TeMA

Journal of Land Use, Mobility and Environment

This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

Tema is the Journal of Land use, Mobility and Environment and offers papers with a unified approach to planning and mobility. TeMA Journal has also received the Sparc Europe Seal of Open Access Journals released by Scholarly Publishing and Academic Resources Coalition (SPARC Europe) and the Directory of Open Access Journals (DOAJ).

input 2014 Naples

Smart City

planning for energy, transportation and sustainability of the urban system

TeMA

SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND

SUSTAINABILITY OF THE URBAN SYSTEM

Special Issue, June 2014

TeMA

Journal of
Land Use, Mobility and
Environment

TeMA. Journal of Land Use, Mobility and Environment offers researches, applications and contributions with a unified approach to planning and mobility and publishes original inter-disciplinary papers on the interaction of transport, land use and environment. Domains include engineering, planning, modeling, behavior, economics, geography, regional science, sociology, architecture and design, network science, and complex systems.

The Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR) classified TeMA as scientific journals in the Areas 08. TeMA has also received the Sparc Europe Seal for Open Access Journals released by Scholarly Publishing and Academic Resources Coalition (SPARC Europe) and the Directory of Open Access Journals (DOAJ). TeMA is published under a Creative Commons Attribution 3.0 License and is blind peer reviewed at least by two referees selected among high-profile scientists by their competences. TeMA has been published since 2007 and is indexed in the main bibliographical databases and it is present in the catalogues of hundreds of academic and research libraries worldwide.

TeMA

This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.
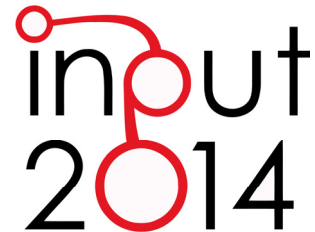
CONFERENCE COMMITTEE

Dino Borri, Polytechnic University of Bari, Italy
Arnaldo Cecchini, University of Sassari, Italy
Romano Fistola, University of Sannio, Italy
Lilli Gargiulo, University of Naples Federico II, Italy
Giuseppe B. Las Casas, University of Basilicata, Italy
Agostino Nuzzolo, University of Rome, Italy
Rocco Papa, University of Naples Federico II, Italy
Giovanni Rabino, Polytechnic University of Milan, Italy
Maurizio Tira, University of Brescia, Italy
Corrado Zoppi, University of Cagliari, Italy

SCIENTIFIC COMMITTEE

Emanuela Abis, University of Cagliari, Italy
Nicola Bellini, Institute of Management, Scuola Superiore Sant'Anna Pisa, Italy
Mariolina Besio Dominici, University of Genoa, Italy
Ivan Blecic, University of Sassari, Italy
Dino Borri, Polytechnic University of Bari, Italy
Grazia Brunetta, Polytechnic University of Turin, Italy
Roberto Busi, University of Brescia, Italy
Domenico Camarda, Polytechnic University of Bari, Italy
Michele Campagna, University of Cagliari, Italy
Arnaldo Cecchini, University of Sassari, Italy
Donatella Cialdea, University of Molise, Italy
Valerio Cutini, University of Pisa, Italy, Italy
Luciano De Bonis, University of Molise, Italy
Andrea De Montis, University of Sassari, Italy
Filippo de Rossi, University of Sannio (Dean of the University of Sannio), Italy
Lidia Diappi, Polytechnic University of Milan, Italy
Isidoro Fasolino, University of Salerno, Italy
Mariano Gallo, University of Sannio, Italy
Lilli Gargiulo, University of Naples Federico II, Italy
Roberto Gerundo, University of Salerno, Italy
Paolo La Greca, University of Catania, Italy
Giuseppe B. Las Casas, University of Basilicata, Italy
Robert Laurini, University of Lyon, France
Antonio Leone, Tuscia University, Italy
Anna Loffredo,Institute of Management, Scuola Superiore Sant'Anna Pisa, Italy
Silvana Lombardo, University of Pisa, Italy
Giovanni Maciocco, University of Sassari, Italy
Giulio Maternini, University of Brescia, Italy

TeMA

Francesco Domenico Moccia, University of Naples Federico II, Italy
Bruno Montella, University of Naples "Federico II" (Director of DICEA), Italy
Beniamino Murgante, University of Basilicata, Italy
Agostino Nuzzolo, University of Rome, Italy
Sylvie Occelli, IRES Turin, Italy
Rocco Papa, University of Naples Federico II, Italy
Maria Paradiso, University of Sannio, Italy
Domenico Patassini, IUAV, Venice, Italy
Michele Pezzagno, University of Brescia, Italy
Fulvia Pinto, Polytechnic University of Milan, Italy
Giovanni Rabino, Polytechnic University of Milan, Italy
Giuseppe Roccasalva, Polytechnic University of Turin, Italy
Bernardino Romano, University of L'Aquila, Italy
Francesco Russo, Mediterranean University Reggio Calabria, Italy
Michelangelo Russo, University of Naples Federico II, Italy
Ferdinando Semboloni, University of Firenze, Italy
Agata Spaziante, Polytechnic University of Turin, Italy
Michela Tiboni, University of Brescia, Italy
Maurizio Tira, University of Brescia, Italy
Simona Tondelli, University of Bologna, Italy
Umberto Villano,University of Sannio (Director of DING), Italy
Ignazio Vinci, University of Palermo, Italy
Corrado Zoppi, University of Cagliari, Italy

