Chapter 10

Comparison

EB, FC, FP and RSS

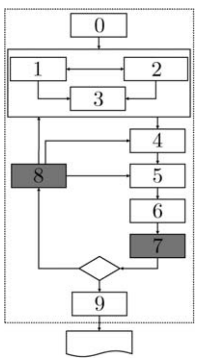

Figure 10.1: The phases of the PIP procedure. Phases 7 and 8, which are analysed in this chapter, are highlighted.

In this chapter we will deal not only with *Comparison* but also with *Mitigation*, i.e. with Phases 7 and 8 of the PIP procedure shown in Figure 10.1. Since the discussion about mitigation involves more practical than theoretic aspects, in this chapter we will just illustrate its aim and refer the reader to Chapter 14 for several examples of how it is carried out in practice. Also the presentation of the Comparison phase will be very soft with respect to theoretical aspects; for more details the reader may refer to Chapter 21 of THEORY.

The negotiation process is assisted by a *Facilitator*, a neutral third party (often the Analyst if he has the ability, as in the Verbano Project), who manages the process in such a way that the Stakeholders proceed constructively towards building of a consensus around one (or a few) alternatives. It is up to him to define the phases of the process in such a way that each of them is a step in that direction. Sometimes the Facilitator acts as a *Mediator*, which means that he assumes a more active role: he does not only facilitate, but he also structures the process, governing the agenda, using tools such as reformulating, active listening and open questions as well as his analytical abilities, and finally suggesting solutions, if desirable. The interested reader can find a detailed description of these activities in Appendix A10 of THEORY, along with a presentation of the psychological and cultural aspects of negotiations.

10.1 The Comparison Method

In the *Evaluation* phase (Chapter 9) a global value function was defined for each sector and its value V (i.e. the value of the *sector index* that we introduced in Chapter 4) was computed for all the alternatives. On the basis of these values (which, from now on, we will call sector indices) we now want to identify the reasonable alternatives, through a negotiation process involving all the Stakeholders. Clearly, the negotiation process actually involves the

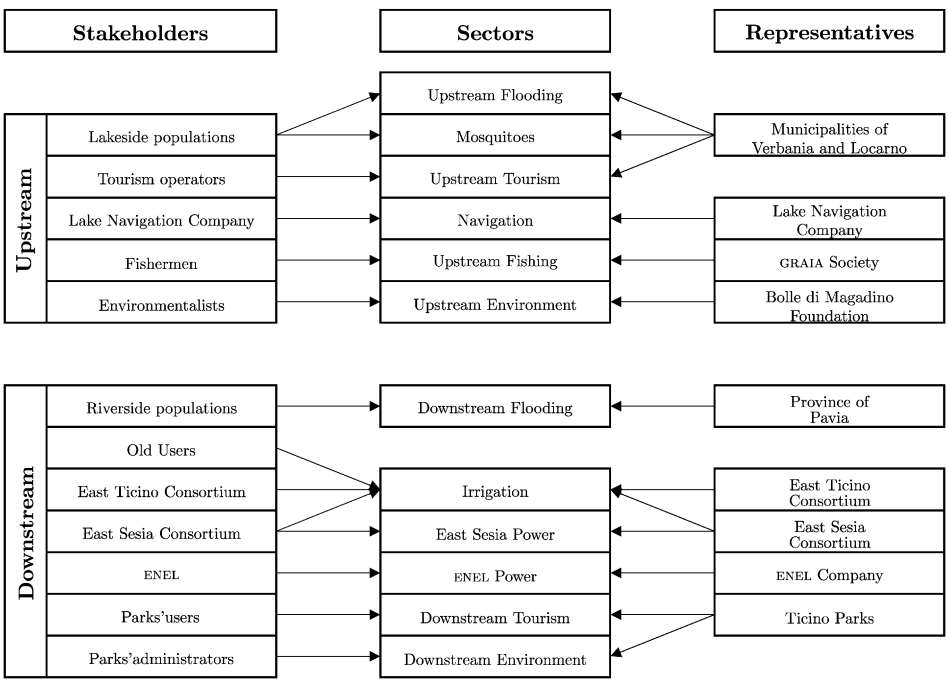

Figure 10.2: Sectors, Stakeholders and their representatives in the Verbano Project.

representatives of Stakeholders, not their totality, which would be impossible because of their number. However, for simplicity's sake, we will use the same term to refer to both the Stakeholders themselves and their representatives. The representatives that were involved in the negotiations of the Verbano Project are shown[1] in Figure 10.2.

