savings of energy result in a reduction of CO_2-emissions. For a particular project in South Africa, Morrison et al. (2001) estimate from a LCA analysis a potential CO_2-reduction of 138,000 t per year. The project has maximum utilities in the economic criteria *Regional Economy*, *Microeconomic Efficiency* and *Technology Transfer*. Except for *Capacity Development*, utilities in social criteria are only medium (indifferent).

SA Project 2 – methane capturing and electricity generation in waste water plant
In a wastewater plant of a township, capturing of methane can offset 5150 t CO_2 equivalents per year (RRS, 2002). Electricity generation with biogas offsets another 650 t CO_2 per year (Winkler et al., 2001).[2] The project has maximum score in *Employment Generation*, but utilities in *Microeconomic Efficiency* and *Air Quality* are lower than medium.

SA Project 3 – methane capturing and electricity or fuel generation on landfill site
Capturing of methane rich landfill gas accounts for 48,000 t CO_2 equivalents per year, which is the major part of the GHG reductions (Gutzwiller, 2001). A further reduction can be achieved either through converting the landfill gas into fuel for trucks or through generating electricity. The replacement of diesel thereby reduces another 16,500 t CO_2 equivalents per year, while the electricity generation with biogas would reduce another 18,500 t CO_2 per year. The landfill project scores maximum in *Microeconomic Efficiency*, but low in *Air Quality*.

Uruguay – electricity generation from rice husks
Near a major rice mill, the project developers plan to develop a small (1 MW) plant to produce electricity from rice husks (Calagua, 2002). The project would offset about 4,900 t CO_2 equivalents per year, as the electricity would otherwise have to be generated from natural gas. The project has maximum values in *Energy Resources* and *Employment Generation*. Utilities in *Economic Efficiency* and *Pay Balance* are lower than medium. Under the current proposal, the political criterion *Citizen Participation* has the lowest utility of zero.

3.5. Aggregation and Interpretation of Results

As discussed in Section 3, the overall utility U of a project P is calculated as the sum of all weighted utilities of the project. The South African Chrome Plant has a utility of 0.34, the Waste Water Plant 0.42 and the Landfill Site 0.32. The utility of the Uruguayan Rice Husk Project is 0.16. Note that different criteria are used in South Africa and in Uruguay. A direct comparison of the assessments in Uruguay and South Africa has therefore only limited practical meaning. Figure 4 provides an overview of the overall utilities of the four projects. Due to the large weight of *Employment Generation* in the South African criteria set, the wastewater plant project yields the highest utility of the four projects.

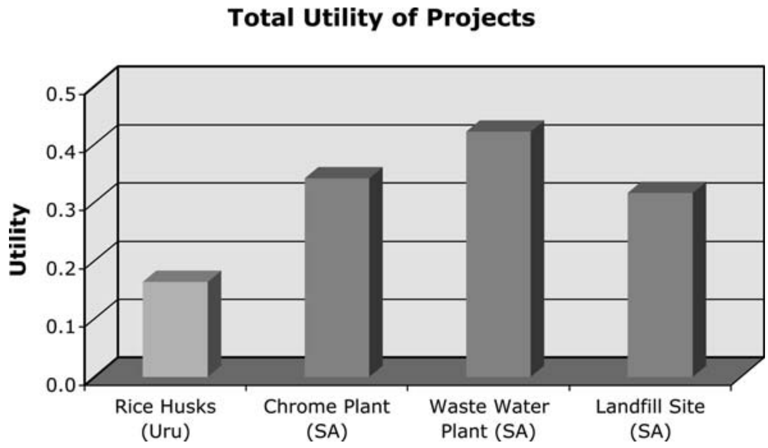

Figure 4. Total utilities in contributing to sustainable development of three South African and one Uruguayan project. The maximum utility is +1, the minimum utility −1. In a project with the medium utility 0 positive impacts just outweigh negative ones.

To get a clearer picture of the sustainability aspects of the projects in each category, a "sustainability profile" can be plotted. In Figure 5, the aggregated utilities in each category are shown for the four projects.

There are two types of uncertainties linked to the final score, the utility of a project: Uncertainty in weighting (Δw), and uncertainty in project assessment (Δu).

