ANP APPROACH FOR IMPROVING PUBLIC PARTICIPATION IN STRATEGIC ENVIRONMENTAL MANAGEMENT PLANNING

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ABSTRACT
Environmental challenges decisions are often characterized by complexity, irreversibility and uncertainty. Much of the complexity arises from the multiple-use nature of goods and services, difficulty in monetary valuation of ecological services and the involvement of numerous stakeholders. From this point of view multicriteria techniques are considered as a promising framework to take into account conflictual, multidimensional, incommensurable and uncertain effects of decisions explicitly. Also principles and practice of public participation can serve to promote environmental equity for disadvantaged social groups.
Thus the objective of this paper is to propose a new methodological approach based on the Analytic Network process (ANP) and to examine the scope and feasibility of the ANP in incorporating participatory approach.
Keywords: ANP, Public participation; Multi-criteria decision-making, Environmental

1. INTRODUCTION

As we said, environmental challenges decisions are often characterized by complexity, irreversibility and uncertainty. Under these circumstances, conventional methods such as cost-benefit analysis are not adapt to evaluate environmental decisions (Ananda, 2003).
From this point of view multicriteria techniques are considered as a promising framework for evaluation since they have the potential to take into account conflictual, multidimensional, incommensurable and uncertain effects of decisions explicitly (Carbone et al., 2000; Munda, 2000; Omann, 2000). The most widely used multicriteria methods include the ANP – Analytic Network Process, multiattribute utility theory, outranking theory and goal programming, developed by LT. Saaty (Saaty, 1980). The ANP does not separate intangible from tangible factors. It is a useful tool to analyse decisions in complex social and political problems. The ANP is also useful when many interests are involved and a number of people participate in the judgement process (Saaty, 2005).
So this method can be useful in environmental challenges planning as it can accommodate conflictual, multidimensional, incommensurable and incomparable sets of objectives. On the other hand principles and practice of public participation can serve to promote environmental equity for disadvantaged social groups.
The effectiveness of this practice in preventing or reducing environmental inequity depends upon the use of participation methodology which caters to the cultural and social needs of such groups. These methods need to provide appropriate forms of information, suitable venues for participation, and access to expertise and education which enable the public to understand policy issues and formulate preferences. The extent to which public preferences are incorporated in policy decisions determines the worth of public participation programs in promoting environmental equity (Hampton, 1999).
From this point of view we noted that some of the participatory methods developed so far have often been criticized as lacking efficacy because of poor rigor and need of better structuring and analytical capabilities.
In spite of this criticism, several studies applying the AHP (and its generalization ANP) to incorporate public participation have concluded that the AHP/ANP method is worth pursuing (Kangas, 1994, 1999; Ananda and Herath, 2003, Mau-Crimminsa *et al.* 2005).
Thus the objective of this paper is to propose a new methodological approach based on the Analytic network process (ANP) and to examine the scope and feasibility of the ANP in incorporating participatory approach and stakeholder preferences into environmental challenges planning (De Felice *et al.* 2010).
To overcome environmental challenges a holistic approach and effective co-management strategies are required. Co-management means all stakeholders, and especially local communities, participate in management: analyzing, proposing actions, taking decisions, applying them, assessing their results, following up on the actions, giving feedback, etc.
Our project is based on the assumption that the barriers to effective decision-making that exist between local communities and other stakeholders cannot be broken down by one party acting alone. We propose to avoid modeling the conflicts of interests on the basis of a win-lose approach, or a top-down flux. The project will take the approach of discussing and proposing alternatives and choosing the most appropriate one from various points of view. The focus is more on active participation and debate, and less on who is in command or whose priorities and preferences are more important.

2. THEORETICAL BACKGROUND OF ANP MODEL

The Analytic Network Process is the generalization of AHP that is Analytic Hierarchy Process. AHP was developed by Thomas Saaty (Saaty, 1980) in the early 1970s. The strength of the AHP approach lies in its ability to structure a complex, multiattribute, multiperson and multiperiod problem hierarchically.

In addition, it can also handle both qualitative (through representing qualitative attributes in terms of quantitative values) and quantitative attributes. The general approach followed in AHP is to decompose the problem and to make pairwise comparisons of all the elements (attributes, alternatives) at a given level with respect to the related elements in the level just above.

AHP usually involves three stages of problem solving: the principles of decomposition, comparative judgments, and synthesis of priority.

