

# Earthquake, urban form and city planning: research perspectives

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## Abstract

*The study on the seismic vulnerability of cities and urban fabrics, referring to the susceptibility to the loss of a city's organization during an earthquake, has become a scientific field which for some time now has acquired own particular specificity, and which involves different research lines and experimentalities in the broad area of the sciences on the relationship between earthquakes and human settlements. This is due to several different reasons.*

*Firstly, building vulnerability in a settlement and the intrinsic vulnerability of the urban structure have been considered for a while to be closely inter-dependent and complementary, and that the appropriate approach to their study should begin from basic hypotheses and concepts which are quite different.*

*In particular, the studies on a town's seismic vulnerability mainly depend on a series of factors directly linked to the different underlying content and approaches which are, in fact, from a different point of view, the features of the urban-planning discipline. These factors are mainly linked to the concepts of urban structure and urban fabric, concepts which have always been of key importance in the study and design of urban form.*

*Concerning the above, at the present moment in Italy, some principal fields of experimentation and research can be identified, regarding the relationship between earthquakes and towns.*

*The aim of this paper is to present an overview of the main points of the most important of the research lines, briefly discussing their respective content and specific features. Therefore, a brief but specific detailed study will be made, based on a "field" experience currently being carried out in the town of Bevagna in the Umbria region. It is a case where the seismic vulnerability study of a town is being conducted simultaneously with a study regarding the appropriate integrating of urban-planning and regional tools. Finally, some important development and research lines will be outlined, where specific perspectives for refining the studies and tools will be highlighted.*

## 1. Seismic vulnerability of the city and urban form

On a properly urban scale, the "response" of a town to a seismic event depends also on the many features and condition of the town's buildings. But firstly, the features and layout of the settlement are of key importance in these situations, and they can be linked to the concepts of *urban structure* and *urban fabric*, key concepts in the study of towns and urban design.

The concept of *urban structure* has been defined and dealt with by many authors in the history of urban-planning, and on the basis of extremely different viewpoints and approaches. The main recurring and important meaning, and which is also of particular interest concerning the studies on urban seismic vulnerability, selectively refers to a system of places – poles and connections – of *primary importance* in a town. Therefore, it is a selective and targeted concept, intended to bring out what are the most "important" aspects (from a morphological, perceptual, functional and important urban viewpoint) and to highlight a clear hierarchy regarding the underlying elements of urban form.

From the specific point of view of urban seismic vulnerability, the elements that can be defined as "priorities" and crucial in an urban structure, that is places and connections of primary importance, may be quite different in nature. They may include strategic structures, different areas important for

civil protection targeting, sites and building complexes with special functions, the town's main sites, entry points, etc.. At the same time, the connections of primary importance may be very different in nature including main thoroughfares of different degrees of importance, main technological networks of different types, etc.. In any case, the concept of *structure* allows for highlighting, selectively and hierarchically, the many different features – and problems – of the system of places and areas, of the buildings and urban connections that are of special and particular importance where the response of a seismic-risk town is concerned. This is both in terms of urban vulnerability and the usability and practicability of the urban space in an emergency, requiring maintenance and care, reducing or eliminating problems, continuously strengthening and adapting the capabilities to recover after the event.

Besides the concept of urban structure, other concepts directly linked to a town's seismic vulnerability concern the morphology of the settlement, the pattern of its building "fabric". The layout and density of the building fabric, the size and proximity to each other of its buildings, the size and morphologic "grain" of the construction elements, influence, differently and in many ways, the response capability of a seismic-risk town.

At the same time, still considering the issue of seismic vulnerability from an urban-planning viewpoint, the need arises to ensure that the regional and urban planning tools are able to translate earthquake vulnerability mitigation into the appropriate laws and regulations, and into comprehensive provisions and action plans, as well as, into urban recovery projects in line with the content and procedures of the plans forecasted by the legislation.

In this case, a dual and basic problem arises, typical of regional and urban planning. Firstly, how can the two integrate organically the studies and regulations on urban seismic vulnerability when, already, many and quite different plans exist (from the so-called “vast area” to the different single municipal plans). Secondly, how can the carrying out of these studies and regulations be divided, rationally and developmentally, into the different phases of drawing up and approving the urban-planning programs (procedures, which, moreover, may involve important differences among the different regions, with their different regional laws and regulations).

Therefore, the studies on urban seismic vulnerability, and the availability of plans and projects to reduce this vulnerability, underlie the concepts (and problems) that properly concern the urban-planning discipline, specifically regarding town morphology, urban design, regional and urban planning and regional legislation.

## 2. Earthquake and cities: main research fields

Thus, by limiting our focus to a specific urban scale, we can highlight that the studies and research on the relationship between earthquakes and the physical layout of a city can be mainly divided into four broad principal fields of research which are currently being carried out in Italy.

The first of these fields has been, for a while, the subject of a considerable and extended series of studies and involves the study of the *seismic vulnerability of urban and regional systems*. The researches have analyzed the regional seismic vulnerability on different scales and of different degrees, from regional and urban interdependence to municipal vulnerability, studying town centers and urban sectors, developing methods for data collection and interpretive analyses, as well as models and proposals for projects involving the application and study of different regional contexts.

A second important field of research involves analyzing a town's seismic vulnerability based on the concept of *urban structure*, specifically referring to the concept of *Minimal Urban Structure* (MUS)<sup>1</sup>, a now widely accepted and shared term in

1. [“Struttura Urbana Minima” (SUM)]. This expression is officially de-

the field of urban-planning. It is an analytical approach mainly based on urban design and linked to planning, analyzing a settlement's features and problems using specific structural analysis categories, developing planning actions on different levels for urban seismic vulnerability mitigation. Important studies have been carried out in this area of research and are being now carried out, particularly in the Umbria and Abruzzo regions. Valid research results underlie the text for important regional legislation (Umbria Region).

