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Chapter 6

A Multi-Criteria Analysis for Open Space Conservation in New York State

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Abstract

Pursuing the goal of large-scale ecosystem protection, the State of New York has for decades been acquiring private land parcels in the Adirondack State Park. While effective in terms of environmental protection, the process has repeatedly caused tensions with local communities who found themselves deprived of development possibilities. To ease these tensions, the involved parties agreed that a more open and participatory process was needed for guiding the Park's future development and conservation strategies. To push further the improvements implemented in 1998 with the State Open Space Conservation Plan, this paper suggests a framework for ranking alternative projects by use of multiple criteria decision aid (MCDA). With reference to data from parcels acquired by the State in the past, it is shown how MCDA is able to take into account a number of (in part conflicting) goals in a coherent and transparent way. For the case study, the NAIADE method was chosen, which can handle a number of different types of data and which supports the analysis of the structure of power interests and stakeholders by means of an institutional analysis.

Keywords: multiple criteria decision aid, NAIADE, sustainable land use, environmental policy, United States.

6.1 Introduction

The Adirondack Park, located in Northern New York State of the United States, is a unique combination of public lands protected by the State Constitution as "forever wild forest" and privately owned land regulated by state and local zoning laws. The State land includes roughly 47 percent of the Park. This combination of ownership has created an unprecedented application of land-use planning compatible with large-scale ecosystem protection. Although this complex pattern of public and private ownership has developed over the past century more by chance than design, New York has to a large degree been able to protect the ecological integrity of the largest park in the contiguous United States (Erickson, 1998).

These gains in environmental protection on behalf of the State's population at large were achieved at the expense of individual development rights of private landowners and local communities. Conflict between public agencies, local and statewide non-governmental organizations, and citizens has erupted around most new State land acquisitions, policy proposals, or management. One reason for these tensions is that today's Park has evolved from a rather top-down acquisition and planning process with little input from local communities. The 105 towns and villages within the Park boundary were left to bear the burden of real or perceived conflicts between a state agenda of environmental protection and a local agenda of economic development (Erickson and O'Hara, 2000).

Given the tensions, controversies, and political shakeup that resulted from the Adirondack Park's top-down protection efforts, decision-makers have agreed that a more open and participatory process is needed for guiding the Park's future development and conservation strategies. This has been a motivating force during the last decade of statewide initiative to devise a more acceptable and transparent land acquisition and management strategy and process. As part of the new statewide process, the relevant public agencies developed a system to evaluate and justify parcel acquisition using diverse criteria and given limited annual budgets. This system is also part of a process that has attempted to elicit public participation and communicate the rationale for continued statewide open space acquisition.

Very few acquisitions in the Adirondacks have occurred under this new formal system, however, numerous projects are currently entering the evaluation process. This paper will review the process of State land acquisition and report on ways to improve the ranking and decision-making processes by applying multiple criteria decision aid (MCDA).

MCDA can be used to support decision making in cases where conflicting economic, environmental, societal, institutional, technical, and aesthetic objectives may be involved. This multidimensionality is characteristic of most questions concerning sustainable development. MCDA allows for the use of heterogeneous criteria such as costs and benefits of the project, environmental quality in physical and qualitative terms, social impact in non-monetary terms, and even verbal descriptions of aesthetics.

6.2 The Case of the Adirondack Park

Decisions on State land acquisition in the Adirondacks have been characterized as a top-down process. At their most extreme, land purchases in the 1970s and 1980s were at times seen as projects stemming from the personal agendas or "wish lists" of state conservation officers or politicians. Opportunity for public comment or local consultation was rarely, if ever, encouraged. The public increasingly felt disconnected from both the rationale and process of spending taxpayer money, principally from State bonds approved by voters, on new acquisitions. State land in the Adirondacks had the additional burden on taxpayers of payment of property taxes in perpetuity.

In 1990, for the first time in State history, New York voters failed to pass an environmental bond issue that would have provided funds for significant additions to statewide holdings, most significantly in the Adirondack Park. Many have pointed to this event as the turning point in state open space planning and acquisition. Change, at least in spirit, that created a transparent process, clear rationale, and proposed management for State property was needed in order to instill faith in and restore finances for new acquisitions.