If the participants in the weighting process are considered as a statistical sample, a confidence interval of the weights must be taken into account. Δw is an intrinsic part of the methodology, which reflects the fact that a statistical sample cannot exactly mirror the opinion of the entire population. Uncertainty in weighting could only be

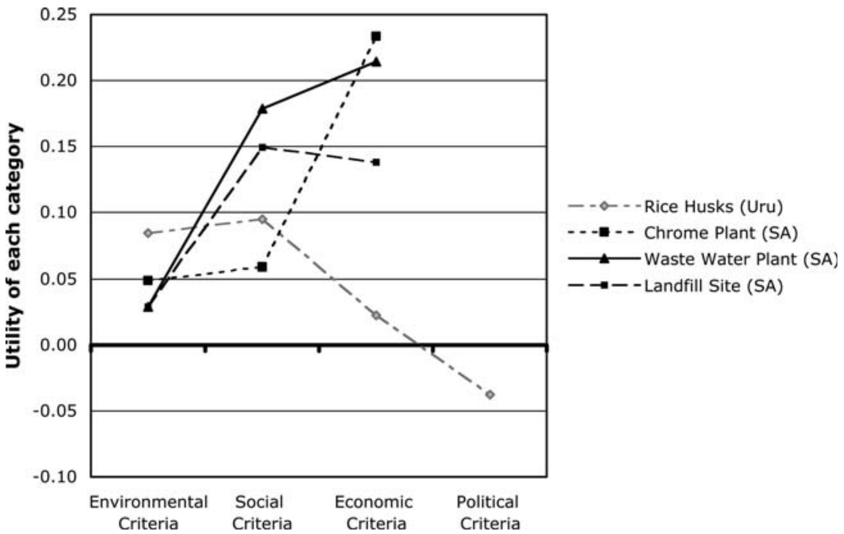

Figure 5. Utilities in each sustainability category of three South African and one Uruguayan project.

omitted if a politically legitimated body, for example a parliament, did perform the weighting process, as the entire population would delegate its "opinion" by democratically electing its representatives.

Uncertainty in project assessment results from two sources: First, the database used to identify the scores was in some cases incomplete. This is especially true for the Uruguayan Rice Husk Project, which is still in a very early stage. Second, the application of the indicators, especially of qualitative ones if their scale is not perfectly elaborated, may vary between different evaluators. In contrast to Δw, the size of Δu can be further reduced by elaborating more sophisticated indicators and scales, and by improving the database of the single projects.

Sutter (2003) calculates the uncertainty of the overall utility of a project ΔU by:

$$\Delta U = \sqrt{\sum_{i=1}^{n} (u_i \cdot \Delta w_i)^2 + \sum_{i=1}^{n} (w_i \cdot \Delta u_i)^2}$$

where Δw_i is the uncertainty of weightings, and Δu_i is the uncertainty in project assessments, which results from data uncertainty and from differing estimations of evaluators. Only limited knowledge about the size of Δu is currently available. As a first approach, Sutter (2003) assumed Δu to be criteria-specific and made estimations for Δu for the 12 criteria that were used in South Africa. The resulting total ΔU is 0.049 for the ferrochrome project, 0.056 for the wastewater project and 0.048 for the landfill project. As the confidence intervals of the three South African projects overlap, it is concluded that a distinction of the utility of the projects under consideration is not possible. Even if it is assumed that a politically legitimated body conducted the weighting and the uncertainty in weighting is zero (i.e. we can omit the first summand in the equation above) the confidence intervals of the projects still overlap.

Finally, there is an intrinsic uncertainty of the assessment: as there is still limited experience with evaluating projects, the scales of the indicators are rather arbitrary. Future applications should, for example, bring clarity for the indicator 'employment generation': how many jobs must a certain project generate in order to deserve the maximum utility?

4. Conclusions

A test-application of the MATA-CDM (Multi-Attributive Assessment of CDM Projects) approach has been performed in South Africa (September 2002), and an implementation has taken place with the Designated National Authority DNA of Uruguay (January to May 2003). The approach aims to assess a potential CDM project regarding its direct effects on sustainability issues that are important for the implementing (or host) country. The methodology consists of five steps: (1) identification of sustainability criteria, (2) defining indicators, (3) weighting the criteria, (4) assessment of the CDM projects, and (5) aggregation and interpretation of results. The approach is discussed with regards to the significance and practicability and its potential to include public participation. Finally, recommendations for further use of the MATA-CDM approach are provided.

