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Participatory multicriteria decision analysis with Web-HIPRE: a case of lake regulation policy

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Abstract

Environmental decision making typically concerns several stakeholders with conflicting views. Multicriteria decision analysis provides transparent ways to elicit and communicate individual preferences. When the stakeholders clearly understand each other's views, a consensus can be reached more easily. Computer software provides a substantial enhancement to support participatory decision making processes, for example, in the preference elicitation and in the analysis of the results. In this paper, we describe the first web-based multicriteria decision support software called Web-HIPRE, and the use of it in participatory environmental modelling. The world wide web provides new possibilities to support the process, for example, by allowing distributed decision support. The stakeholders can be located in different geographical areas, especially in environmental problems. We illustrate the use of Web-HIPRE in a case dealing with the evaluation of regulation policies for the Lake Päijänne in Finland. Decision analysis interviews were carried out and preference models of some typical stakeholders were collaboratively analyzed in order to increase the understanding of other stakeholders' views. This proved to be an applicable approach in trying to reach consensus between the stakeholders. Web-HIPRE also provided a flexible way to allow complementary support via the web.

Keywords: Multicriteria decision analysis; Decision support systems; Lake regulation; Public participation; World wide web

Software availability
Name of software: Web-HIPRE
Developed by: Raimo P. Hämäläinen, Jyri Mustajoki
Contact information: Systems Analysis Laboratory, Helsinki University of Technology, P.O. Box 1100, FIN-02015 HUT, Finland; Tel.: +358-9-451 3054; fax: +358-9-451 3096; E-mail: raimo@hut.fi
Availability: Free for academic use at www.hipre.hut.fi. For commercial and local installations contact 100Gen Oy, Tekniikantie 12, 02150 Espoo, Finland; Tel.: +358-9-2517 2009; fax: +358-9-502 3861; E-mail: aijo@100gen.fi
Available since: February 1998
Online documentation: http://www.hipre.hut.fi/Help.html
Learning material including video clips at: http://www.mcda.hut.fi
Hardware required: Any platform with an Internet connection
Software required: Any web browser with Java support
Programming language: Java

1. Introduction

Public concern of the state of the environment has grown rapidly and this has also increased interest in participatory decision making. Consequently, public approval has become an important decision objective, and the public participation a common element in environmental decision making processes. However, the large number of stakeholders also induces a large number of conflicting views, and transparent and structured processes are needed to reach participants' shared understanding of the problem.

Multicriteria decision analysis (MCDA) and computer based decision support systems (DSS) provide ways to systematically structure and analyze complex decision

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problems. With these, individuals can evaluate and compare the policy alternatives. In participatory planning processes they provide methods to analyze and aggregate the preferences of the decision makers (DM). For recent surveys of MCDA applications, see Keefer et al. (2004) and Hämäläinen (2004).

The proliferation of the internet has greatly enhanced the possibilities to support public interaction including participatory decision processes (see e.g. Bhargava and Krishnan, 1998 or Geoffrion and Krishnan, 2001). The world wide web provides techniques for both multimedia communication and interactive distributed modelling and preference elicitation, as well as the exchange of the results.

In this paper, we describe the use of Web-HIPRE software in participatory processes. Web-HIPRE is a Web implementation of the earlier HIPRE 3+ software (Hämäläinen and Lauri, 1995), and as far as the authors know, it is the first web-based general purpose MCDA software that provides tools for problem structuring, preference elicitation and sharing the results over the internet. The release of Web-HIPRE in 1998 has also stimulated efforts to develop other very similar systems (see e.g. Zhu and Dale, 2001). However, Web-HIPRE still remains one of the few general purpose decision analytical software packages available for on-line use on the web (see e.g. Maxwell, 2002). We shall also briefly discuss the use of another web-based tool called Opinions-Online (Hämäläinen and Kalenius, 1999), to collect and process survey type information over the Internet. Both Web-HIPRE and Opinions-Online are part of the Decisionarium (Hämäläinen, 2000), our site for interactive multicriteria decision support.

The main objective of this paper is to describe and discuss the different possibilities of Web-HIPRE to support participatory processes in environmental decision making. In this respect, this study differs from conventional ones with an aim to validate the given hypotheses. As an example, we also illustrate the use of the software in the case of developing the regulation of Lake Päijänne in Southern Finland (see also Hämäläinen et al., 2001). The use of the decision analysis tools was an essential part of the process. Web-HIPRE and HIPRE 3+ were applied to evaluate the regulation policies and to support the analysis of the results. The main objectives were to identify the values and opinions of representatives of the stakeholders in the steering group, and in this way enhance their overall understanding of the problem. Web-based software was applied to demonstrate the possibilities of new technology. Opinions-Online was used in the closing workshop to bring into discussion stakeholders' opinions about the regulation development project and the recommendations for the mitigation measures presented.