In the *Evaluation* phase the effects of the same alternative were compared on the basis of the indicator values relevant to the sector under examination; on the other hand, in the *Comparison* phase, the alternatives are compared on the basis of the sector indices. In the *Evaluation* phase the value functions were identified by assuming that in all sectors, with the exception of the ENEL *Power* sector, Compensation was allowed. This means that, in each sector, a bad indicator performance can be compensated by a good performance from one of the other indicators. This assumption is often acceptable among the criteria relevant to the same sector, but it is not among sector criteria by the very definition of sector. In fact, a sector is a subset of evaluation criteria whose aggregation is shared by all the interested Stakeholders, which often implies that Stakeholders are willing to accept compromise among the evaluation criteria of that subset; on the contrary, the level of the sector criteria is just the one at which compensation among the criteria is no longer accepted by the interested Stakeholders (see Chapter 4). Therefore, Compensation not being allowed, in the *Comparison* phase the alternatives cannot be compared by simply summing the sector

[1] The GRAIA Society cited in the figure is a society of independent researchers in environmental engineering and ichthyology (the acronym stands for G*estione e* R*icerca* A*mbientale* I*ttica* A*cque* – Management and Research for Environment, Ichthyology and Waters). It was invited as a representative for the interests of the *Upstream Fishing* sector.

indices. It follows that in the *Comparison* phase the MAVT cannot be used, at least in its traditional formulation. This method, in fact, would require that the Stakeholders agree on a vector **w** of weights, and that this vector be used to aggregate the sector indices and define a *Project Value Function*, which could be used to rank the alternatives of set $\bar{A}$. However, by doing so, we would not know if the alternatives that take the first positions in the ranking produce effects that are considered to be acceptable by all the Stakeholders, or if some of them would oppose the implementation of one or more of those alternatives.

To overcome this difficulty, we can ask each Stakeholder to specify *thresholds of acceptability* for the sector indices (s)he is interested in. If more than one Stakeholder has interests in the same sector, as for example in the case of *Irrigation* sector, the threshold with the greatest value is assumed. Once the acceptability thresholds have been defined, we can exclude all the alternatives in set $\bar{A}$ for which the sector indices are below these thresholds, and use the Project Value Function to rank the remaining alternatives.

If this procedure were adopted, the discussion among the Stakeholders would be limited to the definition of the Project Value Function, namely to the definition of the vector **w** of the weights to be attributed to the sector indices. This vector should be derived from the m vectors $\mathbf{w}^i$ provided by each of the m Stakeholders ($i = 1, \ldots, m$). To do this, two procedures can be followed. In the first, the Stakeholders are shown the existing distances between the vectors $\mathbf{w}^i$ that they defined, and they are asked to modify their own position, until a vector that is shared by all of them is achieved. If this procedure should run into a conflict that cannot be overcome, a second procedure can be used. Each Stakeholder is asked to provide a second vector $\mathbf{v}^i$ of weights, whose jth element expresses the importance that Stakeholder i attributes to Stakeholder j. The m vectors $\mathbf{v}^i$ are arranged in a square matrix, from which a vector **v** is extracted that defines the relative importance of each Stakeholder. Vector **v** is then used to weight the m vectors $\mathbf{w}^i$ and obtain vector **w**.

The described procedure seems weak, however, from the point of view of the interaction that is established among the Stakeholders. Therefore, it is not certain that all of them will be willing to accept the ranking that it produces. Further, it is possible that no alternative satisfies the acceptability thresholds indicated by the Stakeholders. For example, this would happen in the Verbano Project if the values of the sector indices produced by alternative $A0$ were used as thresholds, that is, if only 'win–win alternatives' were considered acceptable (remember that a 'win–win alternative' is an alternative that improves the satisfaction of *all* the Parties with respect to the current condition). Such alternatives cannot exist, since in the Verbano Project $A0$ turns out to be an efficient alternative. This consideration is very important: $A0$ is the alternative that would occur in the future if no action were implemented. Since it proves to be an efficient alternative, no alternative exists that produces greater satisfaction for *all* the sectors. In other words, whichever alternative is chosen, at least one of the sectors will be dissatisfied. This stresses the importance of establishing a thorough process of comparison that involves all the Stakeholders.

For this reason *we abandoned the search for a global ranking by means of a Project Value Function, and asked the Stakeholders to negotiate the acceptability thresholds*. To do so, we proposed a negotiation procedure in which the acceptability thresholds are not fixed a priori, but are defined in a recursive way by considering the effects of various threshold values.

To better understand the procedure that we are about to propose, it helps to study two methods, other than the weighting method presented in Section 5.2.6, that can be used to solve Multi-Objective Control Problems. The first is the *Constraint Method*, which transforms a Problem with n objectives into a (family of) Single-Objective Problems (parametric

in a vector **f**), by considering only one of the objectives of the original Multi-Objective Problem, and adding the constraint that the value of the other $n - 1$ objectives must not exceed the thresholds expressed by vector **f** (see Section 18.3.4 of THEORY).

