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# Myths and realities about the recovery of L'Aquila after the earthquake

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ABSTRACT

There is a set of myths which are linked to the recovery of L'Aquila, such as: the L'Aquila recovery has come to a halt, it is still in an early recovery phase, and there is economic stagnation. The objective of this paper is threefold: (a) to identify and develop a set of spatial indicators for the case of L'Aquila, (b) to test the feasibility of a numerical assessment of these spatial indicators as a method to monitor the progress of a recovery process after an earthquake and (c) to answer the question whether the recovery process in L'Aquila stagnates or not. We hypothesize that after an earthquake the spatial distribution of expert defined variables can constitute an index to assess the recovery process more objectively. In these articles, we aggregated several indicators of building conditions to characterize the physical dimension, and we developed building use indicators to serve as proxies for the socio-economic dimension while aiming for transferability of this approach. The methodology of this research entailed six steps: (1) fieldwork, (2) selection of a sampling area, (3) selection of the variables and indicators for the physical and socio-economic dimensions, (4) analyses of the recovery progress using spatial indicators by comparing the changes in the restricted core area as well as building use over time; (5) selection and integration of the results through expert weighting; and (6) determining hotspots of recovery in L'Aquila. Eight categories of building conditions and twelve categories of building use were identified. Both indicators: building condition and building use are aggregated into a recovery index. The reconstruction process in the city center of L'Aquila seems to stagnate, which is reflected by the five following variables: percentage of buildings with on-going reconstruction, partial reconstruction, reconstruction projected residential building use and transport facilities. These five factors were still at low levels within the core area in 2012. Nevertheless, we can conclude that the recovery process in L'Aquila did not come to a halt but is still ongoing, albeit being slow.


## 1. Introduction

On April 6th of 2009, an earthquake with a magnitude of 6.3$M_W$, at a depth of 10 km hypocentral depth, and at an epicenter located in Poggio del Roio, 3.4 km to the Southwest of the city center of L'Aquila in Italy, struck the city (population 72,800). L'Aquila is the capital of the province by the same name, and the administrative capital city of Abruzzo region. Its location and the map of ground motion intensity during the earthquake are displayed in Fig. 1.

The historical city was seriously damaged, 1500 people were injured, 202 of them seriously, 308 lost their lives, 67,500 became homeless [1], 100,000 buildings were

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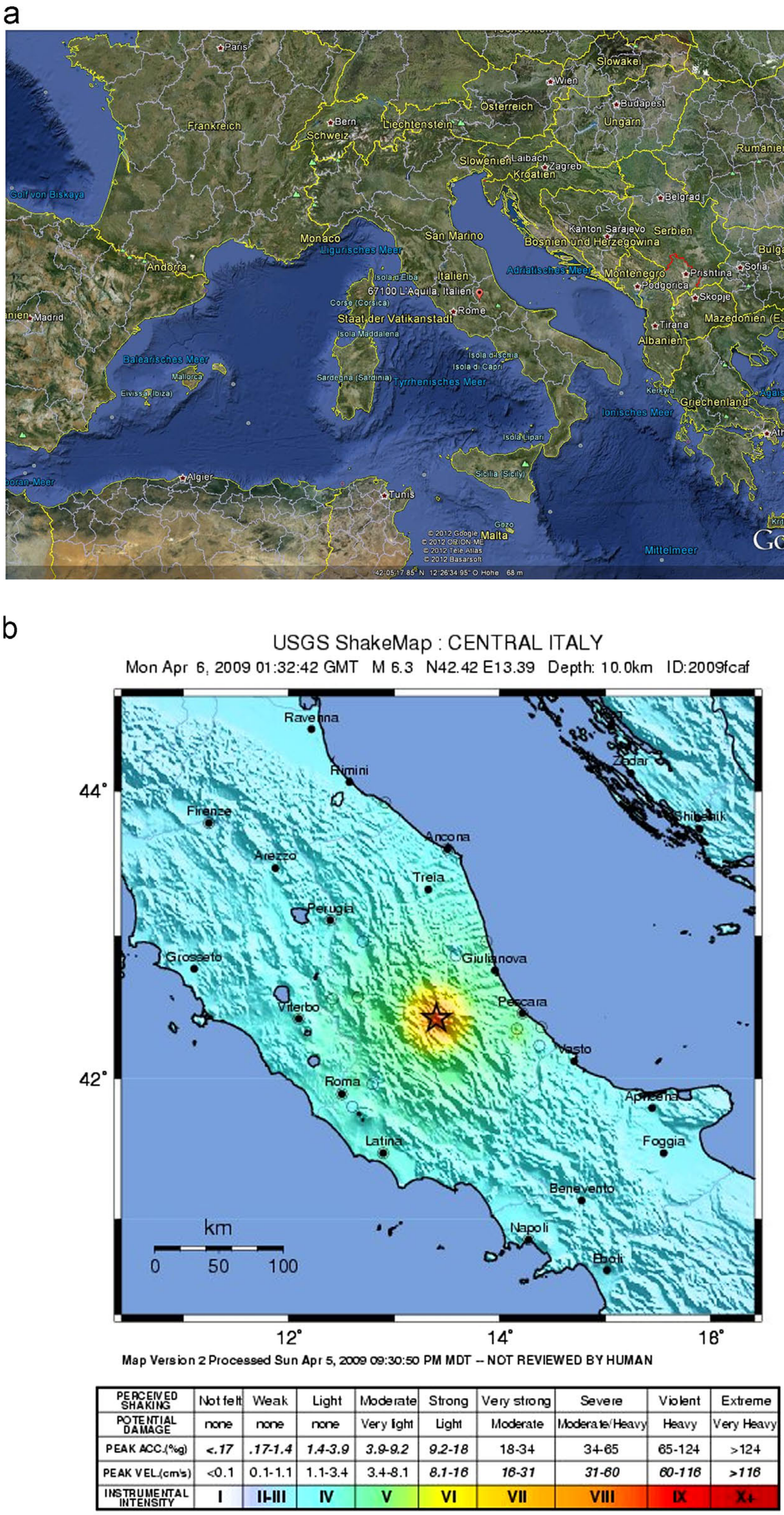



**Fig. 1.** L'Aquila (Italy); (a) location. *Source*: Google Earth, and (b) Map of the ground motion intensity during the earthquake in L'Aquila (Italy). *Sources*: USGS.

damaged. Between 1.5 and 3 million [2,3], and 4 and 5 million tons of waste were generated [4]. The cost of the damage was estimated to be 16 billion Euros [5]. The classification of the degree of damage per block after the earthquake in L'Aquila is depicted in Fig. 2.

According to Alexander [6] the earthquake in L'Aquila "was a moderate seismic event", with a rather insignificant magnitude compared to other worldwide events, but with a very high magnitude for a European country [7]. However, the physical vulnerability level of its masonry buildings (poorly maintained and not strengthened) [7] – mainly concentrated in the historical city center – led to the enormous damage described earlier. The earthquake also affected reinforced concrete structures; and overall all the affected buildings were a typical example of the construction type in several European countries [7]. Nevertheless, it is noticeable there were more casualties due to the collapse of reinforced concrete buildings than in the masonry ones, which demonstrate the high vulnerability of the first ones, as compared to the latter.

Reconstruction programs such as the C.A.S.E (*Complessi Antisismici Sostenibili ed Ecocompatibili*) and M.A.P. (*Moduli Abitaviti Provvisori*) programs helped to build about 284 housing units in 19 new settlements. These new settlements accommodate 23,000 survivors, who used to live in the city center. One year after the earthquake, 5000 people still remained in hotels, 15,000 people in provisional housing and 27,000 in rented houses with a government grant between €600 and €800 monthly [4]. This expensive [8] housing solution, however, involves problems such as the lack of basic services, urban facilities (churches, schools, pharmacies, post offices, supermarkets, social centers, sport centers and so on), limited public transport (low and at unreliable frequencies) [9] social fragmentation and functional living, as well as questionable ecological values [6].

Nevertheless besides the problem of the lack of urban facilities around the new settlements in L'Aquila, there is the problem of its still cordoned-off city center filled with historic buildings [8], which was most affected by the earthquake [7]. Almost five years later some areas of the city center of L'Aquila remain off limits to citizens, and plenty of buildings are supported by electro-welded buttress. This historic city center used to be the central business district and a tourist attraction [10], therefore providing a source of income and employment, both of which are essential elements for the recovery according to Alexander (2012) [11]. Initially after the earthquake cordoning-off the city center was justified with the need to support the damaged buildings using the electro-welded buttresses for safety purposes for the pedestrians and to avoid harmful effects of construction and demolition (C&D) waste on the population and environment [2]. However, in time it became evidence of the political unwillingness[10] and lack of strategic management of the recovery of L'Aquila [8]. As a result, one year after the earthquake, the center of L'Aquila seemed a "ghost town" [10,12], called "the Pompeii of the 21st century" by Settis [12], and "nest of ghosts" by Díez [4]. Previous research has demonstrated that delays in recovery are more related to administrative issues and bureaucracy [4], than directly to the construction processes [13].

There is scarce research about the challenges of the recovery of historic buildings regarding cost and recovery time. Regarding costs, challenges include the quantification of the degree of damage, objective determination of structure types, and historic importance of buildings. The limitations when studying recovery time include the existence of pre-impact recovery plans and/or business continuity plans [13]. The repair or reconstruction of historic buildings does not consist merely of the removal of rubble and bringing in new materials to replace, for instance, the damaged walls [2]. In this particular case, the rubble must be considered raw material for repairing and to be recycled, as it is suggested by authors such as Fetter et al. [14], Brown et al. [3] Xiao et al. [15]; called *deconstruction* by Denhart [16] or integrated waste and resource management by Lauritzen [17]. According to Lauritzen, recycle rates of up to 80–90% of the total amount of C&D waste is economically feasible in most European countries [17]. In the specific case of L'Aquila, the debris must be classified according to its original location and its degree of damage. Then, the appropriate construction method needs to be determined in order to reintegrate the material to its original place, avoiding big modifications as far as possible. The use of new materials will affect the conservation condition, as well as the cultural significance of buildings. All these activities require a considerable amount of time, which can start from the early recovery, and even continue in the development phase, because besides the reconstruction process, they must be updated to the building code requirements in force.

