Conclusion. On a new Internet-based paradigm of environmental decision making

The conclusion is devoted to possible application of the FGM/IDM technique in the framework of a new paradigm of environmental decision making. The new, democratic paradigm tries to involve non-experts into environmental decision processes. Internet resources should help implement the democratic paradigm by supporting of non-experts in their active preparation for political environmental actions. As usually, the FGM/IDM technique can help non-experts to assess the whole variety of feasible decision alternatives and to develop preferable alternatives for further simulation.

Democratic paradigm of environmental decision making

Two main paradigms in the field of environmental decision making can be distinguished – the technocratic paradigm and the democratic paradigm. The technocratic (expert-oriented) paradigm is actually the traditional approach to environmental decision making: experts develop a project, and professional decision makers approve or reject it. Mathematical models and computer decision support systems help to implement the technocratic paradigm, they are used by experts and decision makers. Experts and decision makers, with a help of modelers, system analysts and computer scientists, find more or less satisficing solutions of environmental problems. It is important that the number of people involved into a technocratic decision process is fairly small and known in advance. The technocratic decision making will surely profit from the recent development of Internet. Professional experts and even decision makers gradually master the network tools (both Internet and intranets) including Web servers, distributed simulation and optimization, various forms of Internet communication (say, synchronic or asynchronic meetings), etc.

However, the technocratic approach to environmental decision making does not seem to be sufficient now. It is related to the fact that recent situation in the field of environmental decision making differs from what it was about 50 years ago. Multiple political parties and interest groups, mass media and even particular citizens want to be involved now into decision process. The number of such new players is not known in advance, and it may happen to be very large. It is important that these players are non-experts. Often, they have minimal knowledge concerning the problem and especially the ways, how to solve it: in the framework of the technocratic paradigm, nothing is done to help them to be involved into the decision process. Sometimes, non-experts are informed in general features on the strategies discussed by experts and decision makers, however, they cannot influence the decision processes.

As the most known example of technocratic environmental decision making, one can mention the attempts to solve the problems of global climate change. Mass media inform ordinary people about the threats and costs that presumable are likely to result from the climate change. The people know that experts and politicians keep negotiating some strategies based on national restrictions on carbon dioxide emission, but nobody tries to involve non-experts into the decision process – strategies are not discussed with them. However, such involvement seems to be very important at least for two reasons. First, the negotiated strategies, which promise to abate the consequences of the climate change, have negative economic consequences. So, their implementation may be related to tough political decisions, and therefore the involvement of ordinary people is needed. Secondly, the involvement of ordinary people can help broaden the scope of the possible strategies – economically efficient strategies seem to exist that result in the same decrement of carbon dioxide emission (the problem is discussed in Section 3.5).

In contrast to the technocratic paradigm, the democratic paradigm is based on the idea that “the power to make decisions must be placed as far as possible in the hands of the persons who are the most directly influenced by the decision concerned, and not in the hands of individual decision makers and their experts”(Yan et al 1999). Internet clearly must play an important role in this reallocation of power to make decisions. To be precise, Internet provides the environment for the resources that can support activities of non-experts in decision process. For this reason, the democratic paradigm in environmental decision making needs, first of all, Internet tools that can help multiple non-experts to negotiate and influence the environmental decision process.

It is important to take into account the following aspect of the problem – it is supposed tacitly that the opportunity to get information from independent sources is sufficient to understand the conflicts and even to be involved in decision process. It is clear that such opinion is not true, especially in the case of environmental problems. A database filled with possible data on a conflict cannot help an ordinary (non-expert) person to understand how the conflict could be solved. Cunge and Erlich (1999) stress the need to make a difference

> between *data* and *information.* The *data* may be collected in the field (e.g. measurements of physical quantities such as water level, degree of pollution, etc.); satellite imagery, optical or radar, are also data, although of different kind; state variables defining ecosystem or biodiversity, their evolution, location of houses, regulations and laws – all are data that can be measured or collected in the field or which may result from projections, extrapolations and modeling.

The *information* is elaborated from the data under a form that should be intelligible to the stakeholders.