A third area of study concerns directly the relationship between the town's physical layout and emergency management in the case of an earthquake. It is research that deals with the analyses of urban layouts using methodologies of observation and interpretation typical of the urban-planning discipline, as well as a structural approach. However, its aim is to clearly attain the most appropriate conditions for a fully efficient action in the case of an emergency, and where these conditions depend on the town's structural layout and the efficiency of certain established elements (buildings, areas, infrastructures, building complexes). In this case, in Italy the development and application of analysis methods in the territory is made available by public Institutions (Department of Civil Protection).

A fourth important area of research and of a markedly inter-disciplinary nature, regards the relationship between the settlement vulnerability and the differences in the distribution of seismic movements in the urban area and in the earth itself.

In this context, the studies of *Seismic Microzonation* are aimed at individuating, on the right observation scale (typically municipal or sub-municipal), the geological and geo-technical conditions that can cause important variations in the seismic movements in the area (especially with “amplification” effects), or can produce an instability or permanent ground strain or displacement. In this specific case, the planning and experimentation carried out have for some time provided results widely shared in the technical field, as well as regulations formalized into specific laws in the different regions and a standard and official definition of the survey methods and criteria to be used.

These are, of course, four macro-contexts with their reciprocal correlations and numerous mutual implications and ties, which, however, can be quite distinct as autonomous fields of research and experimentation, in this classification, based on concepts, methods and diverse issues.

In the following part of this paper, we will focus on the second and third of the two conceptual and research fields mentioned above, dealing with the areas where the complementarity between seismic vulnerability of the town's

finned, in particular and among other sources, in a regional official resolution of the Umbria region, as explained later in this article.

areas, urban morphology and regional and urban planning are more evident and significant.

These areas are characterized, respectively, by two main concepts (and operative tools): “Minimal Urban Structure” and “Limit Condition for an Emergency”.

As established in the “Guidelines for defining the Minimal Urban Structure” included in an official resolution adopted by the Umbria Region in 2010, the Minimal Urban Structure is the system of roads, spaces, urban functions and important edifices for the urban response to earthquakes in an emergency phase, and for the maintenance and recovery of normal urban activities, both economic and social, and the follow-up in the successive phase of the seismic event. Therefore, this structure is the fundamental system for the town’s response to the earthquake, also for dealing with the possible collateral chain events caused by the earthquake (fires, landslides, unstable sites and hydrogeological phenomena, etc.).

Thus, the Minimal Urban Structure is made up of all the elements of a town which are strategic from a functional and accessibility point of view (road networks, infrastructures, communication networks and their relative hubs, evacuation routes and safe areas, key functional hubs), but also those places linked to community identity, and productive and cultural functions which can play an important role in the town’s recovery. However, along with these elements, the relevant problems and critical aspects must be identified. These are the susceptibility to damage or loss of functionality arising from the physical damage of single factors or systems. This assessment is necessary to forecast the appropriate and gradual increase in the functioning of the structure, through actions and rules encompassed in the targeted urban planning and projects.

Different and appropriate field experiments have been carried out in different regions, while this tool was officially adopted in the legislation for the Umbria Region, where the 2005 Regional Urban-planning Law n.11 introduced in the “General Plan - structural part”, the individuation of the Minimal Structural Plan (MUS)<sup>2</sup> in order to reduce Urban Seismic Vulnerability<sup>3</sup>.

2. The 2010 Resolution n.164 of the Umbria Regional Junta contains a text regarding the “Guidelines for defining the Minimal Urban Structure (MUS) in the General Plan, to reduce urban seismic vulnerability” [“Struttura Urbana Minima” (SUM)], the result of a specific research by the Umbria Region and the Department of Regional and Town Planning of the University of Rome “La Sapienza” (coordinated by M. Olivieri), which in specifying the features and content of the study to be carried out on the MUS also underlined the importance of the relation between defining the MUS and planning, as well as the sequence of the operative phases for assessing the structure’s problems.

3. The 2010 Resolution n.164 of the Umbria Regional Junta defined *Urban seismic vulnerability* as the “susceptibility to earthquake damage and the loss of organization and functionality of an entire urban settlement”.

Instead, the concept of the “Limit Condition for an Emergency” describes the condition of an urban settlement where, also following the damage caused by an earthquake, should it result in the almost total interruption of urban functions, including residential, the operability of most of the strategic emergency structures, and their connections and accessibility to the regional context, would be, however, maintained. In other words, it is the “minimum” condition to overcome the emergency in the case of a violent earthquake, when all urban functions are interrupted, but the management of the emergency is maintained.

Research in this area has produced some results, such as the drawing up of operative analysis methods and also documents adopted and formalized by the Department of Civil Protection with rules and protocols already experimentally applied in different urban contexts. This institution has specifically prepared methods and standards of data recording in order to define the Limit Condition for an Emergency, identifying the following elements: buildings and areas guaranteeing strategic functions in an emergency, strategic infrastructures linking the town with the region and possible critical factors, urban aggregated fabrics or single structural units which can intervene in accessibility conditions.<sup>4</sup>

The present state of the studies, the experimentation and the institutional resolutions concerning, respectively, the Minimal Urban Structure and the Limit Condition for the Emergency highlight the close complementarity and similarities (and, at the same time, the various differences) of the two tools (Fabietti, 2013. Olivieri, 2013). The first specifically regards the design and planning aspect and is linked to the town’s morphological aspects, and the second is mainly linked to the essential emergency conditions. These differences and complementarities have been emphasized by different authors directly involved in important research in their respective scientific fields, and clearly highlight the diversity, but also the potential for further experimentation and integrating these tools in the future.