LOCAL SCIENTIFIC COMMITTEE

Rosaria Battarra, ISSM, National Research Council, Italy
Romano Fistola, DING, University of Sannio, Italy
Lilli Gargiulo, DICEA, University of Naples Federico II, Italy
Adriana Galderisi, DICEA, University of Naples Federico II, Italy
Rosa Anna La Rocca, DICEA, University of Naples Federico II, Italy
Giuseppe Mazzeo, ISSM, National Research Council, Italy
Enrica Papa, University of Amsterdam, Netherlands

LOCAL ADMINISTRATIVE TEAM

Gennaro Angiello, TeMA Lab, University of Naples Federico II, Italy
Gerardo Carpentieri, TeMA Lab, University of Naples Federico II, Italy
Stefano Franco, TeMA Lab, University of Naples Federico II, Italy
Laura Russo, TeMA Lab, University of Naples Federico II, Italy
Floriana Zucaro, TeMA Lab, University of Naples Federico II, Italy

EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

−   Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;

−   Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;

−   Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

TeMA

SMART CITY
PLANNING FOR ENERGY, TRANSPORTATION AND
SUSTAINABILITY OF THE URBAN SYSTEM
Special Issue, June 2014

Contents

TeMA
Journal of
Land Use, Mobility and
Environment

TeMA

TeMA
Journal of
Land Use, Mobility and
Environment

TeMA
Journal of
Land Use, Mobility and
Environment

TeMA
Journal of
Land Use, Mobility and
Environment

TeMA
Journal of
Land Use, Mobility and
Environment

TeMA

Journal of
Land Use, Mobility and
Environment

TeMA

DEALING WITH RESILIENCE CONCEPTUALISATION

FORMAL ONTOLOGIES AS A TOOL FOR IMPLEMENTATION OF INTELLIGENT GEOGRAPHIC INFORMATION SYSTEMS

GIAMPIERO LOMBARDINI

Dipartimento di Scienze per l'Architettura - Università degli Studi di Genova
e-mail: g.lombardini@arch.unige.it

ABSTRACT

The paper addresses the issue of the representation of the concept of resilience (urban, environmental and landscape resilience) in the context of geographic information systems. In the current technical and scientific debate, resilience is configured as an intrinsic property of a system to switch from one equilibrium state to another without losing its basic internal structure, also definable in terms of "identity." The paths to success or stable growth as well as those of continuing and recursive crisis, although already explained in macroeconomic terms through the mechanisms of accumulation and multiplication (cumulative advantage), are also interpreted in terms of resilience. So, in the field of studies on spatial planning, the concept of resilience became particularly significant in an era characterized by great instability of social systems, deep economic and environmental crisis. In the process of urban and regional planning, conceive the development of an urban region in terms of resilience means using the logic of complex systems and then adapt in this way their methods of knowledge representation. The concept of resilience is multi-dimensional and vague, so its conceptualization is complex. The formal ontologies can be a useful tool to orient geographic information systems towards more complex forms of knowledge representation and to adapt them to the requirements of logic and formal complex systems, such as today's urban regions.

KEYWORDS

Resilience, Formal ontology, Geographic information systems, Knowledge representation

1   INTRODUCTION

In ecological and socio-ecological studies, resilience can be understood as the ability of a system to acquire multiple equilibria: the resilience is presented as an intrinsic property of a system that allows itself to switch from one equilibrium state to another without losing its internal critical structure, otherwise definable also in terms of "identity" (Berkes *et al.* 2003). The paths of success and / or stable growth of a region or a city as well as those of continuing crisis, although already explained in macroeconomic terms through the mechanisms of multiplication (cumulative advantage), can also be interpreted in terms of resilience capability of a system, demonstrating at the same time the link between economic vulnerability, resilience and development trajectories.

Speaking of that particular type of complex systems that are urban regions, it looks like they confront with two main categories of disturbances: sudden shocks and slow processes of change. The first were much more studied (Carpenter *et al.* 2001). Most of the literature on disasters suggests that, in cases of disturbance even intense but rapid, urban regions tend to recover with relative speed the pre-shock status, without remain structurally transformed. By this way, the analysis of resilience may be restored in the field of studies on systems with stable or evolutionary equilibrium. What is interesting in these cases is whether the population and economic growth, for example, have resumed their growth rates within a few years after the event. On the contrary, a system is considered as not resilient when it is unable to resume its original trajectory.

The slow changes, on the contrary, are observed in systems in gradual but steady transformation, systems that can considered out of equilibrium condition. Under these conditions (which include cases of protracted crisis), the institutions have to do with continuous changes in periods of shortage of resources. In such situations, the focus is not on equilibrium condition and stability, but on the ability of the system (included institutions) to adapt to change and to preservation the local identity. This approach in the study of regional resilience (recently in: Berkes *et al.* 2003; Folke *et al.* 2010) which can be defined "evolutionary", resumed conceptual models developed in the framework of studies on socio-ecological systems.

The concept of resilience seems to be particularly useful in the context of (spatial) planning, also when it is applied to territories and coastal regions. These in fact are areas that are particularly vulnerable, subject to continual mutations (generated both by natural forces to strong pressure from human activities, which often tend to be concentrated in these regions), traumatic and often leading to a spatial framework in constantly improvement. The study of the resilience of coastal zones and regions involves the need to build formal models of analysis and interpretation of the territorial changes that are consistent with a complex and evolving conceptualization.