In particular, details on the Analytic Network Process (ANP) model can be found in Saaty (1999); the fundamentals are summarized here for completeness. The ANP model consists of the control hierarchies, clusters, elements, interrelationship between elements, and interrelationship between clusters. The modeling process can be divided into four steps for the ease of understanding which are described as follows:

- **Step I:** pairwise comparison and relative weight estimation. The determination of relative weights in ANP is based on the pairwise comparison as in the standard AHP. Pairwise comparisons of the elements in each level are conducted with respect to their relative importance towards their control criterion based on the principle of AHP. Saaty suggested a scale of 1–9 when comparing two components. The score of aij in the pairwise comparison matrix represents the relative importance of the component in row (i) over the component in column (j), i.e., aij=wi / wj. The score of 1 represents equal importance of two components and 9 represents extreme importance of the component i over the component j. The reciprocal value of the expression (1 /aij) is used when the component j is more important than the component i. If there are n components to be compared, the matrix A, is defined as:

	A_1	A_2	....	A_n
	w_1	w_2....		w_n
A_1	w_1/w_1	w_1/w_2....		w_1/w_n
A_2	w_2/w_1	w_2/w_2....		w_2/w_n
....	.....	...		.....
A_n	w_n/w_1	w_n/w_2...		w_n/w_n

$$A = \begin{vmatrix} 1 & a_{12} & .... & a_{1n} \\ 1/a_{12} & 1 & .... & a_{2n} \\ ..... & & ..... & ..... \\ 1/a_{1n} & 1/a_{2n} & & 1 \end{vmatrix}$$

After all pairwise comparison is completed the priority weight vector (w) is computed as the unique solution of: $Aw = \lambda_{max} w$ where λmax is the largest eigenvalue of matrix A.

The consistency index (CI) of the derived weights could then be calculated by Equation (1):

$$CI \frac{\lambda_{max} - n}{n-1} \qquad (1)$$

In general, if CI is less than 0.10, satisfaction of judgments may be derived.

- **Step II:** formation of initial supermatrix. Elements in ANP are the entities in the system that interact with each other. The determination of relative weights mentioned above is based on pairwise comparison as in standard AHP. The weights are then put into the supermatrix that represents the interrelationships of elements in the system. The general form of the supermatrix is described in Figure 1 where CN denotes the Nth cluster, eNn denotes the nth element in the Nth cluster, and Wij is a block matrix consisting of priority weight vectors (w) of the influence of the elements in the ith cluster with respect to the jth cluster.

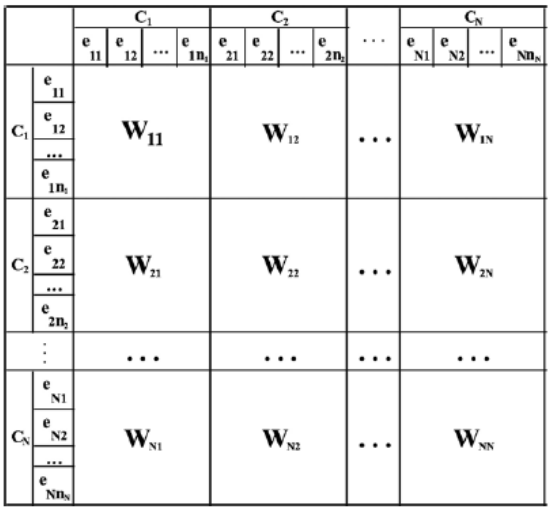

Figure 1: Supermatrix form

- **Step III:** formation of weighted supermatrix. The initial supermatrix consists of several eigenvectors each of which sums to one. The initial supermatrix must be transformed to a matrix in which each of its columns sums to unity.
- **Step IV:** calculation of global priority vectors and weights. In the final step, the weighted supermatrix is raised to limiting power to get the global priority vectors as in Equation (2):

$$\lim_{k\to\infty}(W)^k \qquad (2)$$

Once the matrix of pairwise comparisons has been developed, one can estimate the relative priority for each of the alternatives in terms of the specific criteria. Preferences derived from a criteria or sub criteria matrix are used to calculate a composite weight for each alternative. This part of ANP is referred to as synthesis. This enables ANP to obtain not only the rank order of the alternatives, but also their relative standings measured on a ratio scale. The alternative with the highest overall rating is usually chosen as a final solution.

