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Multicriteria approaches for tackling complexity in integrated assessments of urban and regional planning issues

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Abstract

This paper aims at mainly discussing the general background questions of the Symposium. The topic of policies and policy evaluation for the cultural heritage territorial Units will also be tackled. The starting point of my analysis is given by the concept of "Urban System" developed in the background paper by F. Archibugi. The role of the economic value of heritage (paper by X. Greffe) in the general framework of Urban Integrated assessments will also be dealt with. A point in common with the paper by N. Lichfield is the emphasis given to stakeholder analysis. My contribution focuses on the role of multidimensional analysis in urban sustainability and thus can be considered complementary in nature with the paper by Nijkamp et al.

KEY WORDS: URBAN SUSTAINABILITY, INTEGRATED ASSESSMENT, MULTICRITERIA EVALUATION, COMPLEX SYSTEMS, POST-NORMAL SCIENCE, SOCIAL COMPLEX VALUE, FUZZY SETS, NAIADE METHOD

Complex Systems, environmental integrated assessment and the concept of post-normal science

From systems theory it is possible to draw the distinction between systems which are simple or merely complicated on the one hand, and those which are complex. The former are studied by classical physics, and the latter by biology and the human sciences. Complex systems are defined as those which cannot be captured by a single perspective [Funtowicz et al, 1996; Funtowicz et al., 1997; O'Connor et al., 1996].

Among complex systems, the *reflexive systems* are those with the properties of awareness and purpose. In ordinary complexity, characteristic of biological systems, there is an absence of full self-consciousness and purposes. In order to better understand *reflexivity* it is possible to use a mathematical metaphor from chaos theory, that of a multi-dimensional phase space. The dimensions include those of the relevant mechanistic attributes (space, time, measurable properties), the ordinary-complex attributes of structure and function, and in addition those of the technical, economic, societal, personal and moral realms. These highest dimensions relate to knowledge and consciousness, and of course do not have the same type of metric relations as the lower dimensions. We may use the term "topology" to indicate the difference: the lower dimensions have a "harder" topology, permitting measurement and quantitative gauges while the higher dimensions have a "softer" topology, in which the more qualitative properties are described.

Environmental Integrated Assessment (EIA) deals with reflexive phenomena since an effective assessment, in order to be realistic, should consider not merely the measurable and contrastable dimensions of the simple part of the system, that even if complicated may be technically simulated. It should deal as well with the higher dimensions of the system, those in which power relations, hidden interests, cultural constraints, and other "soft" values, become relevant and unavoidable variables that heavily but not deterministically affect the possible outcomes of the strategies to be adopted. Thus, Integrated Assessment is understood as cross-disciplinary in the horizontal axe, integrating disciplinary perspectives on the issue at stake, and as pluri-participatory on the vertical axe, integrating the evenly legitimate perspectives of the different stake-holders and social actors concerned by the issue (see Figure 1).

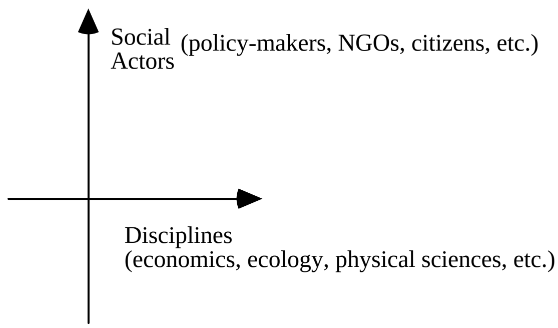


Figure 1. Vertical and Horizontal Integration in EIA

(from Castells and Munda, forthcoming)

Any social decision problem is characterised by conflicts between competing values and interests and different groups and communities that represent them. For example in urban and regional planning, biodiversity goals, landscape objectives, the direct services of different environments as resource and sink, the historical and cultural meanings that places have for communities, the recreational options environments provide are a source of conflict. From a philosophical perspective, it is possible to distinguish between the concepts of *strong comparability* (there exist a single comparative term by which all different actions can be ranked) implying strong commensurability (common measure of the different consequences of an action based on a cardinal scale of measurement) or weak commensurability (common measure based on an ordinal scale of measurement), and *weak comparability* (irreducible value conflict is unavoidable but compatible with rational choice employing practical judgement) (Martinez-Alier et al., 1998; O'Neill, 1993).

From an operational point of view, the major strength of multicriteria methods is their ability to address problems marked by various conflicting evaluations. Multicriteria evaluation techniques cannot solve all conflicts, but they can help to provide more insight into the nature of conflicts and into ways to arrive at political compromises in case of divergent preferences so increasing the *transparency* of the choice process.

To choose any particular operational definition for value involves making a decision about what is important and real; other definitions will reflect the commitments of other stakeholders. As a consequence, the validity of a given approach depends on the inclusion of the several legitimate perspectives as well as the non-omission of the reflexive properties of the system, even though these are not easy to deal with. This requires transparency in relation to two main factors (Roy, 1980):

(1) mathematical and descriptive properties which make the models used conform to given requirements;

(2) the way such models are used and integrated in a decision process.

Is it possible to improve the quality of a decision process? When science is used in policy, lay-persons (e.g. judges, journalists, scientists from another field, or just citizens) can often master enough of the methodology to become effective participants in the dialogue. This extension of the peer community is essential for maintaining the quality of the process of resolution of reflexive complex systems. Thus the appropriate management of quality is enriched to include this multiplicity of participants and perspectives. The criteria of quality in this new context will presuppose ethical principles. But in this case, *the principles will be explicit and will become part of the dialogue.* "The issue is not whether it is only the marketplace that can determine value, for economists have long debated other means of valuation; our concern is with the assumption that in any dialogue, all valuations or "numeraires" should be reducible to a single one-dimension standard (Funtowicz and Ravetz, 1994, p. 198)".

Nowadays, scientists tackle problems introduced through policy issues where typically, facts are uncertain, values in dispute, stakes high, and decisions urgent (Funtowicz and Ravetz, 1991). Thus Funtowicz and Ravetz have developed a new epistemological framework called "post-normal science", where it is possible to use two crucial aspects of science in the policy domain: uncertainty and value conflict. The name "post-normal" indicates that the puzzle-solving exercises of normal science, in the Kuhnian sense (Kuhn, 1962), which were so successfully extended from the laboratory of core science to the conquest of nature through applied science are no longer appropriate for the solution of social problems.

Post-Normal Science can be located in relation to the other, complementary strategies, by means of a diagram (see Figure 2). On it, we see two axes, "systems uncertainties" and "decision stakes". When both are small, we are in the realm of "normal", safe science, where expertise is fully effective. When either is medium, then the application of routine techniques is not enough; skill, judgement, sometimes even courage are required. Funtowicz and Ravetz call this "professional consultancy", with the examples of the surgeon or the senior engineer in mind. Our modern society has depended on armies of "applied scientists "pushing forward the frontiers of knowledge and technique, with the professionals performing an aristocratic role, either as innovators or as guardians.

When conclusions are not completely determined by the scientific facts, inferences will (naturally and legitimately) be conditioned by the values held by the agent. If the stakes are very high (as when an institution is seriously threatened by a policy) then a defensive policy will involve challenging every step of a scientific argument, even if the systems uncertainties are actually small. Such tactics become wrong only when they are conducted covertly, as by scientists who present themselves as impartial judges when they are actually committed advocates.

