

Article

Knowledge Models for Spatial Planning: Ecosystem Services Awareness in the New Plan of Bari (Italy)

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Abstract: The concept of ecosystem services (ES) arises as a formal outcome of historical processes of understanding and interpreting settlements as complex ecological systems. Because of a straightforward, bottom-up demand for environment enhancement, this concept increasingly occurs in discourses, in narratives, in the demands of common people, triggering a new urban environmental awareness. This is now often arising spontaneously in the protocols of participatory plan processes, especially when planning for the future of complex environments such as city areas. The present study tries to elicit reflections around the significance of ES issues awareness in the case study of Bari (Italy), which is experiencing an inclusive and participatory process of construction of shared knowledge for the new master plan. Starting from an initial campaign of civic walks (CWs) along the urban neighborhoods and a subsequent semi-structured interview to the community, the paper carries out comparative analyses using problem-structuring methods (PMs), in order to evaluate and reflect on community behaviors and expectations about ES. Then the paper ends by emphasizing the role of structured knowledge-raising approaches, as critical activities to enhance ecosystem awareness in planning settlements as complex ecological systems.

Keywords: knowledge modelling; spatial planning; problem structuring methods

1. Introduction

In the Italian season of so-called *third-generation plans* following earlier post-war planning experiences [1], issues of qualitative (as well as interstitially speculative) transformation of cities appear, apparently in terms of urban facilities and services.

This type of approach is generally considered as extended until the 1980s, with some medium-sized cities often cited as examples, such as Pavia, Pistoia, Arezzo.

This is also the period, however, of an eruption of the environmental question in scientific debates. New reflections focus on the limits of dissipative growth especially within the residential settlements. What emerges is the need for progressively increased attention to natural resources and their regeneration cycles, especially in urban areas. Some observers even deduce from this circumstance an emerging *fourth generation* of spatial plans, contaminated by new increasing socio-environmental operational programs, such as Agenda 21 [2].

Certainly, a new awareness is growing around the need for closing natural cycles, to avoid problems of liveability, health, consumption of ecological resources. Settlement areas are increasingly considered, planned and managed as complex ecological systems and not as simple territories to be transformed.

The hand of public administration and policymaking can do much in this framework, in its role as a service provider to support the life and welfare of communities. By the new millennium, the new and simple reading of this commitment is thus immediately turned into operationally considering the role played by service places as also resource regenerators.

Also, owing to this simple, natural evolution, the new concept of ecosystem services develops in planning practices, as a lexical outcome of a historical process of understanding and interpreting settlements as complex ecological systems [3] (p. 43). It is therefore a formal name that corresponds to a straightforward, bottom-up demand for environmental enhancement. It increasingly occurs in discourses, in narratives, in the demands of common people, triggering a new urban environmental awareness [4] (p. 161). This is now arising spontaneously in the protocols of participatory plan constructions, especially when planning the future of areas at environmental risk [5].

The present study starts from these considerations, trying to elicit reflections around the weight of ecosystem instances through inclusive processes of cognitive planning, with the aim of verifying their final policy enhancement. This research objective in the present work is not oriented to discuss features, roles, history of ES in planning as such. Rather, the purpose is to reason about the effectiveness of some knowledge-based planning models in embedding and valorizing ES significance in spatial plans. The work refers to the case study of Bari (Italy), in which a multi-faceted process of construction of shared knowledge is in progress for the preparation of the new urban plan of the city. After the present introduction, section 2 shows a basic literature review about ES research in a knowledge-raising perspective, while section 3 presents the case study layout. Section 4 shows and describes the applied methodology and section 5 outlines and discusses some results of the case study. Final remarks and future developments close the paper (section 6).

2. Ecosystem Services in a Knowledge-Oriented Perspective: A Relevant Background

According to a literature review, a large variety of ecosystem service (ES) definitions and classification approaches exist [6–12]. However, it is recognized by the scientific community that ESs offer benefits to the human ecosystem [13]. According to the Common International Classification of Ecosystem Services (CICES) [14], ESs is defined as the effects of ecosystems on people's well-being. The CICES framework uses and classifies ESs into three categories affecting directly the human ecosystem: (i) *provisioning* (e.g., food and fresh water), (ii) *regulating and maintenance* (e.g., water purification), and (iii) *cultural* (e.g., recreation and aesthetics).

In the present study, that started from a thesis work at Polytechnic University of Bari, the CICES framework has been developed according to the Environmental Protection Agency (EPA) [15] as (i) Natural resources: water, land, soil, and air; (ii) drivers of change: policy, land use, climate, pollution; (iii) benefits: economy, well-being, food-water and materials and integrated into the methodology (Table 1).

Table 1. Ecosystem services. Adapted from Environmental Protection Agency (EPA).