For the socio-economic dimension, *building use* often serves as a meta-indicator. Building use can be defined as the purpose served by a building, or the human activity or economic function which can be attributed to it. Building use patterns may serve as proxies for the individual size and the spatial arrangement of single entities, while integrating information on the materials and the structure of buildings [13]. In the center of L'Aquila, most of the historic buildings are churches, public buildings and houses. The study carried out by Al-Nammari and Lindell demonstrated not only that historic buildings take longer to recover (more than ten years) compared to non-historical buildings, but also that the cost of reconstruction or repair of cultural facilities is higher than the cost of housing reconstruction or repair [13], which could be another explanation for the prolonged recovery process in L'Aquila.

In this article, recovery is conceptually defined as a complex multidimensional long-term process of planning, financing and decision making after a disaster, in order to restore sustainable living conditions of a community or an area which is strongly influenced by vulnerable conditions [9] in the physical, social, economic, institutional, cultural and ecological dimensions existing before the event. The recovery process must address the interaction amongst a variety of groups and institutions, with the aim of rebuilding people's lives and livelihoods, as well as reconstructing buildings and infrastructure, and restoring cultural assets and ecological conditions. The recovery is perhaps the phase of the disaster management cycle that better reflects

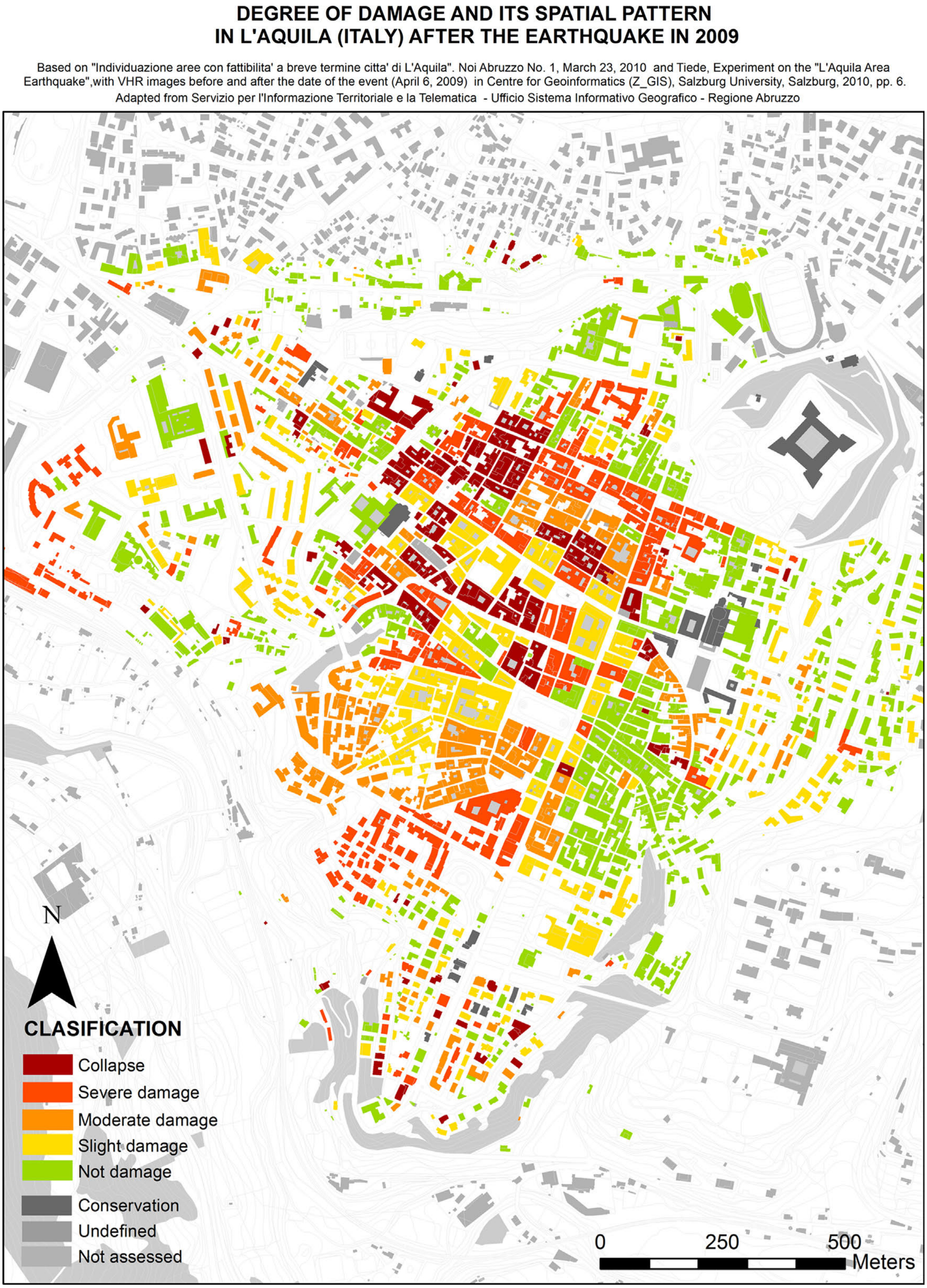



**Fig. 2.** Degree of damage and its spatial pattern in L'Aquila after the earthquake in 2009. Based on "Individuazione aree con fattibilita' a breve termine citta' di L'Aquila". Noi Abruzzo No. 1, March 23, 2010 and Tiede, Experiment on the "L'Aquila Area Earthquake", with VHR images before and after the date of the event (April 6, 2009) in the Department of Geoinformatics, Z_GIS Salzburg University, Salzburg, 2010, pp. 6.

the idiosyncrasy of a population. More vulnerable areas will have longer recovery phases [18] and each recovery case is unique according to the vulnerability conditions existent before disasters.

The terminology of the recovery phase within the so called disaster cycle is well established. We use the naming conventions of the United Nation Development Program (UNDP) for each recovery phase: relief, early recovery, recovery and development [19]. It seems to be agreed upon that the assessment of the recovery process should be based on indicators, in order to guarantee objectivity and comparability [20]. Indicators are qualitative or quantitative measures resulting from systematically observed facts [21] which describe the characteristics and allow the assessment of certain phenomena [22].

Several indices have been developed to measure vulnerability, but only Karatani and Hayashi [23], Shohei [24] and Chang [25] yielded recovery indices with a particular focus on earthquakes. Only Brown et al. [26] formulated a recovery index based on spatial indicators. Since large-scale disasters are relatively rare, it is difficult to accumulate the information and the experience 'across disasters', in order to create a more generic model to evaluate recovery processes [23]. Furthermore the recovery phase is determined by the unique history of the area [23] and vulnerability conditions, as stated earlier.

What is less developed is a spatially explicit analysis of the recovery process. Measuring the spatial component of recovery is important, since both the disastrous event, as well as the recovery process to follow, take place in an explicit spatial context. Spatial indicators are visible measures of the stage at which the recovery process is progressing, making it easier to design a recovery plan at earlier stages, and to evaluate it in a participatory way later.

## 2. Hypothesis

As the perception of reality varies significantly between different observers [27], we may consider that there is a potential for misperception [12] when exclusively relying on qualitative judgments without any quantitative measures or indicators. The use of spatial indicators allows a more "transparent", holistic and evidence-based assessment of the recovery process, overcoming the danger of being subjective. The objective of this paper is to establish key spatial variables of recovery for an urban environment, in order to develop a methodology and a quantifiable index. Such an index should be based on spatial variables and indicators, to monitor and assess the progress of a recovery process after an earthquake.

We hypothesize that (a) variables related to building conditions and building use after an earthquake can be aggregated to two meta-indicators representing the physical dimension and the socio-economic dimension after an earthquake, respectively, and (b) that the spatial distribution of these parameters can constitute an index to assess recovery processes after earthquakes.

## 3. Methodology

The methodology of this research entails six steps: (1) fieldwork, (2) selection of a sampling area; (3) selection of the variables and indicators in the physical and socio-economic dimension; (4) analyzing the progress of recovery using spatial indicators by comparing the changes in restricted size area in 2010 and 2012, as well as building use before (2009) and after the earthquake in 2010 and 2012; (5) combination of results with weights allocated by experts to the key spatial variables, and indicators in a recovery index; 6) determine the hotspots of recovery in L'Aquila. The sequence of the methodology was portrayed in Fig. 3. The building use before the earthquake is based on the observation of the announcements and the photographs taken during the fieldwork, *Google maps*, as well as information extracted from photographs available in the 3D model of the city of L'Aquila in *Google Earth*.

### 3.1. Fieldwork

It is important to realize that the present research separately considers the recovery phases and the evaluation periods for examining the progress. The recovery phases are time periods after disasters, defined by a series of activities, objectives, deliverables and goals, and only once the goals are achieved it is possible to enter into the next phase. Nevertheless, the time to achieve the characteristic goals of each recovery phase, is different in each case, which is the main reason why we cast doubts on the model proposed by Bowden, Haas and Kates in 1977 [28], in which each phase takes around 10 times longer than the previous one, similar to a logarithmic scale of time where they appears as equal intervals. It depends on the hazard (phenomenon, its magnitude, and so on), which affected the territory, as well as the territory's prior vulnerability conditions, the damage extents [15], and mainly resilience (capacity to anticipate, to cope and to recover) [29]. Two strong earthquakes affected Haiti ($7.2M_w$) and Chile ($8.8M_w$) in 2010 with only one and a half months in between. Nevertheless, after three years, if the two recovery processes are compared, the difference in the achievements during the same period of time is abysmal. While Haiti is still in an early recovery [30], Chile is already in a recovery phase, also slow but with some visible results [31]. By mentioning these cases, we want to emphasize that a recovery phase is not a matter of time, but rather a matter of achievements and the same statement applies to L'Aquila. Developed countries are better prepared regarding emergency response than developing countries [17], reducing the disruption according to Gordon and Dion [3], which is a first step to ensure a successful recovery.