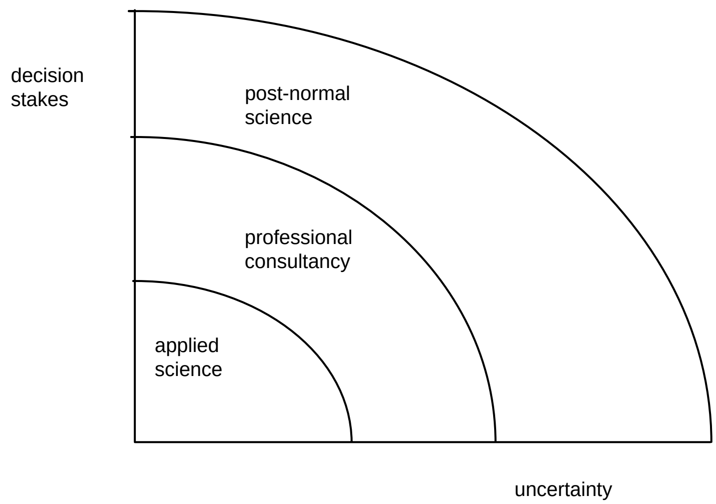


Figure 2. Graphical Representation of Post-Normal Science

Qualitative Multicriteria Evaluation

A typical multicriteria problem (with a discrete number of alternatives) may be described in the following way: A is a finite set of n feasible actions (or alternatives); m is the number of different points of view or evaluation criteria g_i i=1, 2, ... , m considered relevant in a decision problem, where the action **a** is evaluated to be better than action **b** (both belonging to the set A) according to the i-th point of view if $g_i(a)>g_i(b)$. In this way a decision problem may be represented in a tabular or matrix form. Given the sets A (of alternatives) and G (of evaluation criteria) and assuming the existence of n alternatives and m criteria, it is possible to build an n x m matrix P called evaluation or impact matrix whose typical element p_{ij} (i=1, 2 , ... , m; j=1, 2 , ... , n) represents the evaluation of the j-th alternative by means of the i-th criterion. The impact matrix may include quantitative, qualitative or both types of information.

The results of any decision model depend on the available information; since this information may assume different forms, it is useful that decision models can take them into account. But, it has to be noted that this available information depends on the problem definition phase. According to systems methodology, the problem definition process may be synthesised in the following hierarchy of epistemological levels of systems (Cavallo, 1979):

- *source systems* (all possible data that may be gathered),
- *data systems* (measurement of all variables),
- *generative systems* (relations among variables),

- *structure systems* (simplified representation of the whole system),
- *metasystems* (changements in time and space of the structure system).

It has been argued that the presence of qualitative information in evaluation problems concerning socio-economic and physical planning is a rule, rather than an exception [Munda et al., 1994; Nijkamp et al., 1990]. Thus there is a clear need for methods that are able to take into account information of a "mixed" type (both qualitative and quantitative measurements).

An example of a multicriteria method that may use mixed information is the so-called REGIME method; this method is based on pairwise comparison operations; from this point of view it has something in common with outranking methods (Hinloopen and Nijkamp, 1990).

Another issue related to the available information concerns the uncertainty contained in this information. Ideally, the information should be precise, certain, exhaustive and unequivocal. But in reality, it is often necessary to use information which does not have those characteristics so that one has to face the uncertainty of a stochastic and/or fuzzy nature present in the data. If it is impossible to establish exactly the future state of the problem faced, a stochastic uncertainty is created; this type of uncertainty is well known; it has been thoroughly studied in probability theory and statistics.

Another framing of uncertainty, called fuzzy uncertainty, focuses on the ambiguity of information in the sense that the uncertainty does not concern the occurrence of an event but the event itself, which cannot be described unambiguously [Zadeh, 1965]. This sort of situation is readily identifiable in complex systems. Spatial-environmental systems in particular, are reflexive complex systems characterised by subjectivity, incompleteness and imprecision (e.g., ecological processes are quite uncertain and little is known about their sensitivity to stress factors such as various types of pollution). Fuzzy set theory is a mathematical theory useful for modelling situations of such a sort, i.e. it aims to portray in terms of fuzzy uncertainty, some of the indeterminacies of the socio-ecological system under study (Munda, 1995).

Zadeh [1965] writes: "as the complexity of a system increases, our ability to make a precise and yet significant statement about its behaviour diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics". Therefore, in these situations statements as "the quality of the environment is good", "the unemployment rate is low" are quite common. Fuzzy set theory is a mathematical theory for modelling situations, in which traditional modelling languages which are dichotomous in character and unambiguous in their description cannot be used. Human judgements, especially in linguistic form, appear to be plausible and natural representations of cognitive observations. A linguistic representation of an observation may require a less complicated transformation than a numerical representation, and therefore less distortion may be introduced in the former than in the latter.

In traditional mathematics, variables are assumed to be precise, but when we are dealing with our daily language, imprecision usually prevails. Intrinsically, daily languages cannot be precisely characterised on either the syntactic or semantic level. Therefore, a word in our daily language can technically be regarded as a fuzzy set. Fuzzy sets as formulated by Zadeh are based on the simple idea of introducing a degree of membership of an element with respect to some sets. The physical meaning is that a gradual instead of an abrupt transition from membership to non-membership is taken into account.

NAIADE (**N**ovel **A**pproach to **I**mprecise **A**ssessment and **D**ecision **E**nvironments) is a discrete multicriteria method whose impact (or evaluation) matrix may include either crisp, stochastic or fuzzy measurements of the performance of an alternative with respect to an evaluation criterion, thus it is very flexible for real-world applications.

The aggregation procedure of NAIADE can be synthesised as follows (more technical information can be found in Munda, 1995). First, a pairwise comparison of all the alternatives on the base of the set of evaluation criteria is carried out. For each pair, a preference index is determined by:

(1) the *number* of criteria in favour of each alternative (if we think to a Parliament, the number of criteria in favour of a given alternative can be considered as the number of votes received by a proposal (alternative in our case));

(2) the "*intensity of preference*" of each single criterion, measured by the credibility that a given alternative is better than another one.

After the pairwise comparison, there is still a need to derive a ranking of the alternatives taken into account. Let' s think to a soccer championship. After all the matches (pairwise comparison), for each team (alternative) we know the number of teams that it has defeated and the number of teams that have defeated it. We can also know the intensity of its competitive quality, i.e. the goals received and the ones given. This concept of strength and weakness of each alternative is used in NAIADE for obtaining a final ranking of the alternatives. This ranking can be a complete preorder (among the alternatives only relations of preference or indifference exist) or a partial preorder (also incomparability relations may exist). Some indicators of the uncertainty and compensability introduced in the aggregation process are also used.

Equity and distributional issues in multicriteria decision aid are traditionally introduced in two different ways:

(1) by weighting the different criteria (this is similar to what is done in cost-benefit analysis when distributional weights are introduced). Unfortunately, in public decision making a single point-value

solution (e.g. weights) tends to lead to deadlocks in a decision process because it imposes too rigid conditions to reach a compromise;

(2) by taking into consideration a set of ethical evaluation criteria. A weak point of this approach is that it could lead to an excessive number of evaluation criteria. Furthermore, to identify ethical criteria may be not an easy task.

A third possibility is proposed in NAIADE, i.e. the use of conflict analysis procedures to be integrated with the multicriteria results. This to allow policy-makers to seek for decisions that could reduce the degree of conflict (in order to reach a certain degree of consensus) or that could have a higher degree of equity on different income groups. NAIADE uses a fuzzy conflict analysis procedure. Starting with a matrix showing the impacts of different courses of action on each different interest/income group, a fuzzy clustering procedure indicating the groups whose interests are closer in comparison with the other ones is used.