4.1. Significance and Practicability of the Approach

The final results of the application in South Africa indicate that the three assessed CDM projects are not distinguishable in terms of their contribution to sustainable development. Under the conditions of this study, the MATA-CDM approach as described in Section 2 has yet failed to yield a perfect quantitative overall sustainability assessment of CDM projects. Nevertheless, several findings could be useful to further develop the approach with the aim to translate the vague term *sustainable development* to a mainstream project level:

The major challenge to ensure the transparency of assessments arises from the limited availability of data in the early stages of project development as well as the limited amount of reference projects. Using a database, where CDM projects are grouped according to the implemented technology, calculation methods could be standardised and data uncertainties could be reduced.

To minimise uncertainties and ensure significance of results, MATA-CDM requires a clear definition of indicators. Wherever possible, indicators should be measurable with a quantitative formula. If the indicator must be defined qualitatively, a clear scale should be agreed on, which allows a transparent and robust assessment. In this sense MATA-CDM is similar to the Sustainable Development Tool proposed by Southsouthnorth (Thorne et al., 2001).

In both countries the majority of participants judged the amount and the diversity of the chosen criteria as comprehensive enough. However, the approach can only measure the project's direct impacts regarding the given criteria. From the research experience, any attempt to account for more complex interrelations, which try to include indirect impacts, would lead to an unsatisfactory loss of transparency. Therefore, it is concluded that the approach cannot measure "the project's impacts on sustainable development in the host country", but it can measure "the project's direct effects regarding a weighted set of social, environmental and economic criteria".

It might therefore even be advisable to no longer try to find a sustainability assessment tool that is valid for all types of project at the same time. We recommend defining separate sets of criteria for different project categories. Thereby, the focus could be laid on notoriously critical criteria such as the *sustainable use of forests* for biomass fuelled power plants.

A further conclusion is related to the size of the implementing country. It was obvious that in South Africa with its large and heterogeneous population, a process to agree on CDM approval rules was, and still is, very difficult. To be implemented in South Africa, MATA-CDM would have to be adjusted. For instance, because of varying population structures, different sets of weights could be used in different provinces. In a small country such as Uruguay, MATA-CDM proved to foster a very constructive stakeholder process that led to a conclusion within a reasonable time frame.

Finally, the required effort to apply the indicators on the CDM project proposals proved to be reasonable both in South Africa and in Uruguay. This finding is important insofar as high transaction costs are a currently a serious challenge in the CDM process.

4.2. Stakeholder Participation

In the discussion about a sustainability assessment for CDM projects, NGOs in South Africa and Uruguay have repeatedly expressed their demand to participate in the definition of the respective rules. As described by Scholz (2002), the Multi-Attributive Utility Theory, which is the basis for MATA-CDM, foresees a criteria-weighting step, where the preferences of different stakeholders can be included efficiently (Scholz et al., 2002).

In all applications, the weighting step proved to facilitate an efficient and satisfactory stakeholder process. It was found that the weighting process was too complex for those participants in South Africa, who did not have a certain background in sustainability issues. The experts participating in the weighting workshop in Uruguay proved to be well informed, and the process was simple enough to be comprehended.

It was found that stricter rules are required to guarantee a representative composition of the participants, which weighs the criteria. Experience in Uruguay showed that it is feasible and rewarding to extend stakeholder participation beyond criteria weighting. Both the selection of criteria and the rules to aggregate the assessment results and derive a CDM project approval/rejection decision, underwent an auditing process among relevant stakeholders. Procedures fore these processes could even improve the efficiency of participation.

According to stakeholders in the Uruguayan weighting workshop, the quantitative mapping of relevant sustainability aspects is sufficiently transparent. The AHP weighting method, especially for non-experts, is easier to comprehend, and according to Millet (1997) provides more accurate results than Direct Weighting. On the other hand the latter method is superior in terms of transparency as participants directly see the results of their weighting. The major problem with Direct Weighting is, however, that it tends to lead to equalised weightings, whereby the influence of the weights on the overall results become marginal. Figure 3 has shown this effect for four selected environmental criteria.