These models can be implemented within geographic information systems. The fact that the concept of resilience is inherently multidimensional (within the territorial model must find their place natural components, socio -economic ones, symbolic ones), involves the need to equip the information systems of models for knowledge representation both evolutionary and complex. In order to convert these systems in information models for decision support systems, it is essential that the process of conceptualization of resilience is incorporated into the knowledge bases, starting from the metadata and ending with complex systems of indicators. With a complete set of indicators it is possible to build global scenarios of change by which to assess the impact of different actions (or inactions) and policies in the urban and environmental context.

634   TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

2 RESILIENCE AND ITS CONCEPTUALISATION

2.1 DEFINITIONS

It is now widely recognized as the most complete development of the concept of resilience is derived from studies of ecology, subsequently extended to the integration of the ecological component with the social component. However, upstream of the definitions given in the environmental field lie, the definitions of physical and engineering fields, according to which resilience is the property of a system to maintain its stability with respect to a stationary state of equilibrium initial presumed. In these cases, the focus is on the ability of resistance to a disturbance, and on the capacity of return to the point of initial equilibrium. In this field of study, the interest and the attention are on systems with a single equilibrium. This concept of "resistance" (rather than "resilience") tends to dominate still currently in the field of psychology and studies of disaster. The studies of the responses to disasters tend to understand the engineering version of resilience, linking resilience to the concept of vulnerability. The analysis (directed to the formation of policies) focuses on the likelihood that a catastrophic event could cause a systematic set of physical consequences (errors and damage), loss of lives, property and social support networks to neighborhoods, cities or regions. Orienting studies on the medium-long term, studies of disaster try to measure the resistance as a form of learning that allows an urban system of "catch up" in terms of population, economy, or built forms (Vale and Campanella 2005) after a traumatic occurrence. The resilient city, in this view, would be able to resume its previous growth trajectory after an event that has caused a delay.

Further studies have also investigated the ability of a system to acquire multiple equilibria: in these cases, the resilience is presented as an intrinsic property of a system that allows it to switch from one equilibrium state to another without losing its basic internal structure, otherwise defined also in terms of the "identity" (Berkes and Folke 1998). Recent work in institutional economics and macroeconomics are focused on trying to explain the behavior under stress of multi- equilibrium systems. The paths of success and / or stable growth as well as those of continuing and recursive crisis, although already explained in macroeconomic terms through the mechanisms of accumulation and multiplication (cumulative advantage), can also be interpreted in terms of the resilience of a system. In these cases the size of the systemic phenomenon allow give an interpretation of how the links between the economic system and institutions can affect strongly on a trajectory of development (cases of recursive accumulation in which tend to reproduce consistently the factors of success or failure that became self -sustaining).

In the economic field is therefore clear the link between vulnerability, resilience and developmental trajectories. Within the vulnerability concept, in particular, we can identify two characters determinants: in one hand a kind of "structural" vulnerability, which derives from the characteristics of the organization and the structure of space infrastructures and in other hand a "systemic" vulnerability, instead attributable to the characteristics of relationships between the components of the system. The common element among the studies in ecology and those in the economic field is the size of a systemic analysis. No less interesting is the vision to which these studies are leading: an evolutionary interpretation of change (economic in this case, but this concept can be extended easily to the general field of urban studies).

In general terms, the urban regions (understood at this point as "complex systems"), have to face two major categories of disorders: the sudden and deep shocks on one side and slow and incremental processes of change, which usually are interpreted as discrete event or series of events. The first (shock) have been far more studied, especially natural disasters (Carpenter *et al.* 2001).

635 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

Most of the literature on disasters suggests that, in cases of disorders intense but still rapid, urban regions tend to recover relatively quickly in pre-shock state, without great signs of structural transformation. This recovery mechanism to a state of pre-shock lead back the analysis of resilience in the field of studies on systems to stable equilibrium. What is interesting in these cases is whether the population and economic growth, for example, have resumed their growth rates within a few years after the event. A not resilient system (vulnerable system), in these cases, is the one that is unable to resume its trajectory.

2.2 RESILIENCE: THE EVOLUTIONARY APPROACH

The slow changes, on the contrary, are observed in systems in gradual but steady processing, systems such these are probably long out of equilibrium. Under these conditions (which may conditions of gradual improvement, but much more easily deterioration), the institutions have to confront with continuous changes in periods of scarcity of resources. In such situations, the focus is not on equilibrium state but rather on the ability of the system to adapt itself to change and preservation of identity. This approach (recently in: Berkes *et al.* 2003; Folke *et al.* 2010). In this field of study are relevant and are then analyzed those internal processes to a system that allow it to undertake adaptive strategies with respect to the disturbances coming from the extern context, even though these will constantly bring in "danger" the internal structure, inducing a continue process of modification. Already ecologist Holling (1973, 2002) defined ecosystem resilience as the ability of the system to generate and regenerate internal reorganization by way of change management and institutional capacity in order to maintain the same identity, structure and functions. Focusing on identity and structure of the systems, this new idea of resilience explain better the evolutionary trajectory of a system: not only the stability characteristics of the components of the system are decisive (e.g., population , economic activities, fixed social capital), but rather the ability to remain "vital", passing from a state of equilibrium (unstable) to another (more stable). In this perspective, studies on resilience intercept similar experiences in the so called "science of complexity", with interesting analogies with concepts such as self- organization, co-evolution and non-linear behavior (Levin 1999). Along this line of thinking, adaptability and transformability are the two main characteristics that a system (especially if pre-existing conditions of crisis) have to confront with external events: through these two features resilience manifests itself as a form of learning, structural renewal and reorganization.
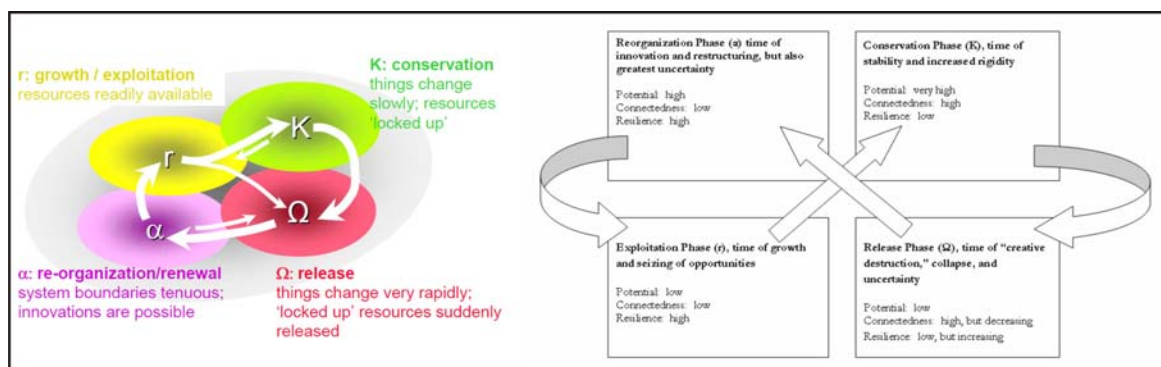
Fig. 1 Resilience phases in a cyclic vision

