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Distributed Knowledge in Environmental Planning: Hybrid IT-Based Approaches in Scenario-Building Contexts*

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Abstract

The new argumentative and communicative approach to environmental planning is replacing the traditional approach of planning derived from cybernetic models and based on the linear control of systems' dynamics. The traditional absolute monologic rationality of planning is today challenged by more complex, multilogic, multi-value and weak rationality, explicitly contextualized to different social and physical environments. Not achieving targets, but rather building discourses and visions related to evolving situations are the new grounds of planning processes, where different stakeholders can intentionally locate behaviours, meanwhile learning about themselves and their realities.

In this context, traditional cybernetic planning seem unable to face the probabilistic and chaotic environmental phenomena, so making it extremely hard to point out elements, to schedule times, to respect consistencies. However, practical cases of experimentation of the argumentative approach to environmental planning are particularly rare.

Given this starting conceptual condition, the present paper will try to contribute to the research field, dealing with the potentials using an ICT-based argumentative and communicative approach to environmental planning. In particular, a proposed process will be discussed, with reference to *Future studies* and to the *Strategic choice* approach, hybridized by information technologies.

The context of such experimentation is a 5-year EU-financed project to build sustainable development futures in the Mediterranean region, ended in 2003.

Key words: environmental planning, scenario building, multi-source knowledge, IT-based participation, conceptual mapping

1. Introduction: The Multi-Agent Cognitive Turn in Spatial Planning, Promises and Dilemmas

Spreading in many fields of current technology, reflections on cognitive interaction have become central in spatial planning, too.

This particularly holds in today's future- and complexity-oriented strategic plans, facing the challenge of understanding and protecting the self-regulating dynamics of environmental systems. These interactive, multi-agent plans seem to be beneficial for the knowledge involved, that is substantial and procedural, in that they appear able both to promise efficient and effective implementation and to emulate system's diversity and resilience (Bousquet

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and Le Page, 2004). Planning tools and systems are also increasingly built in terms of interaction and cooperation of distributed artificial and/or human agents, that perform complex cognitive tasks of memorisation, exploration, problem solving and problem setting, argumentation (Houde 2003, pp. 104–106). In social and environmental co-evolution, cooperation is central to help learning strategies and adaptation in a context of powerful environmental constraints (Nepote and Occelli 2003; Bowles and Gintis 2002). In this context, the definition of strategies for the future are increasingly becoming a mix of optimisation planning approaches, in the systemic and cybernetic tradition based on linear trajectories of states (Simon 1996; Ashby 1957, pp. 9, 25; see also the linear 'toy-block' planning approach in Blum and Furst 1997) and of communicative planning approaches, in the Habermasian logic of social discourse (Habermas 1985). Scenario-building forums for environmental planning, with intrinsic uncertain and multi-faceted features, are able to add further complexity and dynamism to both streams of planning tradition in their current path toward integration. In particular, in most of these experiments, all phases of an optimal-oriented plan, from goal setting to exploration and evaluation of a set of alternative actions, from choice and implementation of action, to action control and revision, are increasingly managed through the interaction of numerous agents, replacing the individual behaviour originally postulated by rational optimisation theory in engineering and social technology. Social structures of agents in a limited and constrained world are increasingly acknowledged (Castelfranchi 2001).

These developments seem to imply a transformation view, by extending the problem space but keeping unchanged the rational model structure, rather than a radically innovative view of rationality. However, the problem of power domination for individual (and social) survival in group behaviours has been raised as a major critique to a compositional view of reality which ignores the powerful forces driving the continuous fragmentation of large aggregates (Brown 2004).

Chaotic behaviours, behaviours without goals, conscious or unconscious constrained behaviours preventing from considering alternative actions, 'frame' models[1] of action remain largely unexplored (Borri et al. 2004). Scale problems which may require completely different organizations of systems for evolving in the world depending on the dimensions and structures of problem spaces remain also controversial issues. The levels of managing water-provision issues is an example in this concern (Shiva 2002).

In this framework, the debate in communicative planning theory of the late 1990s between individual- (Forester 1999) and institution- (Healey 1997) oriented approaches can be seen as a general effort of considering both the internal and the external constraints for the definition of cooperative strategies in real world situations (Nepote and Occelli 2003). Moreover, stemming from the continuous mysterious dialectics between oneness and plurality which operates in the world (Gardner 1999), attempts to tackle the 'Babel' and semantic-gap problems of cognitive interaction and of univocal and conventional world representation and description (situational calculus) by multiple agents are also increasingly calling for attention (Houde 2003, p. 381; Borri 2002; Barbanente and Borri 2000).

In this context, ICT tools are providing promising explorative arenas for multi-agent interaction and communication, so being used to build distributed networks of cognitive agents

and learning systems, while many computer software are being developed to foster remote or contextual multi-agent interactions to build complex environmental development scenarios. In this challenging environment, the present study tries to explore the cognitive potentials of interaction, where cognition is considered an evolving frame on which interaction can play, perhaps, a major role in eliciting hidden relationships and attitudes. Which are the real potentials of multi-agent interactions in this respect? How far multi-agent interactions can really foster more in-depth explorations of any problematic situation and unravel aspects of individual and collective knowledge which remain hidden in the traditional mono-logic cognitive elicitation processes? These are the core questions that this paper tries to address, starting from scenario-building experiences and aiming at highlighting new potentials and promising research patterns.

After this introductory note, chapter 2 critically discusses a multi-stakeholder ICT-based experience for scenario building in the context of a EU-funded project aimed at building sustainable development in the Mediterranean region.[2] Basic questions resulted from that experience are further explored in chapter 3, where two parallel ICT-aided ad-hoc experiments are carried out and discussed, aiming at observing further cognitive aspects of multiple-agent interactions with two different methodological approaches, namely analytical and holistic. Finally, comparative observations are carried out in the concluding chapter, envisaging possible opportunities for further research paths.

2. An Experiential *fil rouge* in the Mediterranean Region

2.1. The research background

Under a project financed by the European Union, oriented to building sustainable development scenarios in the Mediterranean region, some experiences were carried out from 1998 to 2003. A Concerted Action of the EU INCO-DC Commission (Dg XII) was set up, aiming at enabling policies for sustainable development in the Mediterranean region, particularly focused on soil and water. The first activity was concentrated on the Tunis case, and its topic was the interplay between agriculture and urbanization; the second activity in Izmir dealt with coastal zone management; the third activity in Rabat dealt with globalization vs. local resources, under the perspective of the emerging Euro-Med free trade zone (see the official website http://www.iamb.it/incosusw for details) (Khakee et al. 2002). The scenario-building approach first used in Izmir, Turkey (2001), then being amended and fine-tuned in the case of Rabat, Morocco (2002), is based on a variant to the *strategic choice* approach by Friend and Hickling (1997), as developed by the recent evolution of *futures studies* (Ziegler 1991).

One of the most interesting results has been a sensible openness to problem-structuring, more than problem-solving approaches. In complex environmental problems, fragmented opinions and visions can hardly find an agreed set of solution to the set of ill-structured "wicked" problems at hand (Rittel and Webber 1973; Simon 1973): however, interaction among different – even conflicting-stakeholders can induce a deeper knowledge of the multifaceted aspects of problems, so contributing at structuring problems for better management (Forester 1999, pp. 59–112). Hence, a higher stress on participatory arenas, both

Table 1. The *future workshop* methodology (Puglisi 2002).