The *New York State Open Space Plan* of 1998 was the result of these events. It represents New York's first comprehensive plan and justification for statewide open space protection through land acquisition and conservation easements. Most significantly, the plan outlines a formal process for project evaluation and review. Any project under consideration for State land protection must now pass through six screens before the Commissioner of the Department of Environmental Conservation (DEC) will consider purchase of the property in fee or easement (i.e., purchase of development rights only). The six screens are outlined in *Figure 6.1*. Any person or private or public organization can propose a parcel of land to the State for protection. The State first and foremost tries to work only with a willing seller, reserving powers of eminent domain for rare circumstances. Starting with the "Resource Area Screen," the appropriate regional office of the DEC or the Office of Parks, Recreation, and Historic Preservation (OPRHP) determines whether a proposed parcel falls into either a resource area or linear system targeted in the

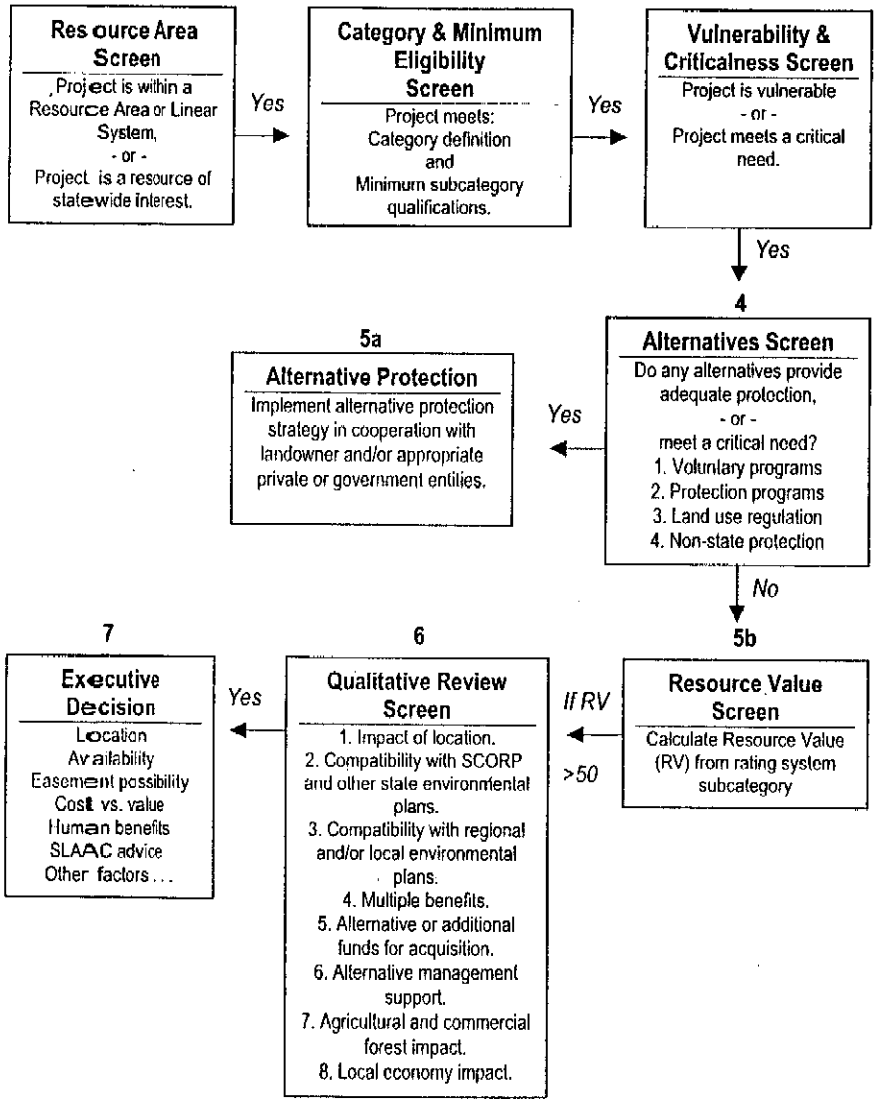

Figure 6.1. Project review and selection process.
Notes: SLAAC = State Land Acquisition Advisory Council; SCORP = Statewide Comprehensive Outdoor Recreation Plan.
Source: DEC and OPRHP, 1998, Figure 13.

most recent State Open Space Conservation Plan. The Adirondack Park is one of nine major resource areas identified in the 1998 Plan. Linear systems include areas that extend along continuous natural features (i.e., rivers or mountain ridges) or trail corridors. Examples include the Hudson River Valley, the New York State Canal Recreationway System, and the Appalachian Trail (a portion of which crosses New York State on its east coast journey from Georgia to Maine). Even if a proposed project does not fall within one of these predefined conservation targets, it can pass this screen if the parcel is considered to be a resource of statewide interest.