To establish the periods for which to evaluate the achievement of the goals in each recovery phase, the case of the recovery process in Kobe (Japan) was taken as a benchmark, because we consider that only people affected and recovered from disasters can formulate reliable parameters (periods, variables and indicators) to measure the progress of the recovery. The government of Kobe carried out recovery assessments in 1999, 2003 and 2005 [32], corresponding to four, seven and ten years after the earthquake. Nevertheless, due to time constraints of the research, in this paper the cuts for evaluation periods have been set to 2010 and 2012, thus being one and three years after the earthquake in L'Aquila (Italy), in which we

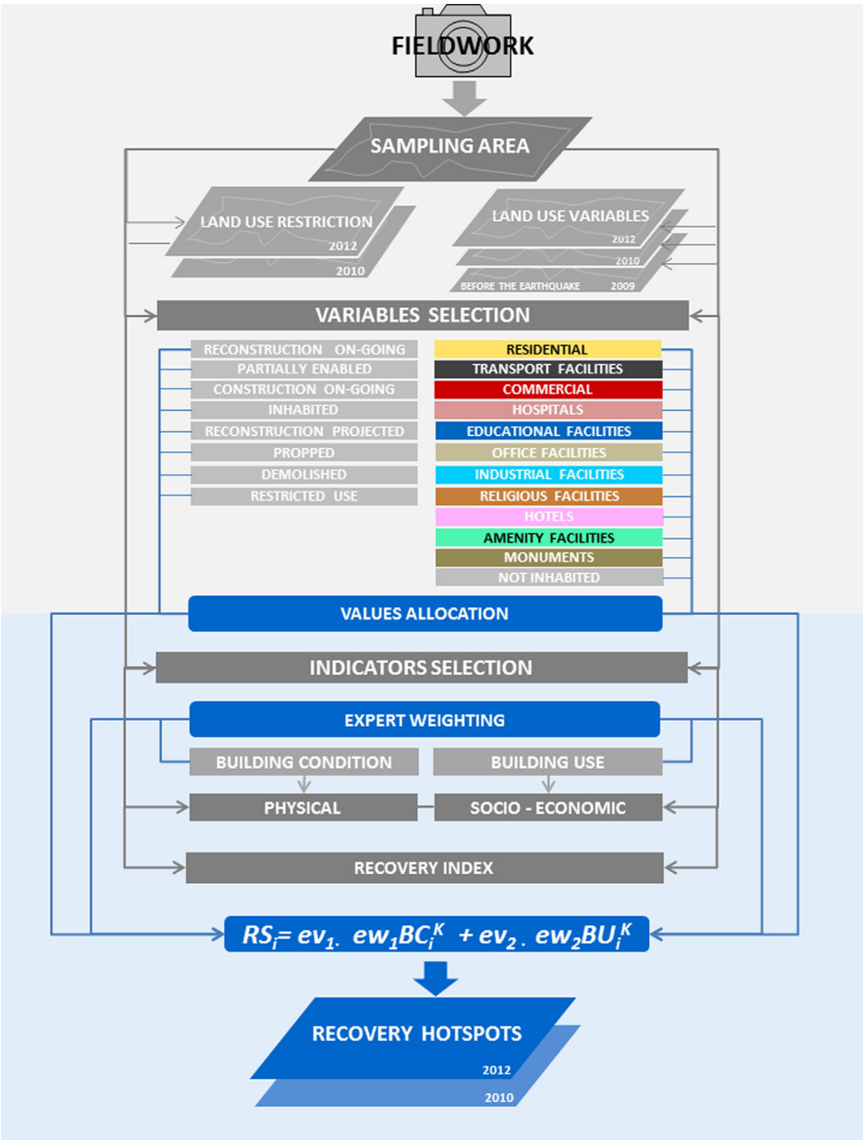



**Fig. 3.** Methodology to assess the progress of the recovery after an earthquake.

consider the first and second phases to have been attained. The fieldwork included mapping the urban conditions of the historic district of L'Aquila and the new settlements in 2010 and 2012, in order to monitor the urban changes in both years.

### 3.1.1. *Stage of the recovery process in L'Aquila*

In 2012, machines and trucks were observed while they were still removing rubble in some places of L'Aquila. This situation can be evidence of poor management of C&D waste, therefore delaying the city's rebuild and the return of normal economic activities [2], which are the main reasons for the frustration of the residents of L'Aquila [4]. Around Piazza del Duomo, only cars from police are observed.

In the piazza del Duomo, the fences have been removed (Fig. 4a and b), but the columns are still propped. Some landscape considerations, such as positioning plants in front of the columns along the Vittorio Emanuele street were done (Fig. 4c and d). In L'Aquila, the areas along Via XX Settembre, Corso Federico II, Vittorio Emanuelle II, Via Sallustio, Piazza del Duomo, and around Piazza Regina Margherita, Piazza Battaglione Alpini and Piazza Fontesecco show signals of recovery, with the reactivation of the commercial activities existing before the event (Fig. 4e and f).

Since 2010, some buildings show some progress in terms of reconstruction (Fig. 5a and b), while others remain in the same stage as in 2010 (Fig. 5c and d), and some appear to have even further deteriorated (Fig. 5e and f). Within the restricted area, you could find houses that were already occupied by 2012. Nevertheless, sometimes it was difficult to determine if a house was occupied or not: at a first glance it may have seemed to


**Fig. 4.** Changes around Piazza del Duomo in L'Aquila (Italy) between 2010 and 2012. (a) Duomo with fences (2010); (b) Duomo without fences (2012), but the entrance remains forbidden; (c) Via Corso Vittorio (2010); (d) Via Corso Vittorio with some landscape interventions (2012); (e) Bar – Caffetteria – Gelateria Fratelli Nurzia (2010) and (f) Bar – Caffetteria – Gelateria Fratelli Nurzia (2012). Photos by Diana M. Contreras M.

be empty, while in some cases a second visit – planned or unplanned, e.g. passing it again – revealed that there were people living there. In areas of the city center of L'Aquila such as the Est of Porta Napoli, it was difficult to map the condition of the buildings, due to the high level of heterogeneity. In only one block it was possible to find inhabited houses, houses in a reconstruction process, or apparently abandoned. Sometimes, it was difficult to distinguish between the lack of maintenance, and damages produced by the earthquake; which can also cause difficulty in determining whether the house was inhabited or abandoned. On the way to the new settlements located in the East of L'Aquila, in the mountainous area, it was possible to observe buildings damaged, propped, with on-going reconstruction, retrofitting projected, or abandoned.

### 3.2. Sampling area

Cities have a public image which is composed of many overlapping individual images, or perhaps there is a group of public images shared by a representative group of citizens. Spatial indicators must go beyond the mere physical dimension [27].

Five elements constitute the physical forms of the city images: paths, edges, districts, nodes and landmarks. Paths

