Test of seismic vulnerability maps and their prospective implementation in Plan4all data models

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1. *The methodology and the model used*

The methodology used to evaluate urban vulnerability considers the urban territory as well as the complex of physical and functional relationships of the urbanized territory and not a simple summation of elements. One of the characteristics of this examination is that it allows for a simultaneous analysis of the multiple factors involved in vulnerability assessment.

The verification of the model has been realized through the comparison of raster files of the map of urban vulnerability, that represents the graphic result of the elaborations effected in 2002, and the map of the survey of fitness for human habitation realized after the earthquake. Such comparison has been realized to evaluate the correspondence between the categories of the two classifications and, subsequently, to verify if the introduction of further parameters, as the seismic characteristics of the grounds, could improve the fit between the two cartographies. The verification and tuning of the model is a necessary operation, as it evaluates whether or not it is possible to extend its applicability to other urban areas.

Post seismic effects can also be validated by a check with teledetected high resolution images: when and if the satellite images are available in the immediate post seismic period, they constitute a tool to support the management of the emergency, in fact they can help to detect quickly the areas and the structures that suffered the worst damages. Recent application (Ajmar et al., 2010) demonstrated that also the simple manual vectorization by unskilled operators can be a valid tool to map the emergency quickly.

For this experimentation five vector 1A scenes were available, they cover the whole territory of the city of L'Aquila, and they were acquired on 17^{th} and 24^{th} April 2009, few days after main seismic event. The experiment was conducted only on 2 satellite images, chosen to cover the areas most affected by the earthquake.

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The tests of detection of damaged buildings were executed by operators more or less skilled (Tab. I) to verify the actual and present possibilities of using the EROS B high resolution images for these specific applications. In the first set of tests («Double blind» test) operators used only orthorectified images, in the second set of tests («Not blind» test) they used images and a map of damaged building together.

It was also evaluated the actual possibility of organizing these themes to fit the data models Plan4all of the INSPIRE project that would have the advantage of allowing a faster exchange of information between the various agencies involved in emergency management.

2.1. Materials used: the vulnerability map

The quantitative vulnerability assessment of an urban centre is a base requisite for optimal planning of interventions for risk mitigation (Guarascio, 2010; Guarascio 2009; Guarascio, 2007). In particular to identify the action priorities, the planner has to know the elements of vulnerability of an urban center. To achieve this purpose it's important to realize a model of the urban center considering all the factors that determine its vulnerability and, therefore, the risk.

The vulnerability has been estimated by an expeditious survey of the features of the buildings, resulting in a classification of buildings into high, medium-high, medium-low and low vulnerability (Beolchini, 2003).

The results of the executed analyses were reported on a vulnerability map that has originally been referred to the Italian national cadastral coordinates systems: CASSINI-SOLDNER, at 1:2,000 scale. This map was then reprojected in the grid UTM-WGS84 to allow the comparison with other cartographies and surveys (reprojection was performed in gvSIG environment). In this model the classes of seismic vulnerability have been selected considering the calculated values of the vulnerability normalized on the maximum value.

Table I. Vulnerability ranges.

Index ranges	Vulnerability categories
0 – 0.25	Low
0.26 – 0.40	Medium to Low
0.41 – 0.70	Medium to High
0.71 – 1.00	High

2.2. Materials used: the map of fitness for human habitation

The evaluation of fitness for human habitation, executed during the first emergency period following the event of April 6th 2009, is a preliminary estimation whose main goal was to establish if the buildings struck by the earthquake can be used without risking human life.

The surveys were performed using technical form, to make the evaluations of different surveyors as homogeneous as possible to allow an immediate digitalization and statistic treatment of the data.

The result of the judgment of fitness for human habitation has to fit in one of the six possible categories specified in the chart, where «*usable*» intends «*building suitable for human habitation*»:

A. *Building usable*;
B. *Building temporarily unusable (everything or part)*: but usable after some interventions, which make it usable in all of its parts, without danger for the residents;
C. *Building temporarily unusable, to be investigated further*: when building presents characteristics that make the evaluation uncertain;
D. *Building partially unusable*: the state of certain portions of the buil ding could cause elevated risk for their occupants;
E. *Building unusable due to structural, non structural or geotechnical risks*;
F. *Building unusable due to serious external risk, in absence of consistent da mage to the building*: for example, an undamaged building contiguous to a building that could collapse.

The original vector maps were not available, so it was necessary georeferencing and mosaic the pdf file in Q-GIS environment: the map was projected in UTM-WGS84-ETRF89.

The map of fitness for human habitation was compared with the high resolution orthorectified EROS B monoscopic images (resolution 0.70 m). At the present, the monoscopic images are widely used for damage valuation (Ajmar et al., 2010; Matsuoka et al., 2004; Sakamoto et al., 2004; Stramondo et al., 2006), as we have done in our experiment (Baiocchi et al., 2010b).