Generally speaking, the mathematical modeling provides a mean for transformation of row data into information. However, the mathematical modeling by itself is not able to solve the problem completely – only specially prepared tools can transform results of the modeling into the form intelligible to non-experts. Internet provides the environment for such tools and a global access of ordinary people to them. Therefore, the democratic paradigm requires special Internet tools for elaboration of information in the desired form.

It would be pretty naive to hope that one particular tool could be developed that would solve this problem completely. For this reason, we propose to develop Internet-based integrated collections of tools, which can provide reliable information and various easy-to-apply tools for assessment and evaluation of feasible decisions.

It is important to stress from the very beginning that we do not hope that application of such tools will result in a coordinated decision. Normally no consensus can be expected. This is related to the fact that different groups have beliefs, values, intentions and interests that are in conflict. Therefore, Internet tools can only help to assess the problem and to facilitate preparation to subsequent negotiations and political actions. We concentrate here on development of Internet resources aimed at supporting the ordinary people in their preparation for political actions based on better understanding of the problem.

Special tools were proposed for supporting the negotiations on Internet, but they are oriented at supporting the negotiations of a small number of people (see, for example, Kersten and Noronha, 1999). Such tools try to bring the negotiators to a coordinated decision using preference-related questions. However, any structured Internet-based procedure seems to be impossible in the case of the democratic paradigm characterized by a non-fixed (and presumably large) number of people with different values. For this reason, we concentrate on common Internet resources that can support individual judgment making in the process of preparation for legal and political actions.

A list of requirements applied to Internet resources under consideration may be pretty large. We concentrate here on several important requirements. The most important group of them is related to *objectivity* of the tools. According to Cunge and Erlich (1999), the objectivity means that the tools must allow "the confrontation of consequences of various potentially possible scenarios and solutions". It is important "to share information in an equitable way, i. e. so that it is identical in content and intelligible to all interested parties". Cunge and Erlich (1999) require that information would be provided to all users under the same form. Only in this case users can hope that the transformation of data into information is performed in an objective way.

Another group of requirements is related to the *transparency* of the form, in which information is provided. The transparent form is needed to make the information intelligible for all parties including non-experts. Visualization seems to be the only technique intelligible for non -experts.

One has to take the above requirements into account during the discussion of Internet resources that aimed at the supporting of non-experts in decision process. Only in this case, non-experts will be able to master the tools used in them.

Concept of Internet resource for supporting the democratic paradigm

Several concepts were proposed for developing of Internet resources aimed at involvement of non-experts into the decision process in the field of water management. One of them is the concept of Internet-based judgment engine (Yan et al 1999). A judgment engine is a tool that must help non-experts to assess environmental impact related to a number of given projects and to evaluate by this the decision making efforts. An example of an Internet-based judgment engine was built upon the commercial software MikeImpact judgment engine developed as a stand-alone Windows-based application by Danish Hydraulic Institute (DHI). Using MS ActiveX, the MikeImpact software was transformed into Internet tool called Web-MikeImpact that facilitates the judgment making via Internet. A four-level hierarchical structure of environmental parameters, components and categories was developed for evaluation of the total environmental impact of a project. User has to apply pairwise comparisons of elements that belong to one level to develop relative importance weights. The total importance weights are distributed downwards the hierarchy. As the result of this procedure, weights are given to any environmental parameter of the project. The judgment on desirability of the project is made on the basis of the difference between the sum over all impacts (the score) for the existing situation and for the proposed new situation.

In the case of MikeImpact system, non-experts have to evaluate several given decision alternatives prepared and explored by the experts in advance. A given list of possible decision alternatives developed by experts in advance results in asymmetric relations between experts and non-experts: experts can develop alternatives and non-experts cannot. This asymmetric situation is not equitable, and the objectivity principle may be violated. Experts may use it to thrust their preferences on non-experts.