The potential of resilience is different in the different phases: it is lower during periods of conservation or collapse (due to the specialization and consequent loss of the system in terms of response capacity: in these cases the system in "locked-in"), while it is higher in the early stages of growth and reorganization.

636 TeMA Journal of Land Use Mobility and Environment INPUT 2014   *Eighth International Conference INPUT - Naples, 4-6 June 2014*
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

According to this model, the disturbance or the shock are a necessary part of the development as they produce change through learning and self-organization. It should be emphasized that in this model the level of connectivity of the system takes different measures with respect to the reverse potential of resilience, being highest in the early stages of growth and preservation and minimum during the collapse and reorganization phases.

In recent years many cases study (Tidball *et al.* 2010) have demonstrated that as well as in cases of traumatic events that have affected physical settlement (e.g.: Hurricane Katrina in New Orleans), social and institutional learning has been crucial in the recovery urban structure. In some cases social learning is coming first (or even in contrast, initially) engineering intervention (excluding the operations of first responders: Peling 2003).

The new conceptual models of ecological and systemic resilience provide an important contribution in the study of regional trajectories, defining a new determinant: redundancy. In fact, in resilient ecosystems, redundancy is represented by the abundance of different function, preferably spatially distributed. This model seems to describe a new model of ideal city (that in fact, maybe it is already partly in reality (and which still represents a possible scenario): a porous city, with many functions distributed in space and with different levels and gradients of intensity (of uses) and density. Thus, the decentralization of many functions such as the provision of distributed services, it can express a high potential for resilience (Vale and Campanella 2005). From this perspective, moreover, the resilience expresses a strong relationship with the ecological vision represented in the patterns of connectivity, as well as some recent achievements in the field of urban economics and regional (Hassink 2009).

2.3 RESILIENCE ASSESSMENT

The resilience of an urban region can be interpreted as an evolution of the concept of sustainability. Resilience encompasses the way in which we face change. As explained above, the more substantial definition of resilience descend from ecology. Ecological definitions of resilience include "the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior" (Gunderson and Holling 2002) and "the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity" (Walker et al., 2006). So, sustainability includes the capacity to create, test and maintain adaptive capability, whereas development is the process of creating, testing and maintaining opportunity (Holling 2001). Sustainable development can thus be defined as development which fosters adaptive capabilities and creates opportunities to maintain a desirable social, economic and ecological systems (Holling 2001; Folke *et al.* 2002a; Folke *et al.* 2002b). Put another way, resilience can be seen as a necessary approach to meet the challenge of sustainable development.

Resilience can be interpreted as a cycle process, subdivided in four phases (conservation, exploitation, collapse, reorganization). To explain systems evolution in terms of cyclic growth, conservation, collapse, and reorganization we can use a heuristic similar to that of Gunderson and Holling (2002). In a regional system we can note patterns of growth (development of each phase), persistence (of each phase due to recovery capacities), collapse and renewal (in terms of strategic technical innovation and adaptations that allow progression from one phase to another). Persistence is the capacity (within each phase) to protect the system (using preventive adaptations), respond to any unexpected hazard, recovering and avoiding changes in order to keep functions and structures. Re-organisation is recognisable when innovations in subsystems structure or functioning are used to adapt changes stepping from one configuration (phase) to a different

637 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

one when thresholds come closer and the existing structure can no longer afford to keep systems functional. Learning process represents the increasing capacity of managing systems that move between persistence and re-organisation strategies, conferring sustainability to the system.

The evaluation of the degree of resiliency (or, conversely, of vulnerability) of an urban region can be conducted through formal models that express the fundamental characteristics of that region and consider their temporal trends, under the influence and impact of factors of change or crisis. In a similar way to what happens in models of sustainability assessment, a practical method of approach to this issue is the construction of frameworks of indicators. Through the indicators it is possible not only to measure the time course of the resilience and adaptability of an urban region, but also provide an overview of the strengths and weaknesses on which act to increase the degree of resilience.

Humans have influenced most of the Earth's ecosystems and shaped or created landscapes through activities that profoundly affect biodiversity and ecological processes. In many landscapes, people and nature have co-evolved over centuries or millennia, creating unique bio-cultural systems. As human societies have often led a process of co-evolution with nature, changing and adapting landscapes around them, the concept of resilience (and indicators associated with it) is to assume the characteristics of a holistic assessment of the man-environment relationship and its evolution over time.