2.3. Materials used: the map of seismic zoning

After the April 6th 2009 earthquake the DPC entrusted a working group for the creation of maps of seismic zoning for the area of L'Aquila city (Fig. 1). Such maps are fundamental: to the critical analysis of the results achieved with the model of vulnerability; to see if the reaction of the structures to the seismic action is notably influenced by the characteristics of the site.

In the seismic zoning map both stable areas, with or without amplification characteristics, as well as unstable areas, due to landslides or liquefaction risk, are shown. Once more the original vector maps were not available so mosaicking of two pdf files and re-projection in UTM-WGS84-ETRF89 (1:10,000 scale) was performed in Q-GIS environment.

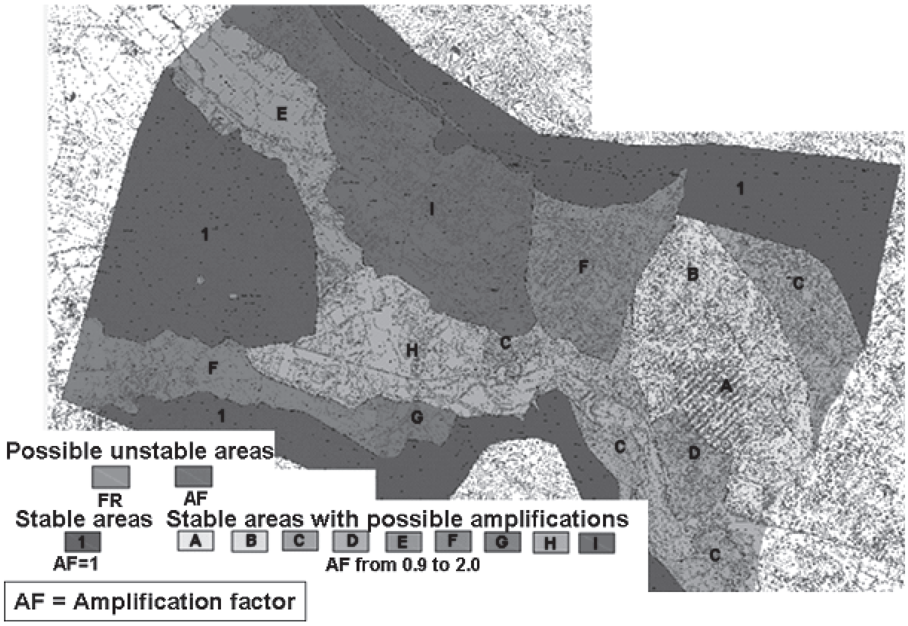


Figure 1. Mosaic of seismic zoning maps for the area of L'Aquila city and surrounding. UTM north is up, EW width is approximately 9 Kilometres, possible unstable areas are only the two lighter tiny areas in the big «1» polygon on the west area and the lighter narrow stripe in the «1» polygon on the north side of the map.

2.4. Materials used: HRSI-High Resolution Satellite Image and DEM-Digital Elevation Model

EROS-B satellite platform, probably one of the less studied among VHR (Very High Resolution) images, releases panchromatic images with resolution up to 0.7 meters in panchromatic modality; no multispectral sensor is reported for this platform. Presently the only commercial SW supporting EROS B are: «ERDAS IMAGINE LPS-9.2», «Geomatica 10.1.1» and «SOCET SET 5.4.1» (ImageSat International, 2008). The images are usually released in 1A format that means only «radiometric system correction» was applied without any geometric correction: this product is the most suitable for photogrammetric use.

EROS-B images are available to the end user very quickly because there is a big number of ground stations and also temporary stations can be installed if needed; furthermore the wait between order and actual acquisition is usually shorter for EROS-B if compared with more diffused competitors as Ikonos and Quickbird, for example; obviously this is only a generic consideration because, on a specific order, availability of the platform and priority of the acquisition can influence deeply delay for release of the single image. The shorter delay can be obviously a fundamental advantage when managing emergency events.