Next, a proposed parcel must fall within a conservation category and meet minimum subcategory qualifications. *Table 6.1* lists the six protection categories along with the 21 specific subcategories. The major categories are forest preserve addition, water resources protection, significant ecological area, recreational opportunity, distinctive character, and enhancement of public lands. Under the current system, a parcel can only be categorized under one subcategory, even though it may have attributes that qualify it for many. Minimum requirements differ widely amongst subcategories. A forest preserve addition can only be considered if it is located within either the Adirondack or Catskill Park and outside the boundaries of an incorporated village or city. A forest and scenic easement must protect productive forestland located within either the Adirondack or Catskill Park. Requirements under other sub-criteria tend to be much more specific than these two forest-preserve categories.

The third stage in the screening process ascertains the degree of urgency for protection, considering for instance the present condition of the site, any pending ownership transfer, the relationship with any local land use plans, and the land use pattern and development trends in the area. In addition, consideration is given to the compatibility of a proposed parcel with objectives other than preservation (i.e., access, resource management) and the availability of alternative sites to meet those objectives.

Once a parcel passes through these initial screens, the regional DEC office must then determine whether alternatives to state purchase or easements exist that can still provide adequate protection or meet a critical need. For instance, voluntary private conservation or enrollment in non-state protection programs may satisfy a particular objective. In recent years, the State has relied heavily on groups such as the Nature Conservancy to protect key parcels because either acquisition funds or ability to acquire a parcel in a timely manner is lacking. The role of land trust organizations in pre-acquisition of permanent State property accounted for 22% of transactions eventually acquired under 1986 Bond Act funds, amounting to 79% of acreage purchased and 68% of dollars spent (The Land Trust Exchange and Russel, 1990, pp. 172–186). The state may also consider regulation versus outright purchase to protect a parcel from development or unsustainable use. If a feasible

Table 6.1. Land protection categories and sub-categories.

Forest Preserve	Water Resource Protection	Significant Ecological Area	Recreational Opportunity	Distinctive Character	Enhancement of public lands
Forest preserve additions	Aquifer recharge area	Exceptional forest	Metropolitan parks and shorelines	Historic preservation	Access
Forest land easements	Watershed protection	Shoreline protection	Parklands	Working landscapes	Buffer
		Unique areas	Public fishing rights	Heritage areas	Consolidation and inholdings
		Wetlands	Trailways and and greenways	Scenic resources	
		Wildlife habitat	Waterway access		

Source: DEC and OPRHP, 1998, Table XI.

alternative can be negotiated without the use of state acquisition funds, then this provides an opportunity to exit the evaluation process outlined in *Figure 6.1*.

At this point in the process, if State acquisition of land or development rights seems like the best course of action then the parcel under consideration enters a formal resource value screen (Stage 5b). The rating is a numerical score, unique to each subcategory, assigned by professional staff (typically a DEC forester) on a scale of 0 to 100 points. A minimum of 50 points is required for consideration under the Open Space Conservation program. Again, a parcel can only be evaluated applying one of the twenty-one subcategories outlined in *Table 6.1*. However, any project meeting the minimum criteria of one other subcategory receives an additional three points. If more than one additional subcategory applies, then five points are awarded. In addition, gifts of land avoid purchase costs and are thus awarded 10 extra points towards the 100 total. *Table 6.2* outlines the resource value-rating scheme for the subcategory of forest preserve easements.

The point system is not meant to compare parcels between different categories or subcategories. Resource values are only comparable within unique subcategories. Under the present system, subcategory scores can be used to rank acquisition, but mainly serve as a threshold before projects are recommended for a final screening. If a project receives a resource value score of at least 50 points then it is eligible to move into the qualitative review screen.

Table 6.2. Resource value rating system: Adirondack and Catskill Park forest and scenic easements.

Characteristic	Rating
a. Proposed project will provide new or enhance existing recreational opportunities.	
(i) Choose one:	
(a)Project provides five or more opportunities for a variety of both land and water related recreational activities;	10
(b)project provides between two and five opportunities for a variety of either land or water related recreational activities; or	5
(c)project provides for a single purpose recreational opportunity of either a land or water related activity.	1
(ii) Choose one:	
(a)Project provides alternate recreational opportunities for an existing recreational area which is currently experiencing high use;	10
(b)project provides recreational opportunity to a geographical area where there is a demand for recreational use but which currently has little or no recreational opportunity; or	10
(c)project provides additional opportunity to an area which is not presently experiencing high use.	1
b. The proposed project's maximum value is:	(30)
(i)protects threatened or endangered plant or animal species	10
(ii)protects significant habitats	10
(iii)protects rare natural communities	10
(iv)protects Class I regulated wetlands; or	10
(v)protects undeveloped shorelines of importance. Importance is defined by designation as: 1. a wild, scenic or recreational river; 2. critical environmental area; 3. scenic area of statewide importance; or 4. national natural landmark.	10
c. Proposed project protects recognized scenic areas or views, including scenic highway corridors that require the manipulation of vegetation to preserve.	5
d. Proposed project provides or enhances access to inaccessible or poorly accessible portions of Forest Preserve or other lands or waters.	
(i)the proposed project would provide access or assist in providing access to public lands or waters which presently have no existing access open to the public; or	5
(ii)the proposed project would provide access or assist in providing access to public lands or waters to which existing access is poor because of physical barriers; or	3
(iii)the proposed project would reduce the length of a circuitous route of three miles or more necessary for public use of existing public lands or waters.	1

Table 6.2. Continued.