ECOSYSTEM SERVICES		
NATURAL RESOURCES	DRIVERS OF CHANGE	BENEFITS
Water	Policy	Economy
Land	Land Use	Well-being
Soil	Climate	Food- Water and Materials
Air	Pollution	Public Health

Natural resources are the resources offered by the planet without any human intervention (UNESCO); according to Millennium Ecosystem Assessment (MA), drivers of change are defined as natural or artificial factors that impact directly or indirectly on the ecosystems, causing a change. While the first kind of drivers influence directly ecosystem processes, an indirect driver alters one or more direct drivers. For this work, direct drivers have been considered; the benefits refer to the advantage deriving from ESs in different fields [16].

A literature review shows a growing interest of ES in the past decades [17–19]. However, in order to deal with the complexity of ES, few approaches exist [20]. A brief review on this topic still shows the lack of practical suggestions for the implementation of ES in spatial planning [10,21,22]. The result is a deep gap between science and political decisions [23]. In the attempt of reducing this gap, literature shows the role of the participatory processes (PP) as critical integration of expert

knowledge—insufficient to support decisions in relation to specific problem situations [24,25]. PP could facilitate information acquisition, contributing to the knowledge sharing and decision implementation [26]. There is no straightforward strategy to elicit, collect, and structure citizen knowledge, experience, and perception, nor to improve their awareness of a problematic situation. Several approaches and methodologies is still being explored, although growing debates exist toward promoting stakeholders' engagement, with mixed results [27]. These suggestions are increasingly effectively today addressed within the field of participatory modelling techniques (PMT) (see a brief review in the chapter 4).

In order to structure the citizen knowledge about ES, the present study tries to apply a methodology based on a combination of PMT and PSM. This methodology is experimentally applied to the case study of Bari in Apulia region (Italy).

3. The Case Study of Bari

The capital of Apulia in Southern Italy, Bari city is extended over 117,38 km² with 324,198 citizens (ISTAT 2011). It is subdivided into five districts characterized by the presence of natural, cultural, and social resources to be reactivated, able to offer numerous ES (Figure 1).

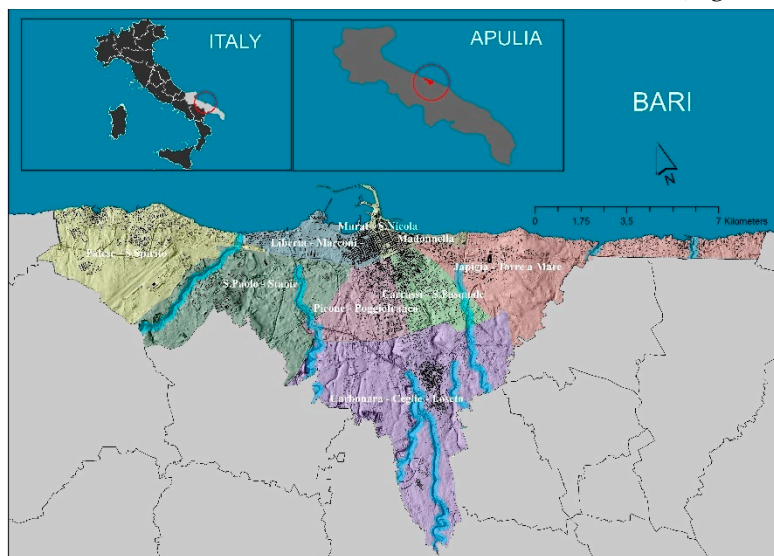


Figure 1. Location of the city, municipality, and nine blades.

The natural capital of Bari can be referred to a number of consolidated aspects, such as (i) The sea, which is embedded in the culture and economy of the city; (ii) the nine blades, organized in a complex ecological system (Figure 1); (iii) areas of archaeological interest and public parks located in different districts. The cultural and social capital can be represented by (iv) the historical pre-existences offered in the city center by houses dating back to the Byzantine era (Figure 2); (v) the lictor architecture developed during fascism in the peripheral center and on the waterfront (Figure 3), and the architecture of twentieth-century rationalism in the peripheral districts (PPTR Puglia 2009) [28].



Figure 2. Archaeological area of San Pietro, (Baritoday, 2013).



Figure 3. The lictor architecture developed during fascism on the waterfront.

While it is easier to trace the benefits for the well-being of humans and of the ecosystems offered by the natural factors (such as, for example, the role of urban green that can regulate the climate by absorbing carbon dioxide and supporting the recycling of nutrients and the formation of soil or attract people for leisure and tourism), it is harder to associate the benefits offered by the built landscape, despite building issues are central to the public discontent with natural resource management decisions [29]. Therefore, setting up a participatory process in the identification and evaluation of ES is an increasing issue in planning agendas. Starting from resolution nr. 565/2015 in 2015 Bari Department of urban planning started a participatory process at several levels, asking citizens to participate in the drafting of the master plan of the city (PUG) [30]. The path was designed in different time steps, performed between May and November 2016, through (i) nr.30 *urban front offices* (UFOs) activated in the municipal area (Figure 4), (ii) nr.9 *civic walks* (CWs) to single out peculiar aspects and features of relevant areas (Table 2; Figures 5 and 6), and (iii) nr.5 *public workshops* (PW). Located in different parts of the city (Figure 4), UFOs have supported the participatory process through the distribution of surveys regarding the themes of (i) public space, (ii) landscape, and (iii) mobility; CWs aim to share new visions of the places [31]. Analysts have chosen nine CWs in order to highlight the peculiarities of each area (table 2); *experts knowledge* (institutional referents and technicians) and *non-expert knowledge* (citizens) have been included in order to present observations, questions, and desires. *PWs* aimed at expanding the dissemination of participation culture in urban policies, through the proposal of some open meetings to citizenship on relevant urban topics.