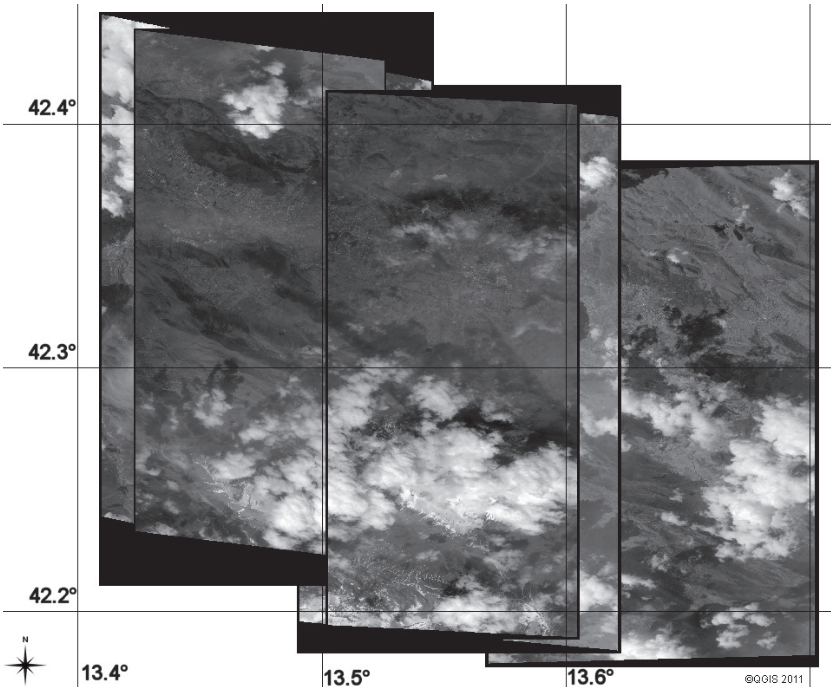


Figure 2. The five images used: foreground from W to E «geo_MBT1-e2166574» and «geo_MBT1-e2166575», background from W to E «geo_MBT1-e2165298», «geo_MBT1-e2165297» and «geo_MBT1-e2165296».

Table II. Characteristics of acquired images as reported on metadata files (please note correspondence between name of the file and ID), γ-s and γ-e is for total angle of off-nadir at the beginning and at the end of the acquisition.

ID	name	γ-s	γ-e	GSD [m]	GSD (across) [m]
im74	geo_MBT1-e2166574	30.4	28.6	0.77	1.00
im75	geo_MBT1-e2166575	25.5	25.8	0.75	0.90
im96	geo_MBT1-e2165296	36.2	35.1	0.83	1.30
im97	geo_MBT1-e2165297	35.3	35.5	0.83	1.20
im98	geo_MBT1-e2165298	38.4	39.2	0.87	1.40

For this experimentation five vector 1A scenes (Tab. II) were available; they cover the whole territory of the center of L'Aquila (Fig. 2) and were acquired on 17th and 24th April 2009, few days after main seismic event (6th April 2009, 3:32 a.m., local time; Ml=5.8, Mw=6.2) of the seismic sequence that included hundreds of aftershocks (more than 30 of them 3.5<Ml<5.0) (INGV, 2009).

DEMs and Ground Points – GPs (Ground Control Points – GCPs and Check Points – CPs) were extracted by 1:5,000 scale digital cartography of Abruzzi Regional Administration: part of the maps used is updated to 2001-2002; the remaining part is updated to 2004-2005 (Regione Abruzzo, 2010).

In Italy 1:5,000 scale maps are expected to have a graphical planimetric error of 1 meter and 1.8 meters for height error, so DEMs obtained by this map are accurate enough (Toutin, 2003) to obtain the maximum accuracy on the final orthorectified map.

GCPs obtained by these maps are, in spite, not enough accurate to obtain the best accuracy on the final orthorectified image (Baiocchi et al., 2005) but we will evaluate anyway the final accuracy obtained because, for this specific application, the maximum accuracy is not needed.

On the other hand, a ground survey with differential GPS/GNSS receivers is not always possible immediately after a seismic event: in fact for this specific event a big part of the city-center is still not easily accessible after almost 2 years from the main event.

To evaluate if a forecasting model can be improved considering some geo-morphological characteristics, steepness and aspect maps were created by the height data contained in the cartography 1:5,000 scale provided by the Abruzzi Region.

The DEM of the city of L'Aquila has been realized for interpolation of the vector cartography files: contours, photogrammetric spot points and ground points for buildings were used to realize a vectorial map of the ground, from which four different DEMs have been produced according to the different combinations of algorithm and vectorial contents used (Peckham, Jordan, 2007).

Two interpolation algorithms have been considered: the Natural Neighbor, that is based on Voronoi tessellation of a discrete set of spatial points (Sibson, 1981), and the Finite Differences that use the Distance Transformation (Almansa et al., 2002) and Finite Difference algorithm (Burrough, McDonnel, 1998).

It was possible to identify the DEM which was most adherent to the real morphological situation orthorectified image with different models; eight orthophotos were produced using the four DEMs combined with two resampling algorithms: the nearest-neighbor, that assigns at a point of coordinates (X, Y) in the output image the value of radiometric depth corresponding to the coordinates of the pixel where the point of known coordinates «falls» in the input, and cubic convolution, that assigns at a point of coordinates (X, Y) in the output image the value of radiometric depth corresponding relating to weighted average on the distance of the coordinates to the nearest 16 pixels.

Comparing the results, we found that the best result is obtained using also the points defining the ground level of buildings and a «Finite difference» algorithm for the DEM (Fig. 3) and the Nearest Neighbor algorithm for the orthorectified image. On this DEM some unnatural morphologies were noticed on NW part of the DEM itself, superimposing the vectorial maps it was noticed that incongruent morphologies match the path of the flyover of the highway; this means that some height spots do not represent the real morphology of the ground. Similar errors can be avoided with a more detailed structure of the geodatabase where heights of the ground and heights of structures that are over the ground are not stored as the same feature; for this experimentation the correct DEM (Fig. 3 right) was obtained through a manual editing of the features.