3 FORMAL ONTOLOGIES AS A TOOL FOR KNOWLEDGE REPRESENTATION

3.1 FORMAL ONTOLOGIES

Ontologies are logical-semantic schemes that represent the complex structure of the world. Formal ontologies have been originally elaborated in order to build thesauri and dictionaries. To this purpose they can linked to semantic networks and usefully employed to build logical models of restricted domains (Gruber 1993). Basic elements of a formal ontology are the classes (taxonomies), the axioms, the instances and the relationships (Guarino 1998). Every class or category in a formal ontology is defined by a set of features and labels with possible restrictions useful to restrict the heredity relationships. By means of tassonomies we can express heredity relationships among different categories. Axioms are statements that define concepts more precisely. Instances represent occurrences of the different elements of a particular category.

In information systems (and in particular in expert systems and decision support systems) a formal ontology can be used to different aims such as reasoning, categorization and problem solving. In these cases the formal ontology is particularly useful to organize a delimited knowledge domain, because it permits to order concepts and the relationships among them (Frixione 2013).

In this sense formal ontologies make it is possible to represent that fundamental function of reasoning consisting in categorization (classification). In the field of knowledge representation another important possibility deriving from the formal ontology application is its capability of solving ambiguity cases in human language (Evans, 2008). In an ontological model of data the classes are sets, collections, or types of objects with the same characteristics or belonging to the same "species". The classification can proceed according to top-down models (requires expert knowledge and methods to share) or second bottom-up modeling (need a "reasoning engine" that brings together objects in a logical manner according to criteria of similarity). Attributes are properties, features or parameters that objects belonging to different classes may have and share; relationships are the ways that objects can be related with each other; the individuals are instances of the model (they are the basic elements of a system). In an ontological model of structured data we can found two fundamental kinds of relationships: logical and topological. The logical-semantic relations are the

638 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

synonymy (in the case of elements that are equal); antonymy (opposite, but not bidirectional relations); hyponymy / iperonymy (IS-A hierarchy), mereonymy (which corresponds to the "is part of" relation and defines the cases in which we found the corrispondence: components / member / particle). The topological relationships are: disjoint, meet, overlap, inside, contains, covers, coverde by, equal (Baader *et al.* 2010).

3.2 FORMAL ONTOLOGIES AND GEOGRAPHIC CATEGORIZATION

Also in the case of information systems and data base concerning the geographical world, formal ontologies are useful. In geography, building a domain ontology is something different than creating a thesaurus, even if it could include this function. This is also true if we enter the field of geographical ontologies. With regard to geography (and above all in town and country planning or in action oriented to landscape studies), there are two fundamental causes of difference.

– Geographical objects have uncertain and vague boundaries because of their inherent spatial and topological features;

– A lot of objects (or concepts) doesn't always find a corresponding term in human language, even if they can be recognizable and identifiable.

With regard to the first item, it can be asserted that many (or most) geographical objects have uncertain boundaries. This is true even for common use terms, which in reality avoid precise definitions. Conventions come into play that are the result of common consent among domain experts: in this case the geographers community. Nevertheless, there are many cases where experts have difficulties in finding a linguistic consent in any way (Smith and Varzi 2000).

With regard to the second item we can take the example of landscape. It is very easy to find situations where according to our "perceptions" we classify it, by dividing it in a range of different geographical parts and places, which are all different and qualitatively distinct. In fact not all these parts have a corresponding term that expresses every concept in a common consent language (Guarino 2009).

With regard to geographical concepts (with some fundamental differences from other domains that build knowledge of natural and artificial worlds) ambiguity cases are more uncommon, whereas matters referring to linguistic consent are more substantial. Linguistic consent is the most important question to solve these cases. This means that in the field of information systems and knowledge representation there is an interoperability problem that is a problem of communication among different information systems as well as between every single information system and human operator.

4 RESILIENCE MODELLING AND REPRESENTATION

4.1 A LOGICAL MODEL FOR RESILIENCE REPRESENTATION

In the construction of environmental information systems during the input phase, the use of logical and computational models derived by computer science (defined in artificial intelligence "knowledge representation") can be very useful. Semantic networks or frames represent examples of this kind of conceptual models. In recent years the logical models based on ontologies spread. In computer science, an ontology is a formal and explicit specification of a shared conceptualization. The "specification of a conceptualization" is a description of the knowledge we have of a certain domain, using classes, relationships between classes and individuals belonging to classes. Ontologies allow to represent semi-structured data. In contrast with structured data that are stored in a rigid format, such as tuples of tables in

639 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

a "model entity / relationship", the semi-structured data format are represented by a tree graph or structures that have the potentiality to vary with respect to a pattern assigned. For example, they may be missing some attributes, as for example some branches of the tree, because the order of the associated schema allows a high degree of freedom of adherence in terms of completeness and spelling. This scheme can also be an implicit part of the data and ask for a later definition. Finally, because of the requirements to handle the heterogeneity of the data, it is often much more extensive and variable in time when compared with the patterns of relational databases. The basic elements of each logic model based on ontologies are concepts and rules. The first are the classes, the latter are used to specify the properties of classes. Each concept is interpreted as a subset of the domain of interpretation (the set of instances of the concept), and each role can be interpreted as the binary relation on that domain (Levy 2000).