Figure 4. Allocation of urban front office (Report PUG 2016).

Table 2. Civic walk description.

Subject of civic walks	Areas
1. Minor historical centers and hypogea	Carbonara e Ceglie
2. Relations between the city and the sea	Libertà e Marconi
3. The places of the “gigantism” of the Quaroni Plan and the city of children	Carrassi e Poggiofranco
4. The reuse and redevelopment of historical fabrics in the multiethnic city	Madonnella e Libertà
5. Archaeological protection as a natural barrier to the consumption of soil and a resource for development	Torre a Mare
6. Recovery of brownfield areas	Santo Spirito
7. The historical nucleuses of public buildings and the landscape resources in the suburbs	San Paolo
8. The quality of living in the large public housing districts: public space and private space in the different neighborhood settlements	Japigia
9. The public housing districts to be reconnected	Stanic



Figure 5. Civic walks (CW) n°1.



Figure 6. CW n°5

The present study starts from a participatory process carried out by the Municipality of Bari, trying to highlight the limitation of the methodology adopted and to elicit some reflections on the weight of ES in citizens awareness. Section 4 describes the proposed methodology.

4. Methodology

Historically, building knowledge models for spatial planning purposes has a very recent genesis. This happened essentially because of a research area, dominant from the second half of the 1900s until around the 1990s, characterized by the qualitative and discretionary data management, often referred to as “participatory planning.” The rationale behind this position can be sought mainly as a response to a strong demand for bottom-up democracy in decisions, after long traditions of top-down decision-making centralism [32] (p.27). Toward the end of this exciting season, dangerous demagogic, rhetorical, and speculative pitfalls ended up characterizing and often degrading the ethical and social effectiveness of participatory planning. The increasing awareness that has fortunately followed has been paralleled by an emerging research on new methodologies offered by information and communication technology for the management of complex and widespread data. ICT-based statistical-mathematical platforms have increasingly allowed the management of multisource and multiagent data in a quantitative or quali-quantitative way [33]. A growing scientific research has emerged regarding the construction of quantitative bottom-up knowledge management models, to support more informed, real-time decisions toward more effective spatial policy and planning. For the social management of environmental resources and components of the territory, the problem is particularly complex as it is linked to an inherently embedded social and environmental complexity. In addition to mainly qualitative methods, e.g., structured in terms of building future scenarios, ontological and relational knowledge management models have evolved in an attempt to preserve such inherent complexity while maintaining a synthesis necessary to allow its management [34–38]. In our paper, the context is characterized by a hybrid methodological approach for which a quantitative knowledge management model accompanies and criticizes a mainly qualitative pre-existing approach.

In particular, the present study proposes an approach based on knowledge structuring to (i) overcome the limits emerging during the participatory process adopted by the municipality, and (ii) to investigate the weight of citizens' awareness about ES through the construction of knowledge models.

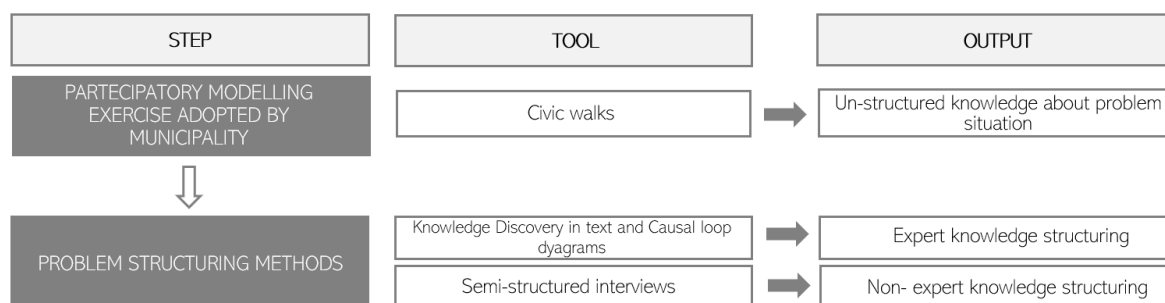
Specifically, the reflection on CWs raised three critical issues: (i) Numerical predominance of considerations by expert knowledge on non-expert knowledge; (ii) the lack of structured knowledge broadly following narrative patterns; (iii) a small number of participants, never exceeding 30 units.

In the present study, in order to overcome these limits, information emerged in narrative patterns deriving from CWs has been recorded and formalized using ad-hoc structuring platforms, particularly relevant to PSMs modelling area. Specifically, a qualitative analysis of the information deriving from CWs through knowledge discovery in text (KDT) was needed to build causal loop diagrams (CLDs) and semi-structured interviews (SSIs). KDT was oriented to structure problem framework [39] and build CLDs, whereas SSIs held a dual function of validating CLDs and involving a more significant sample of citizens. Figure 7 shows the developed methodology.

