

Journées PROMÉTHÉE

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**PROMÉTHÉE 1 - Methodology:
PROMÉTHÉE**

A PROMETHEE software timeline

Bertrand Mareschal

ULB – Solvay Brussels School of Economics & Management

bmaresc@ulb.ac.be

Abstract

Important elements for the success of the PROMETHEE methods have been the development of numerous extensions and interactive software.

The purpose of the paper is to show the evolution of the PROMETHEE methods and of their software implementation over time.

Starting with PROMCALC and the first visual sensitivity analysis tools (Walking Weights), we stress less known extensions of the methodology including a.o.:

- The introduction of variable (percentage) thresholds in the preference functions in PROMCALC.
- The hierarchical criteria structure first available in the Decision Lab software.
- The group decision extension of PROMETHEE and GAIA introduced in Decision Lab.

We then focus on the current Visual PROMETHEE software that includes:

- New visualizations of the PROMETHEE rankings.
- Visual weight sensitivity analysis.
- Enhancements of the GAIA analysis.
- Improved group decision features.
- GIS-integration of PROMETHEE and GAIA with Google Maps.
- Unified PROMETHEE Sort procedure for sorting problems.
- Efficiency (input/output) analysis.

We conclude by outlining the future of PROMETHEE software, especially the features that will be available in Visual PROMETHEE 2.

Axiomatic approaches to PROMETHEE

Marc Pirlot
Université de Mons, Belgium

Characterizing multiple criteria aggregation methods by means of axioms has several benefits. Two of the most important are the following:

- getting a clearer understanding of the conditions under which a given aggregation procedure can be advisedly used;
- providing a precise interpretation of the parameters of the aggregation method, which can help driving their elicitation procedure and avoiding ambiguities.

The universal recognition of the Additive Value Function model is partly due to the existence of meaningful axiomatic characterizations for this model, which led for instance to a precise understanding of the tradeoffs idea.

Is there some sort of characterization of the PROMETHEE method? Actually, several approaches can be followed to give axiomatic characterizations of PROMETHEE or of methods close to it.

It should first be noted that different sorts of axiomatizations can be given for a specific method. One consists of characterizing a particular procedure as a mechanism taking as input an alternatives performance matrix and some other information (e.g. information about the importance of the criteria, information about the nature of the criteria evaluation scales) and transforming this into an output that can be e.g. an overall score assigned to each alternative or an overall preference relation. Along this line, Marchant (1996) published a characterization of the “generalized Borda method” which has close connections with PROMETHEE. The aggregation method is characterized by some of its properties which, basically, describe how the method deals with the input data to produce the output.

Another line of thought, in an axiomatization perspective, consists of characterizing the overall preference relations that can be represented by means of a given aggregation model. This approach provides ways of testing, by asking appropriate questions to the decision maker, whether his/her preference could be possibly represented using the model. Usually such characterizations belong to the theory of *conjoint measurement* (Krantz et al., 1971). This theory essentially deals with the question of measuring multidimensional objects, such as alternatives assessed on several criteria.

To date, no such characterization has been established for the whole PROMETHEE method. However, we may look at PROMETHEE in a different way, i.e. as a two-phase method. In a first step, PROMETHEE produces a valued (outranking) relation, which

represents the intensity of the preference of each alternative w.r.t. every other. This relation is exploited in a second step, yielding a complete ranking (this is the case for PROMETHEE II). The latter is obtained by computing the net flow score of each alternative. The alternatives ranking induced by the net flow score has been characterized by Bouyssou (1992) as an extension of Copeland’s rule to valued relations. This result is again a characterization of the aggregation mechanism leading to the final ranking.

In contrast, regarding the first phase and the characterization of the valued relations comparing the intensity of the preference of each alternative w.r.t. each other, there are some conjoint measurement models, in particular Tversky’s additive difference model (Tversky, 1969), that are related to PROMETHEE’s valued outranking relation. It is the main goal of this presentation to investigate and discuss these relationships. In doing so, we partly rely on the material relative to PROMETHEE in Bouyssou et al. (2006).

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EXPERIMENTS WITH SURROGATE WEIGHTS FOR PROMETHEE

Thárcylla R. N. Clemente, Adiel T. de Almeida, Adiel T. de Almeida-Filho

Universidade Federal de Pernambuco, Cx. Postal 7462, Recife-PE 50.630-970, Brazil

thnegreiros@ymail.com, almeidaatd@gmail.com, adieltaf@googlemail.com

Abstract: In the multicriteria decision-making structuring process, to ensure the results answer satisfactorily to decision-maker's preference the value of the criteria's importance degree for each one must be defined safely and accurately, according to preference's structure of the decision-makers (DMs) about to context analyzed [1]. However, several factors, such as lack of security, discomfort or lack of desire about preference's modeling, may arise to justify the difficulties which DMs face to set exact values about parameters of the problem in many practical situations, specially the flexibility to insert large number of criteria and alternatives, which may increase complexity of the decision problem [2, 3]. In other hand, DMs may resort to the use of partial information, such as ordinal information on criteria [4], and allow that the application of surrogate weights procedures may represent his preferences approximate to the structure of the multicriteria decision methods. Among the methods, there are the PROMETHEE's family [5, 6] feature a sophisticated preference modeling to develop outranking relation, with no compensatory rationality in the evaluation process, and it offers a complete pre-order of the set of alternatives for a decision problem as the final result and it presents various applications in different contexts [7, 8, 9]. The mathematical structure of the PROMETHEE methods assumes importance degree for each criterion, but it does not define specific rules to determine weight values of the criteria in a decision problem. This lack of restriction enables the present study be prepared in order to compare the performance of different surrogate weights procedures, commonly discussed in the literature [10, 11], to identify the contribution of each methodology as more appropriate procedure to represent DMs preferences, taking the ordinal information on the criteria. The study analyzes the performance of surrogate weights for addressing choice and sorting problems using PROMETHEE II method. For this study, four procedures are considered: equal weights (EW), rank sum (RS), reciprocal of the rank (RR) and ranking order centroid (ROC) [11]. The experiments have been performed with the support of a simulation process to build random decision-making structures through Monte Carlo simulation, with different numbers of criteria and alternatives. For each decision structure, the surrogate weights are used to represent importance degree of the criteria. To evaluate the performance of surrogate weights a statistical analysis have been conducted to test each surrogate weight procedure and establish which would be the best procedure for the choice and sorting with PROMETHEE II. Based on Kendall's test and other statistical procedures the results shown the following hierarchy of surrogate weights: $ROC > RR > RS > EW$, in terms of its best performance on PROMETHEE II. The results of this study justifies the use of a new methodology developed for the treatment of real situations such as in [12].