Although the stakeholder process becomes less comprehensive and thereby probably less satisfactory for the individuals, we recommend committing the criteria weighting process to a politically legitimated body (see 3.5) or to a stakeholder forum, whose members are nominated according to clear rules.

4.3. Further Use of the MATA-CDM Approach

Both in South Africa and Uruguay NGO representatives questioned the stringency of MATA-CDM, as the methodology allows for trade-offs between different sustainability criteria. To increase stringency, we strongly recommend extending the approach by formulating certain 'restrictive criteria' or 'threshold criteria', which for every project would be mandatory to meet. An (aggregated) overall utility measure may serve as additional information.

To reduce transaction costs we recommend distinguishing between critical and non-critical criteria. In particular, notoriously critical criteria must be carefully looked at, and should ideally be equipped with a minimum threshold value.

The DNA of Uruguay has used the presented methodology to develop a tool for CDM project approval. Experience from Uruguay will hopefully help minimizing the existing uncertainties and especially establishing robust scales for the indicators. MATA-CDM is applicable beyond a simple approval or rejection decision: based on its results, projects can be prioritised. Quality standards for CDM projects like the Gold Standard of the WWF (2003) or private CDM funds could use the approach to transparently identify sustainable CDM projects.

Notes

[1] Countries listed in Annex-1 of the UNFCCC include all industrialised countries as well as countries with economies in transition.

[2] This project is most likely too small to be elected as a CDM project.

References

Bolloju, N.: 2001, "Aggregation of analytic hierarchy process models based on similarities in decision makers' preferences" in Elsevier Science B.V., *European Journal of Operational Research* **128,** 499–508.

Bossel, H.: 1999, *Indicators of Sustainable Development: Theory, Method, Application, A Report to the Balaton Group*, Winnipeg, International Institute for Sustainable Development.

Brent, A.C., Heuberger, R. and Manzini, D.: 2005, 'Evaluating Projects that are potentially eligible for Clean Development Mechanism (CDM) funding in the South African context: A case study to establish weighting values for sustainable developement criteria'. *Environment and Development Economics* **10**(5) 631–649.

CDM-Connect: 2002, *Discussions on Sustainability Assessment of CDM Projects*, World Business Council for Sustainable Development, https://www.cdm-connect.org.

Calagua: 2002, *Project Idea Note: Small Plant for Electricity Generation from Rice Husks,* Bella Unión Artigas, Uruguay.

Directorate of Global Climate Change and Ozone Layer Protection: 2002, *Approval Criteria for CDM Project, draft for Discussion by the Government Committee on Climate Change*, Pretoria, South Africa.

Factor Consulting + Management AG, Dasag Energy Engineering Ltd: 2001, *Small-Scale CDM Projects Opportunities and Obstacles*, Zurich, Switzerland.

Forman, E. and Peniwati, K.: 1998, "Aggregating individual judgments and priorities with the analytic hierarchy process" in Elsevier Science B.V., *European Journal of Operational Research* **108,** 165–169.

Gutzwiller, L.: 2001, *Energy Recovery from Landfill Gas in Eastern Gauteng, South Africa, Diploma Thesis for W19*, Zürich, Switzerland, Fachhochschule.

Hirst, J. and Fecher, R.: 1998, *Developing AIJ criteria and institutions for South Africa*, University of Cape Town, Energy & Development Research Centre.

INGEI: 1998, *Third National Inventory of Greenhouse Gases, Ministerio de Vivienda*, Montevideo, Uruguay, Ordenamiento Territorial y Medio Ambiente.

Meadows, D.: 1998, *Indicators and Information Systems for Sustainable Development, A report to the Balaton Group*, Hartland Four Corners, The Sustainability Group.

Millet, I.: 1997, 'The Effectiveness of Alternative Preference Elicitation Methods in the Analytic Hierarchy Process', *Journal of Multi-Criteria Decision Analysis*, **6**, 41–51. Penn State Erie, The Behrend College, School of Business, Erie.