It would be very important to make the situation symmetric, i.e. to help non-experts to develop the decision alternatives by themselves, too. We propose to do it on the basis of the Internet application of the FGM technique that may help non-experts to explore the whole variety of feasible decision alternatives. An independent search for preferable decision alternatives supported by the FGM technique can make the judgment phase symmetric and objective. Non-expert may appreciate the objectivity of the tool and be active in its application.

In accordance to the idea expressed above, the new Internet resource differs from the judgment engine – instead of supporting evaluation of given decisions, it includes graphic tools aimed at independent selection of decisions and further exploration of them. Application of the new resource consists of four steps:

- Graphic search for a small number of preferred decision alternatives for subsequent detailed analysis (decision screening);
- Simulation experiments with the selected alternatives for estimation of their results;
- Graphic exploration of the simulation results; and
- Graphic evaluation of the alternatives.

Simulation is the central step in the framework of the resource. In contrast to the problems where the results can be found fairly easily, environmental decision making requires application of sophisticated mathematical models. Simulation helps to study several alternatives in details – a large number of performance characteristics can be estimated. Results of the simulation experiments can be explored using Web-based visualization tools like GIS, Virtual Reality (VR) and other multi-media (MM) tools. Finally, Web-based tools for evaluation of the alternatives (like Web-MikeImpact) can be used.

Since the environmental problems usually have a very large (or infinite) number of alternative decisions, a preliminary selecting a small number of alternatives is needed. Usually, users of simulation tools have to develop the alternatives by themselves, without any computer support, guided exclusively by their experience and feelings. Non-experts, however, have not got any experience in the field of environmental decision making, and so they are not able to develop reasonable alternatives. Therefore, there is a need for computer-based support that would involve non-experts into the process of decision screening.

We start discussing of the Internet resource with the tools that can be used for simulation, exploration and evaluation of the results of particular decision alternatives. We show that current Internet implementations of such tools are ready to be included into the Internet resource discussed here. Only then we turn to decision screening.

The questions of Internet implementation of simulation are fairly well known. It is clear that a Web resource can be used for simulating several decision alternatives. The resource must be based on an objective mathematical model that can be used for estimating the consequences of the alternatives. We cannot suppose that non-experts are able to develop a model by themselves. Therefore, experts have to prepare the model (including the data) in advance. The Internet resource must contain some simple tools that can help to plan the simulation experiment. In the simplest case, standard plans prepared by experts can be used. Due to such plans, output of a decision alternative can be estimated and provided to user who has not got any expertise in simulation planning. Goodwin and Hardy (1999) show, for example, that simulation can be used to assist non-experts in selecting the water management strategies.

The question may arise whether a non-expert would be satisfied with the model and data. This question is closely related to the problem of transparency of the mathematical model. We do not discuss this extremely sophisticated and important problem here (see Abbott and Jonoski 1998). However, the non-expert may be convinced about the quality of the model and data in the case all experts agree with it.

To simplify exploration of the simulation output, the resource must provide it in a form, understandable for non-expert. Visualization of simulation results may be extremely helpful. It can be based on application of GIS, VR and other MM tools. In Tuthill et al. (2000) it is demonstrated that state authorities can use the GIS-generated maps for decision support. We have already discussed it in Chapter 1 that any computer-literate non-expert seems to be able to assess spatial information provided by geographical maps. The GIS have already been successfully implemented in Web (Andrienko et al. 1999), and it seems that no principal problems can exist related to its application to the exploration of a small number of decision alternatives or even selecting the most preferable from them. However, a large variety of possible decision alternatives cannot be depicted completely at a thematic map and one has to provide additional tools for supporting the selection from large varieties of alternatives (see, for example, Jankowski, 2000, and Jankowski et al., 2001).

Additional opportunities are related to virtual reality, which helps user to "participate" in the life of a virtual world that would result from the simulated decision alternative. The first conference on spatial multimedia and virtual reality took place as soon as in the middle of 90s (Camara 1995) and current experience is described in (Neves and Camara, 1999). Though VR tools require enormous computing and information flow (and so they can not be used via Web now), it is clear that they will be available sooner or later.