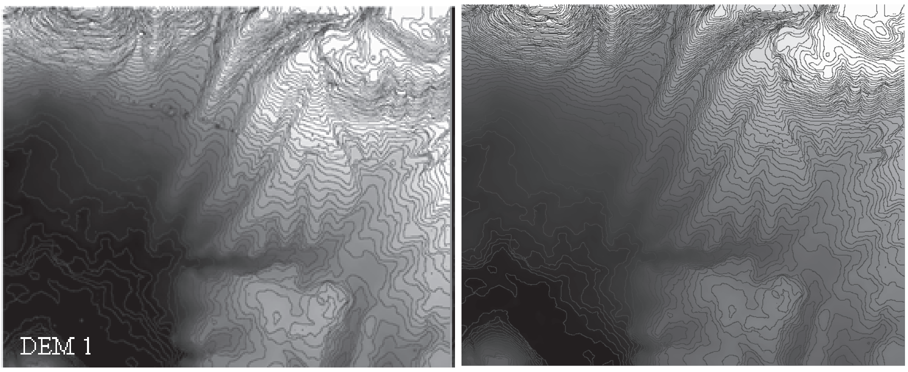


Figure 3. DEM extracted from digital cartography (on the left with spot point on highway, on the right without) North direction is up, resolution is 2 m, NW corner (364824; 4692643) m, SE corner (370827; 4688355) m, UTM WGS84 33N. See height anomaly in detail.

The DEM extracted covers the whole territory of the historic city-center: the area that suffered the worst damages has a 2 meters grid and spans from 359100 to 376410 east and from 4684000 to 4695500 north in UTM33N-WGS84-ETRF89 projection.

For this experimentation five vector 1A scenes (Tab. II) were oriented and orthorectified using Orthoengine 2012 (included in Geomatica package by PCI) and one of them was oriented also using ERDAS IMAGINE 2011 photogrammetric models (Baiocchi et al., 2012a); the mean accuracy achievable is 2.5 meters.

3. *Comparison between the map of vulnerability and the map of fitness for human habitation*

To test the validity of the model of vulnerability, an initial operation of differentiation between the two maps has been carried out; the comparison is based on the supposition that the buildings with high vulnerability should result unusable after the seismic event.

The vulnerability and the results of fitness for human habitation are different models because they are measured in different moments and in a different way. To validate the model of vulnerability it was necessary to operate some hypothesis of simplification and reclassification; this was necessary to compare the two maps that otherwise are not comparable.

At first the class F of the map representing the fitness for human habitation was excluded because it indicates buildings that didn't suffer damage due to the seismic event but could be damaged by an adjacent building in the future so they cannot be inhabited, so this class doesn't mean an actual damage suffered by the building. The classes of fitness for human habitation have become five while those of vulnerability remained four.

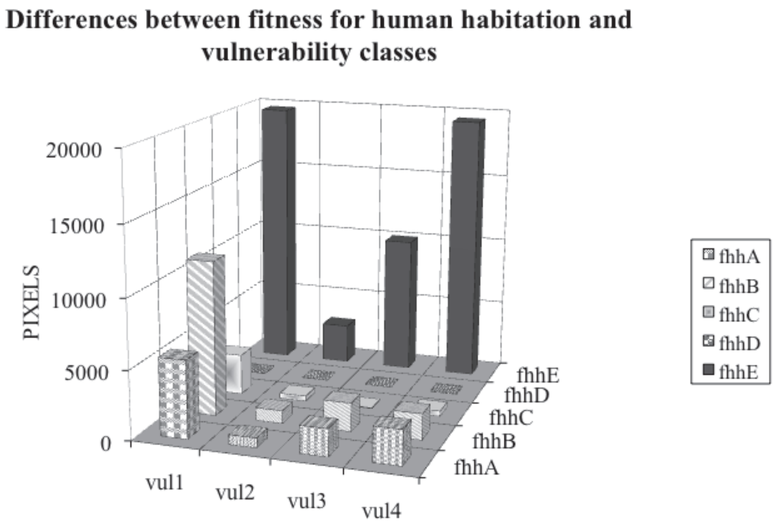


Figure 4. Distribution of vulnerability classes of pixels contained in each fitness for human habitation class.

To appraise if vulnerability and fitness for human habitation were somehow correlated or totally not correlated, a raster calculation was operated in GRASS environment to highlight the distributions of the classes of vulnerability of the pixels contained in each of the five possible classes of fitness for human habitation (Fig. 4). This has obviously limited the analysis to the pixels with a value different from zero both on the map of the vulnerabilities as on the map of fitness for human habitation.