Traditionally, MCDA software has only been used by decision analysts. However, our easy-to-use software is available to everyone on the internet, which makes it possible for the DMs to learn to use the software by themselves. We have developed and made publicly available web-based learning material (Hämäläinen, 2002) for helping in the independent use of the software. It is hoped that this material will minimize the possibilities of using the methods incorrectly, thus generating biased results. In general, our goal is to provide the resources in Decisionarium, and to guarantee the proper use of them.

This paper is organized as follows. Section 2 gives a brief introduction to public participation in environmental processes. Section 3 describes the use of MCDA with Web-HIPRE, and discusses the possibilities of using Web-HIPRE in environmental applications. Section 4 describes the case of Lake Päijänne and the use of Web-HIPRE and Opinions-Online to support the participatory process in the evaluation of the lake regulation policies. Section 5 concludes the paper.

2. Participatory environmental decision making

2.1. Public participation in environmental processes

The objectives of participating the public in environmental decision making processes are various (see for example, Morgan, 1998 or Kapoor, 2001). One of the most important ones is to enhance the mutual understanding and consensus between the stakeholders. This can be achieved by taking all the different views of all of the relevant stakeholders into account and by working with these in a constructive way. Another objective is to encourage stakeholders' accountability and commitment to the decision by giving them a possibility to influence. A participatory process can also provide useful additional information to the stakeholders. In this paper, our focus is on environmental management, and especially on water resources management. The discussion may also apply wider, but studying public participation in general (see e.g. Lowry et al., 1997) is beyond the scope of this work.

Transparency of the process is one of the key requirements. With a transparent process, we can reduce the possible uncertainties and misinterpretations both in communications and in combining the conflicting views. Then, the stakeholders can be assured of that all of them are included in the process. They can also be sure that the process is fair and not used, for example, as means to deliberately serve a single purpose (Kangas et al., 2001).

However, the involvement of several stakeholders with different views makes public participation a challenging task. Especially in environmental problems, the views of the stakeholders are typically conflicting, and the need for transparent methods to settle the differences is evident. A participatory process is often both time and resource consuming, as traditionally it has been carried out in public meetings, exhibitions and workshops, as well as with questionnaires and interviews (Morgan, 1998). Also, the rate of participation may remain low, for example, due to long distances to the meetings and unsuitable meeting times (Kingston et al., 2000).

2.2. Multicriteria decision analysis

MCDA provides a transparent way to structure problems and support the elicitation of preferences in participatory decision making. It is a systematic process where different elements of the problem are identified and modeled, and the stakeholders' preferences elicited within a structured framework. Usually, most time is spent in structuring the problem. This includes the definition of the overall goal, the essential criteria and the alternatives. After that, the alternatives are evaluated in respect to each criterion, and the criteria weighted according to their importance. As a result of the process, one gets overall values for the alternatives indicating the preferences on these. For general textbooks on MCDA see e.g. von Winterfeldt and Edwards (1986) or Belton and Stewart (2001).

There are different ways to carry out the modelling of the stakeholders' preferences. In decision analysis interviews (see for example, Marttunen and Hämäläinen, 1995), each stakeholder is interviewed by a decision analyst, who also makes sure that the interviewee understands the use of the methods. In decision conferences (Phillips and Phillips, 1993), also called decision workshops, a facilitator guides the group through the computer-aided modelling process. However, if the number of stakeholders is high, these approaches may not be applied as such. Then, an alternative approach is to work with a small group consisting of representatives of stakeholders. The results of the analyses can then be presented and discussed publicly. The objective is that by analyzing the models of the other stakeholders, an understanding of their preferences can be achieved (Keeney and Raiffa, 1976).

MCDA approach has been used in numerous environmental applications. These include, for example, cases in energy policy evaluation (Hämäläinen, 1992), natural resources management (Gregory and Keeney, 1994; Keeney and McDaniels, 1999; Marttunen and Hämäläinen, 1995; McDaniels et al., 1999) and strategic planning in forestry (Kangas et al., 2001). See also Keefer et al. (2004) and Hämäläinen (2004) for recent trends in MCDA applications. A characteristic feature in all of these cases has been a conflict between the different interests, such as economical, environmental, political or social ones. MCDA has proven to be able to accommodate these problems in a unified setting.