Summarising, NAIADE can give the following information:

1. ranking of the alternatives according to the set of evaluation criteria (i.e. compromise solution/s),
2. indications of the distance of the positions of the various interest groups (i.e. possibilities of convergence of interests or coalition formations),
3. rankings of the alternatives according to actors’ impacts or preferences.

One should note that sometimes, a serious divergence between the multicriteria ranking and the equity ranking may exist. This mainly because the information provided by these rankings is different in nature (otherwise they would be redundant).

The multicriteria ranking can be considered more “technical”. That is, for instance in an EIA problem, some alternative options can be evaluated according to a set of socio-economic and environmental criteria. These criteria should have been chosen such that they reflect actors’ values (or preferences or interests) or they could even have been chosen directly by the affected actors. However, in principle the determination of the criterion scores is independent of their preferences. For example, an interest group can accept the use of a criterion measuring the effects of the various alternatives on the employment, but the determination of the figure cannot be (at least completely) controlled by them (the same applies e.g. to environmental impact indicators). Moreover, the ranking is a consequence of all the criteria considered simultaneously (in search of the compromise solution).

On the contrary, the impact score of each alternative to each interest group is much more direct. Such a score should be determined by the group itself (or anyway it should be a direct consequence of its preferences). Unreconciliable conflicts may exist between different coalitions or even between single groups. The policy analysis can be conditioned by heavy value judgements such as, have all actors the same importance (i.e. weight)? Should a social desirable ranking be obtained on the grounds of the majority principle? Should some veto power be conceded to the minorities? Are income distribution effects important? And so on.

Once more we would like to stress that formal evaluation tools cannot *solve* the conflicts, what they can do is to help in providing more insight into the nature of conflicts (so improving the understanding of the negotiation process itself) and into ways of arriving at policy compromises, so increasing the transparency of the evaluation process. They can also be considered as learning tools (a kind of Socrates' majeutics) helping the actors to become aware of their own assumptions and preferences as well as those of the other actors.

An example of a multicriteria process in urban water management

At this point of the discussion, one question arises, that is who is taking the decisions? Some critics of multicriteria evaluation say that *in principle*, in cost-benefit analysis, votes expressed on the market by the whole population can be taken into account (of course with the condition that the distribution of income is accepted as a means to allocate votes). On the contrary, multicriteria evaluation can be based on the priorities and preferences of some decision-makers only (we could say that the way these decision-makers have reached their position is accepted as a way to allocate the right to express these priorities. This criticism may be correct if a "technocratic approach" is taken, where the analyst constructs the problem relying only upon experts' inputs. By experts we mean those who know the "technicalities" of a given problem.

To clarify this point I will briefly illustrate a case study of water management in Sicily. For more details on this project see Funtowicz et al., 1998 and De Marchi et al., forthcoming.

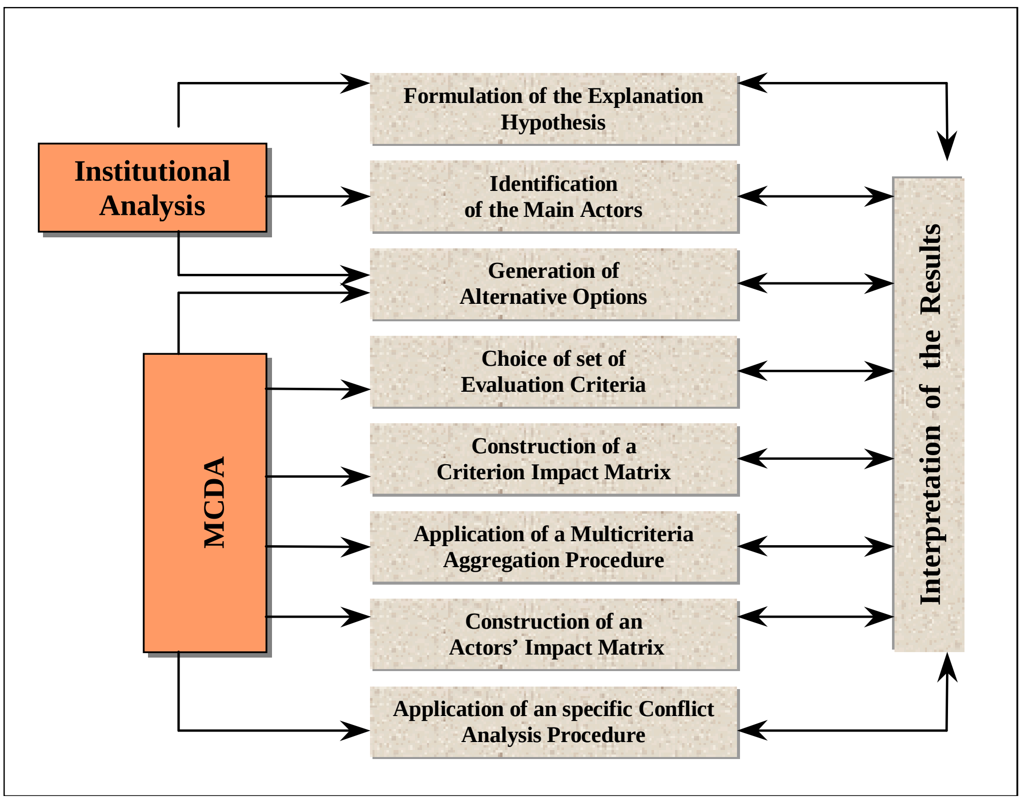
Troina is a small town (10,000 inhabitants) in the North-eastern Sicily, Italy. On the one hand, it seems there is a common assumption that there is an actual water shortage in Troina, which could be remedied by more effective use of existing resources. (Paradoxically, although real water shortage is common in Sicily, Troina is an exception). On the other hand, there is a complex and heterogeneous collection of interests in the Troina water issue, who have hitherto had no effective dialogue. Hence an effective structuring of the water problem at this early stage is an important task, so that eventual negotiations among stakeholders can have a better chance of a positive outcome.The steps of the overall evaluation process followed are schematised in Figure 3.

One has to note that evaluation is not a one-shot activity; on the contrary, it takes place as a *learning process*. It has to be realised that the evaluation process is usually highly dynamic, so that judgements regarding the political relevance of items, alternatives or impacts may present sudden changes, hence requiring a policy analysis to be flexible and adaptive in nature. This is the reason why evaluation processes have a *cyclic nature*. By this is meant the possible adaptation of elements of the evaluation process due to continuous feed-back loops among the various steps and consultations among the actors involved (Nijkamp et al., 1990).

The first question to be answered is the following: *is "business as usual" a possible option in the long run?* Business as usual is a situation where power and water management are fragmented among the main actors and where infrastructure actions are the only ones not requiring agreements. This can be considered the classic case of non-cooperative resource exploitation.

For example, the Comune of Troina is trying to become self-sufficient for its drinking water needs using its own spring water sources, even if this could be perceived as inefficient. To evaluate the business as usual option properly, it has to be compared to a set of different possible options on the basis of some evaluation criteria. At this point, an issue immediately arises: alternatives and criteria for whom? This leads to a need to take into account the preferences of some of the actors playing an important role in the problem at hand.