The choice to use CLDs and SSIs arise from an analysis of existing PMT. Levels of involvement could be enhanced to strengthen the strategic knowledge on the environment, scientific literacy, and the empowerment of citizens in helping to inform and monitor policies and management efforts related to the ecosystem services [40]. Some authors [41–44] have recently proposed literature reviews on PMT (table 3).

Table 3. Type of participatory modelling technique.

Typology	Description	Tool
Group Model Building (GMB)	It is based on the involvement of a group of stakeholders in order to create a conceptual model. The model building process can start from a story telling, a set of interviews or narratives and it is supported by a facilitator.	Causal cycle diagrams and similar visual tools
Mediated Modelling (MM)	It is based on the collect of information by a group of stakeholders in order to create a system dynamic model. The model building process use the computer models in order to create scenarios.	System dynamic model (Stella)
Companion Modelling (CM)	It is based on involving stakeholders through role-plays in order to make them aware of the variety of points of view and their consequences in terms of actions.	Role-playing games
Participatory Simulation (PS)	It is based on involving stakeholder through mobile devices and physical activities. The rules of the games cannot be modified by the stakeholders. Every decision and every interaction are registered for further analyses	Agent-based model
Shared Vision Planning (SVP)	It is based on computer simulation in order to identify alternatives and trade-offs in a manner where stakeholders without modelling experience can actively participate in the modelling process.	Scenario simulation
Collaborative Learning (CL)	It is based on the idea that learning is a naturally social act that takes place through communication. The aim is to teach and learn in groups to work together on problems, complete a task, or create a product.	Workshop, seminar, and similar tool

**Figure 7.** The developed methodology.

For this work, a group model building (GMB) has been used and the model has been built by the analyst following the narratives deriving from the CWs and validated by the SSIs. The analysis led on one of the nine CWs is described below, as an explicatory example.

4.1. Participatory Modelling Exercise: Civic Walks (CWs)

Civil walks are an early and widespread instrument of citizens' participation in the field of urban policies in order to activate new forms of knowledge about the city [31]. They are typically collective walks along the streets of urban neighborhoods, developed by citizens who accompany an expert scholar describing and discussing the features and issues related to the area. Through questions and answers, a mutual interaction of knowledge is established between the participants and the expert, which is oriented to enrich the knowledge base useful for planning purposes. CWs tell the dynamics, spaces, and urban regeneration through the eyes of citizens. CWs aim to enhance

the environmental aspects, the old and new forms of the urban space and economy, the quality of public space in terms of beauty and sociality to calibrate the urban redevelopment actions.

According to the literature analysis, CWs seem to ensure some important features: (i) The implementation of *de-professionalization* visions, i.e., not only professionals shape the future of the districts; (ii) a *demystification* of problems, turning territorial planning into real and concrete perspectives, away from a virtual or mediatized knowledge; (iii) the *democratization* of knowledge and decisions, as many citizens are directly involved in the process of reflection and decision, especially those that represent an interest in the future of the districts [32].

In several Italian cities CWs have been used (see the case of Bologna, Ravenna, Modena, Livorno e Valdarno).

Despite these assumptions, the analyzed CWs present a preponderance of interventions by the expert knowledge. The CW analyzed here has crossed areas coming from two planning seasons of the city of Bari. The first one comes from the urban plan drafted by Calza-Bini and Piacentini in 1954 characterized by a traditional urban design (concentric and equidistant road links, called *mediane*, connected by radial roads). Figure 8 taken from a Google satellite shows the average morning traffic flow of a road that does not relate to the expanding Bari of the post-war years (Figure 8 1a, 1b).