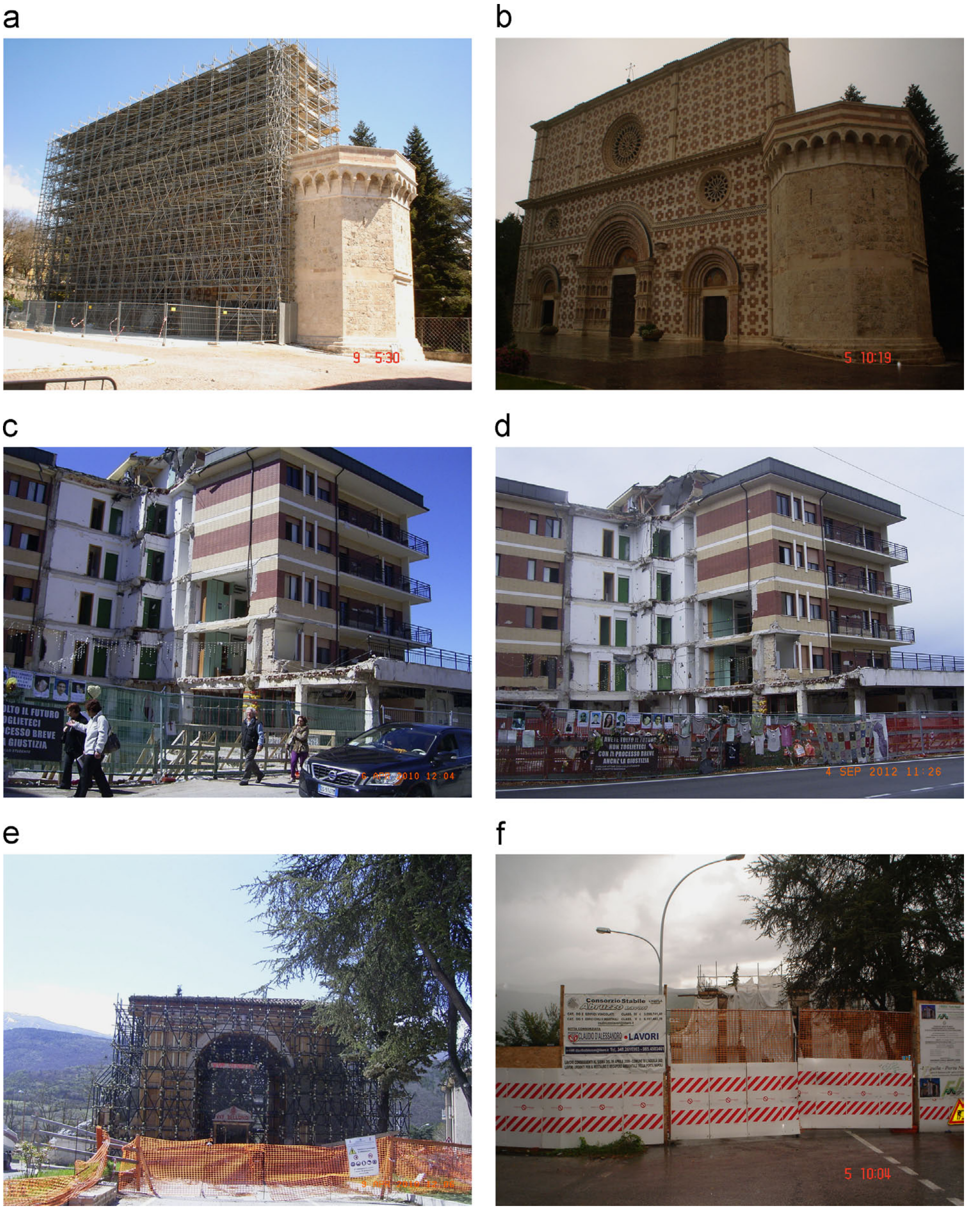



**Fig. 5.** Cases in the stages of the buildings. Progress in the reconstruction: (a) Santa Maria de Collemaggio (2010) and (b) Santa Maria de Collemaggio (2012) (inside is still propped). No changes between 2010 and 2012: (c) Student hostel (2010) and (d) Student hostel (2012). Buildings more deteriorated: (e) Porta Napoli (2010) and (f) Porta Napoli (2012). Photos by Diana M. Contreras M.

are defined as the channels along which the population moves; edges are linear elements or boundaries which cannot be considered as paths; districts are sections of the city characterized by a similar urban morphology; nodes are strategic spots in which the population can enter, hence strategic points to encourage the recovery; different from landmarks which constitute point-references, not accessible to the population [27]. Taking into account these elements, the case study area was reduced to the historic center of L'Aquila as a representative sampling area.

The sampling area was the historical center of L'Aquila as a district and node, limited by the main roads.

### 3.3. Variables and indicators selected

Based on our knowledge and experience, and according to the observations and mapping exercises carried out during the fieldwork campaigns of 2010 and 2012 we designed variables for the building condition and building use. This was complemented with information available through *Google Maps* and *Google Earth*, and we ultimately defined the variables that make up the indicators for the recovery process in L'Aquila.

Eight categories according to their building condition were identified, namely: reconstruction on-going, partially enabled, construction on-going, inhabited, reconstruction projected, propped, demolished and restricted use. These categories were considered variables of the indicator building condition, belonging to the physical dimension of the recovery. In this step of the methodology twelve categories of building use were also identified, thus being: residential, transport facilities, commercial, hospitals, educational facilities, office facilities, industrial facilities, religious facilities, hotels, amenity facilities, monuments, not inhabited. These categories were considered variables of the indicator building use, belonging to the socio-economic dimension of the recovery. Both indicators: building condition and building use are aggregated into a recovery index. The definition was done through an iterative process between the authors based on our experience, local knowledge and literature studies.

### 3.4. *Spatial indicators: building use restriction and building use change*

Through observations during the fieldwork carried out, first in 2010 (one year after the earthquake) and later in 2012 (three years after), it was possible to map and subsequently quantify the changes in the building use restriction between these two years. The changes in the building use between 2009 (before the earthquake), 2010 and 2012 were derived from the combination of secondary and primary data. To deduce the building use before 2009, secondary data was extracted from touristic maps of the city center of L'Aquila drawn before the earthquake, as well as Google maps and Google earth 3D-buildings. Especially in the latter one, it is still possible to observe the aspect of some streets in L'Aquila before the disaster. Looking at the observed announcements above some doors in the pictures posted on Google Earth-3D building and validated during fieldwork, it was possible to infer what the building use of buildings before the event was. The data of the building use in 2010 and 2012 in the city center of L'Aquila was obtained as primary data during fieldwork, through the observation of the activities going on in the streets, and mapping the location of the places in which they occur.

In spite that the restricted area still existed in 2012, its boundaries were already decreasing. Some blocks included in the restricted area in 2010 were still not inhabited, however, people could walk and cars could drive around them. Some streets were already used at least as parking areas. Using the time series method, as it is depicted in Fig. 6, it was possible to appreciate the reduction of the size of the restricted area, which could be considered as a spatial indicator of recovery.

Alexander stated that sources of work and income are essential for the recovery [11]. Many buildings along the streets Corso Federico II, Corso Vittorio Emanuele, via Garibaldi and via Fontesecco were already inhabited in

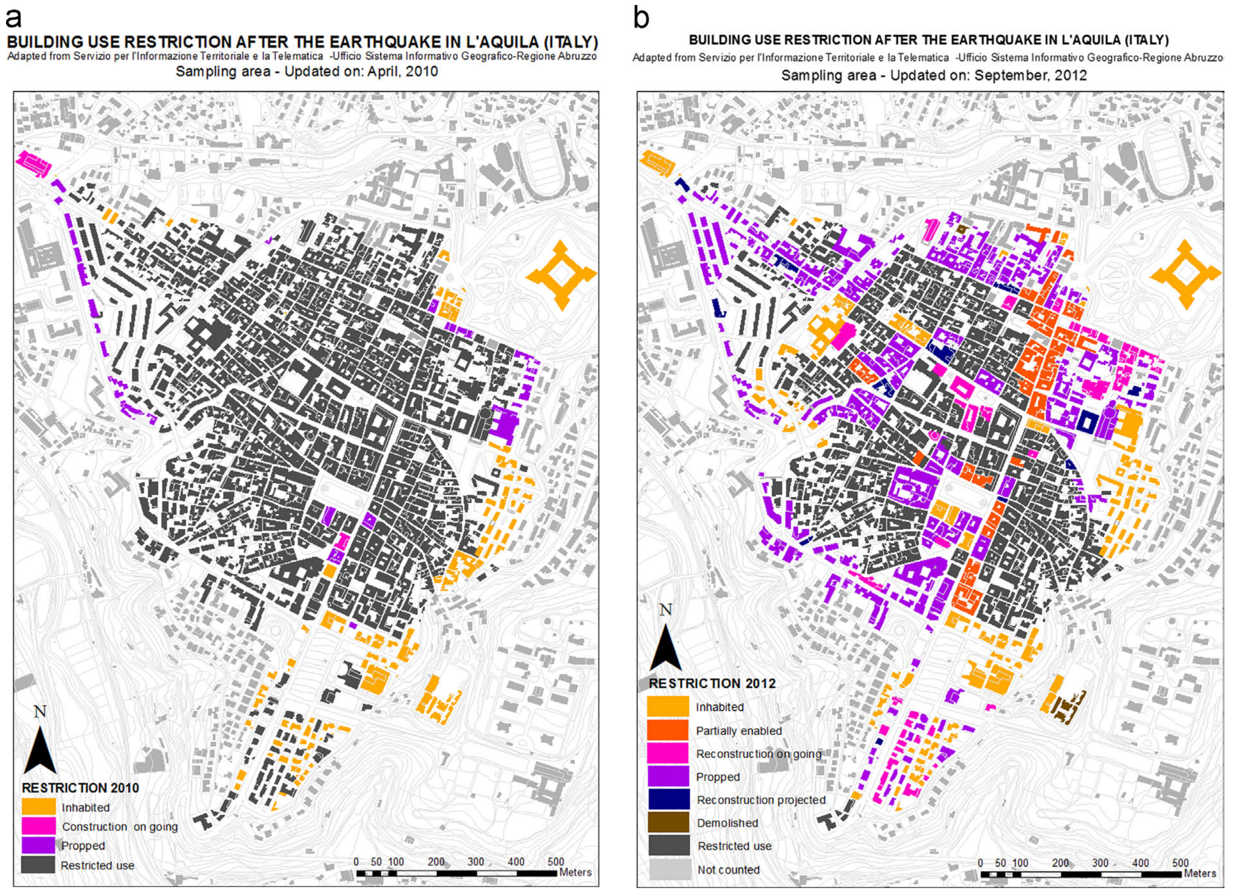



**Fig. 6.** Time series to compare the changes in a sampling area within the restricted zone in L'Aquila (Italy) after the earthquake between (a) 2010 and (b) 2012.

the first floor, while their other floors still remained empty. These buildings host facilities such as restaurants, bars, cafes, banks, hotels, and offices, which have increased in number between 2010 and 2012, as it is portrayed in Fig. 7; some of the facilities were located in the same place where they were located before the earthquake, and