Figure 3. Scheme of the evaluation process



Initially, only the actors playing an important role in the community of Troina (as a result of the institutional analysis) were taken into account. Later on, as a surprising feedback of the process of generation of alternative options, it was clear to everybody that additional interest groups outside Troina also had to be taken into account. This learning process was very interesting particularly for the local administrators of Troina, who fully realised the importance of Troina water resources outside their own territory. As the Mayor acknowledged, such a process of structuring the problem at hand was extremely useful for understanding the hierarchy of interests that is behind the exploitation of local natural resources.

A set of options with a short/medium temporal scale, a low cost and a high probability of being absorbed by the community without any strong impact was generated. These alternatives can be considered as small additions/changes to business as usual. They are:

(1) To use some spring water sources located in the forest to produce bottled mineral water.

This policy option is strongly supported by the present town administration. At the moment, this water flows free in the forest, thus if it is bottled, no water use conflict will exist. It is thought that the symbolic value of this option for the community can be very big (to have a bottled Troina water might create a feeling of re-appropriation of local natural resources). Some uncertainty still exists on the financial impacts of such an option.

(2) To combine mineral water with some recreational activities in the forest.

These recreational activities are connected with the restoration of existing country houses, which are property of the Comune. This would allow to open (for example), a small hotel or a restaurant in the woods, but also to finance the rediscovery by the Troinesi of the habit of spending some time in the forest.

(3) To develop a massive information campaign about local water resources (water cycle, water process, technological uses of water, water management, water distribution).

The objective of this action is to increase the public knowledge. This would probably lead to less protest by citizens. On the other hand, various powerful actors might not like such transparency.

(4) Implementations of the "Galli framework law".

This concerns the creation of a water basin authority, and normally has to be implemented by a decree of the central government. In Sicily the situation is more complex because the subject of water is "a reserved topic" of the regional government. This promises great difficulties in the implementation of a law creating a new power.

(5) Self-sufficiency of Troina's drinking water needs.

This is the main short-term goal of the town administration.

(6) Compensation to Troina community (for the fact that water is appropriated by someone else outside

the community).

Apparently, this seems the main objective of the population at large. It is not clear which form such compensation should take in practice.

(7) Changes of the water irrigation structure in Catania (pipelines, etc.).

This action will improve the efficiency of the water use by Catania farmers, thus saving more water for Troina. This process of renovation is already going on.

Consensus was reached on the use of the following set of criteria:

1. Use of water (in the sense of efficiency).
2. Financial analysis (in the following applications this has been implemented by taking into account returns and financial constraint).
3. Employment.
4. Flexibility of the social-power structure (connected to community vulnerability).
5. Community identity (symbolic value of water).
6. Accountability and transparency of the water management.
7. Social awareness or participation.
8. Environmental impact (in the following applications it has been considered by means of the precautionary principle).

Given the time and resource constraints, it was decided to construct a qualitative multicriteria impact matrix (see Table 1). The criterion scores, modelled as linguistic variables, were determined on the base of intuition and knowledge of the problem at hand.

It was thought that even if such impact scores were roughly (e.g. the environmental impact) and arbitrarily determined, the results obtained might still have some explanatory capacity for the *learning process*.

The NAIADE method was chosen for the problem at hand, because of its capability of dealing with qualitative information and conflict analysis issues. By applying NAIADE to the multicriteria impact matrix illustrated in Table 1, the following ranking was obtained:

1. information campaign
2. self sufficiency
3. compensation
4. mineral water + recreation
5. mineral water
6. Galli law
7. Business as usual
8. Change of the irrigation structure

During the study, the top position of the information campaign was an unexpected surprise. Another interesting result was the clearly bad position of the business as usual option (even in a short time horizon). As a consequence, one would expect that a pressure to change the present situation should exist. Then why do most of the relevant actors in the community seem to be happy with the status quo? To try to understand this apparent contradiction better, we constructed the actors' impact matrix shown in Table 2.

	Alternatives							
Criteria	Business as usual	Mineral water	Mineral water + recreation	Informat. Campaign	Implement. of the Galli Law	Self-sufficiency	Compensat	Change of the irrigat. stru. in CT
Use of water	Moderate	More or less good	More or less good	Moderate	Good	Good	Moderate	Very good
Returns	moderate	Good	Good	Moderate	Moderate	Good	Moderate	Moderate
Financial constraint	very good	Moderate	Moderate	Very good	Very good	Moderate	Very good	Very bad
Employm.	Moderate	More or less good	Good	Moderate	Moderate	Moderate	Moderate	Moderate
Commun. vulnerabil.	Very high	High	More or less high	More or less high	Very high	More or less high	High	Very high
Commun. identity	Bad	Good	Good	Good	Bad	More or less good	Good	Bad
Transpar.	Very bad	Very bad	Very bad	Very good	Bad	More or less good	More or less bad	Bad
Participat.	Bad	Bad	Bad	More or less good	Bad	Moderate	Bad	Bad
Precaution. principle	More or less good	More or less bad	More or less bad	More or less good	More or less good	Moderate	More or less good	Good

Table 1. Multicriteria impact matrix for the policy options

The description of actors' attitudes , perceptions and stakes is mainly derived from the historical institutional analysis, some in-depth interviews, study of available material (published and unpublished) and insiders' knowledge of the community.

By applying NAIADE, the dendrogram of the coalition formation process shown in Figure 4, is obtained. Such a graphic shows the possibilities of convergence of interests among the various actors (on the base of the distance among their policy positions). The values on the left represent the credibility degrees of this convergence (i.e. coalitions). One should keep in mind that the results provided have a predictive value (in the sense of possible outcomes) and not a descriptive one.

	Alternatives							
Actors	Business as Usual (A)	Mineral Water (B)	Mineral water + recreation (C)	Informat. Campaign (D)	Implement. of the Galli Law (E)	Self-Sufficien. (F)	Compens. (G)	Change of the irrigat. stru. in CT (H)
ENEL	good	Good	Good	Very bad	Very bad	Moderate	Very bad	Good
EAS	Moderate	Moderate	Moderate	Bad	Very bad	Bad	Moderate	Good
Troina Comune	Bad	Moderate	More or Less good	Very good	Moderate	Very good	Very good	Good
Catania farmers	Very good	Very good	Very good	Moderate	More or Less Bad	Very good	Very bad	More or Less good
Oasi	Moderate	Moderate	Very good	Bad	Bad	Moderate	More or Less good	Moderate
Environm.	More or less good	Bad	Very bad	Very good	Very good	More or Less bad	More or Less good	Very good
Municip. of Agrigento	bad	irrelevant	Irrelevant	Moderate	Good	Irrelevant	Irrelevant	Irrelevant
Neighbour. Municip. to Troina	More or less bad	More or less Bad	More or Less bad	Moderate	Good	Irrelevant	Bad	Moderate
Const./buil. industry	bad	Moderate	Moderate	Bad	Moderate	Bad	Bad	Bad
Resident Troina farmers	moderate	Moderate	Moderate	Moderate	Moderate	More or Less bad	Moderate	Moderate
Non-resident Troina farmers	More or Less bad	More or less bad	More or Less bad	More or less bad	Moderate	More or less bad	Bad	Moderate

Table 2. Actors' impact matrix for the policy options

From this analysis it appears that the interests of Agrigento municipalities and neighbouring municipalities to Troina seem to run fairly parallel. The same applies to construction/building industry and non-resident Troina farmers. Thus, the group composed by these four actors may have some common compromise solutions. All the others present a much more individualistic character. This also corroborates our assumption that business as usual corresponds to a situation of fragmentation.

The ranking of policy options for the coalition of the first 4 actors is the following:

1. Galli law (E)
2. information campaign (D)
3. mineral water (B)
4. mineral water + recreation (C)
5. self sufficiency (F)
6. Business as usual (A)
7. Change of the irrigation structure (H)
8. Compensation (G)
9.