Phase	Contents	Expected results
	Future workshops	
1. Preparation	The issue to be analysed is decided and the structure and environment of sessions are prepared.	Summary of contributions.
2. Critique	Clarification, on the issue selected, of dissatisfactions and negative. experiences of the present situation.	Problematic areas for the following discussion definition.
3. Fantasy	Free idea generation (as an answer to the problems) and of desires, dreams, fantasies, opinions concerning the future. The participants are asked to forget practical limitation and obstacles of the present reality.	Indication of a collection of ideas and choice of some solutions and planning guide lines..
4. Implementation	Going back to the present reality, to its power structures and to its real limits to analyse the actual feasibility of the previous phase solutions and ideas. Obstacles and limits to the plan implementation identification and definition of possible ways to overcome them.	Creation of strategic lines to be followed in order to fulfil the traced goals. Action plan and implementation proposal drawing.

in knowledge sharing and knowledge enhancing interactions, particularly aiming at turning planning and decisionmaking procedures into democratic processes (Khakee 1999). In particular contexts like the Mediterranean region, where problems and expectations are remarkable, scenarios can be gathered using *futures studies* methodologies, such as the so-called *future workshops* (Jungk and Mullert 1996; Puglisi2002) (Table 1).

While the process is carried out, stakeholders' interests, experience, creativity and common work identify, share and mutually rearrange their knowledge, and produce images with related action lines (Jungk and Mullert 1996). In this process, individual standpoints are intended to be channelled together to set up consistent alternatives: however, the iterative interaction is able to continuously solicit agents to reflect and fine-tune their own autonomous contribution.

2.2. Scenario-building and beyond

Traditionally, phases are carried out as oral brainstorming sessions, helped by handwritten notes taken throughout the interaction. This is clearly a creative process that allows interactive learning and free mutual idea generation, working both in group and individually. An overall better manageability of Delphi routines and issues, and a more effective storing, handling and exchanging of knowledge flows can be induced by IT-based routines. However, the setting up of computer-aided sessions involves several issues that need to be further investigated.

As a matter of facts, most of software tools are today conceived as tools for executive or staff meetings in firms and agencies, where the main goal is to achieve agreement on projects and issues. Recognizing at least in the disclosure of steps the key factor needed for scenario-building activities, the Mediterranean experience was structured on *MeetingWorks*© (MW), an open groupware product for electronic brainstorming, idea organisation and multiple criteria analysis, with real-time reports and graphics.

In multi-agent interactions in environmental planning procedures, the forms of knowledge at hand are often informal and non-expert. Moreover, they are typically characterized by asymmetric information both spatially (in different planes) and temporally (different times) (Sillince and Saeedi 1999). In this complex framework, scenario-building interaction sessions cannot gather an exhaustive and representative quantity of participants and knowledge in the same space and time. Therefore, strategies designed therein and taken opportunities drive to planning visions that are inevitably partial in both the variety and the substantial characters of alternatives. This partial planning is more likely to take place in complex situations, where environmental, social and participatory difficulties induce precariousness in the setting up and management of planning processes.

2.3. Frames of the partial planning perspective

In our Mediterranean scenario-building experiences, the characters of social and environmental complexity were not always compatible with a prototypical participatory procedure, for manifold reasons. An initial knowledge and representation base, gathered through trend analyses or expert reports, was next supplemented by a base deriving from group interactions of single agents, carrying along representations and forms of knowledge stemming from their original and often informal domains (Figure 1). Interactions were reiterated, so driving to subsequent representations (and action lines) more and more shared, but also refined, complex and different from initial representations and knowledge bases. Furthermore, as soon as the scenario-building process allowed the irruption of new agents (such as institutional, social or opinion leaders in the sense of, e.g., Forester 1999, or Healey 1997), importing new, at times critical information, these agents often provoked a reconsideration of reflections, agreements, built knowledge frames, that in turn induced representations and action lines which were still shared, but substantially new (Figure 2).

In this sense, an experiential example has been the 2030 scenario building in the Rabat area. An initial shared definition of visions based essentially on the economic opportunities and limits of Maghreb has been followed by a deep redefinition in religious and social terms, as soon as an external agent, institutional leader, introduced new knowledge semantics. Another example (although not complete, due to contingent reasons) has been the scenario building for the coastal zone of Izmir. The involvement of different stakeholding agents in the several activity sectors (tourism, industry, agriculture, urban area) drove to the definition of visions that were complex, but not complete. In fact, they lacked in the crucial information and contribution given by the numerous foreign second-house holders -that should be added

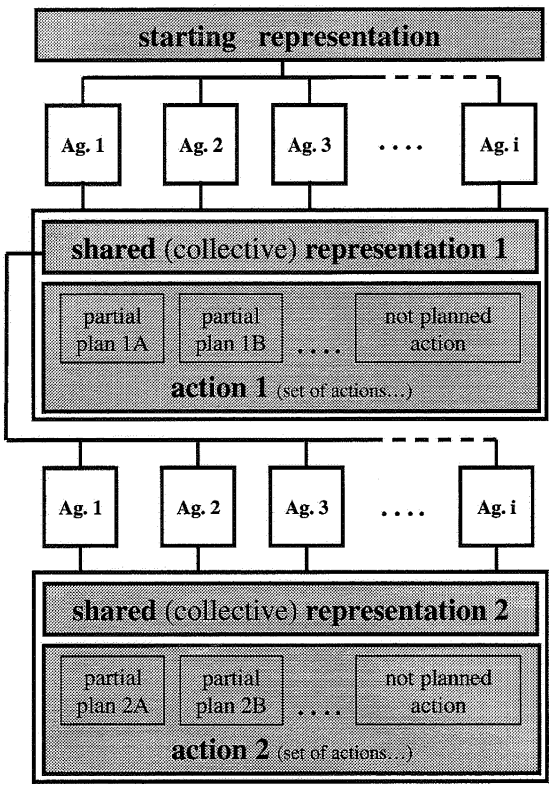

Figure 1. Plan development with no new agent irruption.

now, perhaps via the web-, in order to obtain more complete knowledge representation and exchange. In this sense, therefore, lateral irruptions should represent an enrichment that is often crucial in planning processes, whose disregard might be able to generate simplified and fallacious representations, in turn able to generate reductionist scenarios, not shared and, therefore, ineffective.

As a whole, the Mediterranean IT-based scenario-building experience unveiled important potentials, nonetheless raising some intriguing questions (Khakee et al. 2002). Challenging some of the well known problems of participatory decision-making (Khakee 1999), encouraging outcomes emerged such as a more open and large expression of opinions and – therefore- information, a mutual transparent interaction nearly unfiltered by human facilitators, a real-time availability of exchanged data sets. On the other hand, new and rather unreported problems added up, such as the non-stimulating and error-generating coldness of the computer medium, the black-box character of most routine processes, the difficulty of handling large and often redundant lists of statements, the difficulty of retaining an aggregate, holistic level of analysis during the interaction process.

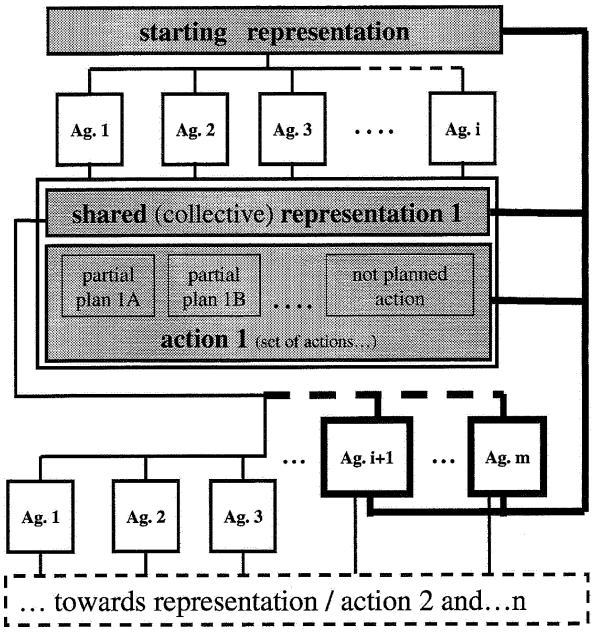

Figure 2. Plan development with new agent irruption.