Keywords: PROMETHEE. Surrogate weights. Simulation. Partial information.

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**PROMÉTHÉE 2 - Methodology:
Adding to PROMÉTHÉE**

Using PROMETHEE in a Multi-Actor Multi-Criteria Analysis (MAMCA): methodological adaptations and visualisations

Hadavi Sheida^a, Macharis Cathy^b, Van Raemdonck Koen^c

a- Sheida.Hadavi@vub.ac.be - MOBI Research Group, BUTO Department, VrijeUnivesiteit Brussel

b- Cathy.Macharis@vub.ac.be - MOBI Research Group, BUTO Department, VrijeUnivesiteit Brussel

c- Koen.Van.Raemdonck@vub.ac.be – MOBI Research Group, BUTO Department, VrijeUnivesiteit Brussel

Keywords: Multi Actor Multi Criteria Analysis, Decision Making, Promethee, AHP

The multi-actor multi-criteria analysis (MAMCA) is a method to evaluate, amongst others, transport projects, and aid groups in complex decision-making processes. The focus is on the inclusion of the different actors that are involved in the project, the so-called stakeholders. Several stakeholders' opinions are explicitly taken into account during the entire analytical decision process in a structured way. In order to include the stakeholders' opinion into the decision process, actors follow the steps of classical MCDA methods: defining the problem, defining alternatives, developing a set of criteria and evaluating the alternatives. When assessing the different strategic alternatives, various multi-criteria decision analysis methods can be used. For instance, the PROMETHEE method has been extended in Macharis et al. (1998) and the analytical hierarchy process (AHP) method in SAATY (1989).

The MAMCA method has already proven its effectiveness in evaluating complex sustainable mobility and transport policy decisions (Macharis et al., 2012). However, in order to create an accessible and global multi-actor multi-criteria analysis application, the MAMCA software, an interactive web tool, has been developed. During the development of the software, further effort has been put into adaption of AHP and Promethee methods in order to better support multi-actor functionalities; diverse visualisation techniques have been adopted to assist stakeholders in exploring different decisions.

In order to evaluate the alternatives, MAMCA expands on the overall score of each alternative (calculated in PROMETHEE as the average of the score that each actor has given), and offers a graph containing, for each stakeholder group, the score that the latter has given for each alternative. At a higher granularity, we graph (one graph per actor) how each alternative has scored on each criterion. It must be mentioned that the score of an alternative can be negative on one or more criteria, for example a windmill may constitute a nuisance on the visual environment. The adaptation of the PROMETHEE method to enable both positive and negative scores on criteria will be explored and validated. Moreover, it is discussed how in each graph, any alternative can be used as a baseline to compare all alternatives. The baseline alternative then receives a zero score on each criterion. Using MAMCA, surveying from a large population is possible, and visualisations can provide a convenient overview on how each alternative has scored in the survey (its average score and standard deviation are visualised, in a box plot). All the aforementioned visualisations are discussed in this contribution. Finally, sensitivity analysis on MAMCA is performed and explained.

In this contribution, the theoretical foundations of the MAMCA method will be shown. Herein, the focus will lie on the adaptation of Promethee and AHP to support the inclusion and analysis of multiple stakeholders' objectives in the decision making process. As the fruit of these efforts, a multi-actor decision-making framework is established, which provides long-term support to all actors involved in the decision-making process.

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PROMETHEE IV THROUGH KERNEL DENSITY ESTIMATION

Pedro Henrique Melo Albuquerque¹.

University of Brasília. Campus Universitário Darcy Ribeiro. Brazil, Brasília-DF. Zip Code: 70910-900. Associate professor. pedroa@unb.br

Mariana Rosa Montenegro

University of Brasília. Campus Universitário Darcy Ribeiro. Brazil, Brasília-DF. Zip Code: 70910-900. Research Assitant. mrosamontenegro@gmail.com

Abstract: This paper presents a new version of Promethee IV which considers the empirical distribution of the criteria through kernel density estimation to evaluate alternatives. The developed method has the ability to treat criteria according to their distribution. The classic Promethee IV can produce divergent integrals, and this could be the cause for its insufficient exploration in literature. The proposed method overcomes this situation since large values have little weight compared to values near the mean.

Keywords: Promethee IV; Decision analysis; OR in tourism; Applied probability; Kernel Estimator.

¹ Corresponding author contact information: (+55 61) 3107-7080. (+55 61) 3107-7095.

A PROMETHEE BASED METHOD FOR NOMINAL CLASSIFICATION WITH MINIMUM PERFORMANCE PROFILES

Maisa Mendonca Silva ^{a*}, Ana Paula Henriques de Gusmao^a, Ana Paula Cabral Seixas Costa^b

^a Universidade Federal de Pernambuco- Centro Acadêmico do Agreste UFPE-CAA
Rodovia BR-104, Km 59 - Nova Caruaru, Caruaru - PE, 55002-970

maisa.ufpe@yahoo.com.br
anapaulahg@hotmail.com

^b Universidade Federal de Pernambuco- UFPE
Av. Professor Moraes Rego, 1235 - Cidade Universitária, Recife - PE, 50670-901

apcabral@hotmail.com

Classifying allows one to assign alternatives into predefined categories—which can be ordered or not, or into non-predefined categories, referred to as clustering. According to Zapounidis and Doumpos (2002), this type of problem is of great interest in many areas concerning practical or scientific issues.

These authors claim that this problem is named “sorting” or “classification,” depending on whether the categories are ordered or not, respectively (Zapounidis and Doumpos, 2002). Many approaches in multicriteria fields have been proposed to cope with this sorting problem, including outranking approaches such as ELECTRE TRI (Roy and Bouyssou, 1993) and its variants, the multiattribute theory UTADIS (Zapounidis and Doumpos, 2002) and rough sets (Greco *et al*, 2001). The ELECTRE TRI method appears as the most popular (Mousseau and Slowinski, 1998) and the most used (Zapounidis and Doumpos, 2002) method for ordinal classification and is based on limiting profiles or boundaries. Adaptations of this method can be seen in many works (Almeida-Dias, Figueira and Roy, 2010; Almeida-Dias, Figueira and Roy, 2012; Ishizaka and Nemery, 2014).