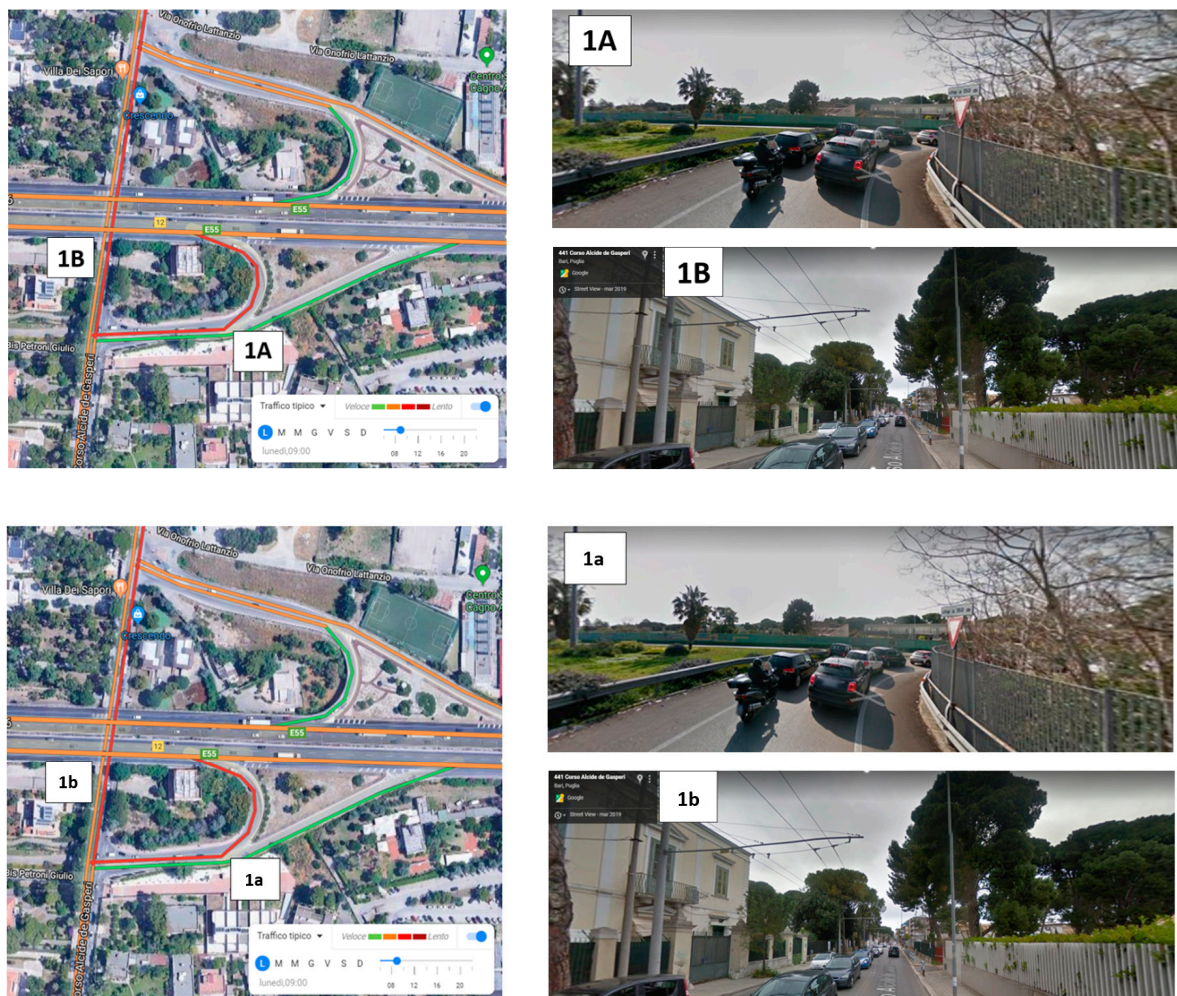


Figure 8. Ring road connection to Alcide De Gasperi street (1a); Alcide De Gasperi street (1b)

The second one is Quaroni's urban plan (1976), characterized by the gigantism of roads and buildings in view of demographic growth and city flows (Figures 9 and 10).



Figure 9. Mother Teresa of Calcutta street, Quaroni’s urban plan.

During the CW analyzed, 22 citizens and 3 technicians were involved. The CW was focused on three places: Alcide De Gasperi street (Place 1); Gandhi Mohandas street (Place 2); Mother Teresa of Calcutta street (Place 3) (Figure 11).



Figure 10. Gandhi Mohandas street, Quaroni’s urban plan.



Figure 11. CW n°3 The places of the “gigantism” of the Quaroni Plan and the city of children.

4.2. Knowledge Discovery in Text (KDT) and Causal Loop Diagram (CLD)

The analysis of the information that emerged from the conversations during CWs was carried out through the knowledge discovery in text (KDT) approach [45]. The selection of this approach depends on its offering the possibility, using automated intelligent systems, to extract knowledge from unstructured texts. Specifically, through KDT it is possible to extrapolate contents from an unstructured text, despite the lexical difficulties inherent in a conversation [46].

The application to the present case study took place with the use of Rapid Miner studio software [47] and is divided into two phases: the first one, in which the text is “cleaned up,” and the second one in which the analysis of contents and the construction of cause-effect links are carried out.

The first “cleaning” phase follows the following steps: (i) Tokenization, able to select the main words (tokens) included in a document according to a frequency logic; (ii) the identification of “Stopwords” in order to delete all the irrelevant words listed in the dictionaries provided by the system (deriving from the Italian dictionary); (iii) stemming, able to reduce the number of words that share the same root as a given token. The pieces of information emerging from the cleaning process are grouped into a correlation matrix (Figure 12) representing the second phase.