3. ANP APROACH TO IMPROVE PUBLIC PARTECIPATION IN EVIRONMENTAL MANAGEMENT

The main objective of our work is to develop a participatory decision-making model which will be used when dealing with key environmental decisions together with local communities and other important stakeholders. To achieve this participatory decision-making model, the following objectives are envisaged:

1. Balance the starting knowledge level of all partners.
2. Analyze and parameterize conflicts of interest in natural resource management.
3. Identify the reference cases.
4. Model the decision-making processes helping the local communities.
5. Model the participation processes.
6. Improve decision-making procedures.
7. Develop the proper support for participation, discussion, learning, evaluation, prioritization, communication, traceability, etc.
8. Improve the capability of local communities to become a partner when defining natural resource management policies.
9. Develop procedures for collective working on line.
10. Construct an Analytic Network Model to enhance participatory approaches.

To structure the decision problem we identified and structured objectives which required careful empirical and literature investigations (De Felice and Petrillo, 2010). They provide the basis for quantitative modeling. Keeney (1992) classifies objectives as fundamental objectives and means objectives. The fundamental objectives are the issues or attributes that stakeholders genuinely care about, and means objectives are ways to accomplish the fundamental objectives. Objective hierarchies can be constructed using this classification. For example, ecologically sustainable development could be the fundamental objective and economic, social and environmental objectives could be the means objectives in case of forest decisions. Attributes to measure these objectives too should be identified. In appendix (Figure 2) we illustrate research framework.

Definitely our model can be used to clarify public preferences in a more rigorous manner. The most natural controversies hinge on disagreements about values. Such disagreements are usually about the degree and not the kind. The model can highlight such value tradeoffs in a useful way. It can also help construct and evaluate options, providing credibility and transparency to the process apart from its educational value. In this context, the model can be effectively used to obtain second best solutions or compromise solutions.

3.1. The research line

The problem is based on principles stated by the European Community (see Appendix in Figure 3 - Research Line Framework*)*. In particular our aims are:

1. Identify where and when the decisions are made and identify managerial procedures;
2. Identify who makes decisions and how they are carried out;
3. Identify a model to manage the environmental challenges or problems:
   - Definition of procedure for modeling and solving problems;
   - Database of sustainable problems and their on-going solutions (Mining, Fishing, Forest Management, Tourism, Waste);
4. Develop a platform to:

- Facilitate/improve the decision procedure (E-Democracy, Participation of all stakeholders);
- Optimization use of natural resources;
- Improve environmental and climate changes;
- Optimization ecosystem services.

Platform should work on-line accessible, as for example a real "decision centre" (see Appendix in Figure 4- the ANP-IT Platform Framework).

3.2. The proposal

The aim of the research project consists in building-up an ANP theoretical framework and the IT internet-based platform allowing stakeholders to actively participate in the decision making process and facilitate the achievement of public consensus.

Stakeholders differ according to the nature of the problem. Principally, referring to classical site location problems of point/linear/areal facilities (e.g. waste-to-energy plants, landfills, production facilities, road/electric/pipelines infrastructures,…) they are people living in the surroundings of site options. Stakeholders also include technical experts and public administrators involved in decision making. The logical structure of a collective decision making will contribute to:

- Point out decision makers and procedures of decision processes;
- Increase public awareness of environmental/social/economic effects of alternatives;
- Increase the e-participation (e-Democracy) of people in the decision making process to achieve public awareness consensus;
- Spread environmental information;
- Facilitate discussions on the environmental matter.

3.3. Description of methodological approach phases

Here below is the description of methodological phases:

Phase 1. Problem and public institution identification.

Aim of this phase is the identification with the local community of the environmental problem.

Phase 2. Structuring decision making model.

The decision making process will be structured by ANP techniques; problem components as well as tangible/intangible decision variables will be defined and clustered. Relations among components will be defined as well as the definition of the scale of preferences. Problem structuring will be carried out by considering scientific literature as well as judgments of experts and public decision makers. Definitely the aim of the decision making model will be:

- The strengthening of the local and regional system planning;
- The definition of an integrated framework for sustainable development, climate and energy to promote research for prevention and environmental protection;
- The individualization of tools for mapping of regional and local actors and relations system;
- The availability of specific set of indicators;
- The integration of the evaluation and monitoring procedures;
- The promotion and support for consolidated planning tools.