Beyond the ELECTRE TRI, some ordinal proposals can be cited: PROMSORT (Araz and Ozkaranhahan, 2009), AHP-Sort (Ishizaka, Nemery and Pearman, 2012), THESEUS (Fernandez and Navarro, 2011), TRICHOM (Moscarola, 1977), N-TOMIC (MASSAGL AND OSTANELLO, 1991), Flow Sort (Nemery and Lamboray, 2008) and a pairwise comparison-based method (Doumpos and Zapounidis, 2004). Proposals to deal with imprecise data have also been made (Nemery and Janssen, 2013; Silva, Costa and Gusmao, 2014; Greco, Matarazzo and Slowinski, 2010).

Among the nominal classification methods, Chen, Kilgour and Hipel (2006) presented a method with additive linear function and linear constraints; Belacel, Raval and Punnen (2007) proposed a fuzzy method; and Perny (1998) proposed a method based on the concordance and discordance concepts.

The aim of this paper is to develop a multicriteria nominal classification method derived from the concepts of PROMETHEE (Brans *et al*, 1986), applied to use in problems characterized by minimum performance profiles (MMP) for the categories. The main advantages of this proposal are criterion and alternative flexibility for categories;

robustness, because it uses the concepts of a well-known method - PROMETHEE; and usefulness, because many real situations are characterized by MMP for the categories. The proposed model was applied in a real case problem of assigning retailers that use the services of a bank.

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TA2

**PROMÉTHÉE 3 - Applications:
General**

Title: Multicriteria decision aid for improved malaria management in Burkina Faso

Valerie Hongoh^{1, 7*}, Pascal Michel^{1, 2}, Pierre Gosselin^{3, 4}, Karim Samoura^{1, 5}, Jean-Philippe Wauub⁶, André Ravel⁷, Céline Campagna^{3, 8}

¹Groupe de Recherche en Épidémiologie des Zoonoses et Santé Publique (GREZOSP), Faculté de médecine vétérinaire, Université de Montréal, 3200 Sicotte, Saint-Hyacinthe, Québec, J2S 7C6, Canada

²National Microbiology Laboratory at Saint-Hyacinthe, Public Health Agency of Canada, 3200 Sicotte, Saint-Hyacinthe, Québec, J2S 7C6, Canada

³Quebec National Institute of Public Health (INSPQ), 945 avenue Wolfe, Québec, Québec G1V 5B3 Canada

⁴Ouranos, Consortium on regional climatology and adaptation to climate change, 550 Sherbrooke West, Montreal, Quebec H3A 1B9, Canada

⁵Université Aube Nouvelle, Quartier 1200 Logement, Ouagadougou, Burkina Faso

⁶Group for Research in Decision Analysis (GERAD), 3000 Côte-Sainte-Catherine, Montréal, H3T 2A7, Québec, Canada

⁷Département de pathologie et microbiologie, Faculté de médecine vétérinaire, Université de Montréal, 3200 Sicotte, Saint-Hyacinthe, Québec, J2S 7C6, Canada

⁸Department of social and preventive medicine, Université Laval, 2325 rue de l'Université, Québec, G1V 0A6, Canada

Background:

Despite the existence of treatments, malaria remains a major cause of mortality, especially infant mortality, in Burkina Faso (1,2). Malaria is a mosquito-borne disease where symptoms can range from mild fever and chills to severe complications including organ failure that can result in death (3). Many preventive and control strategies exist to manage the disease including both individual preventive behaviours and vector targeted control measures, yet Burkina Faso and a number of other developing countries are still struggling to manage and eliminate the disease (1). Economic and health burden based tools have often been used to prioritize health interventions (4,5); however, multicriteria decision aid (MCDA) approaches have not been very widely explored for intervention management decisions, particularly in the context of malaria management. This study explores the applicability of a MCDA approach for improved management of malaria in Burkina Faso.

Methods:

Consultations were held with local stakeholders in Ouagadougou, Burkina Faso to discuss appropriate decision criteria and interventions for the management of malaria.

A previously developed MCDA model for the management of West Nile virus - a mosquito-borne disease that can cause febrile illness and general muscle weakness and currently endemic to Quebec, Canada - was adapted and validated with stakeholders. Though the two diseases are quite different in terms of pathogen type and range of symptoms, both are mosquito-borne diseases, with a potential for overlap with regards to mosquito prevention and control strategies. Stakeholders in both sites were invited to weight the list of identified criteria and translate their conceptual value system into quantitative numbers. Criteria choices and weights were compared by describing similarities and differences across the two study sites.

Results:

Two individual level categories of interventions – personal protection and source reduction – comprising eighteen interventions were identified and retained for the malaria management model in Burkina Faso and three regional level categories of interventions – human targeted, vector targeted and other strategies –comprising an additional eighteen interventions were also identified and retained. Though specific interventions varied between sites, similar intervention categories were found relevant for the management of malaria in Burkina Faso and West Nile virus in Quebec. A majority of criteria identified in Quebec were found to be relevant and applicable in Burkina Faso. Twenty criteria distributed across five categories were retained for the model in Burkina Faso which included two additional criteria from the Quebec model – public awareness of the disease and cost to families. Additional contextual explanations were also required to clarify criteria identified in the Quebec context and make them applicable to the disease context in Burkina Faso.

Discussion:

Similar concerns and criteria around the management of the two mosquito-borne diseases: West Nile virus and Malaria can be found and suggest the potential for a general vector-borne disease decision aid model to help structure reflection and manage intervention planning for vector-borne diseases. While Cost-effectiveness analysis and Disability adjusted life years (DALYs) are important, they answer only part of the question. Vector-borne disease management in a developing country, such as the management of malaria, is a complex problem and needs to be reflected upon as such. The MCDA process provides an opportunity for rich knowledge exchange and problem structuring between stakeholders on the numerous dimensions surrounding infectious disease management. Furthermore, given the vast number of actors in developing settings, multi-sector collaborations across NGOs, local government and community are important and formal mechanisms such as MCDA provide means to foster consensus, shared awareness and collaboration.