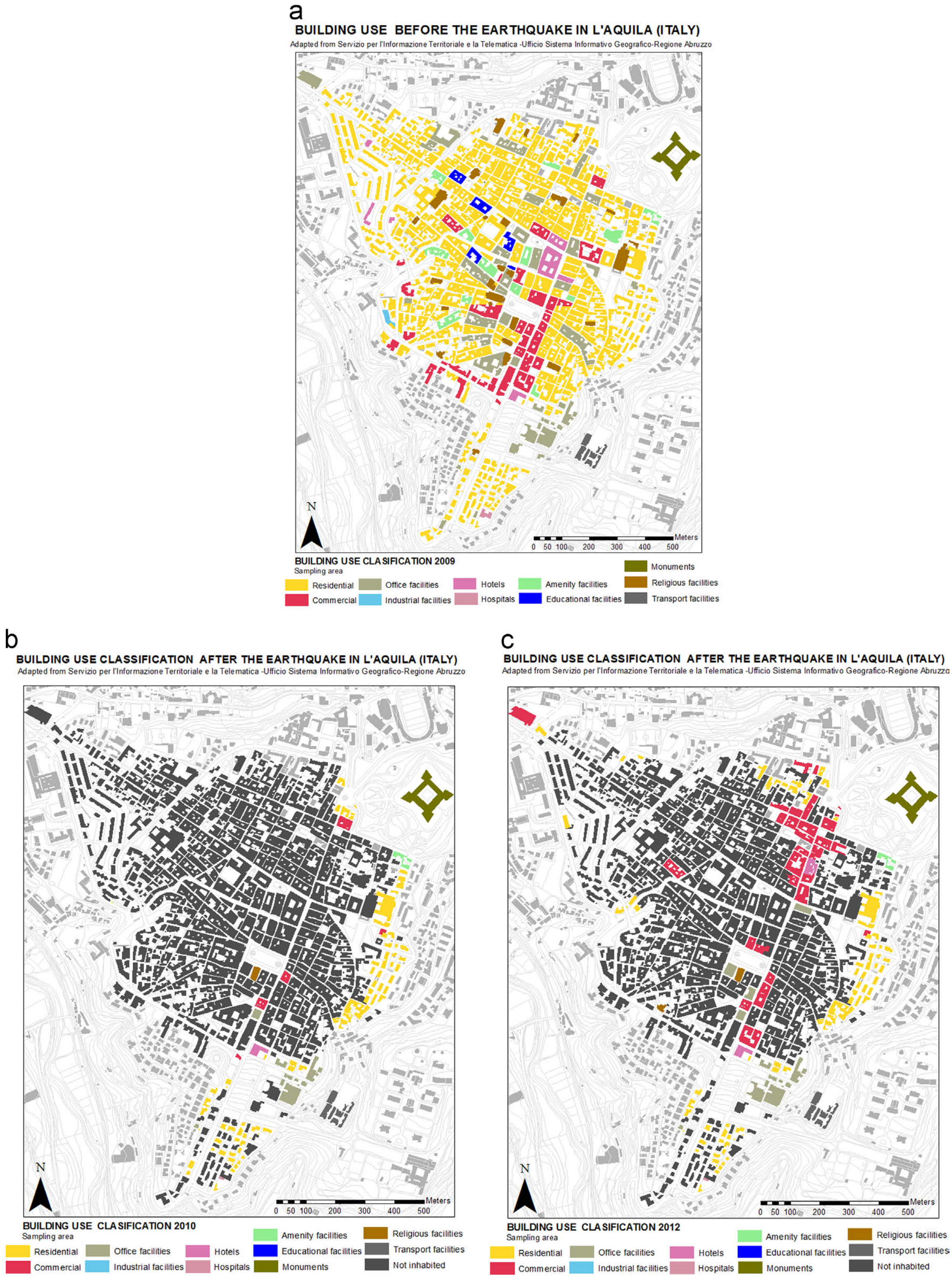



**Fig. 7.** Time series to compare the changes in the building use in the center of L'Aquila (Italy) after the earthquake between (a) 2009, (b) 2010 and (c)2012.

people had started to visit them again, as Díez has also annotated [10].

### 3.5. Estimate the progress using expert weights

After having quantified the changes observed in the buildings within the land restriction area between 2010 and 2012, as well as the changes in building use between 2009 (before the earthquake), 2010 and 2012; expert weighting is subsequently used to determine which categories of land restriction and building use contributes more to the progress of the recovery process after an earthquake. For this to happen we mainly extracted evidence from the MICRODIS project [33], as well as from the surveys carried out in Kobe [32] in order to determine what life recovery means to earthquake victims and what factors citizens consider to be important for the recovery of living conditions. We additionally considered expert weighting exercises documented for Thailand and Pakistan [26]. The degree of significance allocated to each variable of the indicators building condition and building use, is detailed in Table 1 and depicted in Fig. 10.

The three experts considered that the variable *reconstruction on-going*, followed by the variables *partially enabled*, *construction on-going*, and *inhabited* are the stages in the indicator building condition which contribute more to the progress of the recovery. Contrarily *restricted use*, *demolished*, *propped* and *reconstruction projected* does not contribute to the progress of the recovery after an earthquake.

In the same manner, experts determined that the most strategic building use, in order to encourage the recovery purpose is the *residential* use, followed in descended order by *transport*, *commercial*, *hospitals*, *educational*, *office*, *industrial*, *religious*, *hotels*, *and amenity facilities*, as well as, *monuments*. The more harmful condition for the recovery purpose is *not inhabited*. The result of the weightings for all variables considered is portrayed in Fig. 8.

### 3.6. Determining hotspots of recovery in L'Aquila

Experts allocated a value to each variable of the building condition (reconstruction on-going, partially enabled, construction on-going, inhabited, reconstruction projected, propped, demolished and restricted use), and building use (residential, transport, commercial, hospitals, educational, office, industrial, religious, hotels, amenity, monuments facilities, and not inhabited), according to the contribution of each

**Table 1**
Expert values and weights allocated to variables of the indicators: building condition and land use.

| D | IND | Variable | Values | | | Normalized Values | | | | Weights | | | Normalized Weights | | | | ANvi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Experts | | | Experts | | | Av | Experts | | | Experts | | | Ai | |
| | | | 1 | 2 | 3 | 1 | 2 | 3 | | 1 | 2 | 3 | 1 | 2 | 3 | | |
| **Physical** | | | | | | | | | | | | | | | | | |
| | **Building Condition** | | | | | | | | | | | | | | | | |
| | | Construction on-going | 8 | 8 | 8 | 0.17 | 0.17 | 0.14 | 0.16 | 9 | 9 | 9 | 0.47 | 0.53 | 0.50 | 0.50 | 0.08 |
| | | Partially enabled | 9 | 8 | 8 | 0.20 | 0.17 | 0.14 | 0.17 | | | | | | | | 0.08 |
| | | Reconstruction on-going | 8 | 9 | 9 | 0.17 | 0.19 | 0.16 | 0.17 | | | | | | | | 0.09 |
| | | Reconstruction projected | 6 | 6 | 8 | 0.13 | 0.13 | 0.14 | 0.13 | | | | | | | | 0.07 |
| | | Propped | 4 | 6 | 6 | 0.09 | 0.13 | 0.10 | 0.11 | | | | | | | | 0.05 |
| | | Inhabited | 10 | 8 | 3 | 0.22 | 0.17 | 0.05 | 0.15 | | | | | | | | 0.07 |
| | | Restricted use | 0 | 1 | 8 | 0.00 | 0.02 | 0.14 | 0.05 | | | | | | | | 0.03 |
| | | Demolished | 1 | 2 | 8 | 0.02 | 0.04 | 0.14 | 0.07 | | | | | | | | 0.03 |
| | | TOTAL | 46 | 48 | 58 | 1 | 1 | 1 | 1 | | | | | | | | 0.50 |
| **Socio - Economic** | | | | | | | | | | | | | | | | | |
| | **Building Use** | | | | | | | | | | | | | | | | |
| | | Commercial | 9 | 8 | 9 | 0.12 | 0.10 | 0.11 | 0.11 | 10 | 8 | 9 | 0.53 | 0.47 | 0.5 | 0.50 | 0.05 |
| | | Transport facilities | 9 | 9 | 9 | 0.12 | 0.12 | 0.11 | 0.11 | | | | | | | | 0.06 |
| | | Amenity facilities | 5 | 5 | 6 | 0.06 | 0.06 | 0.07 | 0.07 | | | | | | | | 0.03 |
| | | Religious facilities | 6 | 5 | 5 | 0.08 | 0.06 | 0.06 | 0.07 | | | | | | | | 0.03 |
| | | Hospitals | 7 | 8 | 9 | 0.09 | 0.10 | 0.11 | 0.1 | | | | | | | | 0.05 |
| | | Office Facilities | 8 | 7 | 8 | 0.10 | 0.09 | 0.09 | 0.1 | | | | | | | | 0.05 |
| | | Educational facilities | 7 | 8 | 8 | 0.09 | 0.10 | 0.09 | 0.1 | | | | | | | | 0.05 |
| | | Hotels | 4 | 6 | 6 | 0.05 | 0.08 | 0.07 | 0.07 | | | | | | | | 0.03 |
| | | Industrial facilities | 8 | 7 | 8 | 0.10 | 0.09 | 0.09 | 0.1 | | | | | | | | 0.05 |
| | | Monuments | 5 | 2 | 3 | 0.06 | 0.03 | 0.04 | 0.04 | | | | | | | | 0.02 |
| | | Residential | 10 | 10 | 10 | 0.13 | 0.13 | 0.12 | 0.13 | | | | | | | | 0.06 |
| | | Not inhabited | 0 | 2 | 4 | 0.00 | 0.03 | 0.05 | 0.02 | | | | | | | | 0.01 |
| | | TOTAL | 78 | 77 | 85 | 1 | 1 | 1 | 1 | 19 | 17 | 18 | 1 | 1 | 1 | 1 | 0.50 |
| | | TOTAL | 1.00 | | | | | | | | | | | | | | |

**D** Dimension
**IND** Indicator
**Av** Average of normalized values for variables;
**Ai** Average of normalized weights for indicators;
**Anvi** Average of normalized values of variable, times the average of normalized weight of indicators.