The approach will be:

1. Multilevel;
2. Multisector;
3. Multiactor.

As we said the use of ANP involves several steps.

- Structuring the decision problem;
- Identifying management options;
- Identifying criteria;
- Identifying stakeholders;
- Weighting schemes.

We note that participatory tools such as In-depth Groups (De Marchi et al., 1998), Negotiation Forums (Eastman et al., 1998), Focus Groups (Keeney et al., 1990; McDaniels and Roessler, 1998), and Citizen's Juries (Crosby, 1996) can be effectively employed to elicit the most important criteria for a particular forest region. Thus the main criteria could be historic, aesthetic, environmental conservation, recreation, economic, social and cultural and educational values (see Appendix in Figure 5 - a Simplified ANP decision model based on the representative participatory approach is shown).

Phase 3. Building ANP-IT Platform for Internet-based Collective Decision Making.

The model will be implemented by an Internet-based IT platform.

Phase 4. Offline Simulation of the ANP model.

Collective decision making implies preferences are defined as random variables. The IT platform will be able to simulate offline collective evaluation providing statistics of interest for decision making. Outputs (e.g. alternatives rankings and sensitivity analysis, integrated objectives for climate and energy protection, specific set of indicators, specific evaluation and monitoring environmental procedures) will be treated as random variables.

Use of ANP Model will assure:

- Take operating challenges into account;
- Define and prioritize criteria;
- Evaluate decision alternatives;
- Justify those decisions.

Phase 5. Developing a Full Scale Case Study.
The model and AHP IT platform will be tested on a full scale case study of interest for the public institution involved.

4. CONCLUSIONS

Quantifying stakeholder preferences in environmental management is a complex task. From this point of view the methodologies of public participation can be judiciously selected and modified to promote equity. Participation can promote equity if the methodology adopted is culturally sensitive and accommodating.
The provision of information which can be readily processed by the public and education for enabling understanding of issues is critical for the promotion of equity through public participation.
The most critical aspect of promoting equity through participation is the extent to which public preferences are incorporated in policy decisions which govern environmental quality. Limited incorporation reduces participation programs to an inconsequential democratic drama.
On the other hand ANP allows for participation of more than one person as a decision maker, which is important in dealing with several stakeholder groups. Another advantage of the AHP is the ability to include many decision makers in an electronic meeting environment.
Therefore we decided to use the ANP in this study for the following reasons: (1) the ANP is a structured decision process quantitative process which can be documented and replicated, (2) it is applicable to decision situations involving multi-criteria, (3) it is applicable to decision situations involving subjective judgment, (4) it uses both qualitative and quantitative data, (5) it provides measures of consistency of preference, (6) there is an ample documentation of ANP applications in the academic literature, (7) the ANP is suitable for group decision-making.
The results of this study could provide valuable information regarding decision-making tools for strategic environmental management. The ANP could be applied to several problems in a wide range of fields, it has enjoyed relatively little use for natural resources planning. Definitely the ANP could successfully be applied to the experimental problem of wilderness area siting, thus offering potentials for actual application as a public participation tool.

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The scientific activity developed through studies and researches on problems concerning industrial plant engineering. Such activity ranges over all fields from improvement of quality in productive processes to the simulation of industrial plants, from support multicriteria techniques to decisions (Analytic Hierarchy Process, Analytic Network Process), to RAMS Analysis and Human Reliability Analysis. The main courses, both curricular and specialistic for territorial businesses in which he is involved are: Safety of Industrial Plants, Industrial Production Management, Industrial Simulation, Human Reliability Analysis. General Secretary of the Analytic Hierarchy Process – A.H.P. Academy - International Association for the promotion of multi-criteria decision making methods.