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Title: Multicriteria decision aid and strategic environmental assessment of ore ports in Maritime Guinea

Authors

Mariama DIALLO * (First author and presenting author)

Student, PhD program in environmental science at UQAM

Researcher at the National Centre for Fisheries Science

Boussoura (CNSHB), Conakry, Guinea

Phone: 1-438-990 2440

Email: djihoun2004@yahoo.fr

diallo.mariama.3@courrier.uqam.ca

Co-authors

Dan Lansana KOUROUMA

Professor, Environmental Studies and Research Center, University of Conakry

Associate Professor at University of Quebec in Montreal

Phone: + (224) 62 32 71 55

Email : dan_lansana@yahoo.fr danlansana@gmail.com

Alkhaly DOUMBOUYA

Researcher at the National Centre for Fisheries Science

Boussoura (CNSHB), Conakry, Guinea

Phone: + (224) 62 19 60 43

Email : adoumbouyah@gmail.com

Jean Philippe WAAUB

Professor, University of Quebec in Montreal

Geography department, UQAM

GERAD

Phone: 1-514-987 3000 poste 8908#

Fax: 1-514-987 6784

Email: waaub.jean-philippe@uqam.ca

Karim SAMOURA

Ph D, Environment

ISIG International Director

Director of International Relations

Aube Nouvelle University

Phone: +226 62814827

E-mail : karim.samoura@u-auben.org

samourakarim@yahoo.fr

Title: Multicriteria decision aid and strategic environmental assessment of ore ports in Maritime Guinea

Abstract

Maritime Guinea region has 300 km of coastal zones open over the Atlantic Ocean. The Guinean coast is characterized by the almost continuous presence of mangrove swamp, estuaries and near coastal strips located between 0 and 20 meter deep. It houses a rich biodiversity and is subject to multiple socio-economic activities such as fishing, agriculture, shellfish harvesting, salt production, exploitation of mangrove wood, tourism, mining, etc. The latter may affect the environment's natural resources through many planned developments. Indeed the value of the rich mining potential development requires the development of large ore ports likely to impact on fish diversity. In addition to the four existing ports, eight projects of ore port facilities are at the planning stage without consultation between the different promoters involved. Each company plans to make its own port. Furthermore, the environmental and social impact assessment (ESIA) procedures in place are implemented very downstream. Most of the time, those procedures do not discuss satisfactorily of the advisability of the project and are not based on the proper policies that should underpin a good decision. In this context, the use of strategic environmental assessment (SEA) is required upstream to take into account the ecological, economic, sociocultural and political issues of the decision-making process. An approach coupling Multicriteria Decision Aid (MCDA) and geographic information system (GIS) was used to carry out the SEA of the ore ports. MCDA, by stimulating dialogue and exchange of information, has great potential to face the issues of coastal and marine ecosystems. It allowed, as part of this study, to establish a transparent framework of dialogue and contribute to the search for solutions for the integration of conservation issues in the planning of port facilities. The stakeholders from government (fisheries, environment, transport, mines), civil society (fishermen, fishmongers and smoking women, fishing society, NGOs), experts (researchers, engineers) and private sector (mining companies) were involved in the different stages of the SEA process. The option based on the pooling of port infrastructure has been favoured by the majority of stakeholders. This option provides for the construction of two new ports in Boffa and Forécariah.

Keywords

Guinea maritime, fishery resources, ore ports, MCDA , SEA

Selecting of water resource management strategies using The PROMETHEE method in an Algerian region - Tlemcen.

Fatima Zohra BELARIBI¹ & Pr A. BENHABIB²

¹ Assistant professor & Phd, Laboratory MECAS (Management des Entreprises et du Capital Social,) University of Tlemcen, BP 119, 13000, Algeria Tel. 00213 550 434166; Fax: 00 213 43212166; email: belaribi_tl@yahoo.fr

² Professor & Director of MECAS Laboratory (Management des Entreprises et du Capital Social,) University of Tlemcen, BP 119, 13000, Algeria Tel. 00213 550 434166; Fax: 00 213 43212166; email: abenhbib1@yahoo.fr

Abstract

Decisions about water resource management are complex in nature, since they involve consequences of environmental, social and economic impacts on society. Furthermore, the criteria used to determine these consequences are often contradictory and not equally important. However, the use of traditional methods became inappropriate because of their reliance on a single criterion in its analysis.

A new ranking approach using PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluation) is applied to a Multiple Criteria Decision Making (MCDM) problem. This paper describes the application of the PROMETHEE II and PROMETHEE-GAIA to evaluate and select development strategies from a variety of potentially feasible water resources. The PROMETHEE method was selected due to its simplicity and its capacity to approximate the way that human mind expresses and synthesizes preferences when facing multiple contradictory decision perspectives.

In this case study, the evaluation of the resource water management strategies is applied to Tlemcen Region in Algeria. The constitution of a set of alternatives strategies, the selection of a list of relevant criteria to evaluate these strategies and the choice of an appropriate management system are also analyzed in this framework. An inherent advantage of this approach is its ability to comprehensively consider quantitative and qualitative factors, making reliable decisions in an environment of uncertainty and subjective information. Also, the application of the MCDM methods shows that multi-criteria optimization can significantly facilitate and accelerate the decision-making process.

Key- words: Water resources management - Multicriteria analysis - decision making - PROMETHEE II – Tlemcen.

**L'intégration des méthodes d'analyse multicritères et les systèmes d'information géographique pour l'identification des concentrations spatiales du risque routier.
(étude de cas du département de Mascara, Algérie)**

HAMADOUCHE Mohammed Amine^{1,*}, MEDERBAL Khaladi³, KHALDI Abdelkader¹,
DRISS Miloud², FEKIR Youcef¹, ANTEUR Djamel⁴.

hamadouche.mohammedamine@yahoo.fr, mederbal@univ-tiaret, khaldi3dz@yahoo.fr, driss_miloud@yahoo.fr,
youceffekir@yahoo.fr, anteurdjamel@yahoo.fr.

¹ Laboratoire de Recherche sur les Systèmes Biologiques et de Géomatique. Université de Mascara, B.P N°305, Mascara. Algérie. Tél: +213 663 712 515. Fax: +213 45 802 905. <http://www.univ-mascara.dz>

² Laboratoire des Sciences et Techniques de l'Eau. Université de Mascara, Algérie.

³ Laboratoire de géomatique & de développement durable, Université de Tiaret, Algérie
BP 78 Zaâroua 14000, Tiaret, Algérie. Tél: +213 - (0) 46 - 42 - 56 – 88, <http://www.univ-tiaret.dz>.

⁴ Laboratoire des Ressources hydriques et environnement, Université de Saida, Algérie. BP 138 cité ENNASR 20000, Saida, Algérie. Tél.: +213 - (0) 48 - 47 - 77 - 29. <http://www.univ-saida.dz>.