Application of GIS, VR and other MM tools (video and audio comments, etc.) that provide simulation results in a simple form make these results assessable even for non-experts. Therefore, Web simulation augmented with Web implementation of GIS, VR and MM can help non-expert to explore consequences of a small number of decision alternatives.

To evaluate a small number of the decision alternatives, after they have been simulated and explored by GIS, VR and MM, user can apply weighting techniques like those used in Web-MikeImpact. Due to the weights, any alternative is related to a score. Then, the alternative with the maximal (or minimal) score is selected.

Using the weighting techniques it is important to remember that these techniques are heuristic procedures. Psychological experiments prove (Larichev 1992 and Borcharding et al. 1993) that the weighting procedures are usually too complicated for human beings. The theoretical research shows disadvantages related to the weighting procedures. One of them is the effect of so-called supported alternatives. Let us consider the case of quantitative decision criteria, for which the alternatives can be associated with points in the criterion space. It can be easily proven that only those points can be selected by the weighting procedures that belong to the non-dominated frontier of the convex envelope of the criterion points (the so-called supported alternatives).

This theoretical statement can be illustrated with a simple example of three alternative water quality improvement projects (***A***, ***B*** and ***C***) described by two criteria: cost of the project and the resulting pollution level. It is desirable to decrease both criterion values. The weights are supposed to be positive, and so the score must be minimized. Let ***A*** = (1; 5), ***B*** = (5; 1) and ***C*** = (3; 3.1). The picture that illustrates the problem is given in Figure 5.1. Here, the non-dominated frontier of the convex envelope is the segment [***A***, ***B***]. One can see that the point ***C*** is 'behind' the efficient frontier of the envelope, and so it cannot be found using any positive weights. However, the balanced alternative ***C*** may happen to be preferable!

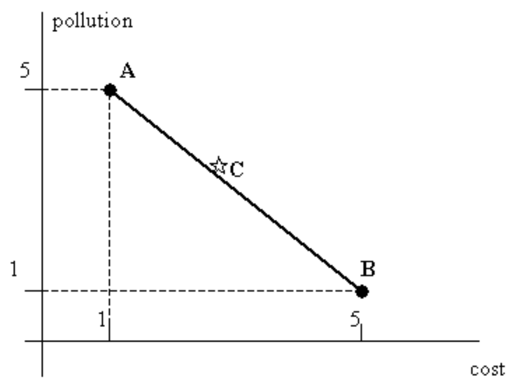

Figure 5.1. Point ***C*** cannot be found using any positive weights

To avoid such problems of using the weighting procedures, it was proposed to use interactive weighting (Saaty 1996). The current weights are visualized in the form of bars, and other bars simultaneously display scores of the alternatives. User can "play" with the weights, looking at the resulting ordering of the alternatives. In this case, an alternative can be selected manually even if it is not optimal for any combination of positive weight. So, the above problem can be avoided in this way. However, the number of alternatives should be small – say, three, but not more than five.

We have tried to show in this section that a combination of the modern Web tools can satisfy most of the above requirements imposed on Internet resources for supporting non-experts. All the requirements are satisfied but one – the requirement of objectivity. It is important that the mathematical models can be made objective, at least potentially. As it was already said, to fulfill the requirement of objectivity, one needs to develop Internet tools that could help non-expert to select a small number of decision alternatives, which reflect his/her preferences. In our book, we proved that the FGM/IDM-based tools help do it in the case of linear simplified integrated models. Sometimes, simplified integrated model may have the form of a large, but finite list of possible decision alternatives. In this case, the RGM/IDM technique (already mentioned in Chapter 1) can help. Application of this visualization technique for supporting the process of selecting a small number of decision alternatives via Internet is described in the next sub-section.