3. Methodological Approaches to Multi-Agent ICT-Based Interactions: A Comparative View

3.1. Background

Some intriguing reflections followed the experiences carried out up to date. As a matter of facts, an important discussion is currently focusing on the real cognitive transformations taking place in multi-agent environments in front of the extreme organizational, procedural and linguistic complexity of such pluri-logic procedures as compared to the traditional mono-logic ones. This literary question appears to be even more remarkable and perhaps more explorable in planning environments, representing organized institutional environments for spatial transformations. In it, the potentials of multi-agency are conditioned by the forms of power distribution, of deliberative practices, of the strong orientation to solution. Therefore, the possibility to check, at least in a qualitative way, if the cognitive and behavioural attitudes of agents change during interactions, could confirm (or refute) the importance of multi-discipline group interactions in environmental planning. Modifying and socializing the knowledge level of agents, especially if allowing some inter-domain transfers, would then be a very interesting perspective in terms of the underlying knowledge-learning process, validating the actual usefulness of pluri-logic procedures.

Under this view, a new research investigation has been set up, in order to explore in depth the modifications induced on single agents by the interactions with others, and the potential

of different kinds of reasoning for the enhancement of creativity and mutual learning among agents. This was done by making two parallel experiments with two homogeneous groups of people, which have been asked to discuss the same issue with different methodologies and related system architectures, aided by ad-hoc computer software able to keep a record of the evolution of statements. Moreover, while the first methodology was aimed at fostering an analytical approach to discussion and interaction, the second one made use of cognitive mapping in order to explore issues at stake under a more holistic approach.

Since the aims of the two experiments were very focused in their scope, we used a very simple experimental setting, involving small homogeneous groups of participants (one class of students from the master programme in Civil Engineering and one from the degree in Environmental Engineering). Moreover, we asked them to discuss, in a short time (about 2 and half hours), the role of local resources and identities for a sustainable development a generic southern Italian region in the next 20 to 30 years, with reference to globalization dynamics and public policies.

The simplicity of the agenda is not exempt from critical considerations. The original idea was to comply with the strategic approach of building future scenarios: however, the setting up of a complete scenario-building process was not suitable to the limited time available to master-class students. Furthermore, the main focus of the experiment was procedural and cognitive, more than actually substantial, so making strategies, contents and physical contexts important only if functional to the major procedural focus. As a matter of facts, the dual picture of desired future images/policies generating is actually resembling the classical tools/ends approach of rational planning: a problem-solving approach which is in contrast with the original problem-structuring approach that allows cognitive and behavioural explorations (Parnes 1992). However, an initial attempts was made to clarify the partial nature of the agenda framework, intended not as a complete scenario-building process, but as a merely exploratory sequence of steps.

Another initial consideration, useful as an understanding filter of the process, is that agents were not stakeholders in different social areas, but homogeneous representatives of the same stakes, i.e. students. This consideration is important when trying to work out differences in approaches, issues, behaviours occurring in the process both at single and collective levels (Schank and Childers 1984).

3.2. An analytical approach using brainstorming and iterated evaluation

3.2.1. Overview

The sessions of interactive participation among agents have been assisted by *Meeting Works*, a software tool that was described above. Two different sessions were carried out independently, involving two different groups of students of the Polytechnic of Bari: 5 students from the Urban planning course and 16 students from the Environmental engineering course.

According to the *Meeting Works* framework, the session was driven by an electronic *agenda* of interactive steps, that was very simply structured on the generation of future images and policies aimed at realizing them (Figure 3A,B).

Each participant was first asked to synthetically generate and describe future images on the following theme: "*The role of local identities and environments in globalization*

processes: perspective visions for the next 20–30 years in a generic Southern Italian region". An iterated procedure followed, allowing the selection of a single image among the ones generated. With reference to that image, each participant was then asked to synthetically generate and describe possible public policies aimed at realizing that image: again, an iterated procedure allowed the singling out of the allegedly most important policies.

Participants were therefore asked to disregard possible considerations about the appropriateness of strategies and to adopt a single-step ad-hoc attitude when going through the process. Both sessions started from this initial condition, that needs to be born in mind when analyzing the whole experience.

3.2.2. First session: Process description

The first session has been carried out by 5 agents on 5 workstations, plus one workstation devoted to the technical facilitator (the *chauffeur*). The image-generating step has let each

A

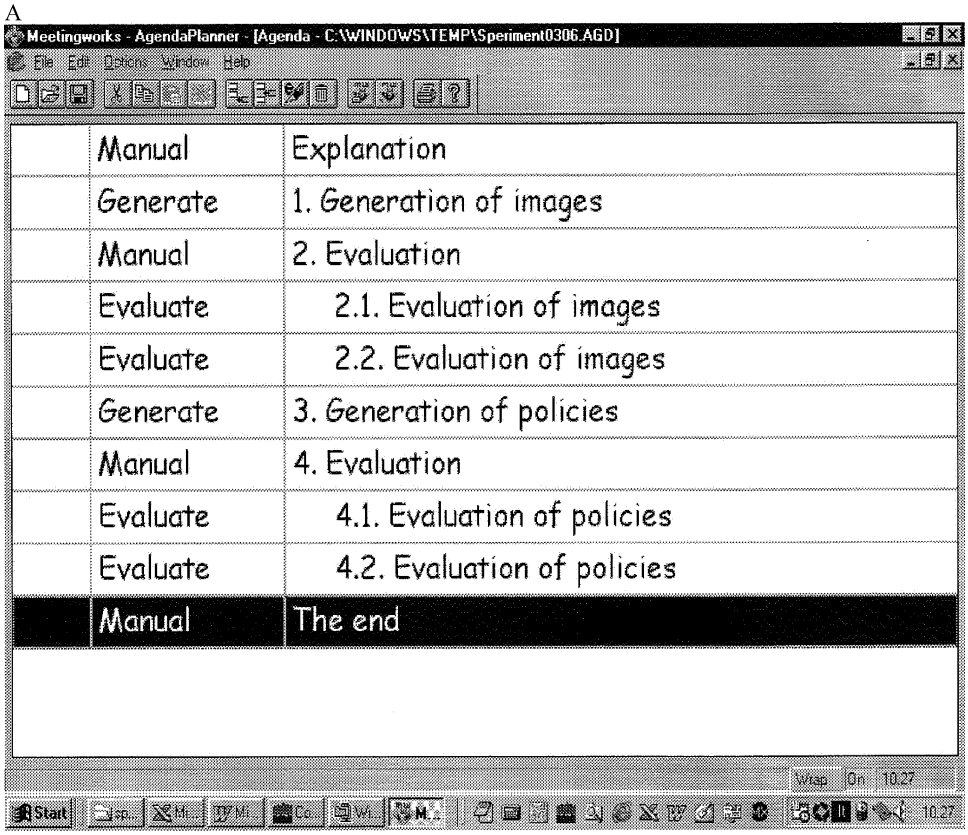

Figure 3. (A) The *Meeting Works* agenda. (B) The process routines.