Some Italian regions, which have already experienced serious earthquakes in the last years, have actually become “laboratories” for research, experimentation and regional legislation regarding the relationship between earthquakes and urban settlements. Different organizations have coordinated the research including regional government institutions, universities and research organizations, using

4. A special “Technical Commission to support and monitor the Seismic Microzonation studies”, cross-institutional and located in the Civil Protection Department, set up by the Ordinance of the Presidency of the Council of Ministers n. 3907/2010 - “Contributions for seismic risk prevention programs”, prepared and formalized standards of representation and analysis of representation and recording of studies on Seismic Microzonation and analyses on the Limit Condition for an Emergency [“Condizione Limite per l’Emergenza” (CLE)]. [[http://www.protezionecivile.gov.it/jcms/it/commissione\\_opcm\\_3907.wp](http://www.protezionecivile.gov.it/jcms/it/commissione_opcm_3907.wp)].

and integrating the results attained into regional laws and different types of official measures.

### 3. Mitigation of seismic vulnerability and coordination of planning tools: the case study of Bevagna, Umbria

As previously mentioned, an important and significant case is that of the Umbria region, where the studies on the Minimal Urban Structure established the tools and procedures now defined by law for the General Municipal Planning tools, and, thus, already applied in different contexts.

As in other Italian regions, the Regional Urban-planning Law for the Umbria region (Regional Law n. 11/2005 as cited above) forecasts a general municipal plan divided into three basic parts and also phases (Programmatic Document, Municipal General Plan – structural, and Municipal General Plan – operative). A 2010 regional official resolution, containing specific “Guidelines”, establishes and explains the phases of drawing up the Minimal Urban Structure in a Municipal General Plan.

Bevagna is one of the municipalities in Umbria where the new general town plan was submitted in the drawing up of the Programmatic Document<sup>5</sup>, which contains schemes and evaluations for the Minimal Urban Structure. Currently (June 2014), the “Preliminary Consultation for the Strategic Environmental Evaluation<sup>6</sup>” is being carried out. The drawing up of the Programmatic Document, an important step in developing the Plan, occurred at the same time as that of a strategic plan (“Strategic Framework for the Valorisation of the Historical Center”) and a sector plan (“Civil Protection Plan”). This was an opportunity to provide for an effective integration of planning tools.

As far as the tools are concerned for urban earthquake vulnerability mitigation and the management of environmental emergencies, the Bevagna Municipal Administration raised again the opportunity of integrating the basic points of the Programmatic Document and the contents of the Civil Protection Municipal Plan. The latter was drawn up by a working group from the Province of Perugia - Service for the Supervision of Construction and Civil Protection, Civil Protection Office, in collaboration with the Municipal Administration, and completed in February 2011. This integration is based on the fact that, by introducing the

Minimal Urban Structure into the municipal urban plan, the plan itself identifies and consolidates the physical and functional conditions which contribute to effectively carrying out the activities and the rules forecasted in the Civil Protection Plan in the emergency phase immediately following a seismic event (Imbesi, Cappuccitti, Di Bernardino, 2011).

Therefore, the Programmatic Document includes, in the part regarding the analysis of the municipal area, the “Maps of the Minimal Urban Structure”, divided into two levels of interpretation, for the whole municipal area and the main town, and an initial overview of the “critical aspects” of the MUS. This overview is also a part of the “Evaluation Report”, which together with the preliminary report on the Strategic Environmental Evaluation, constitutes the basis of the Programmatic Document.

The “Maps of the Minimal Urban Structure” present the structural elements of the municipal area distinguishing between the existing ones and the “project” ones, the subject of provisions for a new adaptation of the plan. This involves a sub-division of these elements into the following categories: *mobility and accessibility system, safe open space system, strategic buildings and structures system, cultural heritage and meeting place system, economic activity and main urban function system, main technological network system (“lifelines”), economic/productive sites.*

Moreover, the two maps include the symbols indicating the relevant *critical aspects of the urban components*, dividing them into the following categories: potentially critical elements for the *road infrastructure network* (classified based on morphological, size, location and building presence factors), *potentially critical constructions* (bridges, overpasses, town walls, supporting walls, historical town entry gates, edifices bordering the roads), *uses in building structures along roads, hydrogeological problems* (areas at hydraulic risk or damaged).

Therefore, these maps establish the framework for the information, the assessment and the planning forecasts to reduce urban seismic vulnerability from different and complementary perspectives. They highlight the urban elements which are necessary to ensure an appropriate response to the seismic event, and where the provisions for further strengthening and adjustments must be focused, indicating the sites and urban aspects which can positively impact the post-event recovery. They also provide a series of assessments and projects, and offering to those responsible for managing the emergency a clear indication of the elements to verify the efficiency for a timely and suitable intervention. These aspects, with their differences and interactions, clearly show how the content of the Minimal Urban Structure responds to the needs of both the general planning and the civil protection.

5. Working group of the Municipal General Plan of the Municipality of Bevagna: Giuseppe Imbesi (Coordinator), Antonio Cappuccitti (scientific collaboration), Mario Cerqueglini (Geology), Paolo Colarossi, Carlo Di Bernardino, Paola Nicoletta Imbesi, Elio Piroddi, Carlo Sportolano (Agronomy).

6. [“Valutazione Ambientale Strategica” (VAS)]. The 2013 Resolution n. 423 of the Umbria Regional Junta establishes technical specifications and procedures in the field of Strategic Environmental Evaluation in urban-planning tools in Umbria.





Figure 1 – Bevagna, Umbria. Aerial view of the Town centre and the surrounding areas (Aerial photo of the Municipality of Bevagna).

However, this framework of the urban form also provides important guidelines for many of the policies regarding conservation and development on which to base the planning choices, and for the rules and regulations governing the development of the planning on a building and urban level. This involves the layout of the public spaces and roads, the types of programs for new constructions and for building redevelopment on which the “operative part” of the Municipal General Plan will be based.