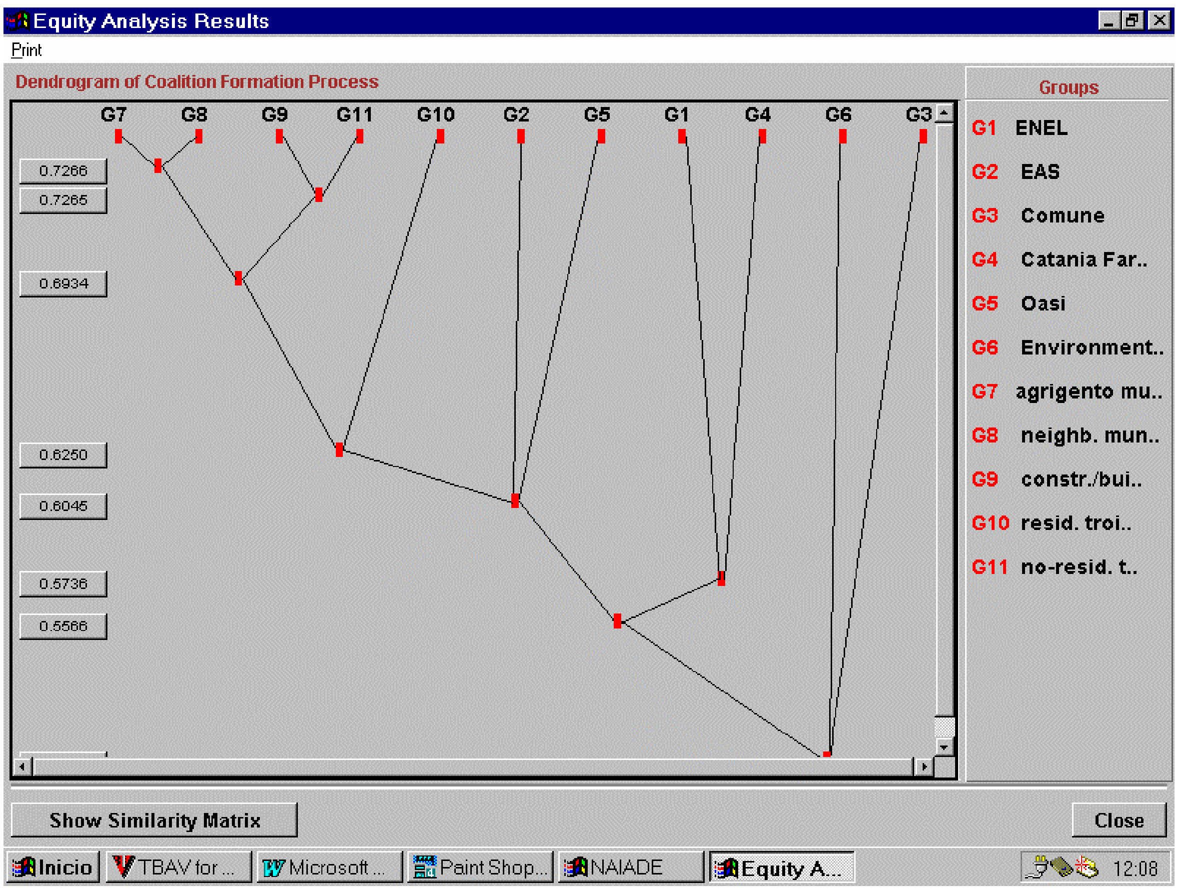


Figure 4. Dendrogram of the coalition formation process

These actors would probably gain if changes in the status quo will occur. The creation of a basin authority could imply more awareness of the water needs in the whole territory. Such awareness could also be created by an information campaign. Changes that imply infrastructures are interesting for the construction/building industry.

According to NAIADE conflict analysis, the other actors present the ranking of the policy options shown in Table 3.

Oasi	**Envir.**	**Comu.**	**Res. Tr. Farm.**	**EAS**	**CT Farm.**	**ENEL**
C	D	D	B	H	B	H
G	H	F	C	C	C	C
B	E	*G*	**A**	B	**A**	B
A	**A**	H	D	**A**	F	**A**
F	*G*	C	E	*G*	H	F
H	F	E	*G*	F	D	*G*
E	B	B	H	D	E	E
D	C	**A**	F	E	*G*	D

Table 3. Ranking of policy options according to each actor

As one can see, the positions differ substantially among the various actors. However, some commonalties can be found. *Business as usual* (A) may present an impact ranked in medium/high position for all the actors (with the only exclusion of the Comune). *Mineral water + recreation* (C) may have a positive impact on all actors with the exclusion of the strong opposition by environmentalists. The *compensation option* (G) seems to be never on the top of priorities, it could be ranked in a medium/low position. According to our analysis, the actors could consider the implementation of the Galli law (E) to be of little importance. The *change of the irrigation structure* (H) by Catania farmers also stays in a medium position. Environmentalists and the Municipality ("Comune") seem to put a high priority on the *information campaign* (D), however for almost all the other actors this options could present a bad impact.

By looking at the conflict analysis for all actors and at the results of multicriteria analysis, some interesting conclusions can be drawn. According to these settings, the *mineral water + recreation* option seems to be a good compromise from the point of view of conflict analysis (it is the only change of the status quo that does not meet any strong opposition). It could be considered more or less "defensible" from the multicriteria analysis point of view, however not at the top of priorities (it is fourth in the final ranking), anyway it is widely preferable to business as usual.

Compensation seems to present a medium/low degree of attractiveness for all actors. A possible explanation may be because it does not directly affect the powerful actors. Only the population at large could receive some benefits from it (whose interests we suppose are represented by the Comune, who however does not consider it as the highest priority). One should note that the multicriteria analysis considers compensation in a third position, thus it could also be considered defensible but not highly attractive.

The multicriteria analysis considers the *information campaign* at the top of priorities, but we also know that strong oppositions against such a policy option may exist. What to do in this case? This is a clear example of a situation where the decision-maker (in our case the “Comune”) has to decide whose interests have priority; no escape from value judgements is possible.

During the study, the top position of the information campaign was an unexpected surprise. The response to this surprise was the idea of implementing, within a very short time horizon, an exposition on water management issues in the town of Troina. The Mayor and the municipal administration thought that the implementation cost of such a policy measure is quite low and the positive impacts on the community could be very high. Of course, the political risks for the administration can also be very high. This point leads us to the initial and principal question, is business as usual a defensible option?

One should note that *business as usual* is ranked almost on the bottom of the multicriteria analysis. While in the conflict analysis, it is in a low position for some actors (Comune, neighbouring and Agrigento municipalities, non-resident Troina farmers and construction/building industry) and in a high/medium position for all the others. To this second group belong almost all the powerful social actors of Troina community. We could say that the status quo is a compromise solution among the opposite internal interests. This can explain why nobody is very much willing to change the present situation (though it is very risky for the community at large). However, this situation looks much more as an *empasse* than as a real equilibrium (with the exclusion of Catania farmers who have an evident self-interest in maintaining the status quo).

In this study it is attempted to avoid the pitfalls of the technocratic approach, by applying different methods of sociological research. The institutional analysis, performed mainly on historical, legislative and administrative documents, has provided a map of the formal decision makers. Much insight has been offered by “participant observation” as some contributor to the study are also members of the community and knowledgeable of its internal dynamics. The possible biases of this “insider perspective” have been checked against the information obtained from some in-depth interviews with key local actors. Finally a survey has been performed on a random sample of the resident population, as to explore their perception of the water issue in Troina.