2.3. The use of the web

The use of the web as communications channel provides new possibilities to support participatory processes. It allows, for example, distributed decision support, which may be especially useful in environmental issues, as the stakeholders typically live in the area where the measures take place. However, there still are people that do not have access to the web. Thus, the web does not yet provide equal possibilities to participate, but it can act as an alternative to traditional ways (Kangas and Store, 2003). Then, each stakeholder can choose the most suitable way of participation for his/her needs, which may increase the motivation to participate.

In simplest form, the web is a communications channel to distribute information for the public. By allowing a possibility to give feedback, two-way communications can easily be carried out. As it is open, platform-independent and global, the web fulfills the requirements for the communications channel for a group support system (Nunamaker, 1997). Yet, the possibilities to create interactive applications utilizing multimedia facilities make it possible to create, for example, sophisticated web tools to support MCDA methods. However, the use of these requires certain expertise. Publicly available decision analysis software packages allow anyone to independently create his/her own preference models, but an improper use of the methods may lead to incorrect conclusions (see for example, Hämäläinen and Alaja, 2003). Thus, in practice, it should also be ensured that the user has an adequate background of the methods, or that proper guidance is given during the use of them.

Web-based public participation has already been applied in several environmental applications, including, for example, the ones in forest planning (Kangas and Store, 2003), urban planning (Kingston et al., 2000), watershed management (Voinov and Costanza, 1999) and ecosystem management (Haas, 2001). So far, the applications have mainly utilized the web for one- or two-way communications. However, a trend for increasing the sophistication of the decision support systems can be observed (Shim et al., 2002).

3. Decision support with Web-HIPRE

3.1. Multicriteria decision analysis

Web-HIPRE supports multiattribute value theory (MAVT) based methods (Keeney and Raiffa, 1976) and the analytical hierarchy process (AHP) (Saaty, 1980, 1994; Salo and Hämäläinen, 1997). These approaches develop a hierarchical model of the objectives related to the problem and the stakeholders' preferences (see Fig. 1). In MAVT, the alternatives are evaluated with respect to each attribute and the attributes are weighted accord-

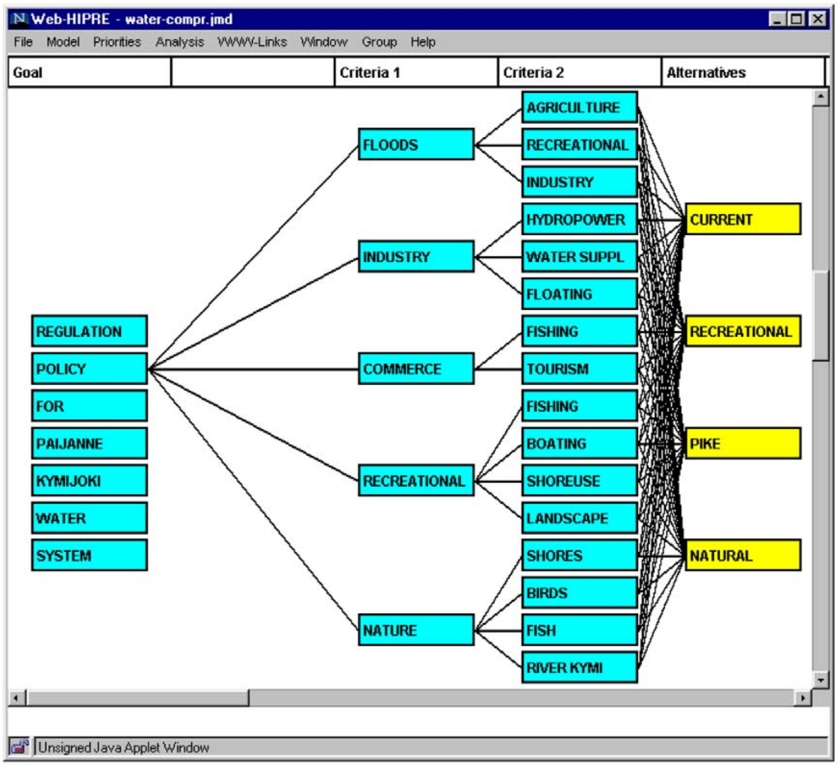

Fig. 1. Value tree of the Lake Päijänne case.

ing to their relative importance. Assuming mutually preferentially independent attributes (for details see Keeney and Raiffa, 1976), an additive value function can be used to aggregate the component values. Then, the overall value of the alternative x is

$$v(x) = \sum_{i=1}^{n} w_i v_i(x), \tag{1}$$

where n is the number of attributes, w_i is the weight of attribute i, and $v_i(x)$ is the rating of an alternative x with respect to an attribute i. The sum of the weights is normalized to one, and the component value functions $v_i(\cdot)$ has values between 0 and 1. The weights w_i indicate the relative importance of attribute i changing from its worst level to its best level, compared to the changes in the other attributes.