The Municipal Civil Protection Plan, with regard to its specific contents, provides for a detailed operative organization under the responsibility of the Municipal Administration, the actions to be carried out, the procedures for the different phases (*normal, warning, pre-alarm, alarm*), the guidelines and requirements for the different types of risk (*seismic, hydrogeological, heatwave*), the sites and use of civil protection evacuation areas (*waiting, rally and assembly points, evacuation shelters*). Moreover, it also includes, as annexes, specific plans for snow emergencies, fires and the management of heatwave risks.

The coordination of the two tools involves an analysis method of issues and was carried out in collaboration with groups

working on drawing up the two plans, specifically concerning hydraulic and geological problems and the individuation of territorial and urban structurally important elements. This led to the drawing up of maps which, as previously mentioned, is equally important for the planning competences of the Municipal General Plan and the Civil Protection Plan.

As far as individuating the base elements of the Minimal Urban Structure is concerned, particularly referring to the *system of safe open spaces*, the coordination was aimed at fully integrating the contents of the two tools, so that this system of areas would be made up of important urban public spaces representative of the town and well-known to the community and, at the same time, the best places in terms of civil protection measures. Therefore, the system of “safe open spaces” laid down by the Minimal Urban Structure is completely in line with the system of “civil protection areas”, each of them being defined in detail, using the appropriate technical diagrams found in the Civil Protection Plan, how to use them, the restrictions and the types and preconditions of use.

Then, the case of the Minimal Urban Structure of the Programmatic Document of the City of Bevagna can highlight the benefits of a coordination of planning tools and authorities



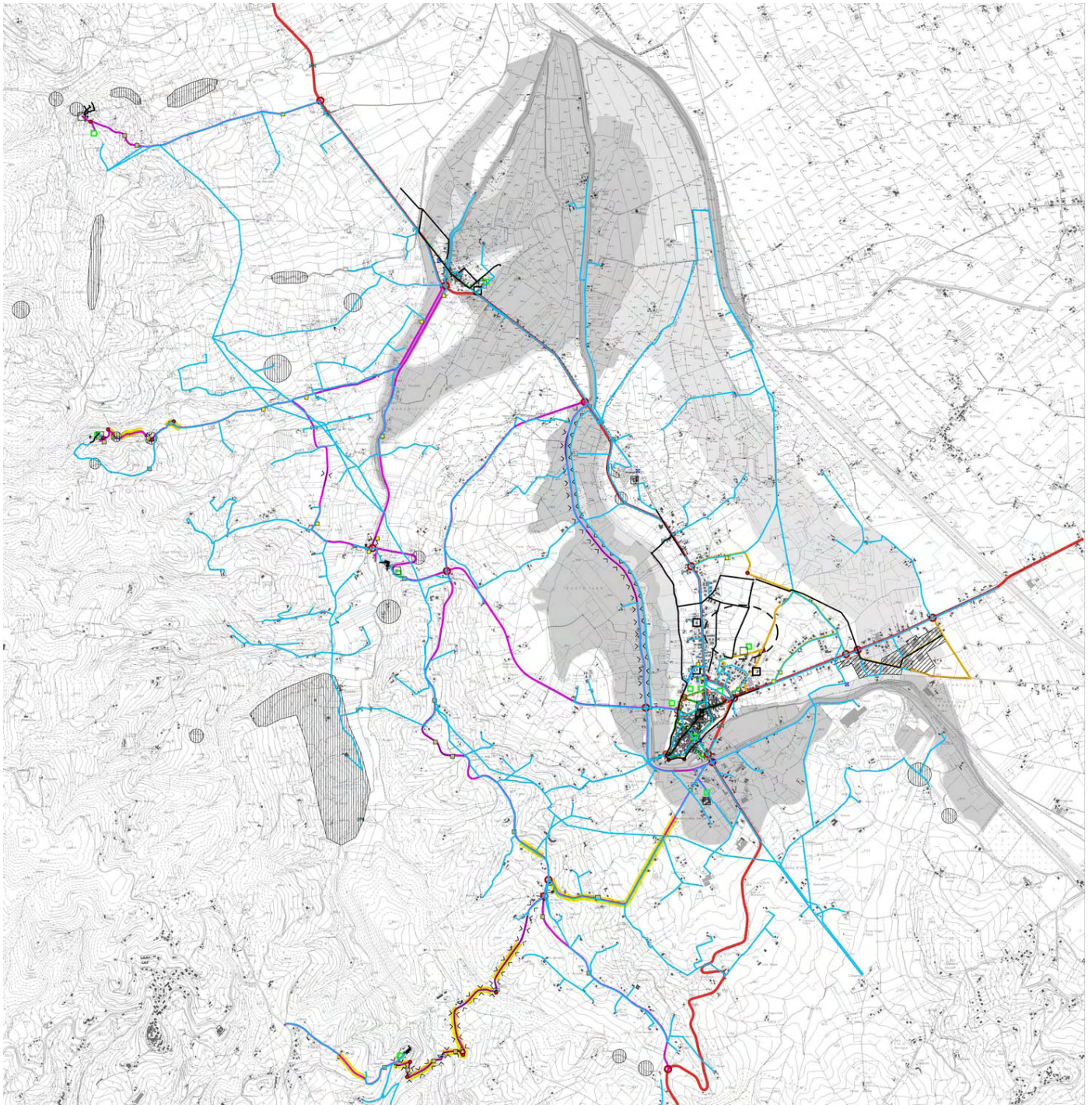


Figure 2a – Bevagna, Map of the Minimal Urban Structure (whole municipal area); annex to the Programmatic Document of the General Municipal Plan, 2013.