Web resources for integrated assessment and screening the decision strategies

In Chapter 1, we have discussed already a possible structure of the Web resource that can be used to inform non-experts on the whole variety of feasible decision alternatives in public problems and to support independent screening of the decision alternatives. The scheme of such Web resources is given in Figure 1.4.3. Once again, the resource consists of a server, which approximates the EPH for a prepared environmental problem for criteria specified by user, of a Java applet, which implements the IDM technique and supports goal fixation, and of middleware that helps to arrange interaction of subsystems. User has to specify screening criteria and, perhaps, restrictions imposed on variables of the model. Then, the EPH is approximated and transmitted to user jointly with the Java applet. User has to explore the variety of possible outcomes and to identify a feasible goal, which is transmitted back to the server. The server computes an associated decision and provides it to user. Such Web resource can help users to screen the variety of possible strategies by themselves in the case of application of linear simplified integrated models for decision screening. We have considered such simplified models throughout the book, and so the screening procedure does not need additional comments.

Now we assume that a non-linear integrated model must be used for decision screening in an environmental problem. In this case, the variety of feasible decision alternatives can be approximated by a large, but finite number of decision alternatives (many thousands or even millions of them). Sometime, the variety of feasible decision alternatives is finite from the very beginning (such example is considered here). In this case, visual decision screening procedure is based on the Reasonable Goals Method (RGM), which is a development of the FGM for non-linear decision problems. Several words concerning the RGM have already been said in Chapter 1. The RGM is based on the enveloping of the feasible set in criterion space, application of the IDM technique for its exploration and further identification of the goal. The simplest version of the RGM is associated with selecting from large lists of decision alternatives.

The RGM for large lists of possible decision alternatives was introduced in (Gusev and Lotov, 1994). It is supposed that the decision alternatives are given as rows of a table, which columns are attributes that describe important features of the alternatives. Three to seven numerical attributes can be specified as selection criteria. Due to this, any row can be related to a point in the criterion space. The RGM is based on the enveloping the variety of the criterion points associated with the rows. Then, user explores the non-dominated frontier of the envelope. It is displayed on-line by the IDM technique. As usually, it is displayed in the form of non-dominated frontiers for pairs of criteria. User is informed about criterion tradeoffs for the envelope. User can identify a preferable criterion vector (goal) of the envelope directly on display. Then, user is provided with several rows from the list that are in line with the identified goal. So, the RGM differs from the FGM – the envelope of the variety of feasible vectors is approximated and explored instead of the variety. For this reason, the identified goal is usually non-feasible. However, it is close to the feasible points. Due to this, it is considered as the reasonable goal.

Speaking mathematically, a table is considered that contains N rows and several columns. It is supposed that m numerical attributes are specified to be the selection criteria. Then, j-th row can be associated to a point y^j of the criterion space R^m. Coordinates of the point y^j are $y_1^j, y_2^j, \ldots, y_m^j$. Since N rows are considered in the table, the variety of N criterion points $y^1, y^2, \ldots, y^N$ must be considered. The RGM is based on enveloping these points, i.e. on approximating their convex hull Y_C defined as

$$Y_C = \text{conv}\,\{y^1, y^2, \ldots, y^N\} \equiv$$

$$\equiv \left\{ y \in R^m : y = \sum_{k=1}^{N} \mu_k y^k, \mu_k \geq 0, \sum_{k=1}^{N} \mu_k = 1 \right\}.$$

The EPH for the convex hull (CEPH), which is denoted by Y_C*, is introduced in the same way as for Y. Once again, the non-dominated frontier of Y_C* coincides with the non-dominated frontier of Y_C, but the dominated frontiers disappear. For this reason, the RGM applies approximation of Y_C* instead of Y_C. The approximation methods are the same as for the linear models. Visualization of the CEPH is based on decision maps and can be carried out using the IDM technique. The preferable goal is identified on display using the computer mouse. Because the goal is not feasible, several feasible criterion points are selected, which are close to the goal. One possible selecting method is described in English in (Lotov et al., 1997c). Real-life application of the RGM/IDM technique at the Ministry of Natural Infrastructures of Israel for energy planning is described in (Soloveichik et al., 2001). As usually, other visualization tools can be used for exploration of the selected alternatives. Say, spatial alternatives can be visualized on geographical thematic maps (an example is given in Jankowski et al., 1999).