Weights can be elicited by different weighting procedures. The simplest way is to give them directly by point allocation. Value theory based weighting methods include SMART (Edwards, 1977; von Winterfeldt and Edwards, 1986; Edwards and Barron, 1994), SWING (von Winterfeldt and Edwards, 1986) and SMARTER (Edwards and Barron, 1994; Barron and Barrett, 1996). All of these can be used with Web-HIPRE. In SMART, 10 points are first given to the least important attribute. Then, more points are given to the other attributes depending on the relative importance of their ranges. The SWING method is similar, but the procedure starts from the most important attribute keeping it as the reference. In SMARTER, the weights are elicited with the centroid method of Solymosi and Dombi (1986) directly from the ranking of the alternatives. For details of the use of different methods available in Web-HIPRE, see Mustajoki and Hämäläinen (2000) or Hämäläinen (2002).

AHP is another approach to hierarchical modelling. It is based on pairwise comparisons of the importance of both the attributes and the alternatives. The ratio scale of integers from 1 to 9 is used in the comparisons. Verbal statements associated with the scale can also be used. The weights are estimated from the pairwise comparison matrix, for example, by the normalized principal eigenvector of the matrix (Saaty, 1980). The original 1–9 scale has a number of weaknesses (Pöyhönen et al., 1997) and thus Web-HIPRE also supports the continuous scale and the balanced scale of Salo and Hämäläinen (1997).

Under certain procedural conditions the results obtained by AHP and MAVT methods should coincide (Salo and Hämäläinen, 1997). Web-HIPRE allows the use of both methods in the same model. This is a useful feature when the analyst wants to compare the methods (see for example, Pöyhönen and Hämäläinen, 2001). Also, one can use methods in parallel on one model. For example, AHP can be used to elicit the attribute weights and value tree analysis can be used for the values of the alternatives. On the level of alternatives the software

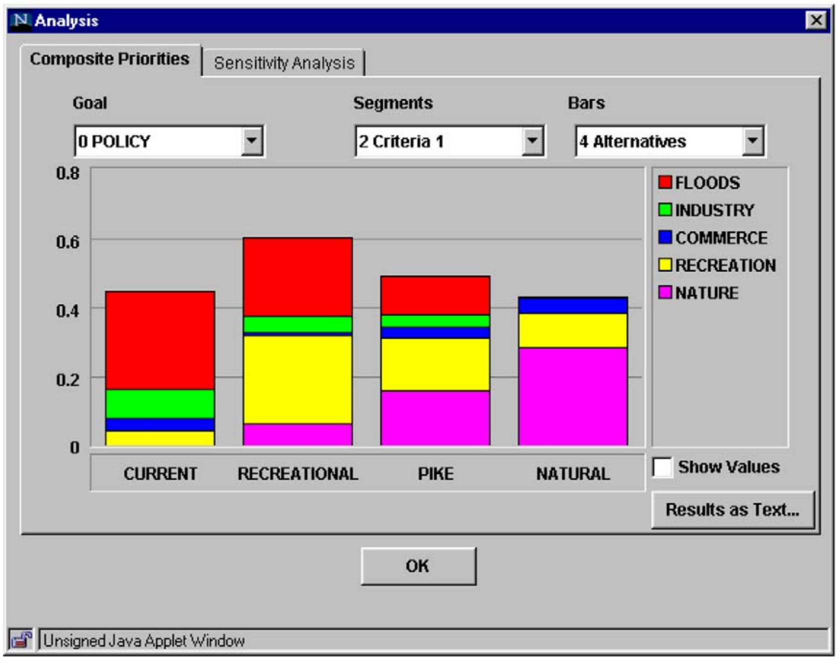

Fig. 2. An example of the overall values of the alternatives.

provides options to convert the results between the normalized weights of AHP and the values elicited with MAVT.

Web-HIPRE provides a number of ways to visualize the results. The overall values of the alternatives can be presented by bar graphs (Fig. 2). These can be further broken down in different ways, for example, by dividing them into segments according to the contribution of the different attributes. One-way sensitivity analysis (Fig. 3) can be applied to study the effects of changes both in the attribute weights and in the component values of the alternatives. Graphical representations can also be used to reduce the biases related to the use of numbers (see for example, Weber and Borcherding, 1993 or Pöyhönen and Hämäläinen, 2001).