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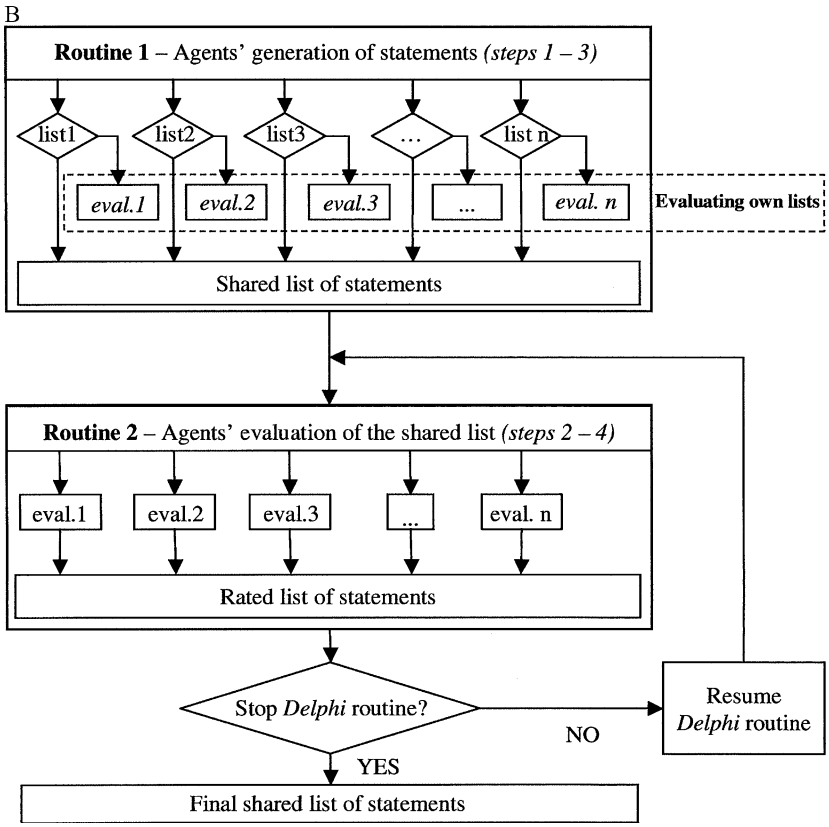

Figure 3. (Continued)

agent first express up to 5 visions concerning the above-mentioned theme, and then vote them (marking 1 to 5), without allowing the disclosure of other agents' images. The rationale for this 'blind' condition was to avoid mutual influences both on statement generation, and on self-voting generated images.

The choice of using quantitative marks instead of qualitative ranking was preferred throughout the entire process, because it allowed the use of simple synthetic indexes (such as statistical average or variability), rapid and easy to be understood and referred to in the process itself. Nevertheless, although stemming from the needs raised by past Med experiences, this choice did show the difficulties and the misinterpretations connected with a forced quantification of conceptual and frequently non-quantifiable issues,[3] as often reported (Schank and Childers 1984).

At the end of step 1, all 25 images, 'blindly' and autonomously generated by agents, were showed to everybody, as a collective awareness of obtained results (Figure 4).

This full picture worked as a new piece of information to agents, irrupting on their cognitive paths and potentially able to re-frame their preliminary self-evaluating approach, as discussed in following chapters. As a matter of facts, this irruption determined the starting

- ➢ Preserving the natural landscape as a resource to survive and as a representation of own original land
- ➢ Creation of an informational network concerning the social context in which we live and our children play
- ➢ Preserving bio-diversity
- ➢ Environmental awareness
- ➢ Encouraging local-based economy, avoiding the disappearing of local typical traditional activities
- ➢ Safeguarding the fishing resource, a disappearing cultural and economic heritage
- ➢ Attention to multi-cultural issues
- ➢ Preserving agricultural spaces
- ➢ Protection of traditional activities as centennial local heritage
- ➢ Severe public controls on environmental protection
- ➢ Encouraging local small firms
- ➢ Restoring a strong community membership feeling
- ➢ Physical elimination of all structures that disfigure the environment and damage mankind
- ➢ Elimination of racial hatred
- Aiming at using environmental resources
- Using "human capital" encouraging culture
- Promoting the coast resource for tourist, market, social ends
- Safeguarding cultural identities
- Stopping the extinction of local crops, trying to encourage the small farmer
- Creating socializing spaces
- "Isolating" local productions from the global productive push, so that it is not possible to generate hybrid products that loose their current genetic weight.
- Restoration of vegetation eliminated by human activities
- Paying more attention to outcast populations
- Preserving the cultural traditions of local background
- Teaching to respect the environment.

Figure 4. Images generated during the first session, steps 1–2.

conditions in order to check the effects of new information on single and collective cognitive frames, if any. Therefore, step 2.1 of the agenda allowed a proper evaluation phase, in which agents were asked to place scores (marking 1 up to 5) to the 5 most important images overall, according to their opinions, disregarding the rest. In step 2.2, a new evaluation phase was carried out, and the outcomes of the previous step were further evaluated, with the same-procedure.[4] While evaluation 2.1 singled out 16 images, the last one further narrowed the selection to 14 items, with a variability among responses that after an initial large agreement on top and least images was replaced by a very narrow agreement on only 2 top images and on the least ones. This is not generally unexpected, given the converging nature of a Delphi procedure.

The top 14 images are represented in the same Figure 2, captioned by a thick sign and listed in decreasing ranked order. In the end, they mainly deal with broad environmental and social issues, with some interest put on the economic potentials of local resources. This is probably largely due to the presence of a strict homogeneity among stakeholders, neither multi-sectoral nor conflicting, and to the specific social/environmental sensibility of planning students. However, far deeper considerations are induced by monitoring the trends of single and collective evaluations of agents, and this will be carried in the following subsection.

As a modular analytical approach, the system architecture of the agenda could allow the set up of the same automated routine for the generation and singling out of actions to accomplish images. Therefore, each of the selected images would be provided with a

- ➢ Environmental awareness conveyed at school
- ➢ Fiscal incentives toward people who makes activities totally respectful of the environment
- ➢ Issuing an economic policy aiming at giving commercial rather than "nominal" identity to products of our lands, perhaps specifying their origin, quality and characters, also showing the path to reach the consumer. My view is a local defence policy with global tools. Protecting and defending lands by defending products is a road toward a larger policy, aiming also at respecting the psyche of local communities.
- ➢ Continuous land monitoring
- ➢ Restoring the typical craft works of each given community, with incentives aimed at creating learning schools and allowing the birth of companies or cooperatives.
- ➢ Defending the environmental heritage is a difficult task in our region as well as in all Southern Italy. A radical policy needs to be put forward, even in lower schools, so that results can be more effective in the long term.
- ➢ Activating a strong social action (events, conferences, etc.), aiming at informing on the usefulness of the preservations of community roots.
- ➢ Safeguarding and regenerating existing green areas, connecting them by green paths; creating new areas were requested by the urban context.
- ➢ Accurately studying the given area in order to activate economic, environmental, social policies able to give new value to available resources.
- ➢ Encouraging the specialization of local public managers.
- Fostering the setting up of organizations that provide assistance
- Finding out the environmental long-term characters of the area, by setting up forums with experts and non-experts
- Improving public transportation
- Optimal management of own land for tourist aims and setting up of more numerous protected areas
- Setting up specific areas, directly preserved by the municipality, working as examples for the rest of the region.

Figure 5. Policy actions generated during the first session, steps 3–4.

strategic path in which groups of policies play their effective role. This increasing amount of items and data is a challenging occurrence for computer-assisted interactions, and literature often warns against the risk of inducing the so-called combinatorial explosion of datasets (Pomerol 2001). However, given the exploratory aim of interactions, it was agreed that information and feedback on cognitive and behavioural modification of agents would have been fairly independent from the number of images to be provided with strategic policy actions. For that reason, only the most voted image was selected, and participants were asked to suggest policies aiming at realizing that single image only. However, before actually feeding the system with the proposed image, a quick survey was carried out with participants, that confirmed the actual consistence of that image as a quite representative one.