The second method is known by the name of *Pareto Race* and it was proposed in the 1980s (Korhonen and Laakso, 1986). It is a method for generating points along the Pareto Frontier (Section 5.2.1) in real time, by solving a sequence of Design Problems formulated on the basis of the preferences that the Decision Maker (termed as DM in the following) expresses as she obtains the results of the previous Problems. It is thus an interactive and iterative method defined by the following procedure:

1. the DM expresses her own vision by specifying the value that she desires for each objective (for example, 100 Mm^3 of average annual deficit and 5 km^2 of average annual flooded area). By so doing, she defines a *reference point* R in the objective space;

2. given R, a Single-Objective Problem can be formulated (see Section 18.3.3 of THEORY). Its solution is an efficient alternative, i.e. it belongs to the Pareto Frontier, which is 'close' to R, in a sense to be specified[2];

3. the values of the objectives that correspond to that alternative are shown to the DM, for example by means of a bar graph;

4. the DM is asked if she is 'satisfied' with those values, in which case the procedure is terminated, or if she wants to obtain better values for one of the objectives. In the second case, a new reference point R is defined and the procedure is repeated from Step 2.

Other methods foresee that the whole Pareto Frontier is identified in advance and that the DM is shown it and chooses what she judges to be the best compromise alternative. The Pareto Race, on the contrary, has the advantage of identifying only the alternatives that the DM thinks are interesting. As the procedure develops, the DM has the feeling of moving along the Pareto Frontier (from which the name *Pareto Race*). She thus acquires knowledge about the conflicts between the different sectors, because she sees that some of the indices increase while others decrease, and can thus appreciate the possibilities for compromise. In this way the best compromise slowly takes shape in her mind. This is why the procedure ends when the DM is 'satisfied'.

In the case of Verbano we cannot adopt the Pareto Race in its classical form for two reasons. Firstly, it is not possible to design the policies in real time: the computing time required for the resolution of one Control Problem varies from a minimum of 35 minutes to about 20 hours (on a Pentium III processor, 600 Mhz, with SCSI architecture) and if the generation of the responses is too slow, it prevents the DM from 'perceiving' the compromise. In fact, it is only when the questions and answers follow each other in quick succession that the DM can 'acquire knowledge' about the compromise, since this is an acquisition process that is based on short-term human memory. The second and more important reason is that in the Verbano Project there are two DMs (the Italian and Swiss governments). Moreover, its Goal is to identify the alternatives that get the widest agreement among the Stakeholders

[2]The adjective 'close' does not perfectly translate the mathematical criterion, for greater clarification see Section 18.3.3 of THEORY.

(the reasonable alternatives), which will be then submitted to the two DMs. Consequently, all the Stakeholders must be involved in the comparison.

The way to overcome the first difficulty is simple: it is just because of the considerable computing time required for the Design Problem that in the PIP procedure the phases of *Designing Alternatives*, *Estimating Effects* and *Evaluation* are conducted off line, i.e. before the *Comparison* (this took about 70 days of uninterrupted computing time). We can therefore overcome the difficulty if we accept that the Design Problem formulated in Step 2 is not solved by searching the whole alternative space, but by screening the alternatives that have already been designed and looking for the one that most satisfies the objectives of the Problem.

The second difficulty remains. However, we can solve it by adopting the procedure described in the following paragraph.[3]

10.1.1 The Elementary Negotiation Procedure

1. Given an initial alternative A_{chosen}, the Facilitator uses a bar chart to show the values of the indices that this alternative produces in the different sectors, and asks each of the Stakeholders to take a position: *supporting* it, *accepting* it or *opposing* it.

2. The Facilitator asks the Stakeholders to identify the sector they judge to be the most disfavoured; let us denote this sector with $Sect^d$ and the value of the corresponding sector index with V_d (the symbol V is adopted because the index value is computed by means of a value function, see Chapter 9). Note that this is not necessarily the sector whose index has the lowest value, because it makes no sense to compare the values of the indices of different sectors, both for psychological reasons and for technical reasons (the value functions are defined on arbitrary scales, see Section 9.4). Let $\mathcal{A}^c$ be the set of alternatives subject to comparison and $\mathcal{A}^d$ the subset of the alternatives that increase the index of $Sect^d$ with respect to A_{chosen}.

3. The Facilitator asks the Stakeholders, with the exception of those interested in sector $Sect^d$, if they are willing to lower the value of the sector indices with respect to the value obtained in correspondence with A_{chosen}. If the answer is positive, the Facilitator asks them to indicate the lowest values (*acceptability thresholds*) for each sector. Otherwise, a stalemate has been reached, because, since all the alternatives in $\mathcal{A}^c$ are efficient, it is not possible to improve the sector index of $Sect^d$ without worsening the value of at least one other sector index. In the case of stalemate, A_{chosen} is a *reasonable alternative*. If, instead, even one of the sector indices can be reduced, the Facilitator identifies the subset $\mathcal{A}^{\text{acc}}$ of the alternatives that satisfy the acceptability thresholds. The intersection of the sets $\mathcal{A}^d$ and $\mathcal{A}^{\text{acc}}$ provides the set $\mathcal{A}^{\text{exp}}$ of the alternatives to explore in the search for an alternative that gets a wider agreement than A_{chosen}.