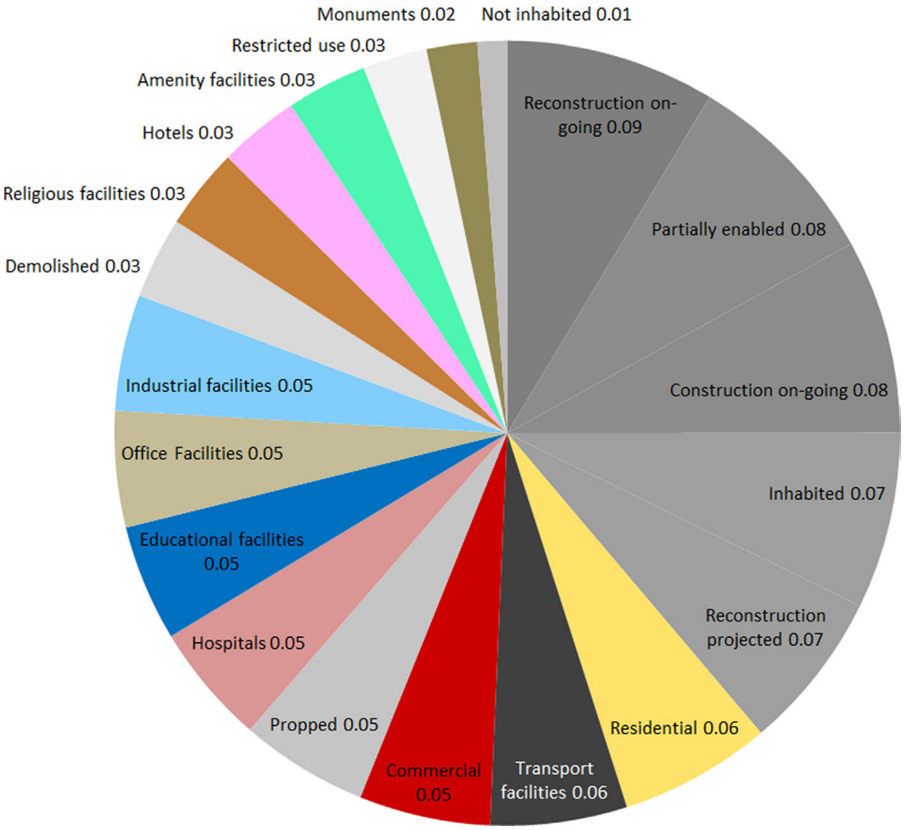



**Fig. 8.** Result of the expert weights for variables of the indicators: building condition and building use.

variable to the overall progress of the recovery after an earthquake. Then the values were normalized, and the average of the normalized values for each variable was calculated.

A similar process was carried out with regard to each indicator for *building condition* and *building use*, but this time a weight was allocated according to what experts consider to be the contribution of each indicator – rather than the variable as described before. Then the weights were normalized, and the average of the normalized weights for each indicator was calculated.

Finally, the average of the normalized values of each variable was multiplied with the average of normalized weights of the corresponding indicator, for which the variable was aggregated. This yields a final score of the contribution of each variable to the progress of the recovery process. Lastly, these two scores were attributed to each building regarding its building condition and building using *ArcGIS*, using the function *selection by attributes*. The two scores were added and the result of this sum was normalized as described in formula (1). Attaching these values in a GIS software rendered possible to identify the hot-spots of recovery.

Therefore, the hotspots of the recovery in the city of L'Aquila are discovered through the mapping of normalized result of the addition of the values that every building gets due to its building condition in 2010 and 2012 respectively; plus the value of its building use classification in the same years.

$$RS_i = ev_1 ew_1 BC_i^K + ev_2 ew_2 BU_i^K \quad (1)$$

where $ev_1$=expert value assigned to the variable 'building condition', $ev_2$=expert value assigned to the variable 'building use', $i$=index of the building, $k$=year, $ew_1$ $BC$=building condition, $ew_2$ $BU$=Building use and $RS_i$=Recovery score for building $i$.

## 4. Results

The sampling area of the historic center of L'Aquila included 753 buildings. In 2010, the most of the buildings included in the sampling area were also counted in the restriction area: 621 (82%). In 2012, this situation still continued but the number of buildings counted in the cordoned-off area constitutes 332 buildings, accounting for 44% of the total number of blocks in the sampling area. This result means that the number of buildings included in the restricted area has decreased in 289 (38%), between 2010 and 2012.

The number of *inhabited* buildings in the sampling area was 99, (13%) of the total buildings counted in the sampling area in 2010; this number rose to 110 (15%) in 2012. In the last year, only 11 more buildings (1%) were re-inhabited in the sampling area.

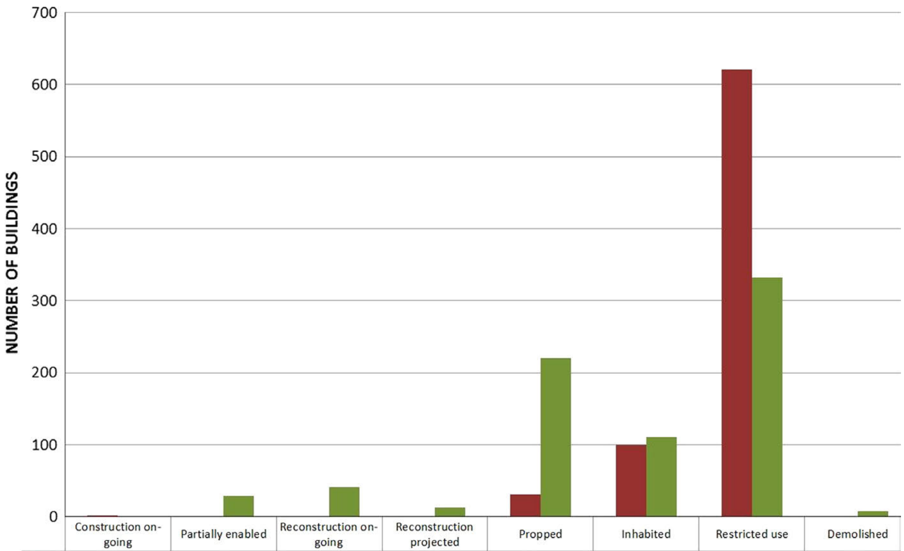
Compared to 2010, at least 29 buildings, constituting 4% of the total number of buildings, were *partially enabled* using the ground floor, mainly with commercial purposes. In the first fieldwork carried out in 2010, two buildings were under *construction*, a process which has meanwhile been completed. The number of *propped* buildings grew to 189 (25%), between 2010 and 2012; counting only 31(4%) *propped* buildings in 2010, and 220 (29%) in 2012. Additionally, only 8 (1%) of buildings have been *demolished*, which is not significant compared with the total number of buildings. The number of buildings under *reconstruction* is 41, accounting for only 5% of the total number of buildings in the sampling area. 13 buildings fall into the *reconstruction projected* category, accounting for only 2% of the total number of buildings in the sampling area. These results are plotted in Table 2 and Fig. 9.

The number of parcels in almost every building use class included in the sample plummeted after the earthquake in 2009. In 2010, 648 (86%) buildings were counted as *not inhabited*, and in 2012 this number slightly decreased to 611(81%), meaning a small reduction of 6% in the number of *not inhabited* buildings in two years. Between 2009, 2010 and 2012, the number of *amenity facilities* only increased by 1 (0%), leaving only 7% of the existing facilities before the earthquake, and showing no progress between 2010 and 2012. In the same period, the number of *commercial facilities* grew to 5 (11%) in 2010, and later rocketed to 33 in 2012, which means a recovery of 75% with respect to the existing *commercial facilities* in 2009. *Educational* and *industrial facilities* disappeared after the earthquake and have been neither reconstructed, nor habilitated by 2012; however, they only represented 1% and 0%, respectively, in the proportion of buildings counted in the sampling area. Only one of the *medical facilities* existing before the earthquake has been recovered, but there were only 2 (0%) in 2009, which is not a

**Table 2**
Comparison of changes in the restricted zone in L'Aquila (Italy) between 2010 and 2012 after the earthquake.

| Buildings condition | 2010 | | 2012 | | Progress | |
|---|---|---|---|---|---|---|
| | Number | Percentage (%) | Number | Percentage (%) | Number | Percentage (%) |
| Construction on-going | 2 | 0 | 0 | 0 | −2[a] | 0[a] |
| Partially enabled | 0 | 0 | 29 | 4 | 29 | 4 |
| Reconstruction on-going | 0 | 0 | 41 | 5 | 41 | 5 |
| Reconstruction projected | 0 | 0 | 13 | 2 | 13 | 2 |
| Propped | 31 | 4 | 220 | 29 | 189 | 25 |
| Inhabited | 99 | 13 | 110 | 15 | 11 | 1 |
| Restricted use | 621 | 82 | 332 | 44 | −289[b] | −0,38[b] |
| Demolished | 0 | 0 | 8 | 1 | 8 | 1 |
| Total | 753 | | 753 | | | |

[a] When there is no progress between 2010 and 2012 in a particular variable, negative values are obtained in the estimation of the progress.
[b] In the case of the variable: restricted use, the reduction in the number of buildings classified under this condition means progress in the recovery process.




| | Construction on-going | Partially enabled | Reconstruction on-going | Reconstruction projected | Propped | Inhabited | Restricted use | Demolished |
|---|---|---|---|---|---|---|---|---|
| 2010 | 2 | 0 | 0 | 0 | 31 | 99 | 621 | 0 |
| 2012 | 0 | 29 | 41 | 13 | 220 | 110 | 332 | 8 |

**Fig. 9.** Comparison of changes in the restricted zone in L'Aquila (Italy) after the earthquake between 2010 and 2012.

significant number compared with the total number of buildings counted in the sampling area. The number of *hotels* open to tourists rose to only one (8%) in 2010, and two more (17%) in 2012; nevertheless, it is still a small advance of 8% between 2010 and 2012 and 17% with respect to the existing *hotels* in the city center before the earthquake. *Monuments* were already recovered to 50% by 2010, and this value was maintained in 2012, which indicates no progress in two years. The number of *office facilities* such as banks dropped to 11 (20%) in 2010, but increased to 15 (27%) in 2012; accounting for another small progress three years after the earthquake. Regarding *religious facilities*, only one (3%) was already open to the public in 2010, and a second one by 2012, which means an advance of only 7% regarding 2009 as a benchmark. *Residential* use covers 580 buildings (77%) in the sampling area, and after the earthquake only 76 (10%) buildings are still counted as *residential*, because the others were *not inhabited*; however this number slightly rose to 79 (10%) in 2012, meaning a recovery of only 14%, compared with 2009. *Transport facilities* (bus stops and transport terminals seemed to be un-affected by the earthquake, at least regarding their structure, but not their functionality). These results are depicted in Table 3 and Fig. 10.