Characteristic	Rating
e. The value of the continuation of forestry uses is determined by application of the following rating scale. The maximum value is:	(40)
(i) productivity factor: rate the overall productivity of the project using such factors as soils, income potential, species composition, products produced, significance to industry, and other relevant factors:	
(a) high,	20
(b) medium,	10
(c) low.	5
(ii) survival factor: rate the likelihood of the project continuing in present use using such factors as: capital investment, product demand, owner commitment, accessibility, and other relevant factors:	
(a) high,	20
(b) medium,	10
(c) low.	5
f. The present degree of development and extent of viewshed proposed for protection is determined by the application of the following rating scale. The maximum value is:	(40)
(i) current degree of development as expressed as a percent of maximum buildout allowed under existing zoning:	
(a) <= 20%	20
(b) > 20% and <=50%	10
(c) >50% and <=70%	5
(ii) ratio of project acreage within either 500 feet of mean high water or 1,000 feet of public viewing point (highway, trail, etc.) to total project acreage is not less than 40%:	20
(a) >75%	10
(b) 60% to <75%	
(c) >=40% and <60%	5

Source: DEC and OPRHP, 1998, Appendix C.

Eight criteria are used at this final stage to justify a formal acquisition or easement proposal to the Commissioner of the DEC. The first six criteria are similar to considerations taken in screens one through four. At this point, considerations of project compatibility, multiple benefits, and the fund source and mechanics of title acquisition are made more explicit. However, the seventh and eighth criteria explicitly consider economic impacts of parcel acquisition for the first time in the review and selection process. At this stage, staff of either the DEC or OPRHP follow a checklist that was developed to help evaluate potential fiscal and economic benefits and burdens associated with a proposed project (DEC and OPRHP, 1998, p. 66). These factors include the project's impact on: real property tax base; local

and regional retail sales and service businesses; real estate values; traffic flow; land use patterns; funding by bonding, direct allocation, gift, federal funds, or private funding sources; and farming and forestry resource base in the town or county.

The ultimate recommendation to the Commissioner follows careful consideration of data from each of the six screens, comment from local government, and any input from the State Land Acquisition Advisory Council (SLAAC). The Commissioner decides whether or not to proceed with acquisitions and has the discretion to rank approved projects.

If the current procedure is taken at face value (ignoring political realities of a very flexible process for the moment), there are a number of shortcomings that can be identified. First, the shortcoming of being able to compare only land parcels within the same sub-category could be overcome, if a sound multi-criteria analysis were the basis of ranking the parcels. Possible incompatibilities between categories can still be taken into consideration under such a framework. Second, the evaluation of the criteria for the land parcels seems rather ad hoc and subjective instead of being based on sound scientific information. Third, there seems to be some degree of misplaced concreteness involved in the evaluation of the criteria. For example, it seems difficult to argue exact differences for the criteria "scenic resources." Aesthetics are usually best expressed in linguistic variables that are, however, best translated into fuzzy variables instead of crisp ones. Fourth, other criteria could be included which would probably increase the acceptability of the evaluation scheme within the population in the area. Such criteria could include economic variables such as estimates of resulting job creation/destruction effects stemming from land use changes, or social criteria like residential attractiveness. Fifth, the transparency of the decision making process should be increased, i.e. the criteria and their evaluation laid open to the public. Sixth, particularly with a history of struggle and dispute as is the case in the Adirondack Park, the involvement of all relevant stakeholders is crucial for achieving widely accepted solutions. Stakeholder input currently is only included before the formal project screening occurs (i.e., in the pre-screening of projects by regional open space committees who recommend formal evaluation).

6.3 Alternative Problem Structuring with Multicriteria Decision Aid

Decision making on sustainable land use usually involves competing interest groups, conflicting objectives, and different types of information. Multi-criteria decision aid (MCDA) is a tool that can be used to consider simultaneously multiple conflicting criteria (e.g., representing economic, environmental, social, institutional, technical, and aesthetic objectives). The aim is "to enable us to enhance the

degree of conformity and coherence between the evolution of the decision-making process and the value systems and objectives of those involved in this process" (Roy, 1990, p. 17). This points to the importance of the decision makers in this process, but also the fact that the result of an MCDA method is only an input into the decision-making process and not the final result.