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APPENDIX

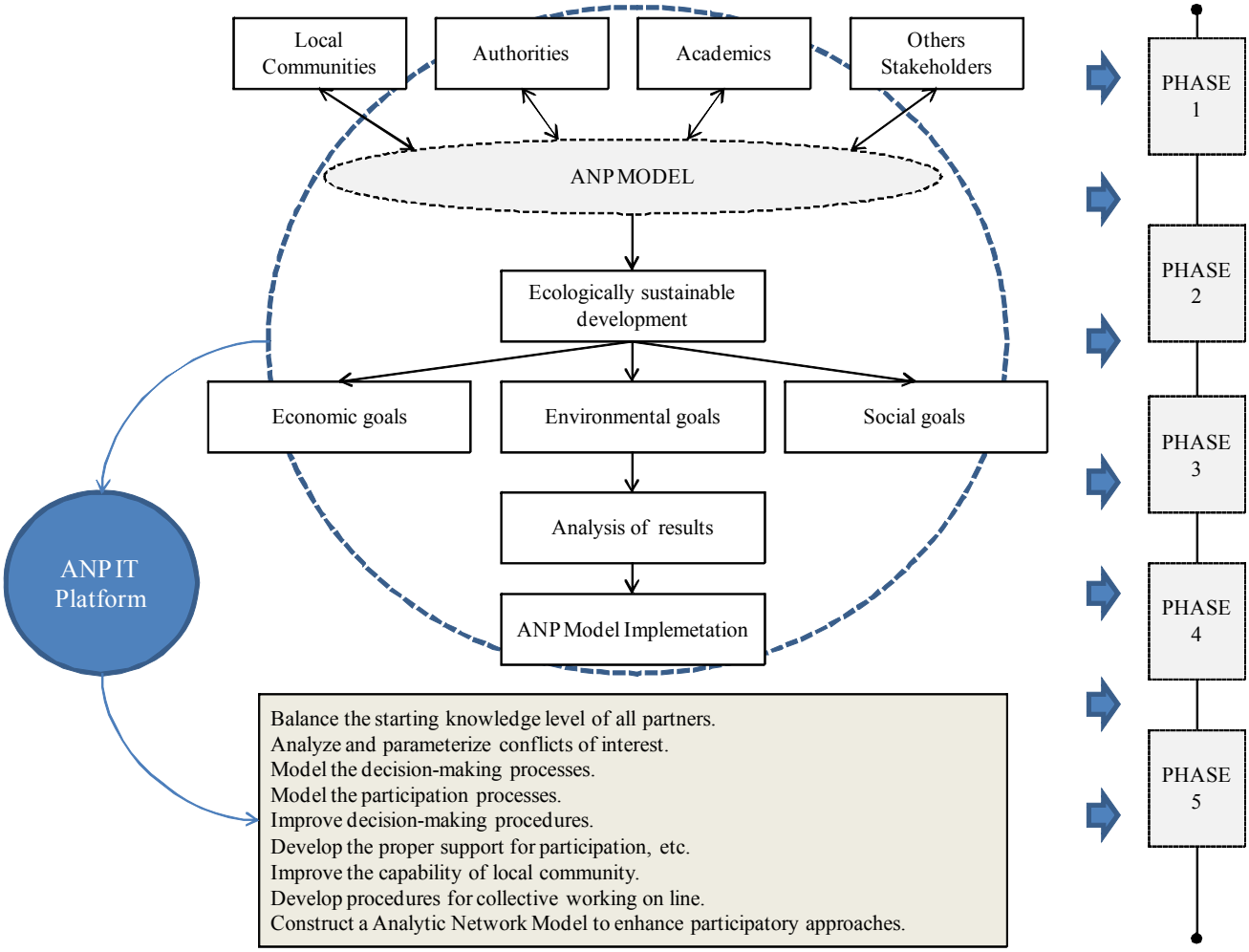

Figure 2: Research framework