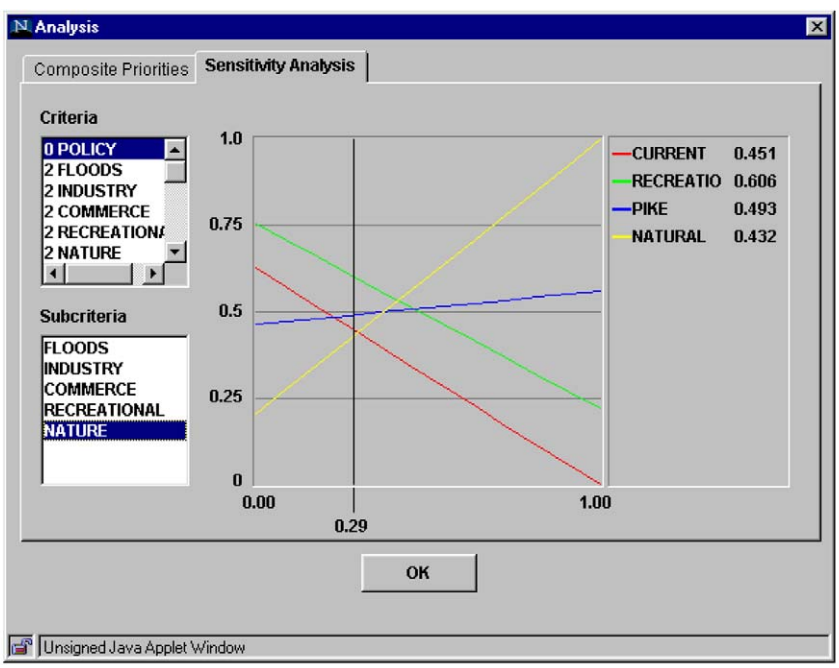

Fig. 3. An example of one-way sensitivity analysis.

3.2. Web support

The architecture of Web-HIPRE takes advantage of the possibilities of the web to support decision making processes. Web-HIPRE is an interactive Java applet, and therefore all the features of the Java-based approaches apply to it. These include, for example, the possibility to carry out interactive processes without any installations on local computers, the possibility to remotely use the software and platform-independency (Bhargava and Krishnan, 1998).

The management of the models takes place on the server, which provides a private password-protected working environment for every user or group. This allows the use of the same model from different locations without a need to transfer the model to the remote computers. In the group processes, the members of the group can work with the same common model, or each DM can create an own model and these can be studied to get common understanding of the problem. Several models can be active simultaneously, which makes the comparison of the preferences of different DMs easy. Web-HIPRE also allows importation of HIPRE 3+ models.

Another way to support group processes in Web-HIPRE is to use the group models, where the preferences of the group members are aggregated with the weighted arithmetic mean method (Keeney and Raiffa, 1976; Ramanathan and Ganesh, 1994). In the group model, each DM is presented as an element in the group value tree, and the component values of these elements are directly obtained from the individual models via the web. As a result, the group model gives weighted group values for the alternatives. The balance between the DMs can be studied by carrying out sensitivity analyses on the weights of the DMs. The assessment of the group members' weights requires interpersonal comparison of group members' importance, and in practice this is not easy (Keeney and Raiffa, 1976). For other ways to support group processes, see for example, Salo (1995).

Another important web feature is the possibility to link elements of the model to web locations. These locations can contain, for example, additional multimedia material describing the element. They are directly available, which may help comparison of the alternatives and weighting of the attributes.

Finally, we have an e-learning site (Hämäläinen, 2002) related to the value tree analysis and Web-HIPRE. It provides multimedia material for independent learning of the use of the methods, as well as the software. The material includes, for example, demonstrative animations and video clips of interactive working procedures. It also illustrates ways to identify and avoid behavioral biases related to weighting and structuring of the value tree (see Weber and Borcherding, 1993; Pöyhönen and Hämäläinen, 2000, 2001; Pöyhönen et al., 2001).

3.3. Use of Web-HIPRE in participatory environmental decision making

Web-HIPRE is a general purpose multicriteria software. However, its web-based MCDA support makes it especially suitable for environmental decision support in a sense of both supporting the analysis of different views of the stakeholders, and providing a tool for remote participation via the web.

In practice, Web-HIPRE can be used, for example, in decision analysis interviews to create example models reflecting the preferences of stakeholders representing certain views. Then, the decision analyst assures the proper use of the methods in preference modelling. The models can then be made publicly available, and analyzed collaboratively in public meetings, or individually via the web, to improve understanding of the preferences of different types of stakeholders. However, a fully independent use of Web-HIPRE to create and evaluate own preference models is not easily applicable with general public, as it requires expertise in decision modelling.