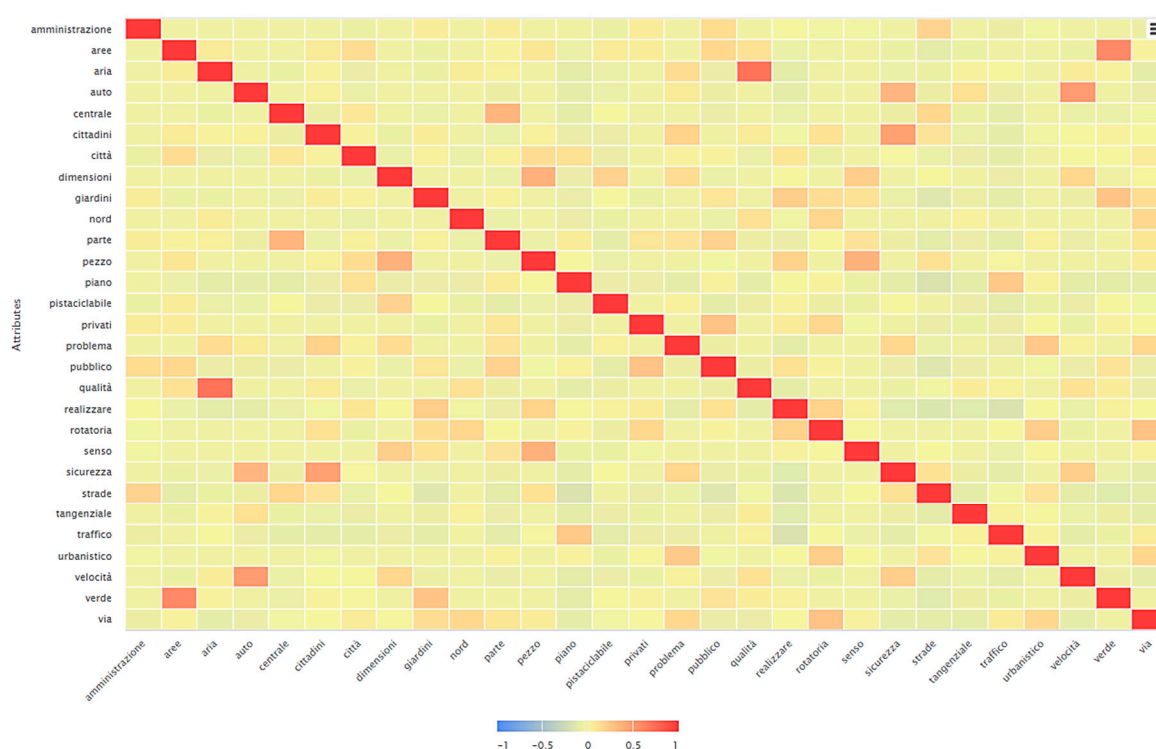


Figure 12. Correlation matrix (excerpt).

Correlation (1) is a statistical technique that shows the extent to which the pairs of variables X and Y are related:

$$r = \frac{1}{n-1} \sum ((X - \bar{X})/S_x)(Y - \bar{Y})/S_y \quad (1)$$

where, X and Y are the frequency of the single words with the relative means and letter S indicate the standard deviation.

Correlation is expressed by a number between -1 and 1 that measures the degree of association between the two words. A positive value indicates the presence of a positive association. It is obtained when high values of Y tend to be associated with high values of X and low values of X tend to be associated with low values of Y . An inverse association, on the other hand, is expressed by a negative value. That is, high values of X tend to be associated with the minimum of the values of Y and vice versa. These relations refer to the instances of the text, thus allowing the creation of a structured cause-effect relationship [48].

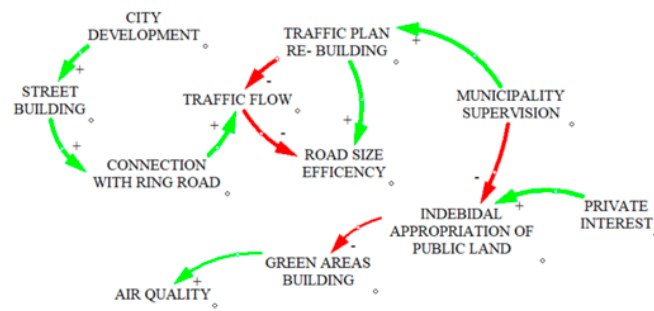


Figure 14. Causal loop diagrams (CLD) referring to Place 1.

Specifically, on one hand, the road section is claimed to be unable to meet contemporary mobility demands. On the other hand, the problem of lacking green public spaces is due to intensive buildings and possibly worsened by the misappropriation of the few remaining areas by some private owners. A re-building of the traffic plan for the management of vehicular flows on the one hand, and the supervision by the public administration on the other, are the solutions proposed by the *expert* knowledge in response to the issues raised.

The second CLDs referring to Place 2 and 3 was carried out using the same procedure (Figure 15).

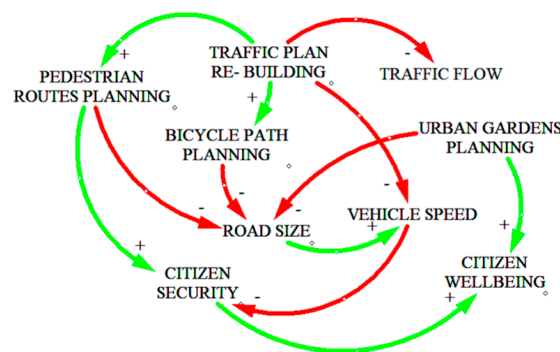


Figure 15. CLD referring to Place 3.