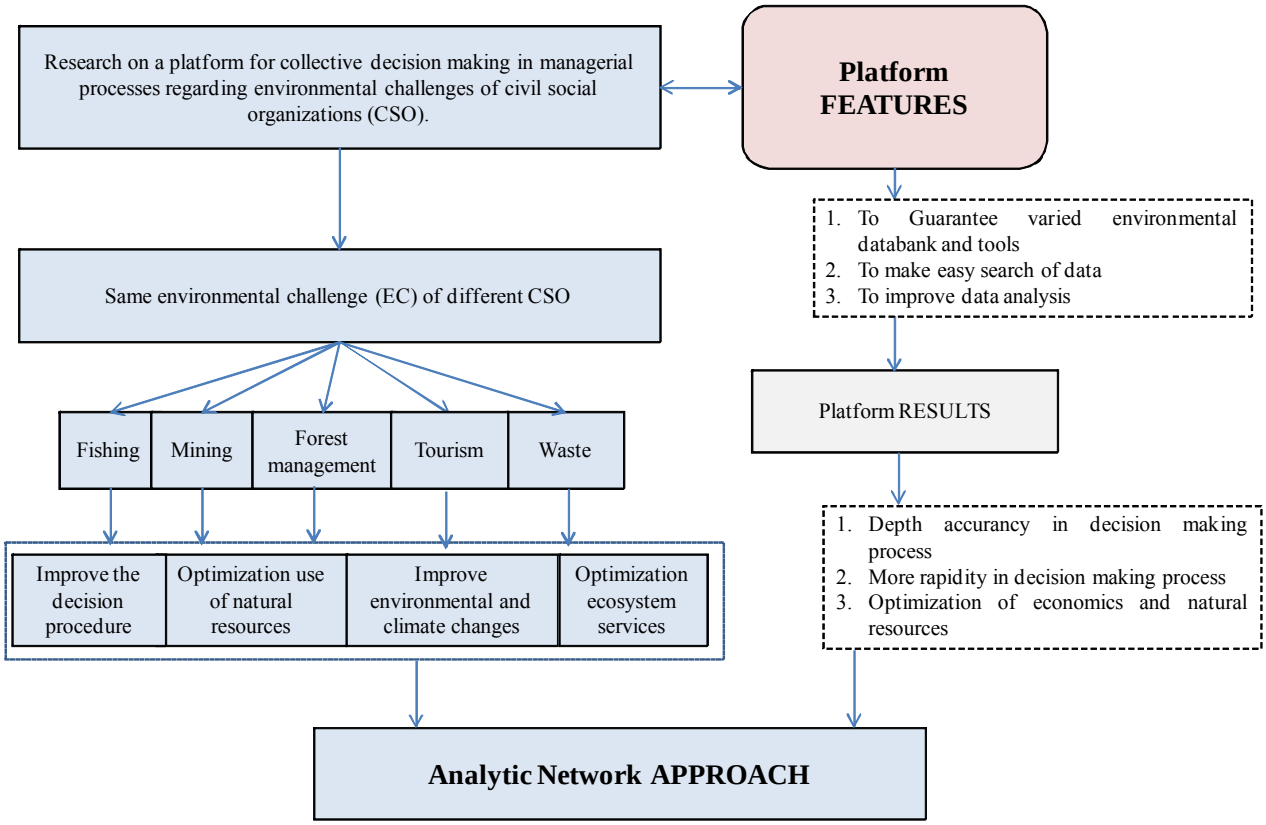

Figure 3. Research Line Framework

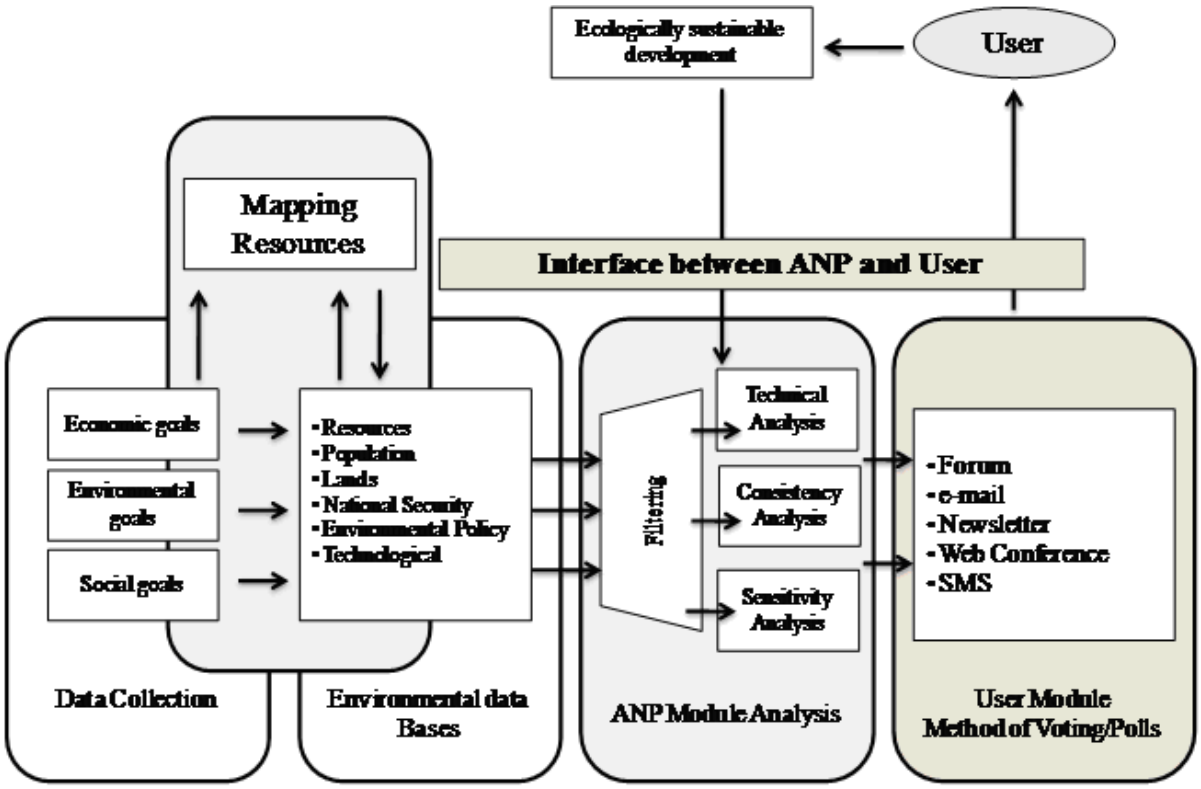

Figure 4. ANP-IT Platform Framework