**Table 3**
Comparison of the changes in the building use in L'Aquila (Italy) between 2009, 2010 and 2012 (before and after the earthquake).

| Building use | 2009 | | 2010 | | 2012 | | Progress 2010 | | Progress 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percentage (%) | Number | Percentage (%) | Number | Percentage (%) | Number | Percentage (%) | Number | Percentage (%) |
| Not inhabited | 0 | 0 | 648 | 86 | 611 | 81 | 648 | 0 | −37 | 0,94[a] |
| Amenity facilities | 15 | 2 | 1 | 0 | 1 | 0 | −14 | 7 | 0 | 7 |
| Commercial | 44 | 6 | 5 | 1 | 33 | 4 | −39 | 11 | 28 | 75 |
| Educational facilities | 5 | 1 | 0 | 0 | 0 | 0 | −5 | 0 | 0 | 0 |
| Hospitals | 2 | 0 | 1 | 0 | 1 | 0 | −1 | 50 | 0 | 50 |
| Hotels | 12 | 2 | 1 | 0 | 2 | 0 | −11 | 8 | 1 | 17 |
| Industrial facilities | 1 | 0 | 0 | 0 | 0 | 0 | −1 | 0 | 0 | 0 |
| Monuments | 2 | 0 | 1 | 0 | 1 | 0 | −1 | 50 | 0 | 50 |
| Office Facilities | 55 | 7 | 11 | 1 | 15 | 2 | −44 | 20 | 4 | 27 |
| Religious facilities | 29 | 4 | 1 | 0 | 2 | 0 | −28 | 3 | 1 | 7 |
| Residential | 580 | 77 | 76 | 10 | 79 | 10 | −504 | 13 | 3 | 14 |
| Transport facilities | 8 | 1 | 8 | 1 | 8 | 1 | 0 | 100 | 0 | 100 |
| Total | 753 | | 753 | | 753 | | | | | |

[a] It is taken for granted that all the buildings were inhabited in the sampling area in 2009, before the earthquake; hence the estimation of the progress is different, because it is associated with the reduction of the number of parcels not used. The percentage of progress is the difference between the calculated percentage and 100.

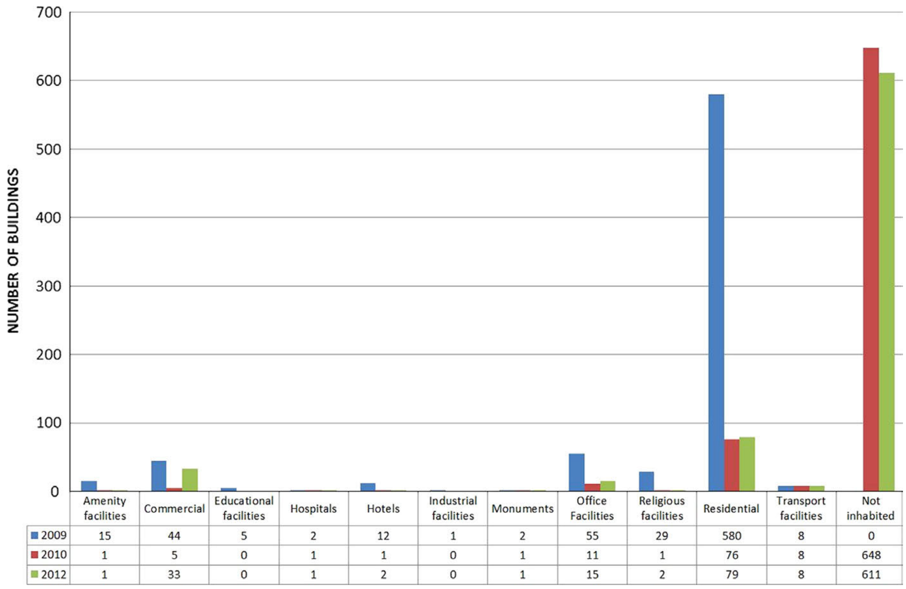



**Fig. 10.** Comparison of changes in the sampling area regarding the building use in the center of L'Aquila (Italy) after the earthquake between 2009, 2010 and 2012.

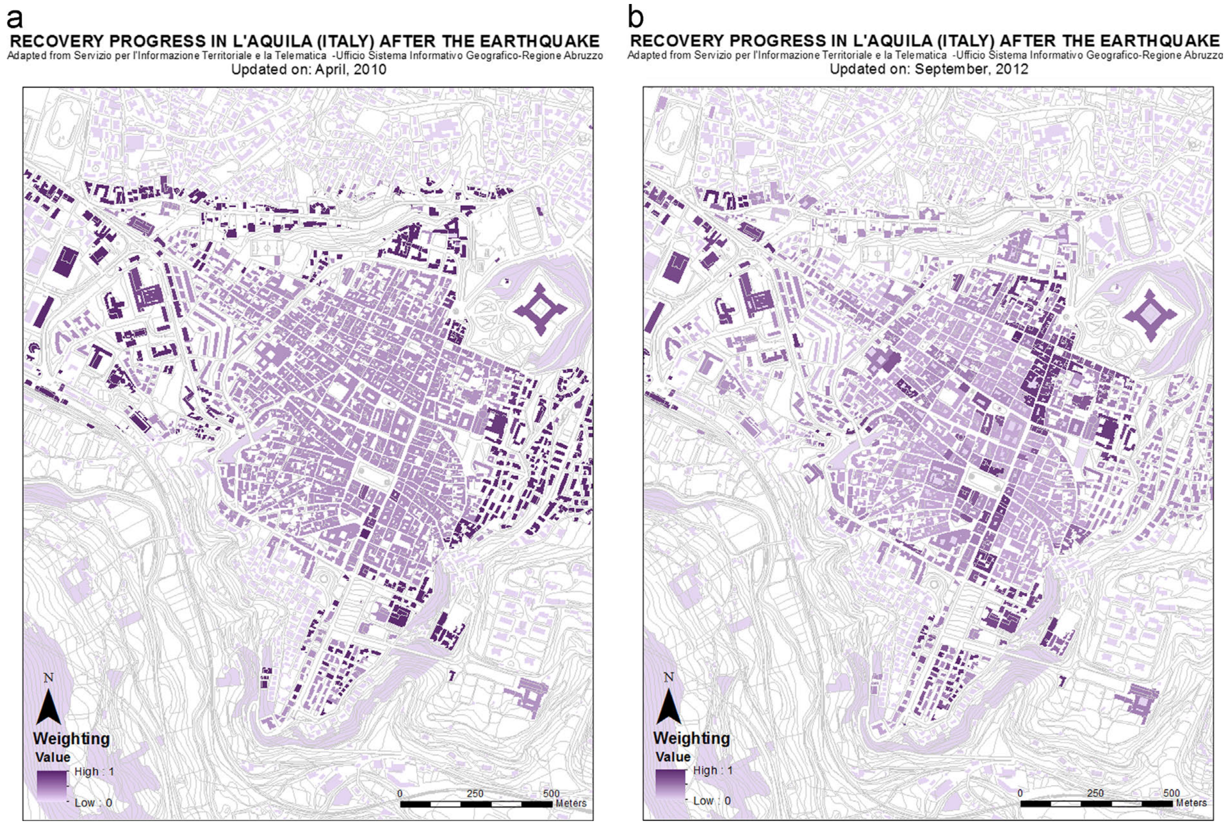



**Fig. 11.** Recovery progress in the city center of L'Aquila (Italy) after the earthquake in (a) 2010, and (b) 2012.

After applying equation No. 1 to process the data collected during fieldwork in 2010 and 2012, plus the weighing criteria from the experts, it is possible to map the hotspots of recovery in L'Aquila in 2010 and 2012 and see its evolution as it is plotted in Fig. 11(a) and (b) respectively.

## 5. Discussion

Recovery phases do not have clear boundaries because the activities in each dimension advance with various speeds according to the decisions of the population in a participatory process, or the decisions of the government, such as in the case of L'Aquila. This proves that the boundaries between the recovery phases are fuzzy for L'Aquila. On the one hand, it is still possible to find machinery removing rubble; the cordoned off area, damaged and deteriorated empty buildings, as well as plants and climbers growing up around the buttress of the propped buildings. On the other hand, within close proximity to the borders of the restricted area in 2012, in an area formerly also restricted (2010), there are now new buildings, bars, cafes, shops, convenience stores, small restaurants, hotels, and tourists walking around and taking pictures, as well as trucks continuously going in with construction material and going out with rubble, buildings being restored, and so on. The seismic base isolation included in the design and construction of new settlements, in order to raise the seismic performance of their structures and protect the buildings against earthquake forces, is already a characteristic of the development phase. In this sense, there is a dilemma in deciding the stage of the recovery process in L'Aquila in 2012, because there are ongoing activities of the early recovery, recovery and development phases at the same time.