4. If $\mathcal{A}^{\text{exp}}$ contains at least one alternative, proceed with the next step. If, instead, it is empty, the Facilitator proposes that the Stakeholders review the acceptability thresholds: if at least one of them can be changed, go back to Step 3; if they all refuse, A_{chosen} is a reasonable alternative and the procedure terminates.

[3] It is an ad hoc adjustment of the more general procedure presented in Section 21.5 of THEORY.

5. To search for a reasonable alternative within $\mathcal{A}^{\text{exp}}$, the Facilitator asks the Stakeholders to define a suitable rule to rank the alternatives of this set. For example, the rule could be one of the following:
   (a) *maximum value of the index*: the alternatives $A_i \in \mathcal{A}^{\text{exp}}$ are ranked by decreasing values of the index $V_d(A_i)$, i.e. the index of the most disfavoured sector;
   (b) *minimum overall dissatisfaction*: the alternatives $A_i \in \mathcal{A}^{\text{exp}}$ are ranked by decreasing values of the following function
   $$\sum_j \alpha_j \big(V_j(A_i) - V_j(A_{\text{chosen}})\big)^-$$
   where $(\cdot)^-$ is an operator that returns the value of the argument when this is negative and zero in the opposite case. The α_j coefficients define the relative weights of the sectors; in practice, they are almost always used as Boolean variables to define the sectors that are considered;
   (c) *compensation of the differences*: the alternatives are ordered by decreasing values of the following function
   $$\sum_j \alpha_j \big(V_j(A_i) - V_j(A_{\text{chosen}})\big) \tag{10.1}$$
   where the weights α_j have the same meaning as in criterion (b). Note that, unlike rule (b), with this rule the decrease of an index can be compensated by the improvement of others.

   Let A_{current} be the first alternative of the ranking obtained.

6. Using a bar graph, the Facilitator shows the values of the indices of A_{current} compared to those of A_{chosen} and asks each of the Stakeholders to declare whether (s)he *supports*, *accepts*, or *opposes* A_{current}. A_{current} is said to get a *wider agreement* than A_{chosen} if all the Stakeholders who support A_{chosen} support A_{current} and at least one of the following cases occurs:
   - one of the Stakeholders who accept A_{chosen} supports A_{current};
   - one of the Stakeholders who opposes A_{chosen} accepts or supports A_{current}.

   If A_{current} gets a *wider agreement* than A_{chosen}, replace A_{chosen} with A_{current} and go back to Step 2.

7. Otherwise, if there exists an alternative that follows A_{current} in the ranking, assume it as A_{current} and go back to Step 6. If such an alternative does not exist because the whole ranking has already been examined, A_{chosen} is a reasonable alternative, since within $\mathcal{A}^{\text{exp}}$ an alternative that gets a wider agreement has not been found. Then the procedure terminates.

For each reasonable alternative it is important to record which Stakeholders *support* it, which of them *accept* it and which *oppose* it, because this information is very useful in the phase of *Final Decision*.

Often in Step 2 it is not possible to reach an agreement among the Stakeholders to designate the most disfavoured sector $Sect^d$: if a conflict exists, in fact, it emerges right now.

When this occurs, the procedure must be split into two or more branches (we term this moment *branching* point). Denote the alternative A_{chosen}, i.e. the alternative in correspondence to which the branching occurs, with A_{bra}. Among the sectors proposed as $Sect^d$, the Facilitator chooses the one whose index has to be improved and proceeds until a reasonable alternative is found. Then, he goes back to the branching point and starts the procedure again by considering another of the sectors proposed as $Sect^d$ and setting $A_{\text{chosen}} = A_{\text{bra}}$. The procedure is repeated again and again until all the sectors proposed as disfavoured at the branching point have been considered.

Note that, by following the different pathways that come off the branching point, different reasonable alternatives can be found. An interesting case is when, by following a branch, the alternative A_{bra} itself emerges as a reasonable alternative. Note that A_{bra} can be considered reasonable only if it proves to be a reasonable alternative also by following all the other branches. In fact, if from at least one of them a different alternative emerges, by construction, this alternative achieves a wider agreement than A_{bra} and, as a consequence, A_{bra} cannot be reasonable. Therefore, in correspondence with a branching point, the above Step 4 must be substituted by the following:

4. If $\mathcal{A}^{\text{exp}}$ contains at least one alternative, proceed with the next step. If, instead, it is empty, the Facilitator proposes that the Stakeholders review the acceptability thresholds: if at least one of them accepts, go back to Step 3; if they all refuse, A_{chosen} could be a reasonable alternative. It will actually be one if, by following all the other pathways from the branching point, no other alternative emerges that gets a wider agreement. In that case the procedure terminates.