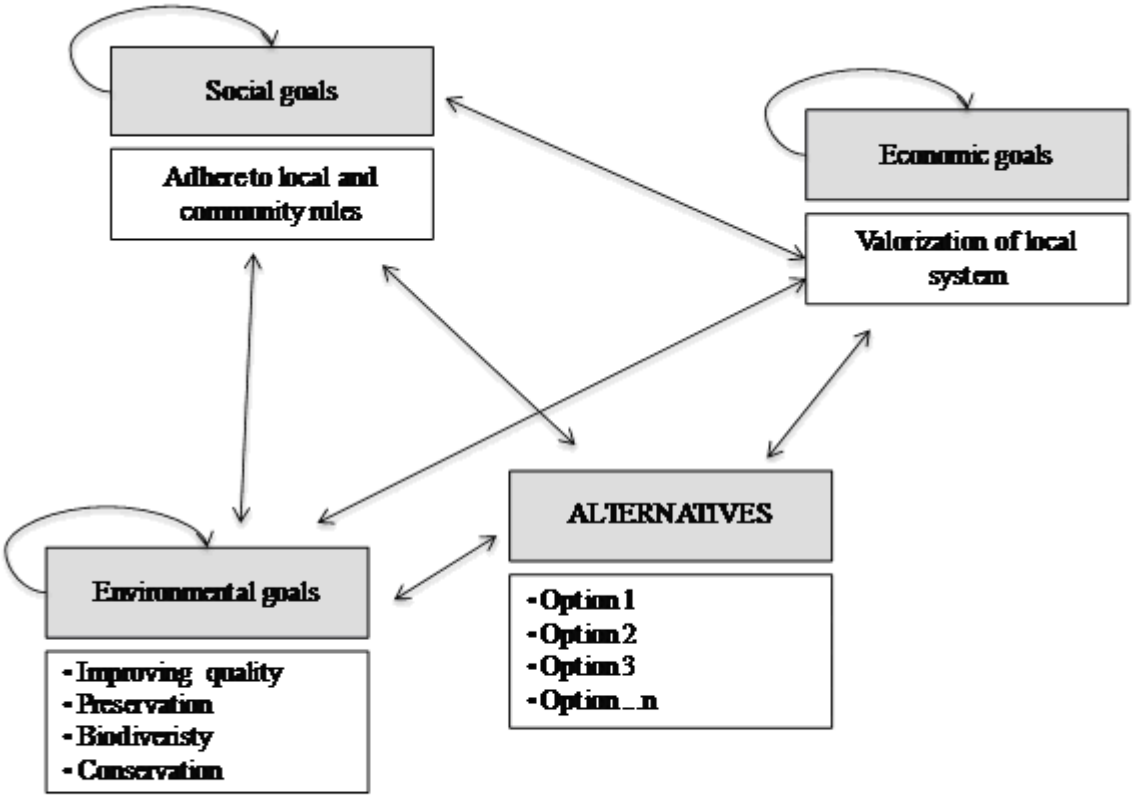

Figure 5. Simplified ANP decision model based on the representative participatory approach