The multicriteria analyses carried out by Web-HIPRE can be further supported, for example, by Opinions-Online surveys. That is, the MCDA approach with Web-HIPRE can first be used to help form stakeholders' structured view about the problem. Then, Opinions-Online can be used to collect the opinions of all the stakeholders, for example, by voting on the best alternative or by approval voting. The results can be viewed from any field in the survey, for example, by separating the answers by demographic or geographic information, such as different geographical locations. This makes the comparison of the opinions also possible in the case where the interest groups consist of a large number of stakeholders.

One can also take advantage of the possibility of using external links in Web-HIPRE. The links can include, for example, live web cam material from the locations where the actions take place. This could be especially useful in environmental cases, as the locations are often far away and difficult to access.

4. The Lake Päijänne case

Lake Päijänne is the second largest lake in Finland with a surface of 1082 km^2. The lake has been regulated since 1964, with the original objectives being to increase hydropower production and to decrease agricultural flood damages.

The lake has extensive recreational housing developments along the shores and there are tens of thousands of recreational users and fishermen on the lake. There has been growing public interest to reconsider the regulation policy to better take into account the increased recreational use and current high environmental awareness. Problems currently recognized on Lake Päijänne include the low water levels during spring, changes in the littoral zone vegetation and negative impacts of the regulation on the reproduction of fish stocks. In addition, many people think that the original regulation policy only helps the production of hydropower in the downstream water system, the River Kymijoki.

An extensive multi-disciplinary research project was carried out in 1995–1999 to re-evaluate the regulation policy of Lake Päijänne (Marttunen and Järvinen, 1999; Hämäläinen, 1999). The aims of the project were to assess the ecological, economic and social impacts of the regulation. Stakeholders opinions were sought about the current regulation and its development, comparison of new regulation policy options, and recommendations to diminish the harmful impacts of the regulation.

At the beginning of the project there was wide distrust, especially among fishermen, towards the project and the organization responsible for it. Therefore, an open and participatory planning process was considered to be necessary in order to gain public support for the project and to find a consensus solution for further regulation strategy. The objective was that with an exhaustive analysis that involves all the interest groups, public acceptance and commitment to the decisions to be made could be achieved. The overall objective was to achieve consensus on the recommendations for the regulation policy through improved understanding of the complex nature of the regulation problem and of the other interest groups' preferences.

A steering group consisting of 18 representatives of different stakeholders (see Table 1) was set by Ministry of Agriculture and Forestry, the permit holder of the regulation license. Additionally, four working groups were established to improve the communication between the water resource authorities, local stakeholders, experts on regulation, and researchers. To inform the public, a local press conference was arranged after almost every steering group meeting. Additionally, five public hearings were arranged at the beginning of the project and five at the end of the project. In order to find out the amount and quality of recreational use, problems related to water use, and objectives for the future regulation practice, a mail questionnaire was sent to over 2000 users of the watercourse. A very essential part of the participation process were decision analysis interviews of the extended steering group.

The goal of the decision analysis interviews was to enhance the learning process of the representatives of the steering group. Our earlier experiences (Marttunen and Hämäläinen, 1995) have pointed out that decision analysis interviews can improve the overall understanding of the problem and to support articulation and analysis of the values. They can also clarify the differences between stakeholders' values and their importance in the comparison of alternatives. Twenty representatives of the different interest groups carried out the interactive preference elicitation process with HIPRE 3+ with the support of a decision analyst.

All the interviews were based on a common value tree (Fig. 1). Before the interviews, there was a long preparation and testing phase during which the objectives and attributes were chosen, the value tree was structured and tested, impacts of regulation alternatives were assessed and presented, and weighting technique was chosen. The structure and attributes of value tree were also discussed in the steering group. However, the final choice of the value tree was made by the project manager who also conducted decision analysis interviews. The common tree was used to make the results comparable with each other. Three different sets of parameters were used, one for normal, one for dry and one for wet seasonal rain conditions. The analyst presented the impacts of various regulation alternatives and the pre-assigned ratings of the alternatives were evaluated. The ratings were based mainly on the extensive studies related to ecological, social and economic impacts of the regulation. Because some of the ratings could be considered subjective, the participants had the possibility to change the ratings if they thought that the default values were unsatisfactory.