<http://www.comune.bevagna.pg.it/mediacenter/FE/articoli/nuovo-prg-comunale-procedura-di-vas.html>.

operating in the territory, in the particular case of tools and actions aimed at reducing urban seismic vulnerability. The full integration of planning decisions regarding the future structure of the city and the seismic vulnerability has resulted in a coordination regarding the planning tools, but also the actions of the municipal and provincial authorities, and this coordination has been adopted in the phases of analysis and decisions set out in the Programmatic Document. Obviously,

this coordination action will continue at various stages of development of the Municipal General Plan and during the completion of the Minimal Urban Structure, in the manner prescribed by laws and regional guidelines mentioned above. The coordination of the two tools by the Bevagna Municipal Administration, and some of its essential features that we have summarized here, could be, in some aspects, a reference point, given that these experiences are quite recent and



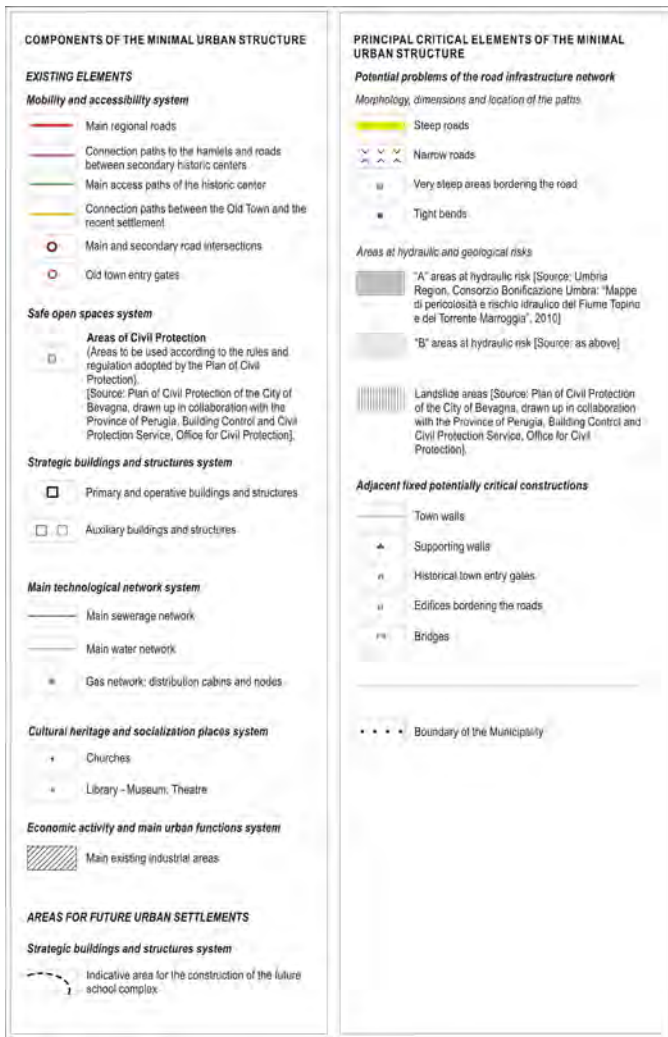


Figure 2b – Bevagna, Legend – key of the Map of the Minimal Urban Structure (whole municipal area).

relevant to the recent enactment of some important regional laws. However, they could also play a useful role in the drawing up of structural maps to reduce seismic vulnerability and to be extended to a regional level, with the view to individuate the "Minimal Regional Structure". The latter has already been indicated as an objective for research to be commissioned and carried out by the Umbria Region.

#### 4. Four keywords for research perspectives

The research and experiences being conducted, the legislation, and the results of the different recent planning experiences such as those we have briefly outlined above, reflect the state and developments of the research underway in this field. However, they also point out potential future research areas. These can be summarized into some key and mutually related terms and research issues – *integration, extension, coordination and programming* –.

The first term, *integration*, concerns different types of potential and valid integration – the integration of the planning tools, integration of the sector tools for urban earthquake risk mitigation and the integration of knowledge and data –.

The integration of the planning tools means making use of coordinated and possibly unified tools, at a moment when too much division and sub-division of tools is seen as an important factor leading to inefficiency and difficulties in urban planning management.

The integration of the sector tools means integrating, usefully and increasingly, the contents and knowledge of the complementary sector tools. Here the complementarity, overlapping and reciprocal implications and correlation of tools such as the "Minimal Urban Structure", "Limit Condition for an Emergency" and "Seismic Microzonation" are clearly evident.<sup>7</sup> A further integration of these tools and the relevant knowledge and data systems could lead to a more direct and easier use on the part of institutions and those who must, for different reasons, use them. It could also establish a more useful planning of projects and works to redevelop and strengthen the urban structure.

Integration also means, at last, a synoptic and complete overlap of cognitive data of different types, which is easily accessible and usable for accurate assessments by all the institutions involved. We are talking about GIS maps which contain, for the different parts of the city, an overlay of data on the urban structure, the morphological configuration and the inherent vulnerability of the urban fabrics, the building-level vulnerability, the local amplifications of seismic motion, the other vulnerabilities of different types, the urban functions. An overlay of this kind could make it easier an accurate assessment of the state of vulnerability of settlement structures, facilitating the strategic planning of necessary actions on the basis of an appropriate and rational order of priority.

At the same time, such an overlap of information and thematic contents could be an important tool for knowledge and management at all stages of the life of the city, providing a full operational efficiency of the authorities in case of need, but above all an awareness of priorities and critical aspects in case of emergency, before, during and after the event. Then it would be not only a tool for planning the future reduction of urban vulnerability, but also - if properly used - a tool for urban management.

7. The overlay field of these three concepts has been recently explored, in the particular regional context of Umbria mentioned above, by the research of the Umbria Region and Sapienza University of Rome (Department of Planning, Design and Technology of Architecture) *Rischio sismico urbano. Indicazioni di metodo e sperimentazioni per l'analisi della Condizione Limite per l'Emergenza e la Struttura Urbana Minima* (Olivieri M. Coordinator). Final research report (november 2013) published on-line on the WEB site of the Umbria Region.