Résumé :

Les traumatismes dus aux accidents de la circulation constituent un immense problème de santé publique et de développement. Les accidents de la circulation sont prévisibles et peuvent être évités par l'amélioration de la prévention. Dans cet aspect, un système d'information géographique (SIG) basé sur l'approche d'analyse multicritères d'aide à la décision (AMC) a été développé afin de prédire les accidents de circulation. En effet, l'utilisation d'un SIG contribue à la récolte des informations, la production d'informations dérivées et la manipulation d'un important volume de données aidant à considérer le problème dans toute sa complexité et à décrire les différentes variantes. Aussi, les techniques d'évaluation multi-critères ont été déployées pour aborder les questions de gestion environnementale dans plusieurs contextes. Ainsi, nous avons développés un modèle qui intègre les méthodes d'AMC (PROMETHEE et Electre,) dans un logiciel SIG de type vecteur (ESRI ArcView3.2) pour identifier les concentrations spatiales des accidents de la circulation sous forme de zones noires en fonction de l'environnement routier. Toutefois, afin d'augmenter le niveau de satisfaction globale de la décision finale et face à l'incertitude dans le processus décisionnel, le modèle de décision est présenté sous la forme d'un algorithme d'agrégation itérative, qui tente de simuler un processus de classement et d'affectation d'un ensemble de solutions. Cette approche permet aux décideurs d'évaluer les priorités relatives des différents impacts, quantitatifs ou qualitatifs basées sur un ensemble de critères fixés pour chaque kilomètre du réseau étudié. L'étude a été menée sur le réseau routier du département de Mascara dans la région nord ouest d'Algérie. Ainsi, les résultats obtenus montrent que les méthodes présentées sont plus efficaces et avantageux.

Mots Clés : SIG, méthodes multicritères, système d'aide à la décision spatial, accident de la circulation, zones noires, réseau routier.

Abstract :

The traffic accidents are predictable and can be avoided by improving prevention. In this aspect, we developed a model that integrates the MAC methods (Electre method, Promethee) in GIS software (ESRI ArcView3.2) to identify spatial concentrations of road accidents in form of black zones. The decision model is presented as an iterative aggregation algorithm, which attempts to simulate the process of classifying and affecting a set of solutions. This approach allows decision makers to assess the relative priorities of different impacts, quantitative or qualitative based on a set of criteria for each kilometer of the network studied. The study was conducted on network road of department Mascara in the region of northwest Algeria. Thus, the results show that the presented methods are more efficient and beneficial.

Keywords: GIS, multicriteria methods, spatial decision making system, traffic accident, black zones, network road.

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**PROMÉTHÉE 4 - Application:
Management**

PROMETHEE-based Approaches for Supplier Relationship Management: a Review of Practices in Two Organizations

Juan Miguel Sepúlveda*, Ivan Derpich, Miguel Alfaro
Industrial Engineering Department
Universidad de Santiago de Chile
juan.sepulveda@usach.cl

Abstract

It is widely recognized, both in academia and practice, that Supplier Relationship Management (SRM) has reached a strategic role in the competitiveness of companies. An increasing number of papers have been devoted to the development of methodologies to solve various kinds of SRM problem. But, despite of the growing number of articles, few of them show their usefulness in corporate environments. In order to narrow the gap between theory and practice, in this paper we discuss selected real SRM problems solved by PROMETHEE and its related methods.

First, we present a supplier sorting application which takes place after a quality evaluation process have been carried out for Logistics Service Provider (LSP) performance in a national supplier of the mining industry . The sorting categories are in order to decide the outcome of a LSP, that is: to continue being a partner of the company, to continue with correcting measures, or to dismiss it due to low performance.

Second, we discuss a supplier segmentation application for determining the management strategy and the type of relationship to establish with the supplier. This is an important task since many types of suppliers are commonly in place and differentiated management approaches are needed according to the value potential and the risks they face in their respective markets. The classic Kraljic's matrix concept is revisited concerning a portfolio of strategies, ranging from simple transactional relationship up to the strategic (out)sourcing. Even though this analysis is commonly performed by experienced managers, in large global organizations due to the numerous suppliers, such a manual procedure becomes difficult and error-prone. Hence, a MCDM method as PROMETHEE provides a structured decision framework. The approach is applied to the global chain of a national bottling company having a large number of suppliers in South America.

In both applications, the results show that PROMETHEE-based methods are suitable in choosing the supplier category and offer some advantages over other well-known classical methods such as AHP, regarding the judgements elicitation phase in practical computational implementation with large supplier bases. Comparisons and discussions on how the problems can be solved by other MCDM methods with the pros and cons are presented.

Keywords: *Supplier Relationship Management, Flowsort, Hierarchical Analytic Process, Fuzzy multicriteria classification.*

Implémentation de l'approche PROMETHEE au problème de sélection des modèles d'affaire en maintenance.

Lalla Samira Touhami (Université Laval) lalla-samira.touhami.1@ulaval.ca

Daoud Ait-Kadi (Université Laval) Daoud.Aitkadi@gmc.ulaval.ca

Mohammed Anouar Jamali (ESITH) jamali@gmail.com

Description de l'article

Toutes les entreprises s'appuient sur des équipements pour réaliser les objectifs industriels reliés à la production, à la qualité du produit & service et à la sécurité. L'impact des défaillances associées à ces équipements est très significatif sur la performance globale de l'entreprise. Les ennuis ainsi générés ne peuvent être évités que par une maintenance efficace. La maintenance implique une large gamme d'activités techniques, administratives et de management, permettant de contrôler ces défaillances ou de remettre ces équipements à l'état opérationnel.

Bien que la fonction maintenance prenne désormais une place stratégique dans le système de management global des organisations et constitue ainsi une réalité qui n'a plus besoin d'être démontrée, son management abonde de problèmes de planning, d'approvisionnement, de personnel, de contrôle qualité et de problèmes techniques. Les équipements pris en charge par le système de maintenance ont des caractéristiques opérationnelles qui se dégradent avec l'âge ou à l'usage. Les procédés actuels présentent des technologies complexes dont les coûts de la maintenance associés sont excessivement élevés. Les enjeux attribués à la maintenance soulèvent un grand nombre de facteurs associés aux aspects techniques stratégiques, économiques et de conformité aux conditions de sécurité aux réglementations environnementales : Enjeux inhérents à la complexité de la technologie des équipements conjugués aux soucis de maîtrise de l'outil de production, enjeux pour réduire les coûts d'opération, enjeux inhérents au respect des délais, à la qualité des produits et des services, à l'économie d'énergie, aux conditions de sécurité, au respect de l'environnement, aux exigences d'adhésion à la charte de développement durable. Autant de variables à caractère conflictuel et difficiles à prendre en considération dans un processus de décision.