According to the California Seismic Safety Commission which estimate a maximum time to resume functionality of buildings after an earthquake, the historic buildings which do not provide essential service for the community have unlimited time to recover [13]. Therefore, having in mind that the city center of L'Aquila is made up of historic buildings such as churches, it is not possible to state that L'Aquila is already delayed in the recovery process of its historical center. However, according to several authors, delays in recovery will bring about social problems [13], as it is it the case in L'Aquila.

The poor management of debris and construction and demolition (C&D) waste management can be another reason for the slow and costly recovery process, not only in the physical, but also in the social and economic dimensions [2]. According to Brown, several studies confirm that a fast disaster debris removal encourages the community recovery process [3]. Another failure in the recovery process of L'Aquila regarding C&D management is the lack of involvement of the community in the decisions regarding the solid waste management programs, which according to the United States Environmental Protection Agency (USEPA) is one of the key elements for the success of the program [3].

Usually the activities taking place in the physical aspect advance faster, or are at least more evident, than the activities for recovering the living and the economic conditions existent before the event. In L'Aquila, houses were quickly built-up in order to solve the problem of the homeless, however, totally isolating of the source of employment, the academic centers and the amenities of the city. However, according to Huichi [32] in the workshops conducted in Kobe, the first element that citizens consider helpful to promote the recovery was housing whereas the economy ranked in the sixth position in a list of seven elements that also included: social ties, community rebuilding, physical and mental health, preparedness, and relationship to government. In 2004, Wu and Lindell claimed that the damages in the houses substantially affects the lives of the victims, hence the recovery time of housing is a significant indicator of community recovery [13]. In the case of Mexico city, the government was criticized, because after the earthquake in 1985,which also affected mainly the historical center, it gave priority to recovering economy services and activities, instead of housing like in L'Aquila [34].

During the day, the fences were often opened to allow the circulation of trucks in charge of the C&D waste management into the restricted area. The access control to the restricted area seemed to be more flexible than two years ago. Cars and people were also allowed to circulate around and through some streets formerly included in the cordoned off area. Metaphorically this could be seen like allowing the blood to circulate around the body [9], if there is blood, there is life.

Many tourists were observed visiting the city. In the years after the earthquake in L'Aquila, it was always possible to find available hotels, whereas in San Francisco after the 1989 Loma Prieta only two years later the reconstruction of the hotels began [13].

However, one source of employment was the construction and demolition industry [3,11] which was very active for that time in the city center of L'Aquila and its surroundings. This activity attracted workers and visitors, encouraging the slow opening or reopening of new restaurants, convenience stores, hotels and tourist attractions such as the church “Santa Maria di Collemagio”. In order to be able to discover these slow changes, it is necessary to go beyond the physical appearance of the facades of the buildings, and to study the socio-economic dynamics ongoing in space and time, which for instance the building use changes can indicate.

The reconstruction initiatives were isolated [2] and focused on individual buildings, instead of belonging to a holistic plan of urban recovery which attracts housing to the historic city center of L'Aquila. The new houses were built in settlements outside of the city's core instead of trying to reconstruct the existing houses in the city center.

## 6. Conclusions

The decline in the number of buildings in the restricted area counted between 2010 to 2012 can be explained for the buildings which have been partially enabled, the buildings where reconstruction was already on-going, or at least projected; the buildings which were still propped but no longer belong to the cordoned-off area, and some others that were already demolished. There was a slight rise in the number of inhabited houses between 2010 and 2012, along with unconnected on-going renovation projects. The fieldwork and the analysis proved that the reconstruction process, although slowly, has definitely started. This can mainly be attributed to the amount of partially enabled buildings, and reconstruction projects as well as a few new buildings. The number of propped buildings increased. They could equivocally be attributed to the reduction of the cordoned-off area: some buildings may have not been mapped before in the restricted area but reconstruction activity has clearly increased.

Community *amenities*, as well as *commercial* and *office facilities* showed a slow recovery for 2012. This is a particular problem because all three categories are important for the process: recovery requires sources of employment, tax revenues, income and work [6]. The recovery of businesses as well as the whole recovery process could have been faster if L'Aquila had a pre-impact recovery plan, but unfortunately it did not have one. The education facilities which are usually a sign of ‘back to normality’ were still closed in the sampling area. This may be a consequence of the domino effect of the lack of housing. Before the earthquake the medical facilities in the sampling area were rare but there were a few and they were very important. Only one is now open to the public, which is another sign of the slow recovery. It is important that hotels have started to open again, which reinvigorates the historic center. Tourists started to come back to the center of L'Aquila. This does not only contribute to the economy of the former business district of L'Aquila, but also reduces a potential image that at nighttime the center of L'Aquila looks like a “nest of ghost” [10]. Existing industry facilities before the earthquake were all small industry businesses. This factor may be less important compared to other cities. Monuments such as sculptures and buildings are symbols, nodes and/or landmarks [27] for the community. Their recovery is important for the imaginary of people. The most representative node, the Castello (Forte Spagnolo), was open to the public since 2010, which is encouraging the recovery of the city [10]. Another kind of monuments are *religious facilities*, predominantly churches. They also serve as nodes for people. Their slow reconstruction can be one major reason that some studies state that nothing has changed since April 6th, 2009 in L'Aquila's recovery process. Such statements clearly ignore the slow but existing progress in other dimensions and/or other areas of the city.

Based on the sum of the various facts presented, we can assume that housing in the sampling area will not increase significantly in the next few years for three main reasons: (1) the cleaning of debris has not finished yet; (2) most of the former inhabitants of the city center are already relocated and will not return; (3) the few existing inhabited houses are the result of private isolated reconstruction initiatives. Nevertheless, housing should be encouraged as a type of building use in the city center as soon as possible, because it is a determining and effluent element in the recovery of daily life of the historic center of L'Aquila.

The result of the expert weighing reveals that physical variables aggregated to the indicator of building conditions are more representative than socio-economic variables aggregated to the meta-indicator building use. However, it is necessary to consider that these physical variables were selected due to their contribution to the impression that people have in mind about recovery. The disaggregated variables which contribute more to the progress of the recovery were ranked in an order that ranges from most important least important: *reconstruction on-going*, *partially enabled*, *construction on-going*, *inhabited and reconstruction projected*, *residential*, *transport facilities*, *commercial*, *buildings propped*, *hospitals*, *educational facilities*, *office facilities*, *industrial facilities*, *buildings demolished*, *religious*, *hotels*, *amenity facilities*, *restricted use*, *monuments* and *not inhabited*.

The hotspots of recovery in the city center of L'Aquila were located along the main commercial axes. All of these roads arrive at the North-West of the city, where Castello (Forte Spagnolo), the main touristic attractions of L'Aquila are located. The recovery in the city center of L'Aquila is dependent on tourism and building uses tied to it, such as: *commercial facilities* (bars, cafes, shops, convenience stores and small restaurants); *hotels*, *monuments*, and *office facilities* (banks). This may somehow contradict the finding of earlier studies and expert opinions which assume that the most important building use type for the recovery processes is housing. In 2012, housing is almost absent in city center of L'Aquila. This fact contributes to the impression of stagnation which our study disproves to some degree.

The hotspot recovery map coincides with the identified changes in the restricted zone as well as with the building use during the post-disaster phase in L'Aquila. Therefore, we can state that the methodology and the index formulated and implemented in the present research can be applied to monitor other recovery process after earthquakes in the world. Nevertheless, the proof of transferability will require further studies.

We can conclude that one may be likely to think that the reconstruction in L'Aquila has stopped when solely focusing on the city center. Nonetheless, our research revealed a more differentiated image. We suggest a deflationary approach while avoiding the term restricted area. We suggest to using terms such as *recovery area*, *area under recovery*, *reconstruction area*, or *area under works*. In fact, the restricted area in 2012 was already very small and the borders were fuzzy because in some cases it was possible to access to restricted streets through another streets which are accessible. In the end, we do not agree with considering L'Aquila as “the Pompeii of the 21st century”[12] or “nest of ghosts” [10] L'Aquila is only in a slow recovery process.

We plan to continue monitoring this process again in April 2014 and potentially in 2019, five and ten years after the earthquake, respectively, to compare it with the situations of 2010 and 2012 and to be able to fully analyze the third recovery phase as defined by UNDP for L'Aquila.

## 7. Recommendations

If the reconstruction initiatives in the city center of L'Aquila continue, the progress of the recovery of the city will be more visible, and according to Denhart, allowing property owners to participate in the deconstruction and resource recovery process of their property generates an especial attachment between people and their houses [3], which was not observed in L'Aquila in 2012.

The commercial and touristic activities in L'Aquila and the Gran Sasso and Monti della Laga National Park [4] can be a driving factor in the recovery of the city, and hence should be more promoted by the government, because as it was stated by Pelling in 2003 [16], disaster impacts set back development.

An academic methodology for monitoring recovery not only allows recording the experience, but also to avoid the sensationalism and lack of dispassion of the media, which instead of supporting the recovery of L'Aquila, are scaring the necessary investors to facilitate progress in the recovery process.

It is important to state that that the methodology proposed in this paper is in principle repeatable and applicable to other post-disaster cases. Nevertheless, the variables as well as the indicators and the particular values and weights attached to them will vary according to cultural differences, pre-existing vulnerability conditions of the affected area, and the background of the experts who assign those values and weights. Ideally, the values and weights should be developed in a participatory process by the affected community as it was presented by Brown et al. [26]. Unfortunately, this study by Brown et al. seems to be a rare exception. It is not only extremely time-consuming and labor-intensive for the scientists to carry out workshops and surveys among the affected population. In many cases, including the community of L'Aquila, many citizens are traumatized, frustrated and do not like scientists to interfere their daily routines.

The assessment of a recovery is a continuous monitoring process which requires the consistent use of indicators throughout the entire process. Using the same indicator framework sets a benchmark for a new evaluation period. The authors will carry out another field campaign in L'Aquila in April 2014 while using the indicator framework developed and described in this article.

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