One after the other, all the branching points that are encountered are examined in this way.

10.1.2 The steps for designing the alternatives

As we explained in Section 5.4, the alternatives of the Verbano Project were designed in two steps. Let $\bar{\mathcal{A}}_1$ be the set of alternatives designed in the first step. All the alternatives in the set must be subjected to the phases of *Evaluation* and *Comparison*: therefore the ENP must be carried out on the set $\mathcal{A}^c = \bar{\mathcal{A}}_1$. By doing so, the first set $\{A^{1,i}_{\text{rea}}\}$ of reasonable alternatives is identified. On the basis of the latter, a second set $\bar{\mathcal{A}}_2$ of alternatives is identified by means of the procedure described in Section 5.4.2. The alternatives in $\bar{\mathcal{A}}_2$, together with the reasonable alternatives identified in the first step, are subjected to a second step of *Comparison*, which provides the second set $\{A^{2,i}_{\text{rea}}\}$ of reasonable alternatives. Therefore in the second step of *Comparison* the ENP is carried out on the set $\bar{\mathcal{A}}_2 \cup \{A^{1,i}_{\text{rea}}\}$.

10.1.3 Initialization of ENP

To complete the description of the ENP we must define a criterion for the choice of the alternative A_{chosen} to be considered in Step 1.

Remember that no discrimination among the sectors is allowed in the *Comparison* phase and that it is essential that both the two sets of reasonable alternatives $\{A^{1,i}_{\text{rea}}\}$ and $\{A^{2,i}_{\text{rea}}\}$ be characterized by the fact that each Stakeholder supports at least one of the alternatives in the set. To guarantee that this occurs, it is sufficient that the following conditions be satisfied

1. After the first step of the alternatives design, the ENP is repeated as many times as there are sectors, and each time the Stakeholders interested in the sector under

examination select the alternative A_{chosen} to start the procedure. The condition of *wider agreement* (see Step 6) ensures that the Stakeholders that choose A_{chosen} at Step 1 will support all the reasonable alternatives that are obtained from it.

2. After the second step of the alternatives design, the ENP is repeated, starting each time with one of the reasonable alternatives in the set $A_{\text{rea}}^{1,i}$, which was obtained at the end of the first step.

10.1.4 The least-bad alternatives

Once the second set of reasonable alternatives has been identified, it is useful to divide it into groups of alternatives that are characterized by the same pairs (SD/RANGE) of actions. For each group, if there exists at least one Stakeholder that is opposed to all the alternatives in the group, the following procedure is carried out

1. Ask each of the Stakeholders that support or accept at least one of the alternatives in the group to what extent (s)he is willing to diminish the values of the sector indices (s)he is interested in, with respect to the worst alternative (for him/her), before changing to the opposition. In this way a set of acceptability thresholds is obtained.

2. Determine the set $\mathcal{A}^s$ of the alternatives in $\mathcal{A}^c$ which satisfy the acceptability thresholds and which are characterized by the same pair (SD/RANGE) as the group of alternatives being examined. If the set $\mathcal{A}^s$ is empty, it must be enlarged by not considering in turn one or more of the acceptability thresholds defined in Step 1.

3. Each of the Stakeholders who oppose all the alternatives in the group is asked to indicate the alternatives that (s)he prefers in $\mathcal{A}^s$. These will be catalogued as *least-bad* for him/her. If the Stakeholder refuses all the alternatives in $\mathcal{A}^s$, this set must be enlarged by not considering in turn one or more of the acceptability thresholds.

4. For each least-bad alternative obtained in this way, each of the other Stakeholders is asked to state how (s)he positions him/herself with respect to it, namely whether (s)he supports, accepts, tolerates or opposes it.

By construction, the least-bad alternatives are characterized by less opposition than the reasonable alternatives identified with the ENP, since they were identified taking into consideration the preferences of the opposers as much as possible. The risk is that these alternatives might be without supporters.

10.1.5 The reasonable alternatives

To further reduce the conflict, all the reasonable alternatives that have been obtained until this point are subjected to the *Mitigation* phase, at the end of which a third and last step of *Comparison* is carried out (Section 10.4). The set of reasonable alternatives resulting from this last comparison is submitted to the DMs for the *Final Decision* (Chapter 16).

The success of the *Comparison* phase greatly depends on the ability of the Facilitator to help the Stakeholders to negotiate and to show them how to get out of a stalemate, without ever forcing them into decisions. To prepare for negotiations, three preliminary activities can be carried out between the *Evaluation* phase and the application of the ENP, which we will describe in the following section.