Thanks to the knowledge and insight derived from the previous phases of our research, it was possible to prepare a questionnaire by using mainly pre-structured (or close-ended) questions. These consist in a query followed by a limited number of answers, among which the respondents select the one, which matches their opinion/knowledge/belief most closely. Some open-ended questions where also enclosed, allowing the interviewees to express their opinions in their own words. The latter option was preferred, for example, when aiming at a clarification of the answer provided to a previous, closed-ended question.

Summing up the results of the survey, it is possible to state the following main conclusions.

1. The starting hypothesis that in Troina exists a common assumption on an actual water shortage seems to be confirmed. The hypothesis that in the community there is a perception of an inefficient water use seems to be empirically corroborated too.
2. The social perception seems to be that water is equally distributed to the users. Thus apparently the starting hypothesis that people perceive an unfair use of the water resource does not seem to be confirmed.
3. A few people are conscious of the delicate hierarchy of interests that are behind Troina water resources. However, it is possible to deduce that the majority of the community would be in favour of the possibility of supplying water to Agrigento.
4. The multicriteria analysis seems to show that Troina is a quite vulnerable and unsustainable place. This view seems also shared by most of the key opinion leaders. Apparently, such a view is not shared by the population at large.
5. The conclusion from the conflict analysis step, that the mineral water option has no real strong opposition in the society seems to be empirically corroborated.

This triangulation of methods, which proves powerful in sociological research, becomes even more so when integrated in a study like the present one, applying multicriteria methods to a problem of environmental valuation. Ideally, in this case the results obtained by the researcher, i.e. his/her data, findings, interpretations and insights) are returned to the community which uses them not as just given, but rather as an input in the decision-making process.

In synthesis, one should not forget that the classical schematised relationship decision-maker/analyst is indeed embedded in a social framework, that is of a crucial importance in the case of public policy decisions. We believe that this type of extended evaluation process can be very effective since it accomplishes the goals of being trans-disciplinary (with respect to the research team) and also participatory (with respect to the local community).

Commensurability, incommensurability and urban sustainability

The concept of "urban environmental carrying capacity"

Does the expression "Taking nature into account" imply money valuation, o rather appraisal through physical indices (which themselves might show contradictory trends)? Are countries, regions, cities moving towards sustainability or away from sustainability? Which are the "measuring rod(s)" to be employed? For instance, statistics are available which show that the Netherlands is sustainable (in the "weak" sense of the word), while other statistics (on environmental space) show the Netherlands occupying fifteen times their own territory, i.e. appropriating the "carrying capacity" of a much larger territory than their own. Such incongruencies (if such they are) also apply to Japan, for instance (Martinez-Alier et al. Forthcoming).

Sustainable development has of course a global dimension, but it is also increasing recognised that there is close mutual interactions between local and global processes. In particular, cities are open systems impacting on all other areas and on the earth as a whole. Therefore, an urban scale for analysing sustainability is certainly warranted. There is actually much work on this issue (under Agenda 21), extending the work done in some cities under the UNESCO MAB programme.

Especially in the European context, the reinforced focus on the city seems warranted, as the European countries are facing a stage of dramatic restructuring and transition. However, the aim to make Europe more competitive in economic terms may beat odds with its environmental sustainability (for example, the current authorities of Barcelona like to say that Barcelona should become a Rotterdam of the Mediterranean). In the long history of Europe numerous cities with an extremely valuable and vulnerable socio-cultural heritage have emerged which deserve strict protection in the interest of current and future generations (Cocossis and Nijkamp, 1995). Therefore, what we are facing here is a problem of *ecologically* sustainable urban development. This is now more important, as some 80 percent of European people live in cities (Nijkamp and Perrels, 1994).

Urban growth rests on a trade-off of agglomeration economies (notably economies of scale and scope including higher wages) versus diseconomies (e.g. population density and environmental decay). It is likely that environmental quality problems may become more severe with urban size, however factors as the land use, the transportation system and the spatial layout of a city are also critical factors for determining the *"urban environmental carrying capacity"*.

For example, Eurostat proposes the following urban pressure indicators (European Commission, 1996):

- population density per area,
- land consumption
- roads and parking areas

- mono functional areas
- derelict areas
- inhabitants per green area
- accessibility of green areas
- emissions of CO_2
- emissions of SO_2 and NO_x
- emissions of VOC
- emissions of PM_{10}
- emissions of lead
- water consumption per capita
- COD/BOD through (non-treated) waste water
- non-treated waste water
- non-treated waste water discharges to urban surface waters
- soil contamination
- municipal waste per capita
- non-recycled municipal waste
- household hazardous waste
- energy consumption
- share of private car transport
- registered motor vehicles
- traffic accidents with victims (injured and/or dead)
- mileage of commuters
- people endangered by noise emissions
- noise emissions of industry
- noise levels of vehicle fleet

Why so many different indicators - it may be asked - when there could be a unique physical indicator of whether human impact on the environment is excessive, simply by using the concept of carrying capacity, as defined in ecology: the maximum population of a given species (frogs in a lake for instance) that can be supported sustainably in that given territory, without spoiling its resource base. Authors who come from a background in Biology and from an emphasis on population growth, such as Paul Ehrlich and his collaborators, have over the years become aware of the shortcomings of the notion of Carrying Capacity applied to humans. This is why they proposed the formulation I = PAT, where I is the human impact on the environment, P is human population, A is affluence, and T is technology.

The definition of carrying capacity is irrelevant for humans, for several reasons.

First, the human ability to establish large differences in exosomatic use of energy and materials means that one first question should be, maximum population at which level of consumption? Second, human technologies change at a much quicker pace than in other species. Third, the territories occupied by humans are not given. We compete with other species, which are pushed into corners as shown by the Vitousek, Ehrlich et al.'s (1986) indicator of Human Appropriation of the Net Primary Production of Biomass. Also, inside the human species, territoriality is socially and politically constructed. There is still another reason why the notion of carrying capacity is not directly applicable to humans, in any particular territory. This is international trade, which may be seen indeed as the appropriation of the carrying capacity of other territories.

At a urban level, the concept of the ecological footprint has been proposed (Folke et al., 1996; Wackernagel and Rees,1995).. Ecological footprint analysis gets around some of the difficulties with traditional carrying capacity simply by inverting the usual carrying capacity ratio. The ecological footprint starts from the assumption that every category of energy and material consumption and waste discharge requires the productive or absorptive capacity of a finite area of land or water. If we sum the land requirements for all categories of consumption and waste discharge by a defined population, the total area represents the ecological footprint of that population whether or not this area coincides with the population's home region. In short, the ecological footprint measures land area required per person (or population), rather than population per unit area.

More formally, the ecological footprint of a specified population or economy can be defined as the area of ecologically productive land (and water) in various classes, cropland, pasture, forests, etc. that would be required on a continuous basis:

- to provide all the energy/material resources consumed,
- to absorb all the waste discharged

by a given population in a given area.

From an operational point of view, the main categories of land use for the calculation of the ecological footprint would be as follows:

- crop and grazing land required to produce the current diet (the sea area could also be included),
- land for wood plantations for timber and paper,
- land occupied or degraded or built-over, as urban land,
- land needed to absorb CO_2 emissions through photosynthesis, or alternatively land required to produce the ethanol equivalent to current fossil energy consumption.