Therefore, in step 3, agents were asked to suggest policy actions aimed at realizing the following image: "*Preserving the natural landscape as a resource to survive and as a representation of own original land.*" In the attempt of narrowing the focus on few significant and coherent actions, and to reduce redundancies, participants were asked to generate only 3 statements. Subsequent phases (steps 3 to 4; see Figure 3) were set up and carried out similarly to steps 1 and 2, and both evaluations 4.1 and 4.2 singled out 10 policies, out of 15 initial items.

The top 10 policies are represented in the Figure 5, captioned by a thick sign and listed in decreasing ranked order.

Even being strictly related to the environmental essence of the scenario image, they also deal with social and economic issues, intended as strategic means to foster the

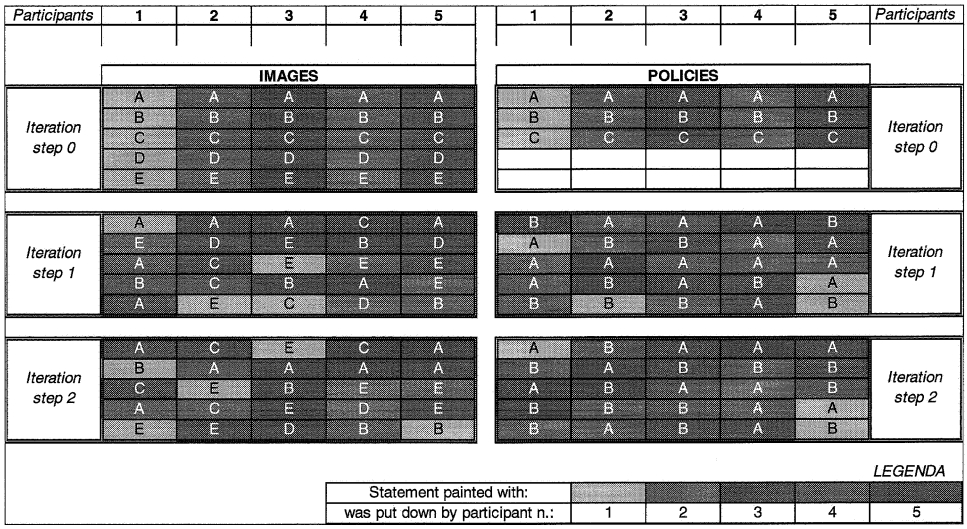

Figure 6. Distribution of statements by agents during the evaluative process in session 1.

socioeconomic potentials of local resources. Particularly interesting are the reflections on the critical importance of environmental education at basic levels, as a crucial means to create a long-term awareness on the social and economic importance of the environment. This is a good sign showing that the difference between images and actions was recognized, notwithstanding the partial and rather inconsequential nature of the experiment. Another feedback concerns the degree of variability among responses, shows a difference with image generation, since evaluation shows no full agreement on either top, medium or least policies, whereas it was easy to find out 2 full agreed top images before. This is a suggesting and intriguing feedback, even if it is difficult to understand if this is due to a deeper stakeholding awareness when evaluating real actions as compared to abstract images, or simply to a smaller number of policies generated – i.e., a smaller debating area.

3.2.3. First session: Cognitive feedback

As mentioned earlier, cognitive and behavioural attitudes of agents are claimed to change during interactions, so raising the importance of multi-discipline group interactions in environmental planning. The present experiments are carried out with mono-sectoral stakeholders, and then they cannot certainly allow inter-domain knowledge transfers: nevertheless, a modification of attitudes induced by informational irruptions under the form of cooperative interactions would be a very interesting feedback in terms of validating the usefulness of pluri-logic processes.

A monitoring of the behaviours of agents in the whole process has been synthesized in a compact table (Figure 6). Each statement has been reported with a letter symbol without its relevant score, in order to facilitate the reading: while preventing from having a strict quantitative feedback, this representation allows an effective quali-quantitative comparison

among ranked items and trends. In both images and policies, the starting iteration step (n.0), a bunch of 5 different statements is listed by each agent, where "A" stands for the highest scoring item, whereas "E" is the lowest.[5]

A first important change in the composition of each agent's list occurs in iteration step 1 (agenda step 2.1), where it must be born in mind that all statements are anonymous to the cooperative arena. In this step agents, rather than being conservative on their preferences, do replace 2/5 to 4/5 of their initial lists. Replacements seem to stem from an awareness of new issues, as shown up by the disclosure of other agents' images.

For example, originally agent 1 generated images related to multifarious aspects of local sustainable development: environment, enterprises, culture, social life. After the first contact with other agents, he replaced 4 images and introduced issues more deeply related to the environment and its revitalization: he narrowed his view, but enriched it with an assortment of environmental themes. In agent 5, instead, a bunch of images mainly related to culture and local economy shifted to a more multifaceted group of aspects, more deeply integrating environmental issues. On the other side, the most voted images of each agent, originally ranging through multi-sectoral issues, became monolithically dominated by environmental issues.

As far as policies are concerned (agenda step 4.1), a similar trend seems to have occurred, even if the need to feed the given image with structured multi-sectoral actions has determined a lower domination of broad environmental issues, even in top-scoring policies.

In iteration step 2 (agenda step 2.2), there seems to be a certain 'flowing back' to original statements, witnessed by the withdrawal of 1–2 previous new entries, so determining a list more similar to the initial one. Yet, lists are substantially different from the original generation of statements, since agents seem to drop out redundancies, inconsistencies and retain what is needed to obtain an integrate multi-sectoral framework. A similar situation occurs in step 2 of the policy-evaluating process (agenda step 4.2), with a further interesting complement. In fact, the interaction process seems to have shifted reflections from reactive short-term policies (preserving green areas) to proactive and structural mid-term (fostering local economies) and long-term (information, training, school) policies.

As a whole, it is pretty clear that the iterative interaction determines some changes in the cognitive attitude of agents, allowing a significant modification – sometimes even structural- of the informational data they exchange. It seems that what Parnes (1992) puts down, describing creative thinking as a combination of "divergent as well as convergent thinking", is actually confirmed also in a procedural light. In fact, an oscillation seems to occur, from a phase of idea generation, diverging agents' issues from one another, to a convergent evaluation phase of agreement on broadly common issues, to a further evaluation phase inducing divergence toward more mutually different issues, under the alternate influence of multi-agent informational interaction.

3.2.4. Second session: Some comparative notes

The second session was carried out in two days with the same *agenda* as the previous session. It was developed by 16 persons on 8 workstations, in such a way that each station was devoted to 2 persons, allowing them to enter issues cooperatively.[6] Although unexpected, the session

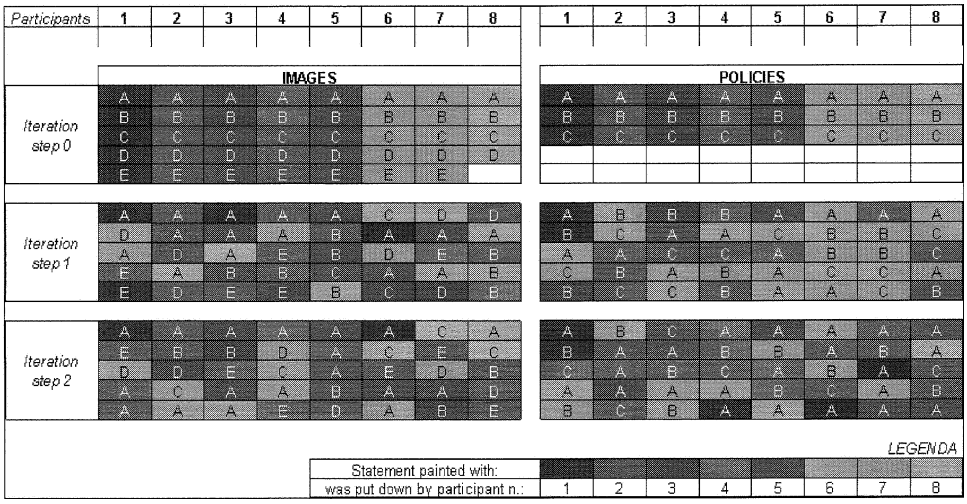

Figure 7. Distribution of statements by agents during the evaluative process in session 2.

took much more time than the previous one, so that it was needed to stop in the first day, after the completion of steps 1 and 2 and the selection of the vision for subsequent policy actions. A major evident reason for that delay was that team agents devoted a significant time to talk with each other and decide on issues to be entered. This seems to have induced some interesting differences in outcomes from the previous session, connected to the substance of themes and the composition of preferences (Figure 7).