Let us consider an example of decision screening on the basis of the RGM/IDM technique. Decision support system for water quality planning in a small region is considered. The DSS is adapted to a small region in the basin of the Oka River – the vicinity of the city of Kolomna, which is a city located at the point where the Moskva River meets the Oka River. Eight sources of wastewater discharge were specified in the vicinity of the city.

Application of the RGM/IDM technique is related to the fact that a large, but a finite number of decision alternatives has been prepared in the following way. Four technologies of the discharge treatment were considered. Therefore, five options were feasible for any wastewater discharge source – to implement one of four technologies or to do nothing at all. In total, there were 390,625 decision alternatives. Three pollutants were taken into account – nitrates, phosphates and BOD. Conventional units were used to measure pollutant concentration, in the framework of which concentration equals to one in the case the environmental requirements are satisfied precisely. The maximal (in the river) concentrations of these three pollutants were used as the screening criteria. The fourth criterion was the cost of the project measured in million of US$.

To explore the influence of the local pollution discharge, it was supposed that the pollution concentration in water coming from the reaches of Oka and Moskva Rivers up to the region is equal to one. It is not so now, the pollution concentrations are much higher, but this assumption was needed to develop local water improvement strategies. So, the problem studied here and the data are fairly artificial.

The software system MIKE 11 was adapted to the region and used for computing pollution transport. The linear dependence of pollution concentrations on the pollution discharge in MIKE 11, which has been discussed already in our paper, made the estimation of all 390,625 alternatives a pretty easy task. Due to this, criterion values related to all decision alternatives were computed and the

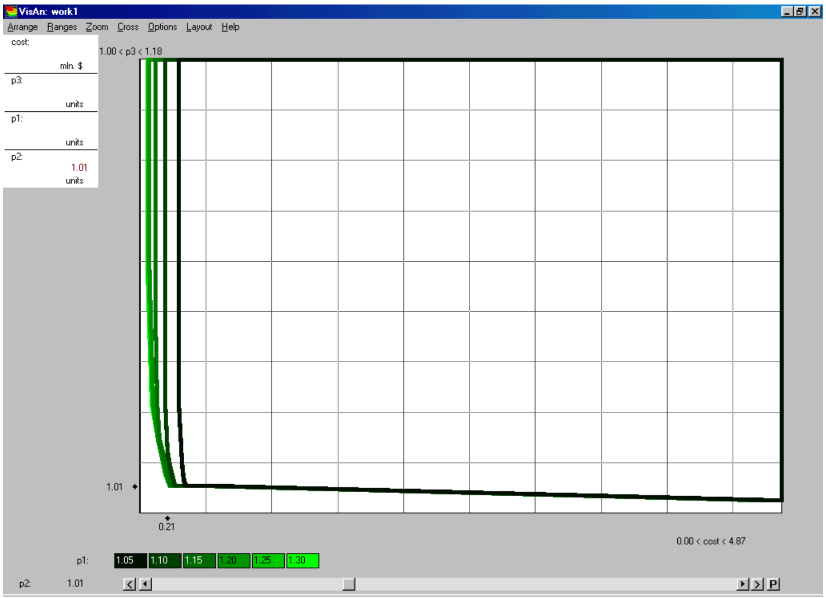

Figure 5.2. A decision map for Kolomna region

envelope of the associated points was approximated. Exploration of the variety of the alternatives is based on the display of the non-dominated frontier of the envelope by the IDM technique. Two implementations of the IDM technique were applied – for stand-alone PC in MS Windows environment requested by the Ministry of Natural Resources of Russia and in Web using the Java applet technology. Figure 5.2 displays black and white copy of one of the decision maps displayed by the PC-based DSS. Non-dominated frontiers (criterion tradeoff curves) are provided in the Figure. Cost is given in horizontal axes, BOD (*p3*) is given in vertical axes, concentration of nitrates (*p1*) is given by shading (color on display) and concentration of phosphates (*p2*) is given by the scroll-bar.