In Rees' hometown of Vancouver, the respective figures for these four items, per person, would be

1 hectare, 0.6 has., 0.2 has., and 2.3 has. (of middle aged Northern temperate forest), i.e. over 4 hectares per person. Notice that only $C0_2$ is translated into a land requirement, and not other wastes, such as domestic waste, or other greenhouse gases, or radioactive waste, not for any reason of principle, but because of difficulty of computation. Notice also that the water catchment area, and the waste water disposal area, are not included.

Similar computations, not for cities or metropolitan regions (whose "ecological footprint" is hundreds of times larger than their own territories) but for whole countries, show that some densely populated European countries (assuming per capita eco footprints of only 3 has.) or Japan or Korea (with per capita eco footprints of only 2 has.) occupy eco-spaces ten times larger (for the Netherlands, fifteen times larger) than their own territories.

Of course, when considering urban population it becomes particularly important the acknowledgement of the existence of physical constraints on matter and energy flows which are determined by the particular type of organization of the society. This set of constraints on the density of matter and energy throughputs is generated by internal characteristics of the system and has nothing to do with external conditions. However, in spite of that, this has still a huge relevance in determining the consequent Environmental Loading for the same unit of human mass sustained or energy consumed or waste generated. A few examples follow (Giampietro, 1997):

Let us consider the case of food supply. A kg of grain consumed per person can have a cost of 2,000 kcal or 35,000 kcal according to the characteristics of the society. If one is in a rich society there is a need to produce food with only 5% of the available work force in agriculture (to produce grain at a throughput of 700 kg of grain per hour of labour). If women are working there is no longer a big fraction of housewives and food products will be more expensive. Totally different is the situation of a subsistence society which is much more "energy efficient". On the other hand this is paid for by a very low productivity of labour - e.g. 10 kg of grain per hour of labour (basically the population is made of poor farmers).

The same applies to the amount of land you have available. The cost of producing food is different if you are a Japanese farmer with only 1 ha of land or a US farmer with 64 ha of land per capita. From these examples the following lesson can be learned: it is not possible to establish once and for all a conversion factor (equivalent of space demand of 1 kg of grain, wood, iron etc.) for the different throughputs of a society (either in terms of input or wastes).

Just to give an example, the following indicators could be quite relevant to urban biophysical analyses (Giampietro et al., 1998):

<u>* household size.</u>

The same 1,000 people can be organized into: (a) 100 families of 10 members; or (b) into 500 families of 2 members. The two solutions will provide an aggregate consumption for the 1,000 people which is dramatically different, Solution (b) means more exosomatic devices per capita, lower redundancy of matter and energy flows in the society, higher consumption per capita – but as reverse of the medallion it means more diversity and adaptability for the society - more degrees of freedom.

<u>* demographic structure: pattern of time allocation.</u>

The allocation of human control on repetitive activities and codified roles (working time and chores) can be seen as control capability allocated on "short-term efficiency" (to sustain the steady-state), whereas the allocation of human control (human time is a proxy of it) on less determined patterns (sleeping/dreaming, leisure, education, and other recreational activities) can be seen as the allocation of control capability on adaptability (long-term horizon).

<u>* profile of distribution of societal resources among primary sectors/services/household.</u>

That is comparing the

profile of allocation of energy,

profile of allocation of time

profile of allocation of money

in the urban areas compared with national averages in terms of fraction.

Any difference [= when the profile in the city is different from national profile] indicates a dependency of the cities on the rest of society (e.g. if what they consume is higher) and a biophysical constraint in the terms of relative size city/rest of the society.

<u>* spatial mapping of flows.</u>

This compares the density of throughputs in different areas (balancing intensive and extensive variables) over the space occupied by city, country, embodied activity of ecosystems indirectly used.

This discussion may be phrased also in the framework of recent work on the so-called "inverted U curve" (or so called "Kuznets environmental curve"- see Selden (1994) and Arrow et al. (1995) for a critical viewpoint). For instance, as incomes grow, in urban situations sulphur dioxide emissions first increase and then decrease. But carbon dioxide emissions increase with incomes. If something improves and something deteriorates, the first reaction from the conventional economist will be to give weights or to put prices on such effects, in the pursuit of strong comparability of values. However, there is so much uncertainty and complexity involved in such situations, there are also so many distribution conflicts involved (the prices of externalities would depend on the distribution of property rights, of power, and of income), that the economists' accounts would be convincing only for the faithful (Cabeza-Gutes, 1996; Martinez-Alier, 1991; Munda, 1997).

Moreover, "there are additional problems in using market prices to value the aggregate stock of natural capital. Resource prices or net prices reflect conditions at the margin andt o use these to value entire stocks can give perverse results. For example, it is possible for the real price or net price of a resource to rise over time at the same rate as (or faster than) the rate of decrease in the physical stock of the resource..... This possibility is of more than theoretical interest. If price or net price rises as resource quantity is declining, the value of resource stocks as an indicator of sustainability can give precisely the wrong policy signal to government. As long as the value of the stock remains constant or rises, the government, through this indicator, will not perceive a problem even though the flow of resource is becoming increasingly valuable (as measured by price) and the physical stock is declining [Victor, 1991, p.204]".

We must learn to live with weak comparability of values. Many items are not easily measured in physical terms and can much less easily be valued in money terms.

Concluding, we can say that:

1. it is difficult (or better impossible) to find scientific sound conversion factors that can transform everything in land as well as in energy, money or whatever common term one would like to use,
2. the ecological footprint is an example of ecological reductionism, i.e. socio-economic and cultural aspects are completely neglected (to transform the “Colosseo” in a wooded area would improve the ecological footprint of Rome!),
3. even if we take into account the environmental point of view only, it is impossible to use just one single indicator.

A Multidimensional Approach to Sustainable Development at a Urban Level

Ecosystems can be divided into three categories [Odum, 1989]:

- *natural environments* or natural solar-powered ecosystems (open oceans, wetlands, rain forests, etc.);
- *domesticated environments* or man-subsided solar-powered ecosystems (agriculture lands, aqua culture, woodlands, etc.);
- *fabricated environments* or fuel-powered urban-industrial systems (cities, industrial areas, airports, etc.).

It is evident that fabricated environments are not self-supporting or self-maintaining. To be ecologically sustained they are dependent on the solar-powered natural and domesticated environments (life-supporting ecosystems). Thus, from a pure ecological point of view, cities are unsustainable by definition (the ecological footprint is a good metaphor of that). When dealing with “Urban sustainability”, thus a wider analysis is needed.

City' s overall sustainability depends on of four kind of capitals*: man-made, natural, human and social capitals*, and by the way in which these capitals are combined, i.e. by their mutual relationship.

The challenge of urban sustainable development is the challenge of matching these different dynamics in a co-evolutive perspective (Norgaard, 1994). Therefore, we need monetary indicators in order to control the processes of planning sustainability, but we need also indicators that can be expressed in different physical and ordinal units for the natural system and man-made cultural capital resources. Moreover, we need indicators of social capital (of the kind and the working of institutions, of local communities organization, of the kind of participation to public decisions, of the third sector's actions, of family, etc.), and of the human capital (Fusco-Girard and Nijkamp, 1997).

A necessary condition for implementing an effective planning system for urban environmental management is the development of a system of suitable urban environmental indicators. Such indicators which should represent a balance between the necessary quality of information and the costs involved, would have to be related to economic, social, environmental and cultural dimensions of the city. Thus a multidimensional framework is relevant here (Archibugi and Nijkamp, 1990).