Le problème de sélection des modèles d'affaire en maintenance est un tournant très important et imposant, dans un monde dominé par les chiffres, pour s'aligner avec la théorie de la valeur ajoutée de la fonction maintenance en entreprise. C'est dans ce contexte que s'inscrit notre problématique de recherche. Pour une activité de maintenance, il s'agit de formuler et développer les questions clés suivantes : **quel sera le modèle d'affaire le plus approprié pour l'organisation maintenance? Comment évaluer les performances**

de chaque modèle? Quels sont les critères d'évaluation? Une telle décision rendue complexe sous l'effet conjugué de contraintes techniques, stratégiques, économiques et environnementales préoccupe les gestionnaires de la maintenance.

En absence d'outil d'analyse, entre continuer à « faire en interne » et subir les coûts excessifs conséquents ou confier une partie « faire faire » pour se concentrer sur le cœur du métier, se place une décision difficile à mener. La bibliographie n'est pas assez étoffée en la matière.

Ce papier concerne la formulation multicritère du problème de sélection des modèles d'affaire en maintenance « Faire en interne FI », « Faire-Faire FF » ou « Faire-ensemble FE ». L'exercice consiste à dresser la matrice d'évaluation de l'ensemble des alternatives « FI », « FF » et « FE » aux regards des différents critères associées aux contraintes techniques, stratégiques, économiques et à la conformité à la réglementation en matière de sécurité et d'environnement. La recherche du meilleur compromis est une difficulté importante incombant aux gestionnaires de maintenance de nombreux paramètres techniques, stratégiques, économiques et environnementaux.

En plus des données de base incluses dans le tableau d'évaluation, la meilleure solution de compromis dépendra également des préférences individuelles du décideur ou gestionnaire de la maintenance. Les poids de l'importance relative des critères sont définis pour traduire sa pensée et rationaliser son hésitation.

Finalement, la matrice d'évaluation secondera la mise en œuvre d'une méthode d'agrégation multicritère de ces données : l'approche PROMETHEE.

Ce document servira de base pour situer la prise de décision d'internalisation/externalisation des activités de maintenance dans le bon contexte de valeur ajoutée économique et permettra de mettre en œuvre des filtres technique, économique, stratégique et environnemental pour sélectionner le meilleur modèle d'affaire en maintenance (FI), (FF).ou (FE). A l'issue de cet exercice, le gestionnaire de la maintenance peut compter sur un outil d'aide à la décision pour déterminer son mode de gestion des différentes activités en maintenance interne, externe ou mutualisée (partage des ressources).

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The Impact of the CAP Reform 2014-2020 on Ecosystem Services production: An Application in the Province of Ferrara

Chatzinikolaou Parthena¹, Viaggi Davide², Raggi Meri³

The ecosystem concept describes the interrelationships between living organisms and the non-living environment. Ecosystems provide a variety of benefits to people that are divided into ecosystem services (ES) and classified in multiple ways. The MEA (2005) identified four categories of ES: provisioning, regulating, supporting and cultural services. The concept of ES is being integrated into current biodiversity policies at the global and European levels (EC, 2010). The objectives of the new programming period are oriented towards the sustainable management of natural resources and climate action. In the RDP for Emilia-Romagna there is almost equal emphasis on the four priorities. Under the 4th priority ‘Restoring, preserving and enhancing ecosystems related to agriculture and forestry’, the region wants to safeguard water quality through the promotion of agricultural production techniques that reduce pressure on the environment.

The objective of this paper is to evaluate the impacts of the 2014-2020 CAP on the provision of ES focusing on the different categories of ES and applying a set of non-overlapping indicators available from secondary data sources. To evaluate the provision of ecosystem services, we used a traditional cultural landscape, the Province of Ferrara, and a set of ES indicators as criteria for the evaluation. The area consists of 26 municipalities, comprising the urban centre of Ferrara and adjoining agricultural lands within the ancient and vast Po River Delta. The area is characterised by historical-cultural locations, the surrounding landscape and protected areas of natural importance.

The approach used is based on the outranking method Preference Ranking Organisation Methods for Enrichment Evaluations (PROMETHEE), which applies the outranking method and provides a complete ranking of a discrete set of possible alternatives, from the best to the worst, using the concept of net flow (Brans and Vincke, 1985). A considerable number of successful applications has been treated by the PROMETHEE methodology in various fields such as water resources, investments, medicine and tourism. Regarding ES evaluation, Segura et al. (2015) applied a PROMETHEE-based method to obtain new composite indicators for provisioning, maintenance and ‘direct to citizen’ services. Fontana et al. (2013) have also used PROMETHEE to compare land use alternatives considering ES as criteria.

In the present study, the model is used to simulate the 2014-2020 CAP Reform, based on the new agricultural policy that can affect the supply or demand of ES. This study aims to analyze how the 2014-2020 CAP design and implementation have influenced the provision of ES. It provides a catalogue of the CAP measures with a direct focus on ES, which have the potential to have a positive (or negative) influence on ES. Along with the application of PROMETHEE II, a comparison and ranking of the 26 municipalities of the province is performed, based on the ES indicators.

The selected ES indicators are those that are considered to give sufficient information on the benefits that people derive from an ecosystem among those available in the regional databases

¹ Corresponding author

University of Bologna / Department of Agricultural Sciences, Viale Fanin 50, 40127, Italy,
parth.chatzinikolao2@unibo.it

² University of Bologna / Department of Agricultural Sciences, Viale Fanin 50, 40127, Italy,
davide.viaggi@unibo.it

³ University of Bologna/Department of Statistical Sciences, Via Belle Arti 41, 40126, Italy, meri.raggi@unibo.it

(i.e. publicly available for the entire region). This was partly done on purpose to assess the usability of secondary data to assess the provision of ES at the municipality level.

Due to its explorative nature, this study is subject to several weaknesses and a number of options for improvement. Results indicate small impacts in relatively productive regions, since land use remains largely unchanged. The main issue concerns the number of gaps in the ES metrics and indicators available at the regional level, with respect to the number and quality of indicators needed to reflect the ES approach in a comprehensive way. The most important challenge in our analysis was, accordingly, the lack of information with respect to the provision of ES at the regional level. The number of ES indicators in each category varies significantly due to the different data availability and reliability. In addition, due to data paucity, it was not possible to consider the interactions between specific services.