It's important to observe that there is not a significant number of pixels of vulnerability that overlap pixels of the class «D» of the map of fitness for human habitation. It's easy to notice the frequency of the classes of lower vulnerability in the lower class of fitness for human habitation («E»), and a greater frequency of the class of vulnerability «1» in the class of vulnerability «A» and still more in class «B».

These first observations allow to hypothesize that a correlation among these two maps in the study zone can subsist and that it is possible to do some simplifications as the join of the first two classes of the fitness for human habitation and the elimination of the fourth class to make the map more significant and comparable with the map of the vulnerabilities.

For the same reason it was necessary to reduce also the number of the classes of the vulnerability to three joining the two intermediary classes and getting two classifications of three classes each, that we can consider low, medium and high (Fig. 5).

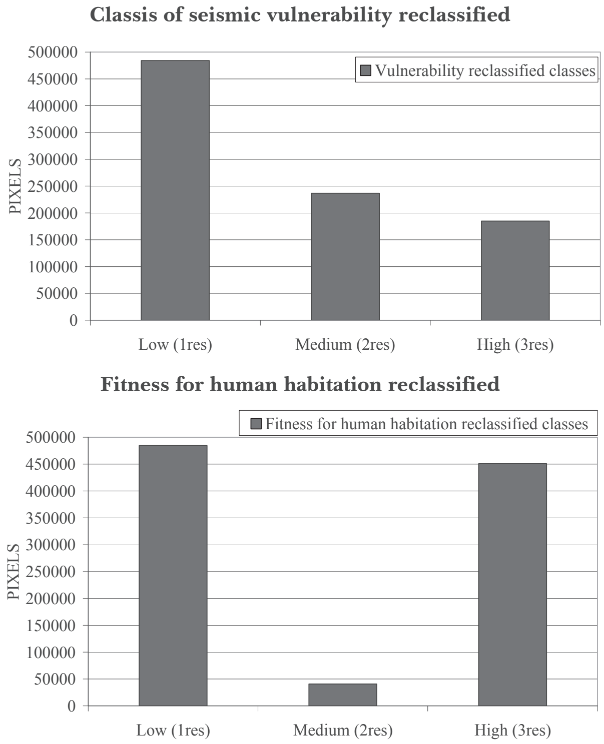


Figure 5. Vulnerability and fitness for human habitation classes reclassified.

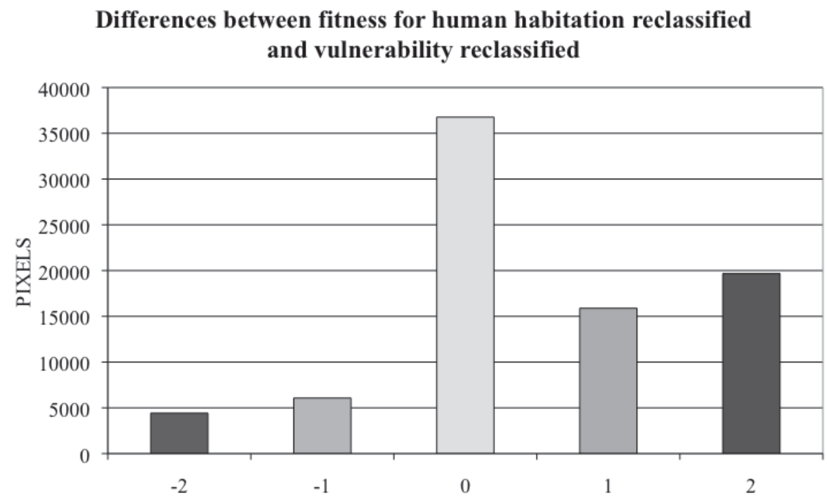


Figure 6. Differences between fitness for human habitation reclassified and vulnerability reclassified.

The new classifications were differentiated, still in GRASS environment, getting a distribution in five classes of difference (Fig. 6).

Observing the distributions of such differences it is evident that the more represented class is the class with null difference between the two classifications, but it seems that there is a preponderance of the positive difference classes that represent under-evaluated damage by the model of vulnerability. This can either depend on the hypotheses of simplification and reclassification we applied to make comparable the two maps, or not having considered some parameters in the formulation of the model of vulnerability. Observing the map of the distributions of such differences (Baiocchi et al., 2012b) it seems that the biggest part of under-evaluated damage by the model of vulnerability is localized in some areas of the map.

4. *Comparison between the map of the over-evaluation and under-evaluation of damage with the map of the seismic zoning and the map of slope*

The distribution of the differences between the two reclassified maps suggests that some characteristics of the ground could have influenced the model of vulnerability if they had not been considered. To assess this hypothesis, such a map of the differences between the two reclassified maps was compared with two other maps: the map of the seismic zoning and the slope extracted map by the DEM, both already described. The purpose is obviously to highlight if, in the areas where the greatest over-evaluation and under-evaluation are observed, some particular seismic or morphological characteristics of the ground are present. Once more, to simplify the operations of comparison, the classes in the original cartographies were reduced to three; in the case of the seismic zoning they are the following: one class for all the zones that show characteristics of attenuation of the seismic waves, a further class containing all the stable zones that not introduce amplifications or attenuations and, finally, a class of all the areas where an amplification of the seismic waves is reported. It is important to notice that the shown distribution covers the whole extension of the area studied for the seismic zoning while the comparisons have obviously been performed only on the «non void» pixels in the map.