In the present case, the ontological model has allowed to pass from the meta-data elementary, that is primary indicators representing the main thematic field: natural capital, human settlements and cultural heritage, to semantic structures of data that allowed to represent the different components of the model in spatial form, according to a scheme which for each component identified, elements that characterize the specific component (structure), the vulnerability factors (related to the nature of the phenomenon), the possible alterations that may be induced by human activities, the values assigned to a specific environmental, anthropic or cultural state of the phenomenon.
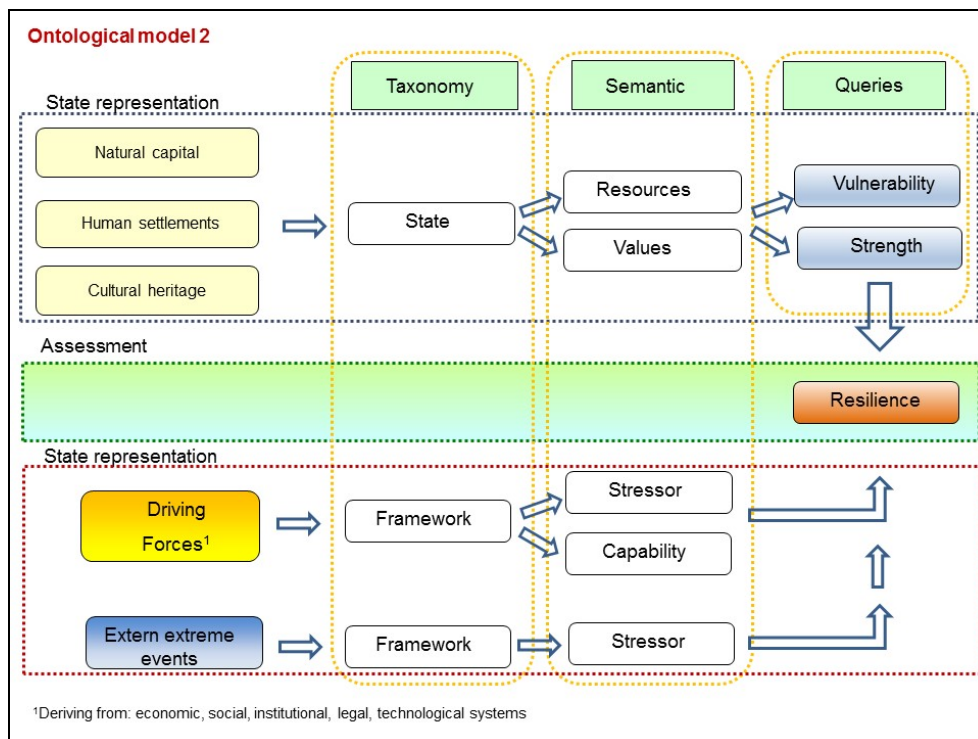
Fig. 2 Ontological model schema to represent the resilience conceptualisation

4.2 THE CASE STUDY: RESILIENCE ASSESSMENT IN A COASTAL ZONE (TIGULLIO – LIGURIA)

The case study concerns the territory of the coastal zone of "Tigullio", a maritime gulf situated in the east part of Liguria (but the methodology could be extended to other cases, because of the problematic of knowledge representation are similar). The territory can be represented in three fundamental systems: the natural capital, the human settlements and cultural heritage, that is the sedimentation of built up signs

640 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

during the historic process of "territorialisation". The territorial context is characterized by a specific spatial structure, a set of environmental infrastructures and, in an holistic vision, by an unique identity landscape. Each of these systems are composed by a set of elements (individuals, in an ontology language), and each element in characterized by a set of specific and variable attributes.

The construction of the evaluation model based on ontology has occurred by means of the Protégé software, developed by a research group of Stanford University. This software allows, through its graphical interface and its logic, to process information models and knowledge bases from ontologies originally developed in the OWL language.

In order to assess the resilience of the urban region of Tigullio, in the conceptual model used it has been essential represent the territory in three different states: natural capital (i.e. the set of natural resources), the anthropic settlement and cultural heritage (consists of physical elements of material type, but which are characterized by specific symbolic values). For each "state" then we have proceeded to the construction of an ontology, which took over from time to time typical forms of a tree (Eco 2014) that is the normal knowledge representation model in this kind of model. The software, however, also allows a graphical display of the objects that are being organised in the ontology. To proceed with the construction of the ontology of each "state", prompted by the logic OWL (which is also elaborated by Protege) to split the first domain of knowledge in classes and subclasses (each subclass then inherits the attributes and properties of the upper classes). OWL classes are interpreted as sets that contain individuals. They are described using formal mathematical) descriptions that state precisely the requirements for membership of the class. Classes may be organised into a superclass-subclass hierarchy, which is also known as a taxonomy.

The second step in the elaboration of ontology has been time the construction of property set. These properties, similarly for the classes and subclasses, can be arranged in a hierarchy. OWL Properties represent relationships between two individuals. There are two main types of properties, "Object properties" and "Datatype properties". Object properties link an individual to an individual. Datatype properties link an individual to an XML Schema Datatype value or an rdf literal. Properties are prefixed with the word 'has', or the word 'is'. Properties may have a domain and a range specified. Properties link individuals from the domain to individuals from the range.