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**PROMÉTHÉE 5 - Applications:
Energy**

**RESULTS FROM A BILATERAL RESEARCH PROJECT: ENERGY
EFFICIENCY, SUSTAINABLE DEVELOPMENT AND NATURAL RESOURCES
CONSERVATION: MULTICRITERIO LIFE-CYCLE ANALYSIS OF DAILY-
USED MATERIALS WITH A LONG-TERM VISION.**

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Number:19071**

Carlos Enrique Escobar-Toledo

Facultad de Química, Departamento de Ingeniería Química. Universidad Nacional Autónoma de México (UNAM).

carloset@unam.mx

Bertrand Mareschal

Solvay Brussels School of Economics and Management, Centre Emile Bernheim, Université Libre de Bruxelles (ULB).

bmaresc@ulb.ac.be

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ABSTRACT:

On February 2011, the European Commission adopted a new strategy to improve measures to access raw materials, considering that EU high dependence of imports of them. The new strategy considers three pillars to improving raw materials access. One of them is boosting resource efficiency and promoting recycling. This paper contains a valuable methodology applicable to some material substitution based on Life Cycle Analysis. We consider that substitution is a multidisciplinary problem in nature dealing with **Multicriterio Aid Decision Making, particular with PROMETHEE methods**. The problem considers the role of energy use in sustainable development and the potential sources to increase energy efficiency during life cycle use of some materials used in a day-to-day basis. A set of criteria to make decisions for choosing alternative materials in the substitution process will be among other: Exergy loss, Green House Gas emissions, real energy flows and material balances needed to the chain of manufacturing processes in the production chain and the whole value added. Nevertheless, alternative materials to substitute the actual ones, it is necessary to look forward. That is why we will also use some other tools in order to compile a set of alternative materials for a long-term use, as prospective, systems dynamics techniques, intelligence activities and life cycle concepts, considering of course, chemical recycling. We present a case study for Mexico's use of Polyethylene Terephthalate bottles (PET Bottles) following a methodology created by the authors.

Energy planning in maritime Guinea: a multicriteria decision aid approach to make choices taking into account environmental and social issues.

Authors:

Dan Lansana Kourouma, Professor at the
Environmental Studies and Research Center,
University of Conakry

Associate Professor at University of Quebec in
Montreal

Phone: +(224) 62 32 71 55

e-mail : dan_lansana@yahoo.fr

Jean Philippe Waaub, Professor at University of
Quebec in Montreal

Geography department, UQAM

Interdisciplinary Studies Group in Geography
and Regional Environment

Phone: 1-514-987 3000 poste 8908#

Fax.: 1-514-987 6784

email: waaub.jean-philippe@uqam.ca

Abstract

Energy is an essential and indispensable factor for development. In Guinea, the various energy sub sectors evolve independently without strategies and overall energy policy, which leads to systemic inconsistencies and inefficiencies. Also, poor governance greatly affects the development of the energy system. It is thus relevant to propose a decision process and a methodological approach suited to the Guinean cultural context in order to design an effective decision aid process allowing the various stakeholders to negotiate key issues and to produce policy and plans facing the energy sector challenges. These challenges include the provision of essential energy services securely and reliably, as well as the reduction of environmental and social impacts associated with the production, transport, distribution and final use of energy. These are essential to achieve sustainable development. Strategic Environmental Assessment (SEA) and multicriteria and multi-stakeholders PROMETHEE approach are helpful processes and tools in the context of sustainable energy planning. The object of the SEA decision process is to make choices between different energy supply options for the country, each one having specific environmental and social impacts. In the resolution of such a complex decision problem, decision makers should take into account knowledge sources to address environmental and social issues, as well as several points of view, often contradictory. Implementing a multicriteria and multi-stakeholder decision aid approach all along the SEA process, allows the stakeholders involved in the energy system to progress effectively in resolving this decision problem where many value systems have to be considered. An experiment of this approach was carried out and focused on environmental and social issues of maritime Guinea. It allowed, through targeted consultations and roundtables, to take into account various energy options, related issues and assessment criteria, and different value systems in place. The case study focuses on the regional dimension of energy policy in Maritime Guinea. The results show that centralized options have more environmental and social impacts than decentralized options, and that offering a specific space for deliberation and negotiation between stakeholders improves the energy planning governance.

Keywords: multicriteria decision support, Maritime Guinea, stakeholders, decision aid, energy options, consultation

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Identification of sustainable expansion alternatives for heterogeneous grid topologies

Tobias Lühn^a and Jutta Geldermann^b

^a Research Assistant, Chair of Production and Logistics, Georg-August-University Göttingen, Platz der Göttinger Sieben 3, 37073 Göttingen, Germany, tobias.luehn@wiwi.uni-goettingen.de

^b Professor, Chair of Production and Logistics, Georg-August-University Göttingen, Platz der Göttinger Sieben 3, 37073 Göttingen, Germany, geldermann@wiwi.uni-goettingen.de

Abstract

The German government intends to increase the share of renewable energies for power generation to 40-45 percent by the year 2025 (§ 1 EEG¹) and, in fact, the installed peak power of photovoltaic (PV) plants has significantly increased from 1 GW_p in 2004 to over 36 GW_p in 2014 (BNetzA 2014; BMWi 2013). Thus, distribution system operators (DSOs) face two major challenges. First, they need to prevent the overload of grid components. Second, they need to keep the voltage range within given constraints specified in the standard (DIN EN 50160). One way to meet these challenges is through grid expansion, which should be economically, environmentally, technically and socially sustainable (Lühn et al. 2014). DSOs need to evaluate different alternatives to achieve a sustainable grid expansion.

In this study, we evaluate two grid expansion alternatives a_1 and a_2 . The first is to increase cable cross-section, lay parallel cables and increase transformer power capacity. The second is to install innovative VRDTs (Voltage-Regulated Distribution Transformers) that can regulate the voltage level of low voltage grids. We evaluate the two grid expansion alternatives in four steps. *First*, the electrical engineers calculate the required grid expansion of the two alternatives (Schlömer, Hofmann 2014). The low-voltage grid of a DSO consists of 160 different local grids varying significantly in their grid topologies. The required grid expansion is modelled by linearly increasing the peak output of photovoltaic systems in discrete steps of 1 kW_p per household (hh) from 1 kW_p/hh up to 12 kW_p/hh. Therefore, 12 PV enforcement levels, that is, 12 scenarios, must be considered. The combination of 160 local grids and 12 enforcement levels of PV results in 1,920 decision conditions for each alternative a_i . *Second*, we assign all local grids to grid groups. The local grids show different requirements of grid expansion depending on their specific characteristics and can subsequently be clustered. *Third*, we evaluate the grid expansion alternatives for each decision condition with a newly developed multi-criteria approach referred to as DC-PROMETHEE. *Fourth*, we aggregate the multi-criteria results for each decision condition to a performance indicator B. On the basis of the performance indicator, a decision table is developed showing which alternative should be applied in future grid expansion. Table 1 shows all performance indicators for this case study.