The central class so defined doesn't overlap with any pixel of the map of differences between fitness for human habitation reclassified and vulnerability reclassified and therefore it is not present in the following comparison.

Also in the reclassified slope map there are three classes:

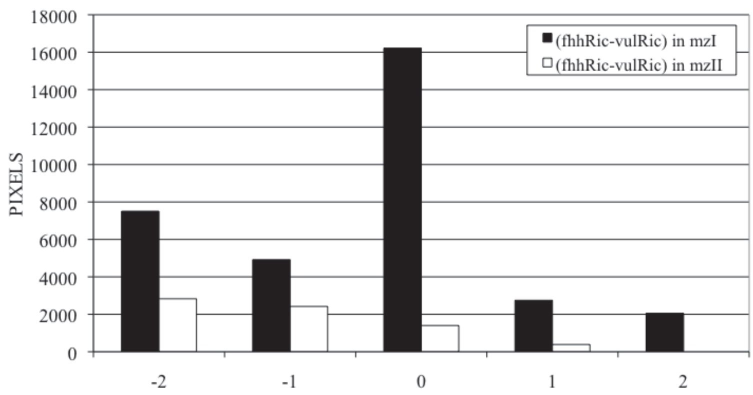
1. «low»: slope between 0 and 20 degrees;
2. «average»: slope between 20 and 30 degrees;
3. «high»: slope higher than 30 degrees.

Also for this distribution the whole area of the DEM is represented, while the comparisons have obviously been performed only on the «non void» pixels of the map.

The comparisons between the reclassified seismic zoning map and the values of differences between fitness for human habitation reclassified and vulnerability reclassified show different distributions in areas with seismic amplification or attenuation (Fig. 7A). Considering such differences a correlation could be hypothesized between the under-evaluation of the vulnerability and the presence of factors of amplification of the seismic waves. In fact, in the areas with factors of attenuation the distribution is similar to that of Fig. 6, with prevalence of areas with null differences (that represent correct estimation of vulnerability model). In the areas with factors of amplification, instead, the distribution is significantly different from the distribution in Fig. 6 highlighting the possible presence of a bias. It is important to remember that the seismic zoning map was not available when the map of vulnerability was prepared and so it was not possible to consider it.

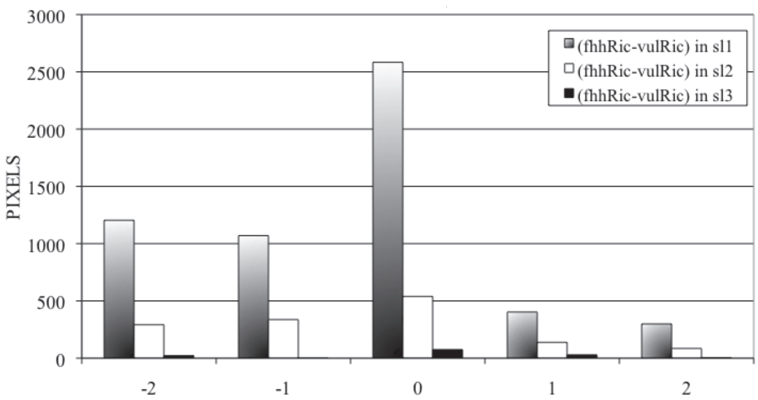
Instead, the comparison with the slope map doesn't seem to underline a similar correlation between the two maps (Fig. 7B), in fact we can note that difference distributions are very similar to those in Fig. 6.

Differences between fitness for human habitation reclassified and vulnerability reclassified in different seismic zones



A

Differences between fitness for human habitation reclassified and vulnerability reclassified in different slope reclassified zones



B

Figure 7. Distributions of «errors» of the predictive model considering seismic zoning (A) and slope (B). It seems that may exist a correlation between errors and seismic zone while no correlation with slope is evident.