6.3.1 NAIADE algorithm and software

The multidimensionality is also a characteristic of the scenario of open space acquisition under investigation. For this reason MCDA is used. Specifically, the NAIADE (Novel Approach to Imprecise Assessment and Decision Environments) method (developed by Munda, 1995) was found to be effective in this specific case for several reasons.

NAIADE belongs to the group of discrete multicriteria methods, i.e., the set of alternatives is finite (for a good overview of methods see Vincke, 1992). Using a pairwise comparison technique, NAIADE generates a ranking of alternatives according to the set of evaluation criteria. The comparison of criteria scores of each pair of alternatives is carried out by means of semantic distance which mirrors a possible degree of equality between two fuzzy sets or a similarity degree between them; the larger the distance the smaller the possible degree of equality. Fuzzy binary relations are used to model different possible preference/indifference situations. The aggregation of the evaluations of the alternatives according to each single criterion is done such that the intensity of preference is incorporated.

More specifically, the intensity index $\mu_*(a,b)$ of preference $*$ (where $*$ stands for $>>$, $>$, $\cong$, $=$, $<$ and $<<$) of alternative a versus b is defined as follows (Munda, 1995:137n.):

$$\mu_*(a,b) = \frac{\sum_{m=1}^{M} \max(\mu_*(a,b)_m - \alpha, 0)}{\sum_{m=1}^{M} \mid \mu_*(a,b)_m - \alpha \mid}.$$

The intensity index $\mu_*(a,b)$ has the following characteristics:
$0 \leq \mu_*(a,b) \leq 1$
$\mu_*(a,b) = 0$ if none of the $\mu_*(a,b)_m$ is greater than α;
$\mu_*(a,b) = 1$ if $\mu_*(a,b)_m > \alpha \forall m$, and $\mu_*(a,b)_m \geq \alpha$ for at least one m.

The parameter α, which can be changed in the analysis, is the 'minimum requirement' imposed on the fuzzy relation to distinguish between different degrees of preference and indifference in the aggregation (Munda, 1995). This means that with increasing α only values having a high intensity of preference or indifference are used. Or more precisely, only those criteria whose indexes are above the threshold will be counted positively in the aggregation (Menegolo and Pereira, 1996).

Moreover, when α increases, a lower degree of compensation among the criteria is allowed. If too high or too low values are used, it is difficult to discriminate between actions (Munda, 1995).

The ranking of alternatives in NAIADE is based on the preference intensity indexes $\mu_*(a,b)$ and corresponding entropies $H_*(a,b)$ for the alternatives a and b. The ranking process is based on the basic idea of positive (leaving) and negative (entering) flows of the PROMETHEE methods (Brans *et al.*, 1986). A partial ranking of alternatives can be deduced from the positive (ϕ^+) and the negative (ϕ^-) outranking flows (see PROMETHEE I). Both rankings are usually not identical. The final ranking comes from the intersection of the two separate rankings. The first one $\phi^+(a)$ is based on the better and much better preference relations; its value ranges from 0 to 1 indicating how a is better than all other alternatives. The second outranking flow, $\phi^-(a)$, is based on the worse and much worse preference relations; its value ranges from 0 to 1 indicating how a is worse than all other alternatives (Menegolo and Pereira, 1996).

In comparison, the much more widely used method of 'Analytic Hierarchy Process' (AHP) is based on the construction of hierarchies and pairwise comparisons that are used for establishing weights. Since AHP is based on measuring preferences cardinally, its underlying ideas differ significantly from the ones of NAIADE. Also, AHP does not address uncertainty.

The NAIADE method is a recently developed MCDA approach, whose impact matrix can include crisp, stochastic, or fuzzy measurements of the performance of each option with respect to a judgment criterion. No weighting of criteria is used explicitly (Munda, 1995). Hence, it allows the use of information affected by different types of uncertainty. In addition to the ranking of alternatives, NAIADE supports the analysis of conflicts between different interest groups and the possible formation of coalitions according to the proposed alternatives. The method is implemented by a software application also called NAIADE (for case studies applying this method see, for example, De Marchi *et al.*, 2000; De Montis *et al.* 2000).