The multi-criteria results of the case study show a high overall potential of the VRDT for future grid expansion in the low-voltage grid of the investigated DSO. In all sensitive and rather sensitive local grids, the VRDT grid expansion alternative should be installed, regardless of the PV enforcement level. In all rather robust local grids, conventional line expansion should be implemented. Thus, we recommend that the VRDT be considered as an alternative to conventional grid expansion.

¹ EEG: Renewable Energy Act

The DC-PROMETHEE can be applied by other DSOs by considering the individual grid topology and preferences of the DSO. Other fields of application are infrastructure investments in the service area, in which expansion alternatives are evaluated in a large number of decision conditions. Examples include telecommunication, gas supply and water supply.

Table 1: Performance indicators depending on the PV enforcement level and the grid group

PV enforcement level		Grid group				
		Sensitive	Rather sensitive	Rather robust	Robust	
	1 kW per household	No grid expansion required				
	2 kW per household					VRDT (B ₂ = 96,7%)
	3 kW per household					VRDT (B ₂ = 87,5%)
	4 kW per household					VRDT (B ₂ = 72,2%)
	5 kW per household	VRDT (B ₂ = 75,4%)	VRDT (B ₂ = 72,7%)	No grid expansion required		
	6 kW per household	VRDT (B ₂ = 71,4%)	VRDT (B ₂ = 62,9%)			
	7 kW per household	VRDT (B ₂ = 80,2%)	VRDT (B ₂ = 79,3%)	conventional (B ₁ = 73,3%)		
	8 kW per household	VRDT (B ₂ = 77,0%)	VRDT (B ₂ = 74,8%)	conventional (B ₁ = 66,7%)		
	9 kW per household	VRDT (B ₂ = 76,2%)	VRDT (B ₂ = 73,7%)	conventional*/VRDT (B ₁ = 57,7% B ₂ = 42,3%)		
	10 kW per household	VRDT (B ₂ = 68,3%)	VRDT (B ₂ = 68,4%)	conventional (B ₁ = 62,6%)		
11 kW per household	VRDT (B ₂ = 69,0%)	VRDT (B ₂ = 70,2%)	conventional (B ₁ = 73,8%)			
12 kW per household	VRDT (B ₂ = 71,4%)	VRDT (B ₂ = 65,8%)	conventional (B ₁ = 66,7%)			

* No recommendation can be given.

Keywords: PROMETHEE; multi-criteria decision analysis; grid expansion; Voltage Regulated Distribution Transformer

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Authors

Mandjee, Shazmane Student, Master in geography,
University of Quebec in Montreal Geography department,
UQÀM GERAD
Email: s.mandjee@gmail.com

De Robert, Arthur Student, Master in environmental sciences,
University of Quebec in Montreal
Institute of environmental sciences,
UQÀM GERAD
Email: arthur.de.robert@gmail.com

Waaub, Jean-Philippe Professor,
University of Quebec in Montreal
Geography department, UQÀM GERAD
Phone: 1-514-987 3000 poste 8908# Fax: 1-514-987 6784
Email: waaub.jean-philippe@uqam.ca

Title: A modelling approach for integrated energy and land-use planning: the case of the Great Montreal

Abstract

Introduction

In a world where space and natural resources are scarce, the choices that we make in terms of energy supply have enormous social, economic and environmental impacts. Our energy consumption is closely linked with our use of space (Kim & Brownstone, 2010; Mindali, Raveh, & Salomon, 2004). Computer modelling allows us to develop new opportunities for planning and managing such complex dynamic systems. The use of Multi Criteria Decision Analysis (MCDA) methods is an example of an essential tool for energy planning. Indeed, in a field subject to numerous uncertainties it is challenging to decide solely on the basis of cost, especially since intensive investments are required (Løken, 2007).

In North America, dense population and industrial activities are essentially concentrated around urban areas. Hence, planning and managing energy systems at the level of the agglomeration is imperative.

Objectives

This research project aims at creating an environmental and energy planning tool for the Great Montreal.

Through a multi-model approach, using an optimization model for energy system and a MCDA (Mirakyan & De Guio, 2013) coupled with a Geographic Information System (GIS), this research analyses the impacts of alternative scenarios on the energy system.

Using a systemic approach, urban landscapes are defined by population density and energy profiles, characterized by a specific urban topology. Thus, the optimization model satisfies a demand in population according to alternative energy scenarios. In this model, urban landscapes are in competition with each other and the model optimizes the “investment” using one or another. Each optimized scenario generates an investment plan and a spatial pattern for a given time period. Next, the environmental, energy, social and land-use impact of each scenario is assessed, taking into account diverse conflicting values and issues of stakeholders committed in energy planning, in order to better negotiate and create a Land-Use and Energy Plan for the Great Montreal.

Tools and Methodology

Scenarios for demand in energy services of the optimization model are defined according to the method of Environment Canada (2012). It considers energy price index, technological development, investment in Research and Development, and energy objectives at different levels of governance. Energy data are then desegregated to conform to the land-use database level of the GIS.

GIS allows to combine energy data (buildings and transportation) to land-use data in order to fuel the optimization model. The latter is built on the structure of OSeMOSYS to integrate the notion of space. It optimizes the supply in demand (housing and transport), from diverse sources of energy (oil, electricity, natural gas, etc.) in a system subject to constraints (CO₂ emissions, space, etc.).

The results of the optimization model (evolution of emissions, energy intensity, renewable energy rates, densification, etc.) enable to identify a spatial pattern of urban landscapes at a given time. They are then assessed using GIS and MCDA methods.

The MCDA method allows us to compare actions (spatial patterns of urban landscape units) according to impact criteria to assess a global performance.

In this research, we use Visual- PROMÉTHÉE software which allows to incorporate qualitative and quantitative criteria with various measurements (km², \$, GJ, rating scale, etc.). Indeed, PROMÉTHÉE is based on the concept of over-classification which prevents scales or compensation effects and allows us to identify the conflict in the impact assessment. For instance, an action with a low rating in energy will not be compensated with a high rating in economy (Côté, Waaub, & Mareschal, 2015). Further, PROMÉTHÉE methods enable to incorporate various values systems of stakeholders. Ranking of actions are then produced for each stakeholder and for the group. Other results (strength and weaknesses analysis of each action, visual analysis of conflict and synergy of criteria and stakeholders, sensitivity analysis and robustness analysis) facilitate deliberations and negotiations to reach the best compromises.

Therefore, policy-makers have in their possession factual information on various actions and preferences of all stakeholders.

Results

This research project establishes the ground for a multi-model aid tool for deliberation, negotiation, and decision in public policies. It facilitates the integration of energy resources issues in land-use planning policies.

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