Table 1
The organizations represented in the steering group

Organization
Ministry of Agriculture and Forestry (1 representative)
Water management authorities: Regional Environment Centres of South Savo, Central Finland, South-Eastern Finland and Birka land (4)
Provincial federations of Central Finland, South-Eastern Finland and Päijät-Häme (3)
Fisheries authorities: Employment and Economic Development Centre of Häme and Central Finland (2)
Recreational Fishermen Association (1)
Päijänne Nature Centre (1)
Timber Floating Association (1)
Hydro power companies: Regulation Committee of Lake Päijänne (1)
Local fisheries organization: North and South Päijänne fisheries areas (2)
The Central Union of Agricultural Producers and Forest Owners (1)
The environmental protection authority of Heinola town (1)

After this the relative weights of the attributes were determined following the SWING procedure. The most important attribute was given 100 points and the other attributes were given points between 0 and 100, depending on their relative importance from the point of view of the respondent. The last phase of the interviews was the analysis of the obtained priorities and overall value scores of the alternatives. The impacts of different attributes were studied by dividing the overall values into bars representing effects of attributes (Fig. 2) and by carrying out sensitivity analyses on the weights of the attributes (Fig. 3). The preferences of all respondents were analyzed and the differences were discussed in the steering group meetings.

The main results of the interviews were as follows:

– The stakeholders had large differences in the perceptions of the importance of the ecological, social and economic impacts, which naturally affected the preference order of the regulation alternatives. However, the differences within some stakeholder groups were larger than those between the stakeholder groups (Marttunen and Järvinen, 1999). For example, among the fishermen, the weight of the attribute *nature* varied from 0.1 to 0.5.
– The importance of the objectives depended on the water year type considered. For example, during wet spring the original objectives of the regulation, hydropower and flood protection, were more acceptable objectives than under the other water conditions.
– The interviews improved the stakeholders' overall picture of the problem, gave them new information of the impacts of regulation and encouraged them to think and analyze their own values more carefully than before (see Table 2).

The results of the interviews were applied to prioritize the objectives of regulation in the different water conditions. This information was further used when the final consensus recommendation for the sustainable regulation strategy for Lake Päijänne was created. The draft recommendations were compiled by the experts and authorities responsible for the management of Lake Päijänne. These were presented, discussed and revised in the steering group meetings and finally unanimously accepted by all representatives. All in all there were about 30 recommendations concerning, for example, regulation policy, fish stocks, restoration of shoreline and communication. The implementation of the recommendations have been very fluent because all major stakeholders committed to the result of the process.

The multicriteria analysis approach proved to be a good way to take the large number of conflicting interests into consideration and consequently to reach a consensus. Feedback from the stakeholders also supports this view. In the Opinions-Online survey carried out in the closing workshop (see Table 2), 80% of the respondents at least partly agreed that 'the recommendations for the regulation have been able to combine the different and conflicting interests of both the people living on the Lake Päijänne and the downstream water system'. The positive result was a surprise, as there were many people who criticized the recommendations in the discussions. The result supports the general finding that in public hearings those who have the most critical opinions can easily dominate. This can result in wrong conclusions about the general opinion of the public.

The web features of the software were also demonstrated in the project. The role of these was not emphasized, but they were tested as a complementary way to support the process. The aim was to increase the transparency and openness of the process, by also giving people not attending the workshops the possibility of accessing the models and results. Information about the objectives and the impacts, the results of the Opinions-Online survey, and some typical Web-HIPRE models of

Table 2
Results of the survey carried out at the closing workshop

Number of respondents: 51	Strongly agree	Partly agree	No opinion	Partly disagree	Strongly disagree
There are more beneficial than adverse impacts in the regulation of Lake Päijänne	18 (35%)	21 (41%)	3 (6%)	7 (14%)	2 (4%)
The development project has produced a significant amount of new information about the effects of the regulation both on Lake Päijänne and on River Kymijoki and about the ways to diminish the adverse impacts of regulation	37 (73%)	9 (18%)	0 (0%)	5 (10%)	0 (0%)
Enough attention has been paid to consulting and participating with the local people during the development project	25 (51%)	13 (27%)	3 (6%)	7 (14%)	1 (2%)
The recommendations for the regulation have been able to combine the different and conflicting interests of both the people living on the Lake Päijänne and the downstream water system	12 (24%)	29 (57%)	4 (8%)	6 (12%)	0 (0%)
Implementing the recommendations would reduce the adverse impacts of the regulation and dissatisfaction of recreational users to the regulation	19 (37%)	21 (41%)	6 (12%)	5 (10%)	0 (0%)
My view about the possibilities of improving the regulation of Lake Päijänne has considerably changed during the development project	11 (22%)	27 (53%)	8 (16%)	3 (6%)	2 (4%)

the representatives of the steering group are available on the project web site (Hämäläinen, 1999). The interested shareholders can open the models on their own to study these and carry out sensitivity analyses or test their own preferences (see Figs. 1–3). The elements of the models were linked to the web pages describing the attributes including pictures from Lake Päijänne (Fig. 4). As the same software packages were used in the workshops, it required practically no extra work to give public an access to the models via the web. In this respect, the use of a web-based system provided an easy complementary way to support the process. Also, the steering group recommended further development of the use of the web as a communications channel (Marttunen and Järvinen, 1999).