The CLDs show the causes and the effects that these variables entail. Following the same procedure, the other map has been built, in which the CLDs of Place 2 and 3 have been aggregated referring to the same issues. The use of land, deriving from the reduction of some road sections first conceived as urban highway and never completed, was a central theme referring to the Place 2 and 3. Specifically, two suggestions have been proposed: (i) Urban gardens for community along the roads and (ii) the reorganization with partial pedestrianization and bicycle path of the street to reduce the speed of traffic. The need to expand public spaces, by redeveloping the underutilized areas, was claimed in a different part of the district.

In the next section the validation of CLDs is explained through SSIs.

4.3. Problem Structuring Method: Semi-Structured Interviews

SSIs are commonly used in policy research and are applicable to many research questions [53]. They combine some structured, formalized questions with some unstructured exploration. They are useful when dealing with complex systems, owing to the use of spontaneous approaches able to better explore, understand, clarify answers to questions [54]. In this context, SSIs have been carried out and submitted to citizens, retracing the same places of the CWs, also aiming at checking the relevance and consistency of issue previously raised by *expert* knowledge.

SSIs have been structured in three sections: (i) citizen profiles, (ii) mobility issues, and (iii) public space issues. Citizens could express own preferences on a Likert (1932) 1–5 scale of agreement and

to insert a free contribution on the actions to be addressed on the issues raised (figure 16). A sample of 88 citizens, divided into 53 women and 35 men, aged between 35 and 50 years, were interviewed.

MOBILITY	1	2	3	4	5
Alcide De Gasperi street is undersized in relation to daily vehicular traffic					
On Calcutta street the cars speed reduces the pedestrians' safety					
Lack of signage and lighting on pedestrian pathways reduce pedestrian safety					
The crossroads should be managed with the integration of roundabouts					
Car parks are adapted to the traffic flow					
In order to improve mobility in your neighbourhood, please suggest some actions					
PUBLIC AREAS	1	2	3	4	5
Children and elders have adequate entertainment facilities					
Don Tonino Bello park is adequately maintained					
There are many empty spaces that could be redesigned for other public functions					
There are public facilities for citizens' support					
I feel safe in my neighbourhood					
In order to improve growth of public areas, please suggest some actions					

Figure 16. Semi-structured interview.

5. Results and Discussion

A qualitative analysis of the information deriving from CWs through KDT allowed us to build the CLDs in order to structure *expert* knowledge and SSI in order to validate *expert* knowledge and at the same time to structure *non-expert* knowledge.

The results emerging from the application of the methodology are described below. CLDs building tried to overcome the limit relating the unstructured approach emerged during CWs. The information thus emerging was subsequently connected to ES (EPA) classes, so making it possible to draw out considerations regarding the issues related to ES, by observing Table 4.

Table 4. Ecosystem services (ES) emerged from CW expert knowledge.

NATURAL RESOURCES	PLACE	DRIVERS OF CHANGE		BENEFITS	
		Policy	Land Use	Well-being	Public Health
LAND	1	Municipality supervision	traffic plan re-building	decrease traffic flow	increase air quality
			use of public green area	areas for children	
	2/3		traffic plan re-building	increase bicycle path planning	decrease vehicles speed
			urban gardens planning	increase citizen well-being	

It can be noted that the most common drivers of change are the land use and policy. The benefits related to well-being and public health are connected through cause–effect relationships.

The “traffic plan re-building” variable emerged in all three places. Referring to Place 1, it was suggested to act on the traffic flow, through a study of vehicular flows, not being able to physically modify the undersized road section. Referring to Place 2 and 3, the construction of cycle paths, pedestrian route and urban gardens was suggested. The latter seems to meet a dual function of reducing the road section and (consequently) vehicle speed, while promoting sustainable mobility and equipping the district with urban gardens. In terms of benefits, these actions induce an improvement in the well-being of citizenship owing to the presence of areas for leisure, a decrease in vehicular traffic with more safety for pedestrians, an increase in health and clean air-related benefits.

The above statements have been submitted to citizens’ opinion and degree of validation through SSIs. On the one hand, this allowed a general validation by the citizens on the issues emerged from expert knowledge, thus somehow balancing the preponderance of interventions by expert knowledge. On the other hand, it helped to bring out new issues such as waste management, the inclusion of public lighting, and the planting of new plant species. Variables have been relocated to relevant ES categories (Table 5).

Table 5. ES emerged from semi- structured interviews by non-expert knowledge.

NATURAL RESOURCES	PLACE	DRIVERS OF CHANGE		BENEFITS	
		Policy	Land Use	Well-Being	Public Health
Land	1		Planting of different tree species		Decrease of allergies
	2/3		public lighting	pedestrian security	
			waste management	neighborhood cleaning	increase air quality

The issues emerged, which are added to those already known to be derived from expert knowledge are: the planting of new tree species in order to reduce the problems linked to allergies that characterize children residing in Alcide De Gasperi street (Place 1); the strengthening of public lighting at Place 2 in order to increase pedestrian safety and finally, at Place 3, the need of improving the waste management system to guarantee adequate hygienic conditions of spaces and healthiness of air. The validation of CLDs took place through the analysis of semi-structured interviews. The preference of citizens in relation to questions have been analyzed. For the sake of simplicity one example is shown “Corso Alcide De Gasperi is undersized” (Figure17 a).