10.2 Preliminaries to the Comparison phase

The *Comparison* phase must be characterized by three conditions:

- *Transparency*: each Stakeholder must account for his/her own preferences;
- *Completeness of Information*: each Stakeholder must understand as much as possible how the effects of the alternatives were estimated and evaluated for each sector;
- *Availability of Information*: all information must be archived in a structured way, so that it can be accessed easily at any time.

To satisfy these conditions the negotiation process should be preceded by the following three preliminary actions:

1. *Sharing the results of the evaluation*: it helps if each Stakeholder knows how each sector index was defined (not just his/her own!) and if (s)he is able to associate some significant values of the indices with the corresponding effects on the system. The moment for sharing this knowledge is a collective meeting of all the Stakeholders, in which each in turn presents this information for the sectors (s)he is interested in.
2. *Preliminary Analysis*: the results of the sensitivity analysis used to assess the interrelations between sector indices and actions are presented to all the Stakeholders, considering one sector at a time. For example, the way that the index of the *Upstream Flooding* sector varies with the stage–discharge relation, or with the regulation range, is shown. In this way, the Stakeholders can understand which combinations of structural and normative actions are advantageous to each sector and how much the regulation policy influences the sector index. The analysis is conducted by the Facilitator and presented to the Stakeholders either collectively or individually. The Stakeholders must also have the opportunity to conduct this analysis first hand.
3. *Individual Exploration*: it is important that each Stakeholder explore the performance of the alternatives autonomously, with the aim of gaining a feel for the interconnecting links between the different sector indices. (S)he should identify the alternative that (s)he will propose at Step 1 of the ENP when it is his/her turn. In order to avoid preconceived ideas influencing this choice, it is important that the exploration of the alternatives be carried out without knowing the combination of actions that has produced each alternative.

   Examples of these three preliminary activities are provided in Chapter 12. After these activities, it is time for the
4. *Negotiations*: they are carried out through the ENP in several steps, each of which is fulfilled through a collective meeting of all the Stakeholders.

To facilitate the satisfaction of the three conditions of Transparency, Completeness and Availability, it is advisable to conduct all the interactions with the same information support system, so that they take place in the same conceptual environment, which the Stakeholders can master progressively over time. This is one of the purposes of the MODSS TWOLE, described in Chapter 24 of THEORY.

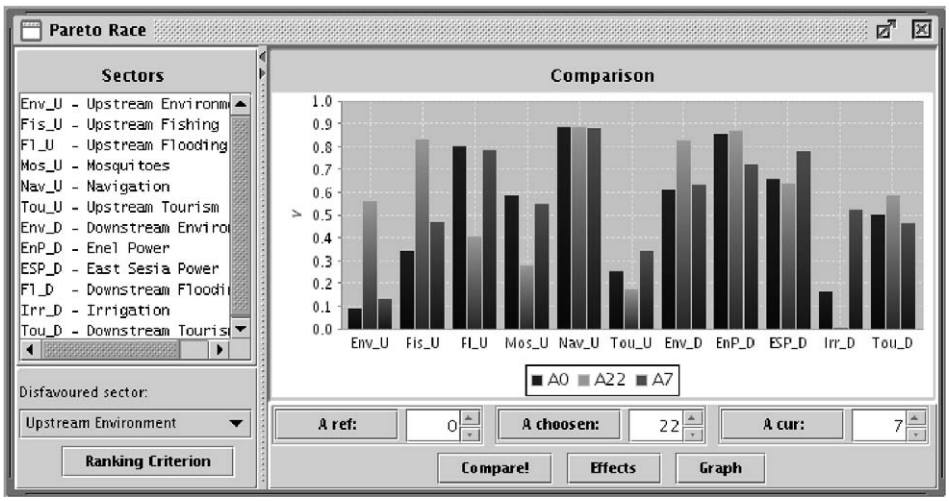

Figure 10.3: A screenshot from TWOLE, which implements the ENP.

10.3 Identification of alliances

Cognitive psychologists (Miller, 1956) have shown that, in general, human short-term memory cannot elaborate more than seven units of information at a time (in some rare individuals as many as nine units but as few as five in other rare cases). Above that threshold, a person may experience a sense of confusion and an inability to make judgements, which are manifested in asking several times for the same information, because it seems to escape him/her. For this reason, it is advisable that the number of sector indices compared in the ENP not be more than seven. The reader can experiment with this limitation to human cognitive ability by observing Figure 10.3, that shows the TWOLE's screenshot that supports the ENP. Eleven sectors are compared[4] and the effort required to express even very simple judgements is evident: for example, ascertaining if one of the three alternatives is efficient is not easy. If, as in the Verbano Project, there are more than 5–7 sectors, it is advisable to try and reduce them. Clearly, it is not possible to simply exclude several sectors (the related Stakeholders would be opposed). Instead, it is necessary to eliminate the redundant information and this is achieved by identifying the *alliances*.