5. *Detection of damaged building tests*

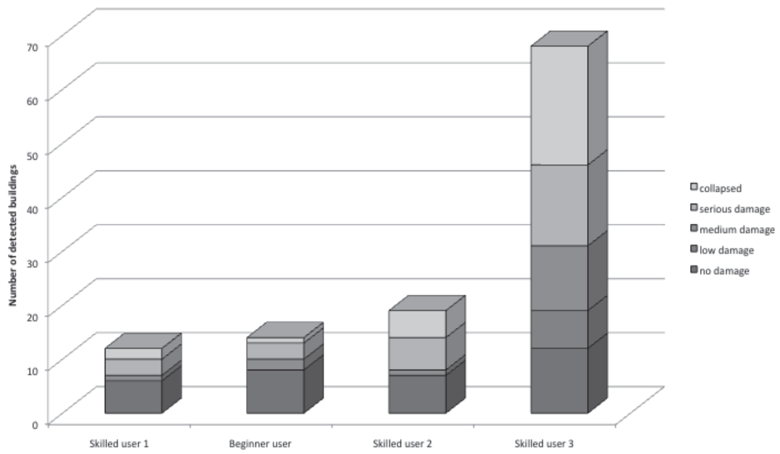
To assess the actual possibility to manually vectorize damaged buildings by EROS-B imagery, «Double-blind» tests of detection were performed by four voluntary operators with different skills: three operators are used to work with remotely sensed images while the fourth is a beginner user like some of the volunteers that were employed during recent disasters. Some resampling techniques as Nearest Neighbor show also little details that can be useful to detect a damaged building but some other algorithms as Cubic Convolution are in some situations more easily interpretable. Thus it can be useful to use sinoptically two images resampled with both techniques; anyway some effects of the earthquake are easily detectable on the images whatever resampling algorithm is used.

Tests were performed on a limited area of the historic city-center for which the damage maps are freely available on the web site of the municipal administration http://www.comune.laquila.it/documenti/terremoto/esiti.htm). These maps were realized by DPC considering the survey of the damaged buildings. During «double-blind» tests the operators couldn't look at the damage maps during detection; only after completing the tests on both the images covering this area («geo_MBT1-e2166574» and «geo_MBT1-e2165296»), they compared the results to observe how many detected collapsed buildings are actually damaged building according to «damage maps». From these results (Fig. 8A) it seems that in a historic center it is not very easy to detect damaged or collapsed building using monoscopic panchromatic image with such resolution. In fact only a percentage between 35 and 69% for image «geo_MBT1-e2166574» and from 50 to 72% for «geo_MBT1-e2165296» percent of detected building on the images are reported as «collapsed», «serious damage» or «medium damage» on the maps; the remaining detections have to be considered almost surely as false detections.

It seems that there is no big difference between the results of skilled and less skilled operators, what really makes the difference is a good knowledge of the site (Tab. III). To check if such images can be, instead, usefully utilized to confirm expected collapsed buildings coming, for example, from a first ground survey, the same operators were allowed to compare again the images with maps of damaged building overlapped to verify suggested damage.

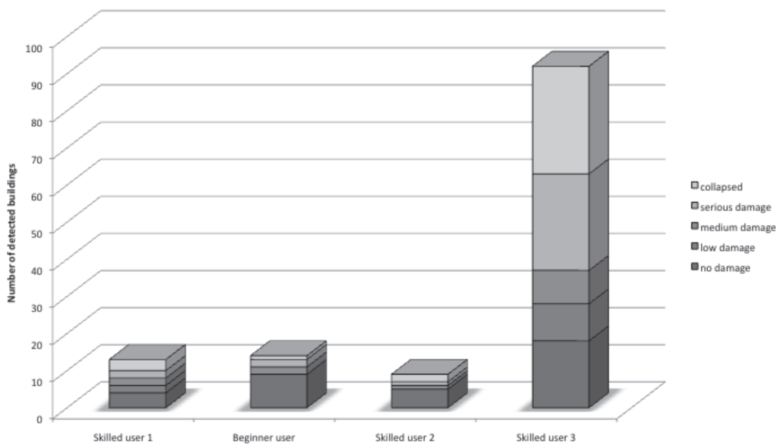
In these second tests most part of damaged buildings was recognized (from 32 to 80% for image «geo_MBT1-e2166574» and from 23 to 73% for «geo_MBT1-e2165296») but still not all of them (Fig. 8B), so again from these first tests we didn't observe a significant difference between skilled and not skilled operators.

Distribution of detected buildings for im96



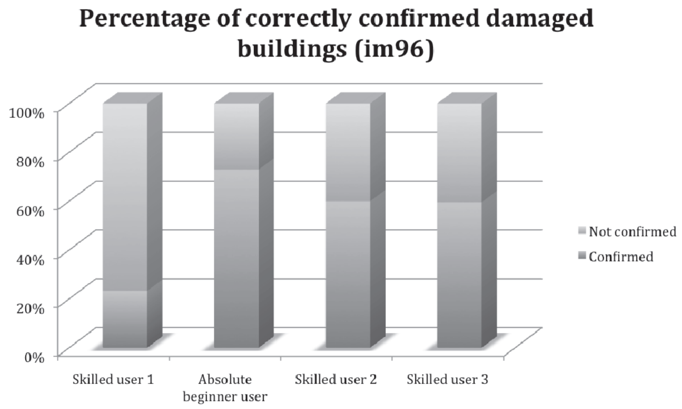
Im96	S.u. 1	Beginner	S.u. 2	S.u. 3
Collapsed	17%	7%	26%	32%
Serious d.	25%	21%	32%	22%
Medium d.	8%	14%	5%	18%
Low d.	0%	0%	0%	10%
No d.	50%	58%	37%	18%