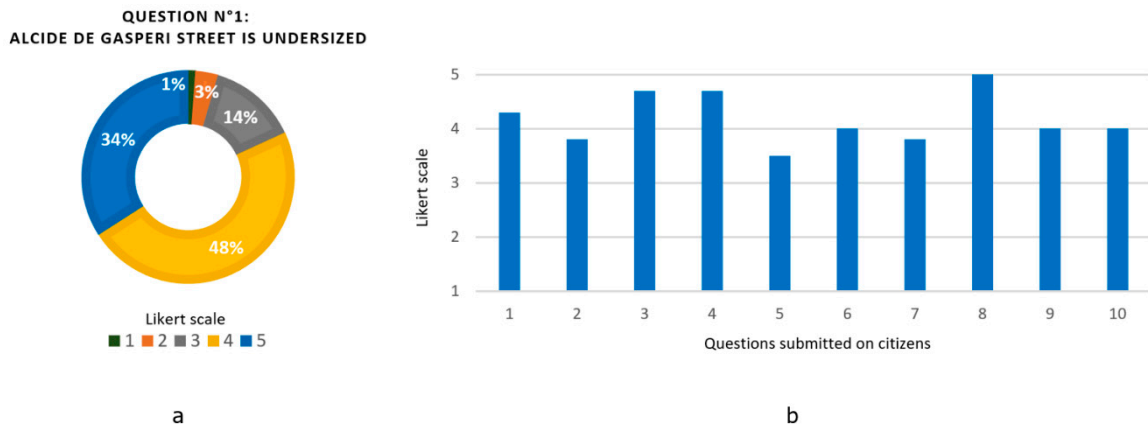


Figure 17. (a) Percentage of citizens' agreement with the question n°1; (b) average of 88 citizens' preferences on each question of the semi- structured interviews.

A total of 48% of citizens involved expressed an agreement at Likert scale 4, whereas 34% of citizens agreed at grade 5 (figure 17a). Most citizens involved acknowledges that Alcide De Gasperi street is undersized. It is possible to summarize the results obtained from the questionnaire through a histogram in which the abscissas represent the questions, and the ordinates represent the average of citizens' preference for each question (Figure 17b).

6. Conclusion

The application of knowledge structuring models through PSMs aims to challenge some limits of PMT and to investigate the level of citizens' knowledge and then, the awareness about ES.

The study has brought about some general considerations, that can be synthesized as follows.

First, CWs seem to be not completely able to lay out, analyze, and understand issues and problem situations emerging along walking discourses. An integration offered by other methods, such as extended SSIs, seems to be effectively integrative of the knowledge building process, being also possible to involve a greater number of people.

Second, the concept of ES seems to be now somehow inherent in the culture of citizens. In fact, virtually every action that emerged from CWs and SSIs can be assigned to a category of ES. However, some limitations still appear, such as: (i) Emerging ESs consider only the natural resource *Land*; (ii) the drivers used are only *Policy* and *Land* use and the benefits arising are only related to *Well-being* and *Public Health*.

Interestingly, CLDs seem to usefully integrate future-modelling activities, such as scenario-building models. For example, they seem to be useful to investigate the implications of citizen potential decisions on areas, as well as to facilitate citizens' knowledge about ES and, more broadly, to support the construction of collective futures. In this perspective, more work will be devoted to check such issues on different case studies.

Collective futures show up here as being certainly based on expert knowledge, but also largely non-expert, common, bottom-level knowledge. As a matter of facts, for the first time non-expert knowledge is considered in a computationally structured way and not only in qualitative sense, through the search and identification of knowledge database management models.

Actually, we must say that the results of the present work do parallel a constant evolution of attempts to structure informal data [55,56]. Stimulated by a well-known urgency of the environmental problem both at the global and at the local level, spatial decision-making and planning processes tend to confront complexity, rather than reducing or even denying it as occurred in the past [57].

Yet for this this knowledge-inclusive confrontation to be operational, intelligent and operationally refined instruments are needed. This represents a clear limitation of the hybrid approach used here, which represents just an explorative effort to evaluate an applied qualitative

methodology, rather than propose an original one. This is in fact a path with a large experimental and area-based component, able to provide the details and the experimental assortment that guarantee the usefulness, quality, and effectiveness of the path itself. But the availability and/or construction of these instruments is still far from being in step with theoretical approaches and methodologies and requires continuous and reiterated efforts.

In many ways this recalls a famous scientific approach of *Simonian* memory, whose trial-and-error steps allow just the necessary clarification and operational fine-tuning to problem management [58]. It is therefore a still wide and interesting research path in perspective to which our next research efforts will be oriented as follow-up activities.

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