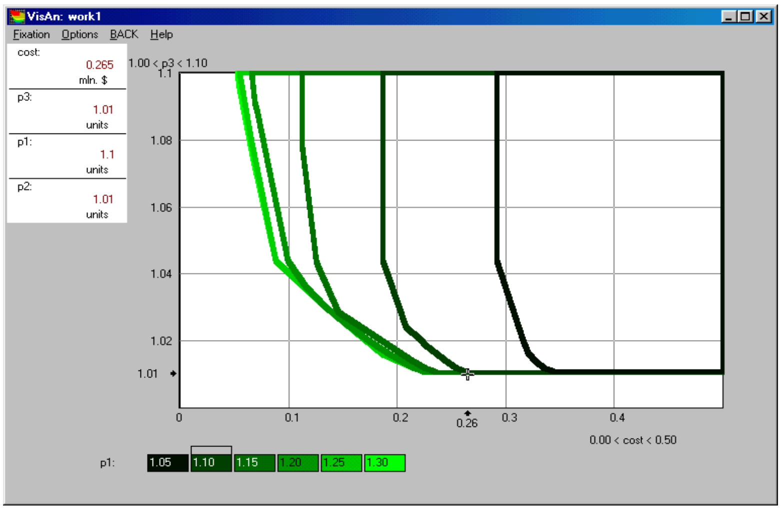

Figure 5.3. Detailed decision map with the reasonable goal given by the cross

One can see in Figure 5.2 that US$4.87 million is needed to minimize the BOD. At the same time, only US$ 0.21 million is needed to have its excellent value *p3*= 1.01. This fact shows how misleading the single-criterion optimization can be. Indeed, minimization of the cost while the a priori restriction on *p3* is imposed (*p3* is not greater than one) requires about 24 times more money! At the same time, Figure 5.2 shows that it is important to use visualization of criterion tradeoff curves. Animation, which cannot be shown here, proves that the value of *p2* has no influence on the decision map. Therefore, it makes sense to consider a more detailed picture by restricting the cost to, say US$0.5 million and selecting *p2* about 1.01. The related decision map is given in Figure 5.3.

One can see the cross in this decision map that is located at the point associated to *p3* = 1.01, *p2* = 1.01, *p1* = 1.10 and cost equals to US$ 261 thousand. One can clearly see that about US$70 thousand of additional cost is needed to decrease the value of *p1* from 1.1 to 1.05 for the same values of *p2* and *p3*. On the other hand, further increment of *p1* to 1.15 or even 1.2 can not save more than US$30 – the associated non-dominated frontiers are close to point where the cross is located. So, user may want to identify the position of the cross as the reasonable goal.

Goal point	0.2630	1.1000	1.0100	1.0100
Alternative	**Cost**	**p1**	**p2**	**p3**
C40431000	0.2630	1.1170	1.0010	1.0110
C40441000	0.2650	1.0980	1.0010	1.0110
C30441000	0.2560	1.0980	1.0010	1.0120

Figure 5.4. Decisions alternatives resulting from the goal point

The decision alternatives associated with that goal are given in Figure 5.4. In the first line the goal point is depicted. The second row contains the names of the columns: the first column is the code of the alternative; the second column is the cost; the third, fourth and fifth columns are concentrations of nitrates, phosphates and BOD after the project would be completed. A digit of the code (located the first column) contains the numbers of technologies used at particular discharge sources. One can see that though the first alternative is formally efficient and coincides with the goal cost, only additional US$2 thousand are required to decrease the value of *p1* for about 1%. The third alternative displays another opportunity – one can save US$9 thousand (in comparison to the second alternative) while *p3* increases only about 0.1%. Surely, selecting of a preferable alternative depends on user's preferences.

As usually, the selected decisions are visualized in the geographic maps. However, we do not display them here. The described DSS was developed on the request of the Russian Federal Ministry for Natural Resources in the framework of the Federal program "Revival of the Volga River". The DSS was coded by L.Bourmistrova and R.Efremov.