A possible reduction of complexity, a pre-condition for management actions, consists in the aggregation of non-equivalent representations, which arise in the interaction between the various observer subjects and the different systemic levels. The reduction of the number of non-equivalent representations introduces the problem of the descriptors: indicators and indices.

It is generally useful to distinguish between "direct" and "indirect" indicators. Direct indicators refer to objects, qualities and attributes, which have a direct connotation of measurement. Indirect indicators instead assign a magnitude of measurement to objects which in themselves do not possess it. As an example, the concentration of a pollutant in the atmosphere has an impact value on human health only as the result of the evaluation of a relationship between this concentration and a damage to people: these relationships are often based on long and uncertain event chains.

Often the complexity of many real situations does not allow investigation of the long relational chains, possibly random, which assign the cause of an impact to the presence of an object of an attribute. In these cases the indicators constructed, as well as obviously being indirect, are called estimated. Their construction rests on analogies and "similarities" of behaviour: i.e. on inferential models. The use of these indicators, although subject to discussion, is obviously very wide and is often fundamental in describing the system being studied.

However, one should not forget that scientific assessments can be correct from a formal point of view (i.e. consistent with a set of axioms), but still biased or even irrelevant from a descriptive point of view. When dealing with complex systems operating in parallel on several hierarchical levels, the simultaneous existence of contrasting but “correct” scientific assessments is unavoidable (Giampietro, 1994). For instance, geographical connotations of complex urban systems are entities that change their identity according to the particular space scale at which they are described. These scales depend on the hierarchical level chosen to describe the system.

For example, in urban integrated assessments, to look at a block inside a city, or at the administrative unit constituting a "Commune", or at the "Metropolitan area" could give completely different and contrasting views and policy suggestions. Thus, if we consider e.g. the hierarchical level "Commune of Barcelona", the statement that quality of life is becoming higher and higher seems to be correct (or at least shared by most of its inhabitants). If we look at the whole Metropolitan area, the same statement is probably not that right.

In urban planning distributional issues play a central role. Key questions are "good" for which point of view? For whom? How long? Any policy option always implies winners and losers, thus it is important to check if it looks good just because losers are not taken into account!

Urban development means the creation of new assets in terms of physical, social and economic structures, but it is at the same time recognised that each development process often also destroys traditional physical, social and cultural assets derived from our common heritage. This is an important issue above all in European cities where the cultural heritage is very big.

Monuments represent part of the historical, architectural, and cultural heritage of a country or city, and do not usually offer a direct productive contribution to the economy. Clearly, tourist revenues sometimes may reflect part of the interest of society in monument conservation and/or restoration, but in many cases this implies a biased and incomplete measure, so that monument policy can hardly be based on tourist value. On the contrary, in various place one may observe a situation in which large-scale tourism does affect the quality of a cultural heritage (e.g. Venice).

To attribute monetary values to the historical heritage implies to capture user (actual, option and bequest) and non-user (existence, symbolic, etc.) values. Moreover, which time horizon has to be considered? Which social discount rate? Indeed in human history no society has mind about efficiency when building e.g. a cathedral. This is quite evident nowadays in Barcelona with the building of Sagrada Familia. Although almost all the "experts" agree that it should not be completed, the society at large (i.e. "the non-experts") feels a strong commitment and involvement with its construction maybe because there is a wide perception of its symbolic value in terms of Catalan identification.

When dealing with cultural heritage, talking about substitutability and compensability loses any meaning. Which would be the willingness to accept compensation for destroying the "Sagrada Familia" or the "Colosseo"? The only concept useful is the one of *strong sustainability*, this of course implies that the overall society (mainly the non-experts), outside the economic system, would decide the "amount" of cultural capital desired. From an economic point of view, the only instrument left is *"cost-effectiveness";* that is given a certain "physical" target, it is rational to try to get it by means of the lowest possible use of resources (i.e. at the minimum cost). Here it is obvious that there are <u>several</u>

targets possible. The notions of "post normal" science and "extended peer reviews" will then again apply. This is explicitly acknowledged in many instances of environmental management, such as water quality standards negotiated quite legally among stakeholders.

This implies that in general, there are two rankings possible:

1. according to the lowest cost,
2. according to the physical target (the more monuments preserved, the better).

Perhaps a discussion would lead to a judgement that the improvement of a worse target to a better one worth the extra economic cost. Or perhaps the judgement could be that, given the costs of compliance, is preferable the worst physical target . In both cases we would have an ordinal ranking of alternatives, i.e. weak commensurability. Perhaps, however, a consistent ranking of the three alternatives proves impossible to achieve. Then, in this case, "cost effectiveness" could not make it even to the weak commensurability grade, and it would "fall down" into weak comparability only, i.e. incommensurability, operationalized by means of multicriteria evaluation.

Thus, the socio-economic and historical artistic value of a cultural good is a multidimensional indicator or *"complex social value"* (Fusco Girard, 1986). The process of "sustainable urban planning" should maximise the "complex value" of urban resources, i.e. both use value and independent-on-use value, taking into account every conflict among intrinsic (existence and symbolic) values, use values and relational values, and the implications of land use changes on exchange value.

A system of indicators that reflects and expresses the above value theory is then needed. However, behind a list of indicators there would always be a history of scientific research and political controversy. Moreover, one should note that a list of indicators is far from being a list of targets and lower limits for those indicators. These would depend on the social evaluation processes and reflexive practices, which lead to the choice of concrete indicators and target setting.

Then a question arises, how could such indicators be aggregated? Often, some indicators improve while others deteriorate. It has to be noted that this is the classical conflictual situation studied in multicriteria evaluation theory.

When dealing with the issue of the aggregation of several indicators by means of multicriteria methods, an important distinction is between compensatory and non-compensatory aggregation procedures. The aggregation of several dimensions implies taking a position on the problem of *compensability*. Intuitively, compensability refers to the existence of trade-offs, i.e. the possibility of offsetting a disadvantage on some indicators by a sufficiently large advantage on another indicator, whereas smaller advantages would not do the same. Thus an aggregation procedure is non-compensatory if no trade-off occurs and is compensatory otherwise.

One has to note that if environmental, socio-economic and cultural indicators are taken into consideration, complete compensability implicitly means complete substitution among the various forms of capital, then implying weak sustainability. An important consequence of noncompensability is that it is possible to operationalize the concept of strong sustainability. The possibility of limiting the compensability among indicators and to put lower bounds of acceptability (e.g. by the notion of a veto threshold) is of a fundamental importance to operationalize the strong sustainability concept (Martinez-Alier et al., 1998).

Conclusion

The management of our urban systems requires different kinds of decisions and involves many institutions. When "planning" first became recognised as an important function, it was hoped that a scientific assessment of resources and needs would define correct policies. Although scientific methods still remain a necessary element of the process, it is well recognised that they are not sufficient in themselves. In particular, the assignment of quantities to the values held by various stakeholders is not straightforward.

It has to be explicitly recognised that regional and urban planning is also characterised by significant institutional, political, cultural and social factors through which action is carried out.

When dealing with complex systems operating in parallel on several hierarchical levels, the simultaneous existence of contrasting but “correct” scientific assessments is unavoidable.The use of a multidimensional approach seems desirable.

This implies that in the framework of Urban Environmental Integrated Assessment, the strong commensurability and strong comparability assumptions have to be changed. Since multicriteria evaluation techniques are based on a "constructive" rationality and allow one to take into account conflictual, multidimensional, incommensurable and uncertain effects of decisions, they look as a promising assessment framework for Urban EIA.

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