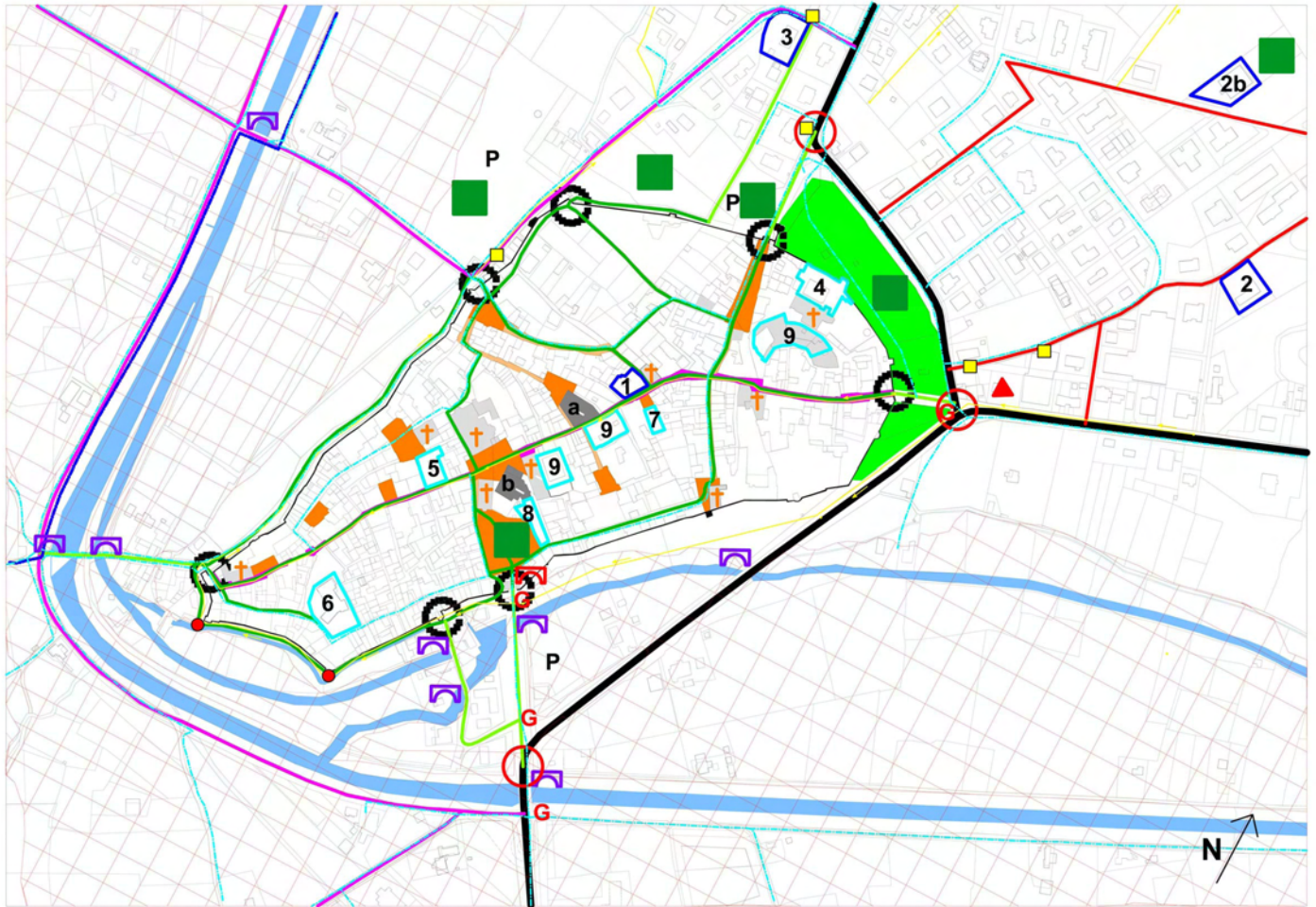


Figure 3a – Bevagna, Map of the Minimal Urban Structure (Town Centre); annex to the Programmatic Document of the General Municipal Plan, 2013. The map clearly highlights the close complementarity between the Minimal Urban Structure and the morphological structure of the historical settlement.

<http://www.comune.bevagna.pg.it/mediacenter/FE/articoli/nuovo-prg-comunale-procedura-di-vas.html>

*Extension* is a key word that, instead, concerns the extent of the area involved in the organizational and qualification actions, and for which, for some aspects, can be undoubtedly adapt a “vast area” point of view, in lieu of the prevalently municipal one which represents the majority of recent experiences.

The term *coordination* regards an indispensable operative coordination of the different entities and institutions responsible for land use planning, but also, and especially, a correct coordination of the laws and regulations that are often different from one region to another.

Finally, *programming* is a term concerning the required division

and progress over time of the planning actions to reinforce and redevelop the urban and regional structures, improving their ability to respond to an earthquake emergency. Programming that, with the right decisions regarding priorities, must be based on the appropriate and correct availability of knowledge and data, and on the right measures and actions in different plans and, at different moments, in drawing up those plans, all suitably coordinated.

These are concepts and perspectives of research that are of major importance in areas, such as in parts of Italy, very often exposed to environmental risks and, thus, extremely vulnerable.