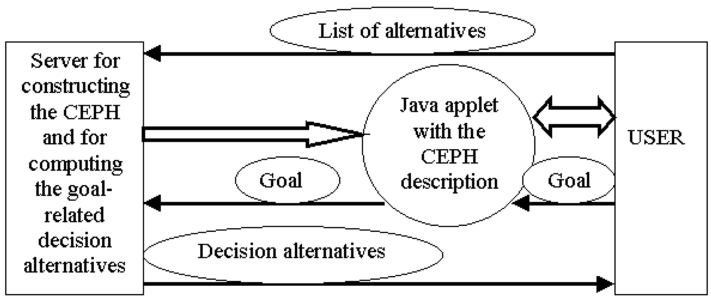

Figure 5.5. Scheme of the Web application server

Now let us consider the RGM-based Web application server for selecting preferable alternatives from large databases. The Web application server can be applied in various cases, say in e-commerce (Lotov et al. 2001). In particular, it can be applied to support non-experts in the process of decision screening. The scheme of the Web application server is given in Figure 5.5.

First, user has to provide the table of decision alternatives to the server. In the demo version of the Web server, it can be done with a help of clipboard and browser. Then, the server envelopes the variety of criterion points related to alternatives and approximates the Edgeworth-Pareto Hull of the envelope (CEPH). The approximation of the CEPH along with the IDM-based Java applet is transmitted to user's computer. The goal identified by user is transmitted back to the server. Then, several alternatives close to the goal are selected by the server and transmitted to user.

It is clear that the interaction with the Java applet that implements RGM/IDM technique is not more complicated than the interaction with the applet based on the FGM/IDM technique. Therefore, non-experts may use an RGM/IDM-based Web application server for environmental decision screening, too. The only existing complication is related to the fact that several alternatives are related to a goal instead of one in the case of the FGM. However, it may be even desirable for user since he/she receives additional opportunities to think on his preferences and to use the above weighting-based technique for evaluation of a small number of selected alternatives.

Now we are ready to outline the structure of a possible Internet resource that can help to exercise the democratic paradigm in water management. The structure of the process has been already discussed in general features. Internet application of the process is based on consequent application of four component groups:

- Web-based tools for selecting the preferable decision alternatives,
- Web-based simulation tools for estimating the output of the selected alternatives,
- Web-based visualization tools for exploration of the simulation results, i.e. GIS, Virtual Reality (VR) and other multimedia (MM) tools; and
- Web-based tools for evaluation of the alternatives.

Here, we provide additional details of the process. The following subsystems can be included into the Internet resource:

1. subsystem for informing non-experts on the problem (it may be based on various Web visualization tools including GIS, VR and other MM tools);
2. subsystem for specification of criteria for screening the variety of decision alternatives and, may be, formation of restrictions imposed on other performance values;
3. subsystem for EPH or CEPH approximation;
4. Java applet for subsystem for interactive and animated display of decision maps and for identification of the goal;
5. subsystem for computing of a goal-related decision alternative(s);
6. subsystem for visualization of the computed alternative(s) in Web GIS, etc.;
7. subsystem for Web simulation experiments with the selected alternative(s);
8. subsystem for visual exploration of the simulation output (based on the same Web tools as subsystem 1);
9. subsystem for Web evaluation of the alternative(s) based on interactive weighting.

Here, we tried to show that it is possible to use Internet resources for providing a basis of the new democratic paradigm in environmental decision making. Such Internet resources, which involve non-experts into decision processes, can include various already developed Web tools that have been developed already and can be used in real-life applications. Along with such well known tools as Web simulation, Web GIS and other tools for graphic exploration of particular decision alternatives, the Internet resource must include graphic tools for independent search for preferable decision alternatives. These tools help satisfy the requirements of objectivity of the Internet resources. We have demonstrated that the FGM/IDM and RGM/IDM techniques could be applied for it. Real-life water-related applications of the FGM/IDM technique described in Chapter 3 show that the technique is sufficiently convenient for experts. The existing Web resources prove that it is possible to implement the techniques on Internet. Long-time systematic application of the software in computer laboratory works for university students as well as its sporadic application in computer games for people without university education (including schoolboys) makes us hope that the software can be used by any computer-literate non-expert. Due to this, the development of the described Internet resource for particular water-related problem can be started already. The question is whether the society is ready to try to involve non-experts into environmental decision processes.

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