Finally , the last step to build the ontology is constituted by populating the ontology itself with specific individuals. Protégé is a tool to logically organize the concepts and relationships that relate them to each other, but obviously has no analytical functions or spatial representation of the data. For this reason it was necessary to develop a system of communication between the data organized in logical form within the knowledge bases developed in Protege with a geographic information system outside (in the case study it has used an open-source software: QGIS). The connection between the two software has been built by the union of the data tables. In this sense, the construction of the ontology (which is an ontology of spatial type) has allowed a bi-directional flow of data, in the sense that sometimes the queries constructed with GIS, have formed the basic elements to define classes and properties within Protege. This phase of the work, conducted as a final result in the construction of a series of maps, which represent in a structured way the three "states" on which it has been built then the assessment.

In our ontological model of data classes, relations and attributes contribute to formation of the taxonomy of a certain environmental or anthropic phenomenon. Properties instead define the semantic structure of the knowledge base. At this step, new complex concepts emerge: with an organization of knowledge based on taxonomies defined by class hierarchy and properties, the recognition of individuals (by the way of integration of Protegè with geographical information system) brings to the emergence of a new level of

641 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

knowledge: the semantics of the system. In the case of study, from the built taxonomies emerge a semantic level that define two new concepts: resource and values. The first ones concern the physical state of environment, settlement or heritage the second ones define their value in terms of rarity, dimension, localization and so on. The terms of "resource" and the term of "values" define new maps that are maps of geographical values (and not only maps of distribuited objects).
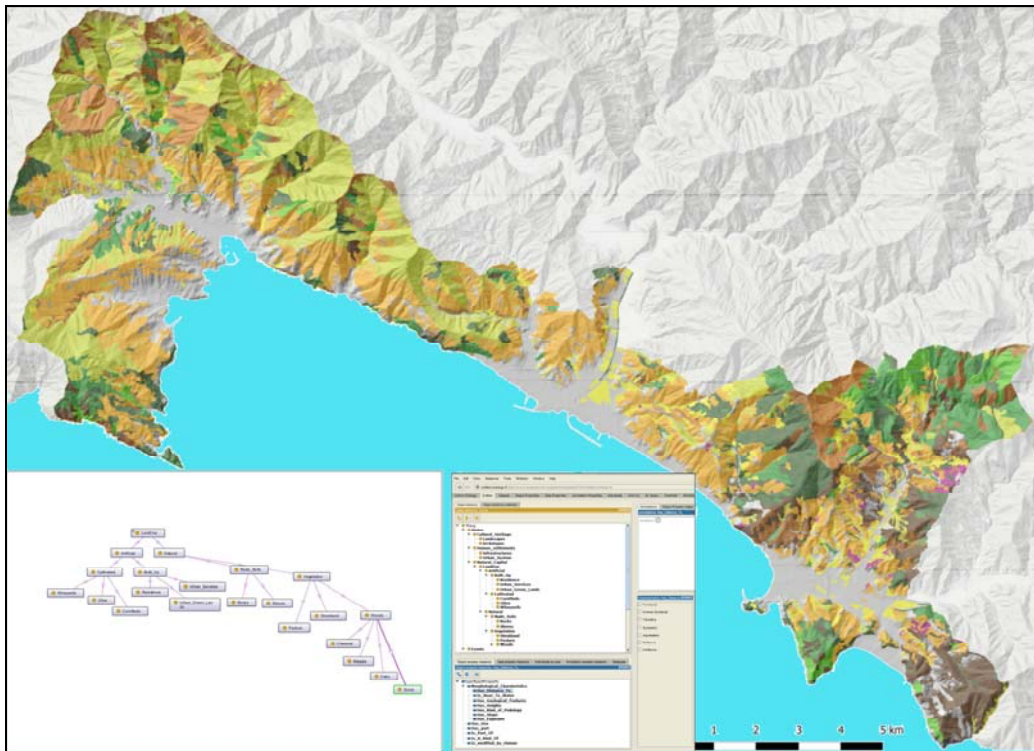

Fig. 3 A land use map built on the basis of a taxonomy (ontological organization of data)

Finally, queries define the intrinsic characteristics of resources and values: so the geographical map set of vulnerability or strength in done (Hagen-Zanker 2006; Maguire *et al.* 2005).

In a following step the set of anthropic actions defined within a framework of "stressor" (due to building and use of artificial infrastructures and manufacts and, more in general, to human activity) or "capability" (in the case of increasing of safety and wealth) are considered to reference to their impact and effects on originally state components. In this step it is possible to build the map of weakness (or critical areas) and then a set of map of resilience indicators. The analysis of impacts and actions generated by human factors or external events of natural type (especially extreme weather events), built with models of spatial type (so that it is possibile determine the location of the impacts themselves) leads to the construction of maps of criticality and capability. These results are obtained, from a logical point of view, with the same methodology used for the analysis of "states": that is through the construction of an ontology. In this case is an ontology of events (actions that can be created by anthropogenic or natural events, often the result of cumulative impacts). Even for the events has been constructed ontology built from their preliminary division into classes (in this sense it has been adopted the use of logic and topology) and subsequently awarding the properties to classes. The results of logical queries to databases so constructed has allowed to obtaining maps of criticality and capability. The overall assessment, that represent the formal outcome of the last logical step of the assessment model, was obtained through the processing of spatial queries to the two data sets: the "states"

642 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

and "events". The queries are the means by which it was possible to construct a first set of indicators useful to specify the concept of resilience for the area under study. Each indicator has a temporal dimension: in this way, it is possible to construct scenery maps that can represent the evolution of the regional system with respect to possible change determined by traumatic events or incremental trajectories alteration and variation.