First, visions issued are generally more extended, argued and often multi-subject, so becoming harder to be sythesized and discriminated by agents when carrying out the subsequent evaluative steps, as often occurring in pluri-connected domains (Gibson 1998). Second, the composition of visions generated by each agent is more multifaceted than in the first session, ranging from sustainable development, to environment, to local-global interplay, to culture, to planning participation, to social issues. A third consideration, related to this, is that the first evaluation phase of visions (step 2.1), although inducing a strong change in the composition of each agent's preferences (agents 6 and 7 replace their visions completely), does not add new subjects to original lists, so meaning that agents were probably influenced by better arguments, not subjects. A fourth interesting consideration is on the last vision evaluation phase (step 2.2), where a sensible addition of new subjects does seem to occur in each agent's preferences, even if more faintly than in the previous session. As a whole, vision generation and evaluation phases suggest that agents seem to be less influenced by the interactions, and that a slight modification in their cognitive attitudes seems to need more iterations to appear. If true, this occurrence might be induced by the fact that each (even the initial) contribution of agents to the process is never autonomous but derived (i.e., generated cooperatively by the two persons), and therefore also the informational patrimony might have been intrinsically modified at the beginning, as often occurring in vis-à-vis interactions (Khakee et al., 2002). This could perhaps let us suppose that a previous interaction

phase was actually informally and cryptically carried out within each agent team, and that the 'oscillation' previously mentioned may have been in fact anticipated.

As far as policies are concerned, the differences with the homologous steps of the first session are really less evident, so enhancing the contrast with the image-generation phase of this second session. In particular, the first interaction (step 4.1) does induce a change in the policy portfolio for each agent, with a certain 'flowing back' in the second interaction (step 4.2) – this occurrence being very different from the image-related phase. Therefore, since a certain lack in focus was one of the image-generation character highlighted before, we might conversely note that the focus character, typically embedded in policy actions, may have helped agents to narrow arguments, so facilitating the interaction.

3.3. A holistic approach using cognitive mapping

This experiment has been made twice, first with 5 students from the master programme in Civil Engineering and then with 14 students from the degree in Environmental Engineering. Each time, students have been asked to first comment separately on what they considered a desirable future development of their region in the next 20 to 30 years, linking descriptions and images to policies and actions (on-going or potential); subsequently, they have been asked to read all comments made by their colleagues and to modify, if they liked, their own previous ones.

In doing all this, their comments have been expressed through cognitive maps (CM), whose nodes represents all the relevant concepts, linked to others in argumentative chains of thoughts. The cognitive mapping technique has been chosen for twofold reasons. On one hand, cognitive maps have been used for their potential to link descriptions, value judgement propositions and statements for action in an argumentative flux, thus allowing the possibility to express ideas in a more holistic way and without framing individual thinking into a given analytical framework like occurred when using *Meeting Works.* On the other hand, they have been chosen for their potential to perform as a 'visual thinking' tool, which makes ideas explicit and concise, thus easily sharable among people.

Cognitive maps have been drafted through *Decision Explorer*, a software package developed by Banxia to foster issue/problem structuring in the context of action oriented strategic management in the organization field. This is, indeed, the field in which cognitive mapping has found the largest application, since the '80s, when these maps begun to be used as a very powerful tool to foster group thinking and mutual learning, aiming at the development of strategic management policies[7] (Eden 1989). In this field, cognitive mapping techniques are often used with an explicative and reflexive function, as tools able to elicit assumptions and aspirations regarding a particular situation or a messy problem,[8] although some authors underline that cognitive maps should be considered intentional descriptions of what the interviewees want to make explicit, which might be only a partial truth (Barbanente et al. 2003).

Decision Explorer has been clearly developed with an explicative aim, since its basic clustering and merging functions are appropriate for this, enabling the analysis and merging of individual perceptions into organizational memory, and working as a group decision

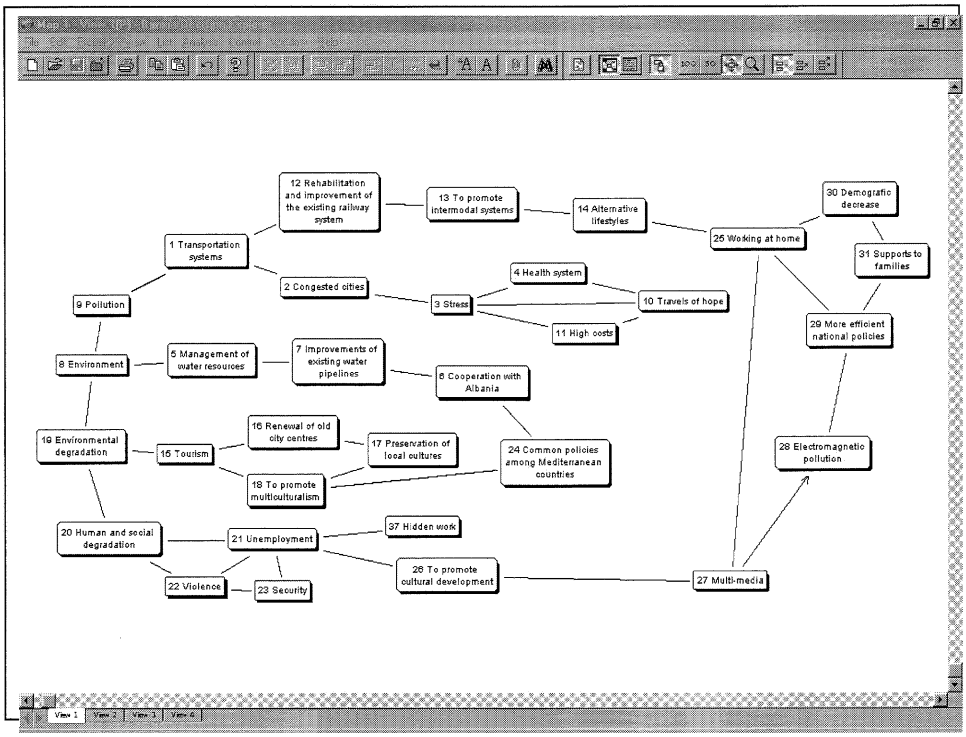

Figure 8. Map made by interrelated argumentative concepts chains.

support system (Eden et al. 1992). Nevertheless, we have decided to use this software by adapting its functions and potentials to the different goal we had in mind, i.e. not to get convergence but to foster the broadening of problem definition and of possible future courses of action. We have, thus, decided to use cognitive maps as explorative more than descriptive devices (Albino et al. 2003), in order to explore values, perceptions and action-oriented statements of interviewees. In this light, our experiment is also one of the very few applications of cognitive mapping techniques as supporting tools in the field of future scenario building (Warren 1995).