The NAIADE method is used in this case study for several reasons. First, the current evaluation procedure consists of several steps that are based on different types of information. The impact (or evaluation) matrix in NAIADE may include either crisp, stochastic, or fuzzy measurements of the performance of each option with respect to a judgment criterion (Munda, 1995). Some of the criteria (like acquisition costs, loss of agricultural land, or impact on retail sales) can be measured in quantitative terms. Others (like protection of scenic area or multiple benefits) are expressed in qualitative terms. In order to incorporate this diverse information, a method was necessary that incorporates both types of data. In addition, the information may be available – as it is in the cases under consideration – in rather rough categories. While unsatisfactory from a scientific point of view, the data may not

be available in a more precise way (or too expensive to be gathered). To include rough categories into a transparent and consistent analysis is preferable to dropping the information completely or to including unfounded information. In other cases, it may be impossible to express criteria in concrete numbers absent of fundamental uncertainty. In particular, criteria on the interface between the social and the environmental system may be greatly affected by uncertainty.

The second reason for the choice of NAIADE over other multi-criteria techniques is the ability to conduct conflict analysis. In addition to the ranking of alternatives, NAIADE supports the analysis of conflicts between different interest groups and the possible formation of coalitions according to the proposed alternatives. This may help to make the decision process more transparent, and will be explored in a future extension of this work.

Furthermore, the selection of operators and choice of parameters allows us to apply the software to problems where differing degrees of compensation of criteria performance is desired and to test for sensitivity of the results.

6.3.2 Data

The criteria were given in the *Open Space Plan*. Using the evaluations of five recently considered parcels from the sub-category 'forest easement,' an impact matrix was constructed. The data were provided by the DEC of New York State and complemented wherever necessary by expert opinion.

As can be seen in *Table 6.3*, all variables were defined as linguistic variables. The data from the Qualitative Review Screen were only available in this way. Even the points assigned in the Resource Value Screen are mere representations of a discrete number of linguistic evaluations. This view is supported by the fact that points are only assigned in discrete steps and not on a continuous scale of numbers. To assure that the decision-makers' preferences are accounted for, we kept the distances between and the different weights of the respective points (for details see notes to *Table 6.3*). In NAIADE, the linguistic variables are defined by means of fuzzy sets defined by a 0 to 1 scale, whereby 1 indicates 'perfect' and 0 indicates 'extremely bad.'

Unfortunately, the data describing parcels that were not eventually acquired in fee or easement is not archived by the DEC. Therefore it is not possible to analyze a complete decision situation and to compare the administrative decision with the results of the model-based decision framework.

If more precise information were available for some of the criteria – costs, for example – (see Notes to *Table 6.3*) it could be introduced into NAIADE in real numbers or ranges of numbers (fuzzy sets).

Table 6.3. Evaluations for five parcels with the criteria from Resource Value Screen and Qualitative Review Screen.

Criteria	Long Pond Tract (A)	Otetiana (B)	Santa Clara Tract (C)	Tooley Pond Tract (D)	Croghan Tract (E)
1. Types of recreation	more than 5	more than 5	more than 5	more than 5	more than 5
2. Complementarity to existing recreation opportunities	w/o high use	w/o high use	w/o high use	no	high use
3. Protection endangered species	no	yes	no	no	no
4. Protection significant habitat	yes	yes	no	no	yes
5. Protection rare natural communities	yes	yes	yes	yes	yes
6. Protection wetlands	no	no	no	no	no
7. Protection shorelines	no	no	no	no	no
8. Protection scenic area	no	yes	no	no	no
9. Improvement of accessibility	little	no	no	no	little
10. Productivity factor	high	medium	high	high	high
11. Survival factor	high	medium	high	high	high
12. Impact of land use patterns	weak no	no	no	weak no	no
13. Conflicts w/other State plans	no	no	no	no	no
14. Conflicts w/environmental plans	no	no	no	no	no
15. Multiple benefits	weak yes	yes	weak yes	weak yes	weak yes
16. Alternative/additional funding sources	no	potentially	no	no	no
17. One time costs	low	low	high	high	high
18. Future annual costs	low	low	high	high	high
19. Possibility to share costs	no	potentially	potentially	potentially	potentially
20. Agricultural land loss	no	no	no	no	no
21. Impact on local tax base	weakly positive	positive	very positive	very positive	very positive
22. State paying real property tax	yes	partially	partially	partially	partially
23. Impact on retail sales/service business	neutral	somewhat positive	somewhat positive	weakly positive	weakly positive
24. Impact on local real estate values	neutral	weakly positive	neutral	neutral	neutral

Table 6.3. Continued.