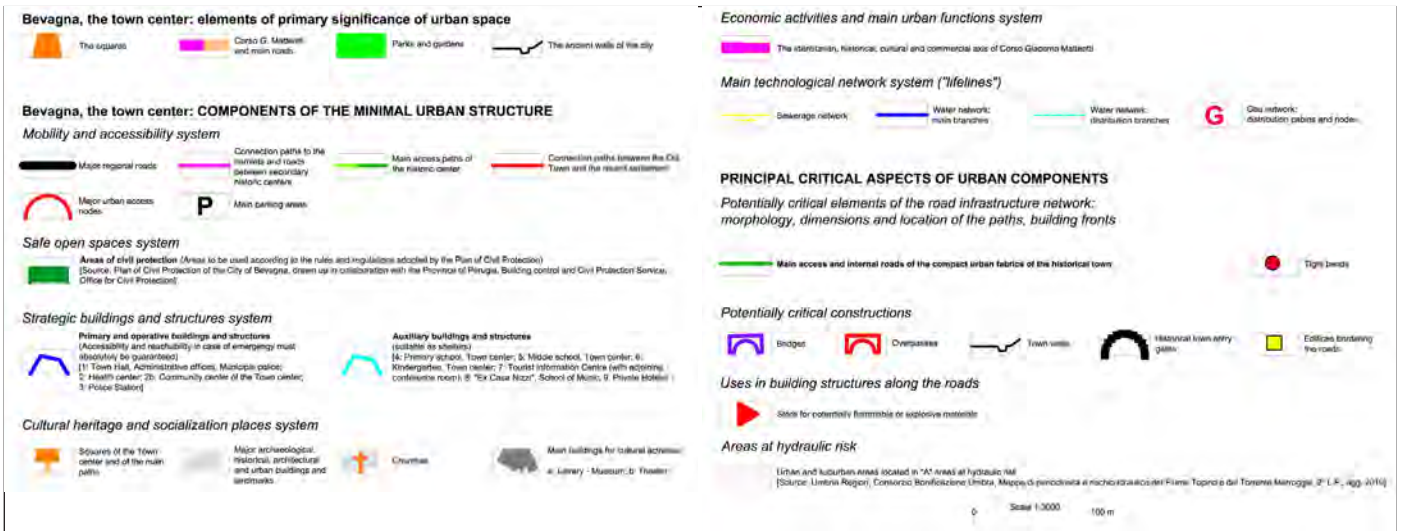


Figure 3b – Bevagna, Legend – key of the Map of the Minimal Urban Structure (Town Centre).



Figure 4 – Bevagna (Perugia), View of the Old Town (photo A. Cappuccitti).





Figures 5, 6 – Bridges and historical town entry gates: urban morphologic landmarks and critical elements of the Minimal Urban Structure at the same time (photo A. Cappuccitti).





Figure 7 – Bridges and historical town entry gates: urban morphologic landmarks and critical elements of the Minimal Urban Structure at the same time (photo A. Cappuccitti).



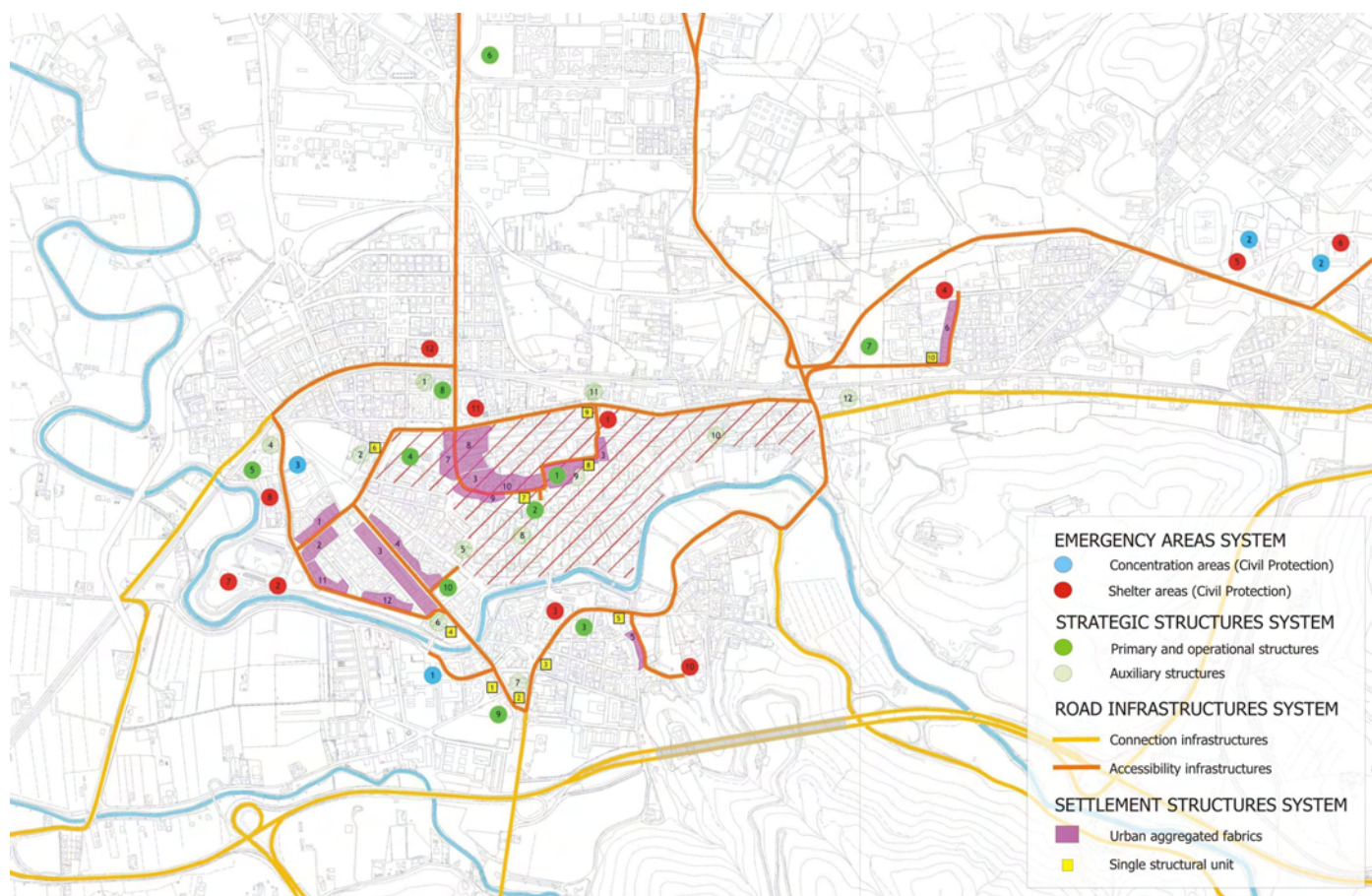


Figure 8 – An experimental schematic map of “Limit Condition for an Emergency” for the city of Rieti, Lazio, drawn in the Degree Thesis “Minimal Urban Structure for the mitigation of the seismic vulnerability of the city of Rieti”; Specializing Degree Course in “Engineering of Building Constructions and Environmental Systems”, Pole of Rieti of the University of Rome “La Sapienza”. Author: Alfredo Angeloni; Supervisor: Antonio Cappuccitti, 2014.