Furthermore, our experiment has also another peculiarity, which refers to the way in which cognitive maps have been produced. Indeed, the traditional way to develop cognitive maps is through the collection of semi-structured interviews (Eden 1988), which are later interpreted and represented in the map format by the researcher-interviewer. Nevertheless, in the literature different other approaches are acknowledged, ranging from more structured interviews to what Bougon calls "Self-Q technique" (1983), which is a form of self-interview developed in order to reduce the interference of the researcher in the process.[9] Our experiment tries to proceed even further, since participants were asked to draw themselves their own maps through the use of the *Decision Explorer* software. In fact, we have just given them a broad question to reflect upon, letting them draw those concepts and links (not only

causal, but also connotative and temporal), which they considered most relevant. Indeed, we have decided to try this approach to the development of maps because we assumed (and this assumption proved to be correct) that all the participants would be comfortable in using the *Decision Explorer* software, since they all already had a strong background and training in ICT and graphical representation fields.

As a result of this tentative approach, we succeeded in eliminating most of the ambiguities in interpreting the participants comments since they themselves judged the importance of each concept by synthesizing their ideas into short sentences and positioning them into different areas of the map with a specific sequential entry path. Moreover, we obtained much richer and diverse maps than those produced by a single researcher interpreting different interviews, since some students chose very creative representation chains of concepts. As a result, what students have produced is spectacular not only in relation to the richness of ideas and concepts represented, but also in relation to the accuracy and creativity in drawing.

Some of them decided to draw concepts in an argumentative chain of intertwined descriptions, value judgements, proposition of actions and reflexive thoughts, simply following the way in which images, policies and judgements were coming to their minds and linking different argumentative chains to the others in a discoursive way. In these maps concepts are clearly represented through well identifiable chains that are interrelated with others in few points (Figure 8).

In other cases, the map is build around a central concept, which constitute the core argument or the core image or value attached to the issue under discussion. In this case, the map develops around this central node, with explicative argumentative branches (Figure 9).

After the interaction, many of the interviewees enriched their maps in different ways. Some enriched it by scaling down the argumentative chains into more specific and situational issues, while others added new argumentative branches, which represent related concerns which had not come to their mind during the first step and which might have been suggested by the reading of the other maps. In most cases, the branches added are directly related to some well-identifiable concepts or argumentative chains that are contained in other maps.

Nevertheless, they are not simply added, but in most cases the new maps contain the elaboration of fragmented and scattered concepts, taken from different maps, into a new clearer and richer argumentative chain. This suggests that the reading of maps must have prompted many agents to make connections and to go in depth to some reflections, unraveling new concepts and links, so producing something which is richer than the basic sum of different maps. And this is an important result, which has to be acknowledged when discussing the potential of multi-agent interactions and multi-logic procedures versus mono-logic ones.

With this respect, we have also to acknowledge the potential of this cognitive mapping technique as a tool which foster the representation of knowledge frames instead of fragmented statements, giving room to holistic thinking and broadening of visions. As a result, the visions and strategies obtained with the cognitive mapping technique are more coherent and less fragmented that those obtained with the analytic approach supported by *Meeting Works.* This acknowledgement is particularly valuable since this form of knowledge is very important in the public planning field in which we operate, and it might foster a

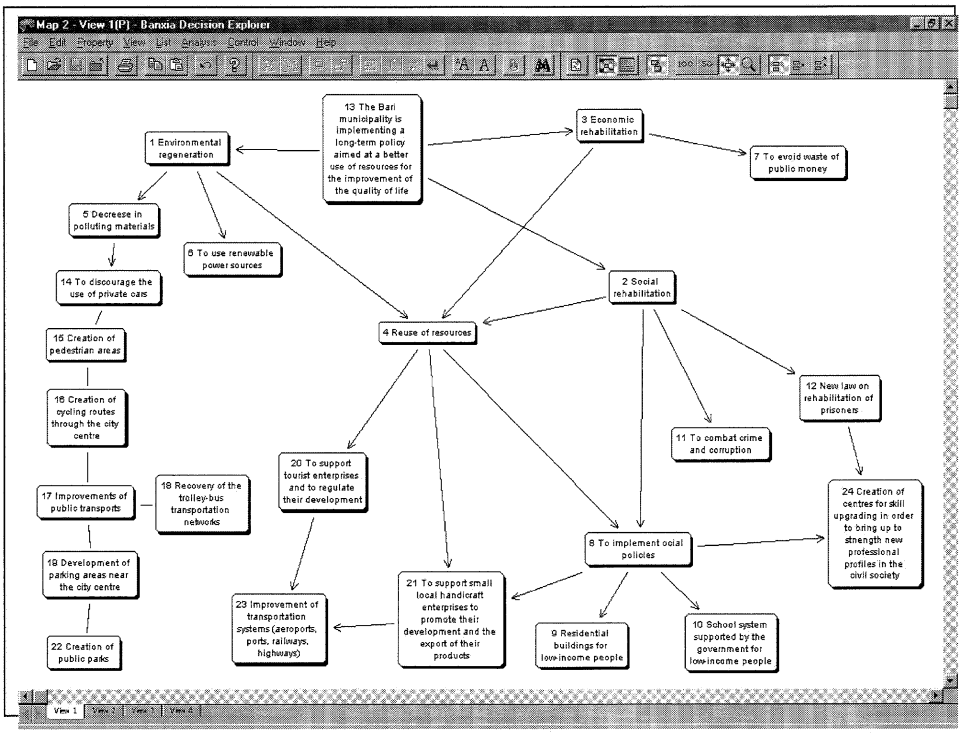

Figure 9. Map developed around a central core concept.

more holistic thinking, thus helping to overcome some dilemmas typical of reticular and sequential thinking.

Moreover, this argumentative form of knowledge is very interesting also because of the intertwining of descriptions, value judgements, hopes, fears,. . .,which makes cognitive maps a powerful tool to support the elicitation of pieces of stories and personal beliefs of people, whose importance in planning is now more and more evident. Indeed, in a recent article, Sandercock (2003) argues that stories have a special importance in planning, although this has never been fully understood and only partially investigated in the planning field (Forester 1989, 1999). According to her, one of the most valuable aspects of story telling in planning is the possibility offered by stories to get in touch with people understanding of any issue in a context that is not distorted by product-driven aims. In this light, cognitive maps can be considered very good tools to tell stories and pieces of persons' everyday life without trying to fit them into pre-defined categories of analysis. In our experiment the interaction among the agents is, thus, fostered to give people the opportunity to learn from each other and to stimulate them to make further reflection, without the aim to get any convergence. So, it's the richness of each and every description the final goal of the interaction and not the reduction to a single future image and policy development.