	Criteria	Long Pond Tract (A)	Otetiana (B)	Santa Clara Tract (C)	Tooley Pond Tract (D)	Croghan Tract (E)
25.	Impact on traffic flow	neutral	weakly negative	weakly negative	neutral	neutral
26.	Impact on local land use patterns	no	no	no	no	no
27.	Direct cost to NYS tax payer	negative	negative	negative	negative	negative
28.	Direct cost to local tax payer	positive	positive	positive	positive	positive
29.	Impact on farming/resource base	positive	neutral	positive	positive	positive

Notes: To account for preference intensity equivalents, points were assigned to the nine-part scale of qualitative evaluations suggested by the software. Hence, the highest value represents 20 points in the Resource Value Screen, decreasing at equal distances to zero (relevant for criteria 1 to 11). The only difficulty with this procedure arose for values 1 and 3 where 2.5 had to be assigned as an approximation. Criteria 12 to 29 came from the Qualitative Review Screen. The options for the questions related to criteria 12 and 15 are: 'absolutely,' 'yes,' 'weak yes,' 'maybe,' 'not certain,' 'don't think so,' 'weak no,' 'no,' 'no way.' The options for the questions related to criteria 13, 14, 16, 19 and 20 are: 'yes,' 'potentially,' 'no.' The options for the questions related to criteria 17 and 18 are: 'low,' 'medium,' and 'high.' The options for the questions related to criteria 21, 23, 24 and 25 were 'very positive,' 'positive,' 'somewhat positive,' 'weakly positive,' 'neutral,' 'weakly negative,' 'somewhat negative,' 'negative,' and 'very negative.' The options for the questions related to criteria 27, 28 and 29 are: 'positive,' 'neutral,' and 'negative.' The options for the questions related to criteria 22 and 26 are: 'yes,' 'partially,' and 'no.' All criteria are maximized except 'one time costs' (17), 'future annual costs' (18) and 'agricultural land loss' (20), which are minimized.

6.3.3 Results and discussion

A critical factor in determining the results provided by the NAIADE method is the parameter used in the equation on approximate reasoning operations.

By use of the minimum operator, which is known as a representation of the logic 'and,' the ranking obtained for a low value of α (0.3) is given in *Figure 6.2*. The NAIADE program computes separate rankings for the positive and negative outranking flows with their respective values. The higher the value of the positive outranking flow, the higher its 'power,' i.e., the better one alternative is compared to the others. In our case, A (project: Long Pond Tract) is better than B (project: Otetiana) which is better than E (project: Croghan Tract), etc. The higher the value of the negative outranking flow the higher its 'weakness', i.e., the worse is one alternative compared to the others. Here, B is worse than C (project: Santa Clara Tract) which is worse than D (project: Tooley Pond Tract), etc. Hence, the higher the value of $\phi^+(a)$ and the lower $\phi^-(a)$, the better is alternative a. The final ranking

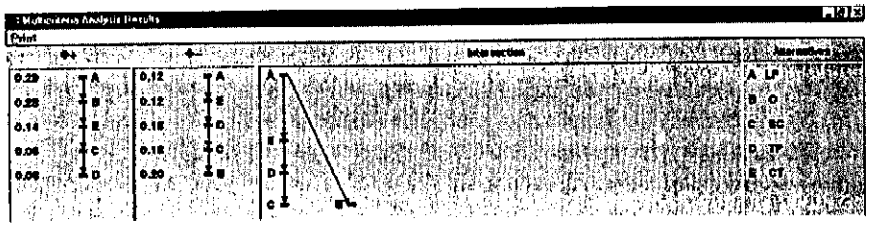

Figure 6.2. Ranking of parcels (minimum operator, $\alpha = 0.3$).

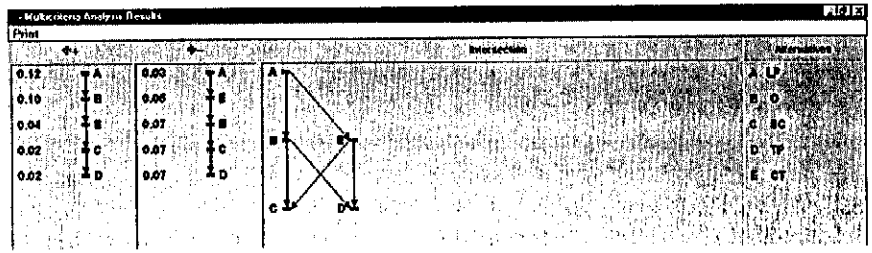

Figure 6.3. Ranking of parcels (minimum operator, $\alpha = 0.5$).

is obtained from the intersection of the two outranking flows. A has the highest positive outranking flow and the lowest negative outranking flow and is therefore preferred to all other alternatives. B has a high positive outranking flow but also a high negative outranking flow, i.e. it is on the one side better than the three other alternatives, but also worse then these alternatives, and therefore not comparable. The difference between alternatives A and E in the negative outranking flow is very small (less than 0.01). However, A is significantly better than E in the positive outranking flow. In total, E is therefore dominated by A. Differences in the values of both outranking flows of alternatives C and D are very small. The domination of D over C is therefore very weak.