5. Conclusions

A web-based decision analysis software, Web-HIPRE, is described and illustrated in the support of environmental decision making. The reference case is the evaluation of the regulation policies in Lake Päijänne, where the MAVT approach supported by Web-HIPRE proved to be an applicable approach. The analysis was able to clarify the views of the stakeholders, and a consensus on the new regulation policy was reached.

We also tested the web-based communication possibilities of the opinions with Web-HIPRE and Opinions-Online. They provide an easy way to additionally support participatory decision making processes. Transparency and openness of the process is important, and these tools also make it possible to activate people who would not have possibilities, for example, to participate the public meetings. However, new techniques cannot yet completely replace traditional face-to-face meetings and interaction, but they provide complementary ways for the stakeholders to participate.

There is growing interest in improving public participation in the environmental processes by using modern computer technology, including the web, teleconferencing, on-line decision support, as well as geographic information systems. Consequently the needs and opportunities for decision support with web-based software, such as Web-HIPRE, will also increase. However, if we want stakeholders with different kinds of backgrounds to independently work with software, this may become cumbersome with general purpose software

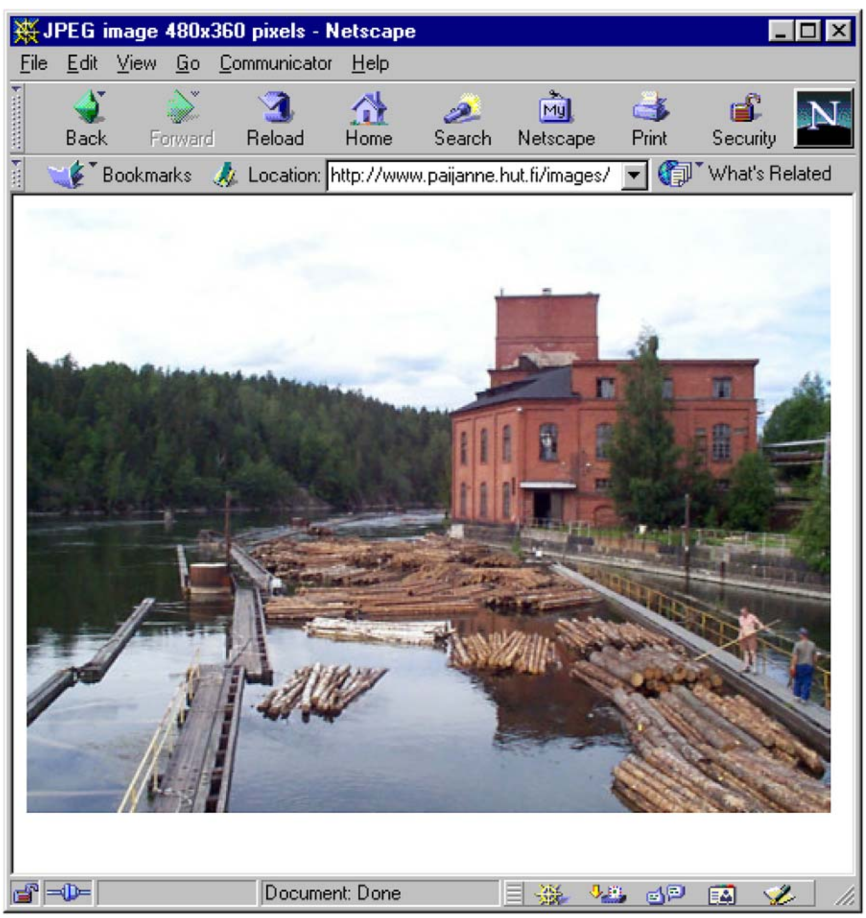

Fig. 4. Web page describing the attributes of the case. Timber floating on the River Kymijoki.

with generic instructions. Thus, in the future we could also expect to find customized problem specific decision aids on the web. However, in general, the training of researches and practitioners to the correct use the MCDA methods remains a future challenge. We see the availability of web-based learning materials as one way to meet this challenge.

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