Two sectors are natural allies (excluding the possibility of irrational envy) if their indices are positively correlated, i.e. if the alternatives that increase the first sector index also increase the second and vice versa. If this relationship exists between two sectors and the Stakeholders are informed about it, one of the two sector indices will not need to be visualized during the ENP without any Stakeholder interested in it feeling disfavoured: given two alternatives, it is easy to say which is preferable for the omitted sector by observing the index of the allied sector. However, if the Stakeholders need to know the value of the index of the omitted sector, for example to compare it to a threshold, it can be immediately provided.

[4]The reader might notice that the *Downstream Flooding* sector does not appear in Figure 10.3. In fact, it was excluded from the *Evaluation* and *Comparison* phases for reasons that will be explained in Chapter 12.

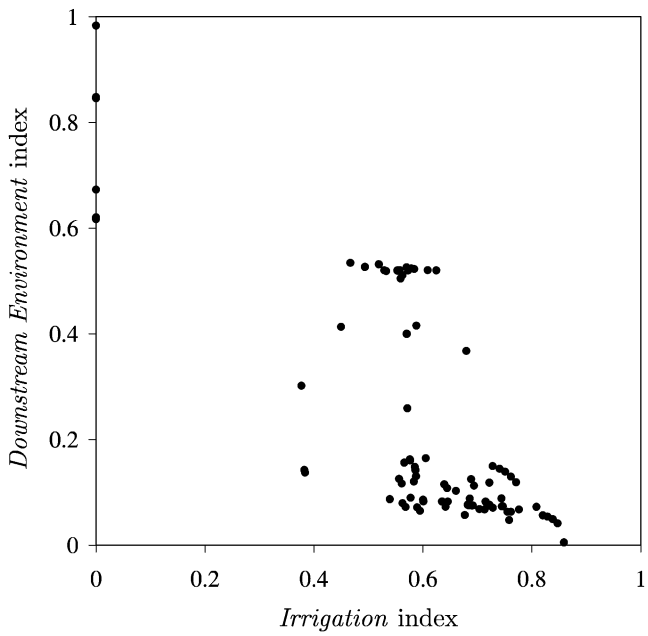

Figure 10.4: Plot of the *Irrigation* index values against the *Downstream Environment* index values. Each point represents a different alternative.

The alliances can be identified by considering one pair of sectors at a time and producing a scatter plot of their indices values for different alternatives. For example, from Figure 10.4 it can be inferred that the *Downstream Environment* and *Irrigation* sector are in strong conflict: high values for the first index are produced by alternatives that produce low values for the second and vice versa.

Therefore, these two sectors are not allies.

The following three cases can occur:

1. *Positive correlation*: the pairs of points that represent the two sector indices are close to a straight line with a positive slope. The two sectors are natural allies and it is possible not to show one of the two indices during the ENP.

2. *Negative correlation*: the regression line has negative slope. Also in this case it is not necessary to visualize both the sector indices, because if the first sector prefers one alternative over another, the preference of the second is certainly the opposite. Nevertheless, when possible in the ENP it is preferable to show both the index values for psychological reasons.

3. *Independence or uncorrelation*: if the pairs of indices are aligned along parallel horizontal or vertical lines, the two sectors are independent. They are uncorrelated if the scatter plot gives a 'cloud' of points. In both cases, knowing one sector index does not provide any information about the other. In the ENP it is therefore essential to visualize both the sectors.

10.4 Mitigation

Mitigation measures are interventions that aim at reducing the negative effects of an alternative on a particular sector, in order to reduce the opposition from the interested Stakeholders or even obtain their support. With the exception of particular or extreme cases, mitigation measures are not financial indemnities, which would simply conceal the problem without resolving it, but specific interventions designed to fit the particular conditions that are encountered. In Chapter 14 we will give two examples.

Once the mitigation measures have been identified for a given alternative, the latter should be considered to be a new alternative and thus it should be evaluated and compared to the reasonable alternatives that have already been identified. All the Stakeholders must participate in the new comparison, not only those that have interests in the concerned sector, since the new alternative could produce negative effects in other sectors. At the end of the comparison, the new alternative usually replaces the initial one, but it is also possible that both are taken forward to the phase of *Final Decision*.

10.5 Identification of the reasonable alternatives

In conclusion, the identification of the reasonable alternatives for the Verbano Project was divided into the following steps (see Figure 10.5).