## References

- Bramerini F., G.P. Cavinato, and V. Fabietti (eds) *Strategie di mitigazione del rischio sismico e pianificazione. CLE: Condizione Limite per l'Emergenza*. Roma: Urbanistica Dossier 130, INU Edizioni, 2013.
- Caldaretti S., V. Fabietti and A. Riggio, *La vulnerabilità sismica dei sistemi territoriali*. Roma: Edizioni DEI, 1987.
- Cappuccitti A., and E. Piroddi (eds) *Il Nuovo Manuale di Urbanistica. Volume III, Lo stato della Pianificazione urbana in Italia. 20 città a confronto. Torino, Milano, Trento, Bolzano, Trieste, Venezia, Genova, Bologna, Firenze, Ancona, Terni, L'Aquila, Roma, Napoli, Campobasso, Matera, Bari, Reggio Calabria, Palermo, Cagliari*. Roma: Mancosu Editore, 2009.
- Cremonini, I. (ed) *Rischio sismico e pianificazione nei centri storici. Metodologie ed esperienze in Emilia Romagna*. Firenze: Alinea, 1994.
- Cremonini, I., and A. Galderisi (eds) *Rischio sismico e processi di piano: verso l'integrazione, Urbanistica, n° 134*. Roma: INU Edizioni, 2007.
- Dipartimento della Protezione civile e Conferenza delle Regioni e Province Autonome, *Indirizzi e criteri per la microzonazione sismica*. Roma: Dipartimento della Protezione civile, 2008.
- Fabietti, V. (ed) *Vulnerabilità urbanistica e trasformazione dello spazio urbano*. Firenze: Alinea, 1999.
- Fabietti, V. “Dalla CLE alla SUM: i contenuti urbanistici della protezione dei rischi”. *Urbanistica Dossier 130*. Roma: INU Edizioni, 2013: 38-40.



- Fera G. *La città antisismica. Storia, strumenti e prospettive per la riduzione del rischio sismico*. Roma: Gangemi editore, 1991.
- Galderisi A. *Città e terremoti – Metodi e tecniche per la mitigazione del rischio sismico*. Roma: Gangemi editore, 2004.
- Imbesi G., A. Cappuccitti and C. Di Berardino. "Rischio sismico e strumenti urbanistici nel PRG di Bevagna". *Urbanistica Informazioni*, n° 237. Roma: INU Edizioni, 2011: 60-63.
- Olivieri M. (Coordinator), F. Fazio, R. Parotto, and B. Pizzo, *Linee guida per la definizione della Struttura Urbana Minima nel PRG*. Regione Umbria, DPTU – Dipartimento di Pianificazione Territoriale e Urbanistica, Sapienza Università di Roma. *Deliberazione della Giunta regionale della Regione Umbria 8 feb. 2010, n. 164 "Linee guida per la definizione della Struttura Urbana Minima (SUM) nel PRG, ai fini della riduzione della vulnerabilità sismica urbana (Art. 3, comma 3, let. d) della LR 22 febbraio 2005, n. 11*, Official Bulletin, Region of Umbria, March 2010.
- Menoni S. (ed) *La salvaguardia dei valori storici, culturali e paesistici nelle zone sismiche italiane. Proposte per un manuale*. Roma: Gangemi editore, 2006.
- Monaco A., and R. Monaco, *Urbanistica Edilizia e rischio sismico*. Napoli: Sistemi Editoriali, Gruppo Editoriale Simone S.p.A., 2012.
- Municipality of Bevagna (Region of Umbria, Province of Perugia) *Documento programmatico del Piano Regolatore Generale, October 2013. Schemi della Struttura Urbana Minima*. Working group: G. Imbesi (Coordinator), A. Cappuccitti (scientific collaboration), M. Cerqueglini (geology), P. Colarossi, C. Di Berardino, P.N. Imbesi, E. Piroddi, C. Sportolaro (agronomy). Published on-line in March 2014 on the WEB site of the Municipality of Bevagna. [<http://www.comune.bevagna.pg.it/mediacenter/FE/articoli/nuevo-prg-comunale-procedura-di-vas.html>].
- Olivieri, M. (ed) *Vulnerabilità urbana e prevenzione urbanistica degli effetti del sisma: il caso di Nocera Umbra*. Roma: *Urbanistica quaderni 44*, INU Edizioni, 2004.
- Olivieri, M. "Dalla SUM alla CLE: strategie a confronto per la sicurezza degli insediamenti". *Urbanistica Dossier 130*. Roma: INU Edizioni, 2013: 34-37.
- Regione Umbria. *1997-2007. Dieci anni dal sisma. Oltre la calamità: sviluppo e innovazione*. Perugia: Quattroemme, 2007.
- Regione Umbria – Direzione Regionale Programmazione, Innovazione e Competitività dell'Umbria – Servizio Geologico e Sismico; Sapienza Università di Roma – Dipartimento di Pianificazione, Design e Tecnologia dell'Architettura. Research *Rischio sismico urbano. Indicazioni di metodo e sperimentazioni per l'analisi della Condizione Limite per l'Emergenza e la Struttura Urbana Minima* (Olivieri M. Coordinator), november 2013. Final research report published on-line on the WEB site of the Umbria Region. [<http://www.rischi.regione.umbria.it/Mediacenter/FE/CategoriaMedia.aspx?idc=392&explicit=SI>]