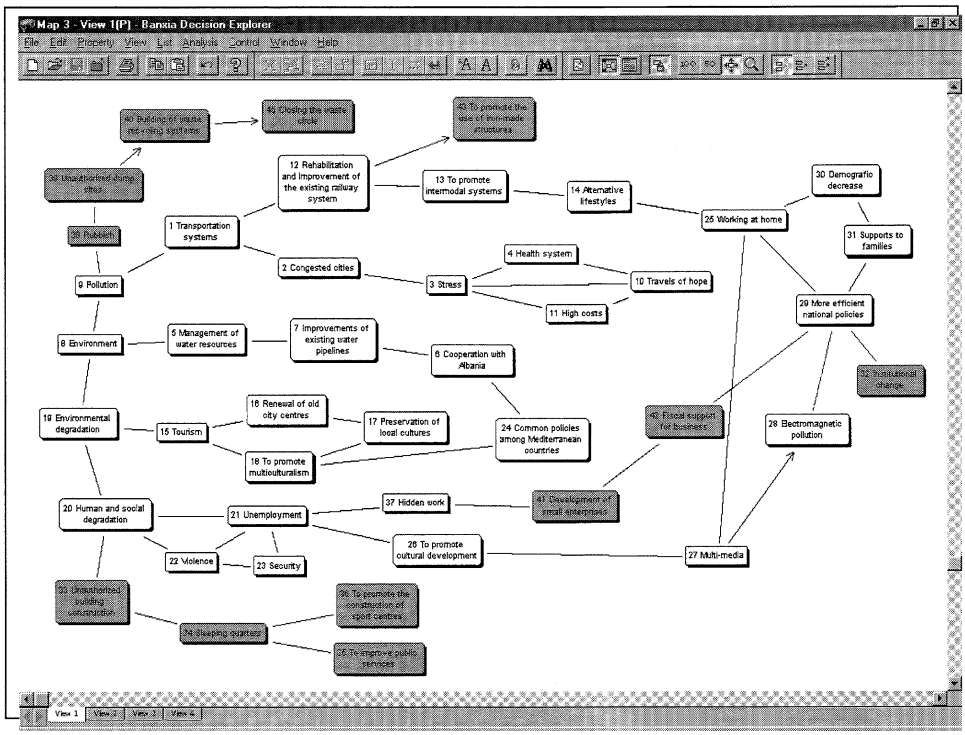

Figure 10. Concepts in red are those added after the interaction (gray color added by the authors of the article).

4. Conclusions

In socio-environmental domains, the traditional cybernetic approaches based on the linear elements/phases control of processes is being increasingly replaced by the participatory and argumentative approach to planning. Values are today mutable and adaptive, and increasingly searching for structures and questing for ways to solve problems created by systems themselves. In anthropic as well as in environmental domains, systems evolve dynamically, involving both cooperation and/or conflict among multiple agents with multiple cultures. In this context, as said, a weak and contextual rationality, multilogic and multivalue, is claimed to replace the classical strong and absolute rationality.

More than achieving targets, the new plans aim at building discourses and visions related to evolving situations where different stakeholders can intentionally locate their behaviours, learning at the same time about themselves and the realities in which they are immersed. As a matter of facts, a notion of immersion replaces the one of direction (Sardar 2001). In this light, the roles of awareness and learning processes are particularly crucial, since agents who become aware of their cognition as well as experiences, and learn other agents' actions, may reconsider situations and act consequently. Interaction then becomes the key element by which to start off and explore environmental planning paths.

The development of information and communication technologies and information sciences gives new opportunities to cognitive negotiations (Schank and Childers 1984) through forums of "knowledge" and "interests", as also witnessed by such emerging experiences as the Concerted Action mentioned above. Negotiations become increasingly multi-cultural and extended in space and time and such expansion creates in turn inter-cultural and intra-cultural contexts in which negotiations take place.

Through our experience carried out in the Mediterranean area, with its hard unbalances, an attempt was made to embed the space of common narratives, discourses and representations into the environmental decisionmaking and policymaking process. Unfortunately, also due to lack of experimentation, the extent to which ICT-based interactions are effective in promoting knowledge sharing, learning and shaping is still disputed, and requires time and research occasions to be explored.

The two above experimentations were conceived as an opportunity in this sense, as a way to compare two approaches, namely Delphi-brainstorming and cognitive mapping, aiming at investigating the cognitive mechanics of knowledge-based multi-agent interactions.

Under this light, specific comparative outcomes can be carried out interestingly. As far as generated visions are concerned, the ones provided by means of cognitive maps seem to be more structured and rich than visions attained by using the analytical approach. Scenarios resulted from CM look quite clear and consistent, whereas scenarios generated by MW seem fragmented, and relevant policies are shorter, more focused and narrowly oriented to specific issues. On the other hand, the CM approach seems to show a lack in 'colour': i.e., statements are less argued than in the analytical approach, and therefore there is the risk of misinterpretation and semantic faults in the process.

The set of outlines provided by using CM resembles a typical Misky's 'cognitive framework' facet, able to prevent agents from loosing orientation within the dilemmas of several tiny cognitive analytic occurrences and to sketch out the overall perspective of visions and actions (Minsky 1988; Schank and Childers 1984). This would be particularly helpful when dealing with minor dilemmas, redundancies, subsumings, incoherences: nonetheless, as the CM mechanism of occurrence purging is not clear, it would be risky to uncritically accept unknown simplifications on major issues.

On the other hand, the MW analytical approach succeeds in allowing a greater disaggregation and argument on issues, a building and re-building of alternatives and scenarios as if manipulating little knowledge bricks. Admittedly, this great advantage is frequently challenged by the presence of contextual and literary inconsistencies, repetitions and nested statements, even able to make the whole interaction cryptical and unmanageable (Warren and Gibson 2002).

In the end, the whole experience on ICT-based multiple-agent knowledge interaction, although partial, did give an interesting feedback under many points of view. First, it suggests that scenario-building activity may prove more effective when supported by automated routines, provided that the support is monitored and at times hybridized by human-based systems of process control. Second, analytical and holistic approaches provide levels of item analysis and aggregation that are different, but usefully integrable to each other in order to enhance the richness of arguments and to understand the scope and structure of cognitive exchanges. Third, both approaches seem to confirm the structural importance of

interactive participation as a cognitive informational moment able to modify the knowledge patrimony and attitude of agents.

As a whole, this set of responses represents a very rich and stimulating outcome, particularly in terms of research evolution. The extent and the perspectives of a more structural ICT-aided involvement of distributed agents represent intriguing pathways that deserve to be further explored in the next future, especially when facing the complexities of planning and managing multifaceted socio-environmental domains.

Notes

1. Frame models are models not linear and sequential as in the traditional optimisation planning, but based on selecting optimal actions among sets of memorised actions by matching external situations in the world to internal situations in the brain/mind system (Shanahan 1997).
2. This experience, that is indeed composed of three different activities carried out in three Countries in the Mediterranean, provided some hints and intriguing questions related to the real cognitive transformations occurring in multi-agent environments and to the real potential of different kinds of reasoning for the enhancement of creativity and agents' mutual learning.
3. In ex-post verbal comments, interactions showed that often the most voted images did not entirely represent the actual shared belief of the group.
4. In a typical Delphi evaluation, these phases can be considered as subsequent steps toward a possible convergence of issues (i.e., images): however, convergence was not the aim of the interaction and therefore, although gaining convergence, the cycle was stopped just after the 3rd phase.
5. In this first self evaluation of this session, agents were given the option of expressing even scores: this means that some items may have been given the same importance in the starting list.
6. In this second session, the term 'person' is used to indicate the single student who takes part in the couple working on each workstation. Terms as 'agent' and 'participant' are therefore used to indicate the whole team of 2 persons working on one workstation. This choice stems from the need to keep homogeneous references among experimental sessions.
7. Indeed, the applications of the cognitive mapping techniques as a negotiation device are now spreading out of the organization field into the policy realm, entering also the public planning field (Hjortsϕ 2003).
8. In fact, cognitive maps were initially used as a tool to reproduce the way of thinking of human beings. In this respect, their theoretical foundations can be found in constructivist psychology and in George Kelly's theory of personal constructs (1955), according to which we continually try to make sense of the world through a 'construct system' made up by a finite number of repeated themes or concepts (constructs) in order to act within and upon the world.
9. In fact, in this approach the participants ask themselves questions and thus determine themselves what concepts are relevant in the chosen domain, since the researcher only gives pre-written instruction and does not participate in the discussion or in the definition of concepts.

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