- The set $\bar{\mathcal{A}}_1$ of efficient alternatives was designed and evaluated; this will be illustrated in Chapter 11.
- After the preliminary activities had been carried out, the alternatives of set $\bar{\mathcal{A}}_1$ were compared and the first set $\{A_{\text{rea}}^{1,i}\}$ of reasonable alternatives was identified, as will be reported in Chapter 12.
- Based on set $\{A_{\text{rea}}^{1,i}\}$, a new set $\bar{\mathcal{A}}_2$ of efficient alternatives was designed and then submitted to evaluation. The new alternatives, together with the alternatives of set $\{A_{\text{rea}}^{1,i}\}$, were compared in a second negotiation step, and a new set $\{A_{\text{rea}}^{2,i}\}$ of reasonable alternatives was identified. The union of the latter and of the set $\{A_{\text{lb}}\}$ of least-bad alternatives formed the set $\{A_{\text{rea}}^{3,i}\}$. All this will be described in Chapter 13.
- Mitigation measures for the alternatives in set $\{A_{\text{rea}}^{3,i}\}$ were designed, and the alternatives so obtained, together with those of set $\{A_{\text{rea}}^{3,i}\}$, were compared in the third negotiation step, as will be illustrated in Chapter 14.

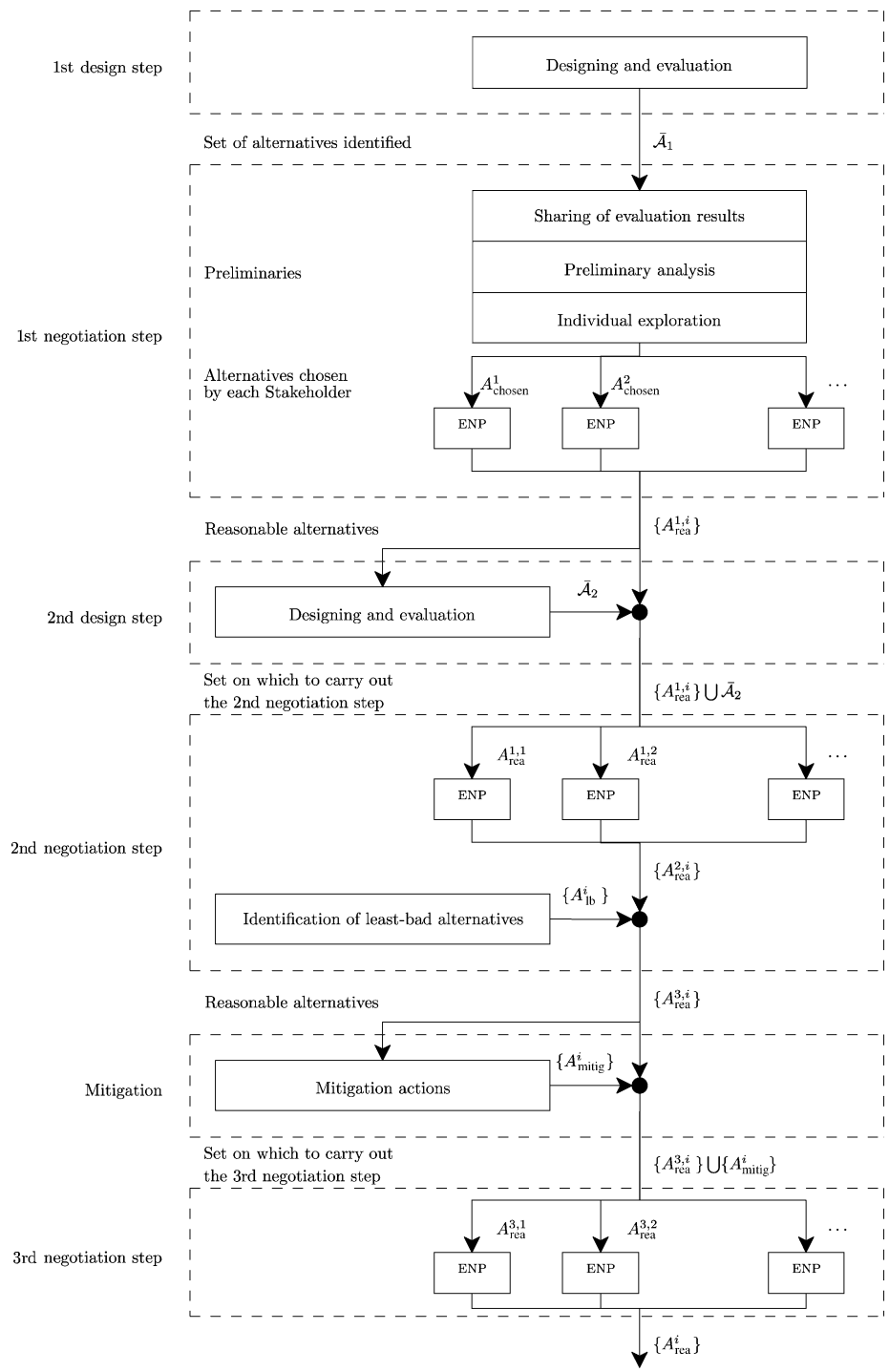

Figure 10.5: The steps for identifying the reasonable alternatives.