Morrison, A.M. and Singh, V.: 2001, *An LCA Evaluation of Ferrochrome Production Processes*, Pretoria, South Africa, CSIR Process Technology Centre.

MVOTMA: 2002, *Estudio de apoyo a la aplicación del Mecanismo de Desarrollo Limpio del Protocolo de Kioto en Uruguay, Ministerio de Vivienda*, Montevideo, Uruguay, Ordenamiento Territorial y Medio Ambiente.

National Strategy Study NSS: 2003, *National Strategy Study for the Application of the CDM in Uruguay*, Montevideo, Uruguay, Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente.

National Strategy Study NSS: 2002, *South African National Strategy Study on the Clean Developoment Mechanism*, prepared for the South African Department of Environmental Affairs and Tourism & The World Bank, Johannesburg, South Africa.

Resource Recovery Systems (RRS): 2002, *Electricity generation from methane from anaerobic digester gas*, Detailed Project Proposal for Johannesburg Climate Legacy, Midrand, South Africa, 2002.

Saaty, T.L.: 1980, *The Analytical Hierarchy Process*, New York, McGraw-Hill.

Saaty, T.L.: 1986, 'Absolute and relative measurement with the AHP', *Socio-Economic Planning Sciences* **20**(6), 327–331. Graduate School of Busines, Univ. of Pitsburg.

Saaty, T.L.: 1987, 'The Analytical Hierarchy Process – What it is and how it is used'. *Mathematical Modelling* **9,** 161–191.

Scholz, R.W. and Tietje, O.: 2002, *Embeded Case Study Methods: Integrating Quantitative and Qualitative Knowledge*, Sage Publications, Inc.

Spalding-Fecher R., Clark A. and James B.: 2002, 'Economic assessment and development evaluation of climate change mitigation projects in South Africa' in O. Davidson and D. Sparks (eds.), *Developing Energy Solutions for Climate Change: South African Research at Edrc Energy and Development Research Centre*, University of Cape Town, pp. 20–43.

State Ministry for Environment: 2001, *National Strategy Study on the Clean Development Mechanism in Indonesia*, Jakarta, Indonesia.

Sutter, C.: 2003, *Sustainability Assessment of Energy related Projects under the Clean Development Mechanism of the Kyoto Protocol*, Zurich, Switzerland, Dissertation submitted to the Swiss Federal Institute of Technology.

Thomas, F., Ulrich, S. and Schlenzig, C.: 2001, *Ranking Methodologies for Sustainable Development and CDM Project Checklists*, Stuttgart, Germany, Start-up Clean Development Mechanism in ACP Countries (CDM-SUSAC).

Thorne, S. and Raubenheimer, S.: 2001, *Sustainable Development (SD) appraisal of Clean Development Mechanism (CDM) projects – experiences from the SouthSouthNorth (SSN) project*, Cape Town, South Africa.

Triantaphyllou, E.: 2000, *Multi-Criteria Decision Making Methods: A Comparative Study (Applied Optimization: Volume 44)*. Kluwer Academic Publishers, November 2000.

UCC: 2003, *Propuesta de criterios de desarrollo sostenible para la aprobación de proyectos en el marco del Mecanismo para un Desarrollo Limpio*, Montevideo, Uruguay, Unidad de Cambio Climatico.

UNFCCC: 1997, *Kyoto Protocol to the UN Framework Convention on Climate Change*, New York, United Nations.

UNFCCC: 2001. *The Marrakech Accords + the Marrakech Declaration*, New York, United Nations.

Villavicencio, A.: 2002, *The Sustainability of the Zafrana Project, UNEP Collaborating Centre on Energy and Environment*, Denmark, University of Risoe.

World Commission on Environment and Development WCED: 1987, *Our common future*, Oxford University Press, p. 47.

Winkler, H., Spalding-Fecher, R., Sathaye, J. and Price, L.: 2001, *Multi-project baselines for potential Clean Development Mechanism projects in the electricity sector in South Africa. Research by the Lawrence Berkeley National Laboratory*, Berkeley CA, (LBNL).

WWF: 2003, *The Gold Standard: Quality Standards for CDM and JI Projects, Draft Version*, WWF International.