5   CONCLUSION

The construction of a single logical system for descriptive environmental, anthropic and cultural data permit to achieve some results. The first is reducing the complexity resulting from very large databases. The second was to be checked at each step the set of relationships that relate each other but interrelated phenomena so difficult to be synthesized. It has also permitted to make a set of indicators to describe the resilience and its trajectory I during the time. The model permit to evaluate forces and constraints of potential changes. This framework, with data derived, can be useful in the perspective to build a support system decision model, by that assess the choices for regional spatial and environmental planning. Finally, it allowed to organize knowledge in a way that would be represented spatially (key issue since the evaluation must be anchored to the geographical space).

REFERENCES

Baader, F., Calvarese, D., McGuiness, D., Nardi, A.,Patel-Schneider (2010), *The Description Logic Handbook: Theory, Implementations and Applications Readings in knowledge representation*, Cambridge U.P., Cambridge, MA.

Berkes, F., Folke, C. (1998), "Linking Sociological and Ecological Systems for resilience and sustainability," In id.. *Linking Sociological and Ecological Systems: Management practices and social mechanisms for building resilience*, Cambridge University Press, New York, 1-25.

Berkes, F.; Colding, J., Folke, C. (2003), *Navigating Social-ecological systems: Building resilience for complexity and change*, Cambridge U.P., Cambridge, MA.

Caragliu, A., Del Bo, C., Nijkamp, P. (2009), "Smart cities in Europe", *Proceedings of the 3rd Central European Conference in Regional Science*.

Carpenter, S., Foley, J.A., Folke, C., Walker, B. (2001), "Catastrophic shifts in ecosystems", *Nature* 413(11), 591-596.

Eco, U. (2014), *From the Tree to the Labyrinth. Historical Studies on the Sign and Interpretation*, Harvard UP, Cambridge, MA.

Evans, J.S.B.T., Frankish, K. (2008), *In Two Minds: Dual Processes and Beyond*, Oxford U.P., New York, NY.

Folke, C.; Hahn, T.; Olsson, P., Norberg, J. (2005), "Adaptive governance of social-ecological systems", *Annual Review of Environment and Resources*, 30, 441-473.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T., Rockström J. (2010), "Resilience thinking: integrating resilience, adaptability and transformability", *Ecology and Society*, 15(4), 20.

Frixione, M., Lieto, A. (2012), "Representing Concepts in Formal Ontologies: Compositionality vs. Typicality Effectes", *Logic and Logical Philosophy*, 21, 391-414.

Gruber, T.R. (1993), *Toward principles for the design of ontologies used for knowledge sharing*, Technical Report KSL 93–04, Knowledge Systems Laboratory, Stanford University, Stanford, CA.

Guarino, N. (1998), "Formal Ontology in Information Systems", *Proceedings of FOIS'98*, IOS Press, Amsterdam.

643 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System

Guarino, N. (2009), "The Ontological Level: Rivisiting 30 Years of Knowledge Representation", *Conceptual Modeling: Foundations and Applications*, 52-67.

Gunderson, L.H., Holling, C.S. (eds.) (2002), *Panarchy: Understanding Transformations in Human and Natural Systems*, Island Press, Washington D.C.

Hagen-Zanker, A. (2006), "Map comparison methods that simultaneously address overlap and structure", *Journal of Geographic Information Science*, 17.

Hassink, R. (2009), "Regional resilience: a promising concept to explain differences in regional economic adaptability?", *Journal of Regions, Economy and Society*, 1-14.

Holling, C.S. (1973), "Resilience and stability of ecological systems", *Annual Review of Ecology and Systematics*, 4, 1-23.

Komninos, N. (2009), "Intelligent cities: Towards interactive and global innovation environments", *International Journal of Innovation and Regional Development*, 1(4), 337-355.

Levy, A.Y. (2000), "Logic-based techniques in data integration", in Minker J., *Logic-based Artificial Intelligence*, Kluwer Academic Publisher, 575-595.

Maguire, D.J., Batty, M., Goodchild, M.F. (2005), *GIS, Spatial Analysis, and Modeling*, ESRI Press, Redlands, CA.

Pelling, M. (2003), *The Vulnerability of Cities: Natural Disasters and Social Resilience*, Earthscan, London.

Smith, B., Varzi, A.C. (2000), "Fiat and Bona Fide Boundaries", *Philosophy and Phenomenological Research*, LX(2), 401-420.

Tidball, K.G., et al. (2010), "Stewardship, learning and memory in disaster resilience", *Environmental Education Research*, 5, 591-609.

Vale, L.., Campanella, T.H. (2005), *The Resilient City: How Modern Cities Recover from Disaster*, Oxford University Press, New York.

Berdini, P. (2008), *La città in vendita*, Donzelli, Roma.

IMAGES SOURCES

All schemas in this paper has been elaborated by the author. Maps have been elaborated within the PRIN Research Project Prin_2010PEA4H8-005, Univerity of Genoa Unit (coord. Prof. R.Bobbio). Subject of research: "The coastal landscapes. Reduce vulnerability and increase resilience".

AUTHORS' PROFILE

Giampiero Lombardini

Giampiero Lombardini, Architect and Planner, is Doctor of Research in Urban and Regional Planning (Italy, 2001). He is Assistant Professor at the University of Genova (Sector ICAR/20). Fileds of interests are urban and regional planning, landascape planning and environmental managment, GIS, spatial support systems, Strategic Environmental Assessement. He is presently the Official Professor of the Module of Urban Planning at the Department of Architectural Sciences of the University of Genova.

ACKNOWLEDGEMENTS

644 TeMA Journal of Land Use Mobility and Environment INPUT 2014

Eighth International Conference INPUT - Naples, 4-6 June 2014
Smart City - Planning for Energy,
Transportation and Sustainability of the Urban System