Increasing the value of α (0.5) (see *Figure 6.3)* increases incomparabilities, but the main findings remain the same. A has a higher positive outranking flow and a lower negative outranking flow than the other alternatives and is therefore preferred to the others. While B has a higher positive outranking flow than E, alternative E has a lower negative outranking flow. These two alternatives are therefore incomparable. Alternatives C and D are dominated by all the other alternatives. Differences between them are too small, therefore they are also incomparable in this specification.

Since the outranking flows are already quite low, increasing α further is not recommendable.

The pairwise linguistic evaluations give indications of the relative credibility degree of preferences and therefore complements the ranking which is ordinal in nature. The alternatives considered here were all successful ones and therefore the evaluations are very similar, hence it is not surprising that the differences between most parcels seen through the pairwise comparisons are not very high.

In sum, it can be seen that NAIADE is a tool that can help decision-making in this case by providing rankings allowing for different degrees of compensation between the values of the fuzzy relations. The results vary to some degree with the specifications, but not in the main findings. The selection of specifications reasonable in this context needs to be done by the decision-makers.

The framework and procedure presented here allow the inclusion of other features that may be useful for better decision making. First, if more precise information were available, this could be included either as real numbers or at least as ranges of values (fuzzy numbers). Second, the application of similar criteria to all sub-categories would enable decision-makers to compare parcels across categories in a coherent and (publicly) defendable way. The criteria, however, need to be global, i.e., applicable to all categories, because incomparabilities will result otherwise. This does not mean that no distinction could be made between the characteristics of the different sub-categories. The criteria would have to be defined broadly enough and could then be filled with the information adequate for the respective sub-category.

On a different level, the decision process could be improved by integrating different groups of stakeholders into the decision-making process. Besides an "impact matrix," each group also constructs an "equity matrix," which contains linguistic evaluations of alternatives. In particular, "equity analysis is performed by the completion of an equity matrix from which a similarity matrix is calculated. Through a mathematical reduction algorithm, it is possible to build a dendrogram of coalitions which shows possible coalition formation, and a level of conflict among the interest groups'' (Menegolo and Pereira, 1996, p. 1).

Unfortunately, the information necessary to do such an analysis was not available in our case. The inclusion of stakeholders in a transparent process could, however, increase the acceptability and defendability of the decision.

6.4 Conclusions

Due to major economic structural changes, large tracts of private land are currently for sale in the Adirondacks. The state authorities used land acquisition and conservation easements, among other instruments, to enhance sustainable land use in the Adirondack State Park. The goals, the extent, and the process have often been

criticized for a lack of transparency and consistency and resulted in fierce disputes among the various interest groups. In order to address these criticisms this chapter suggests a framework that applies MCDA.

MCDA helps to structure the decision-making process and the relevant information. It increases the transparency of the process and provides an algorithm for ranking parcels. Its ability to include quantitative and qualitative criteria within a consistent framework is particularly useful. Even where quantitative data exist they are very often qualitative in nature and should and can be treated as such.

NAIADE has proven to be particularly suitable in this context because the uncertainty inherent in sustainability questions is addressed with the concept of fuzzy sets as used in the evaluation matrix. Despite the imprecise information, NAIADE allows a consistent evaluation without imposing strong assumptions. The structure of the method shows weaknesses in data and shows the direction of further data collection. Furthermore, the diverse values expressed by different stakeholders can be included with the addition of an equity matrix, which can highlight coalition potential in conflicting situations. The information provided by the stakeholders and the analysis of their positions is a valuable input into the process towards an acceptable decision. Coalitions and values are made explicit and therefore allow an open discussion of assumptions and valuations.

The current analysis has been restricted due to the unavailability of data on parcels not chosen after the review processes. Inclusion of those parcels would enable transparency of the current decision-making process and would increase the acceptability by all involved or affected. This paper has relied on documented information.

A discussion with decision-makers and stakeholders is a necessary next step to discuss questions of desired compensability between criteria. A difficult issue remains to be explored in the application: How deep an insight do users need to get into the sophisticated technicalities of the method (e.g., the ranking procedure or the concept of fuzzy sets) in order to feel comfortable using results from the analysis? It is our conviction that the appropriate choice of technical specifications, their translation by the researcher into non-technical language, and the discussion of crucial specifications is essential for acceptable results. It is the responsibility of the researcher to ensure this through non-technical discussions with stakeholders. Hence, we do not find that simple methods which require strong and unrealistic assumptions should be preferred. In the past, NAIADE has been applied successfully in several cases with stakeholder involvement (e.g., De Marchi *et al.*, 2000; Race, 2000).

This chapter represents a valuable contribution in the evaluation process and provides a starting point for reevaluating the decision-making process as well as a procedure to include the groups concerned.

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