Distribution of detected buildings for im74

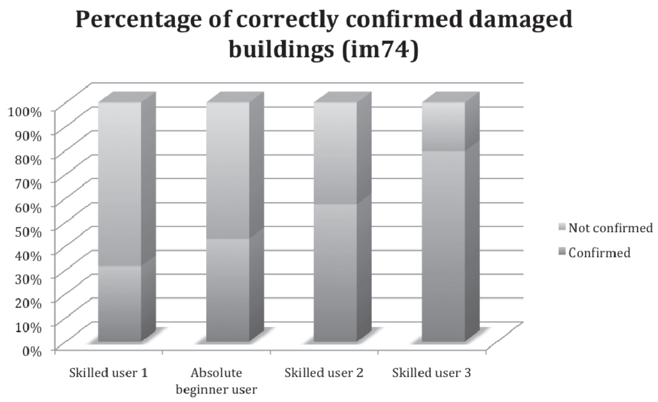


Im74	S.u. 1	Beginner	S.u. 2	S.u. 3
Collapsed	23%	7%	22%	31%
Serious d.	15%	14%	11%	28%
Medium d.	15%	14%	11%	10%
Low d.	15%	0%	0%	11%
No d.	32%	65%	56%	20%

Figure 8 (A). Distribution of buildings detected during «double-blind» tests compared with damage maps classes.



Im96	S.u. 1	Beginner	S.u. 2	S.u. 3
Confirmed	77%	27%	40%	40%
Not confirmed	23%	73%	60%	60%



Im74	S.u. 1	Beginner	S.u. 2	S.u. 3
Confirmed	68%	57%	43%	20%
Not confirmed	32%	43%	57%	80%

Figure 8 (B). Percentage of correctly confirmed damaged buildings during «not-blind» tests.

Table III. Skill and site knowledge of the operators.

Operator	Skilled	Site knowledge
Skilled user 1	Yes	No
Beginner user	No	No
Skilled user 2	Yes	No
Skilled user 3	Yes	Yes

6. *First considerations on implementation of seismic vulnerability and risk as defined in Italy in the data models Plan4all*

Moreover it was evaluated the possibility of including these themes in the data models Plan4all of the INSPIRE project that would have the advantage of allowing a faster exchange of information between the various agencies involved in emergency management. At first analysis it seems necessary some adaptations of the data model for natural hazards in specific case of seismic risk at least as defined in Italy.

In fact, the earthquake risk in Italy is not bounded as high-risk areas and areas without risk at all as expected in the INSPIRE project; this can be a correct model for risk as landslides or floods, for example where we can identify areas at risk (more or less high) and areas that will never be at risk.

The areas at higher and lower seismic risk in Italy are classified with a logic much more similar to the raster format: this mean that the whole territory is (or should be) divided in areas of greater or lesser risk, subdivided by discrete cells.

The format provided by the INSPIRE project seems (at least at a first glance) more inspired at a vector GIS model with polygons and attributes linked to each polygon.

These two models are not incompatible: in fact it's possible to obtain vector polygons map from intersection of raster maps, obtaining polygons with the same value of each item.

Some items are of difficult interpretation, for example item «risk duration» is very hard to define because a seismic zone is seismic forever.

The use of Plan4all models for these specific features can be very useful to improve interoperability between different databases involved but presently it has to be studied and improved to fit the particular needs of seismic data.

7. *Conclusion*

The evaluation of the vulnerability of the buildings performed before the seismic event seems to show a good fit with the evaluations of the damage assessed on the buildings after the seismic event. Such comparison has to be considered as a preliminary study whose purpose, to the present state of development, is only to assess the possibility of such comparison with geomatic methodologies and to verify if some hypotheses could have a statistic confirmation. From these first results we can affirm that a correlation may exist between the evaluations of the model of vulnerability of the buildings and the assessment of the damage post-seismic event. It can be observed besides that it exists a correlation between the factors of amplification of the seismic waves and the higher under-estimation of the damages by the model of vulnerability of the buildings.

Such correlation seems to be absent instead if we consider the slope of the same areas; this could point out that in the realization of the model of the vulnerability the slope of the ground has no influence.

The EROS-B images orthorectified allow to identify some of the damaged buildings but a percentage between 28 to 73% are false detections, even if taken by a skilled operator. This may be caused by the particular urbanization of historic center like the one of L'Aquila. Best results can be obtained using images to confirm suspected collapsed buildings after a first ground survey, but also in this case not all the collapsed buildings can be confirmed.

More refined statistic tools could be used to evaluate how the information of seismic zoning has to be used to improve vulnerability model. The model so updated then has to be verified on other areas interested by similar seismic events to make it independent from the characteristics of site.

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Riassunto - Validazione cartografica di un modello di vulnerabilità sismica e le sue possibili implementazioni con i formati Plan4all

Nel 2002, nell'ambito di una collaborazione tra il Dipartimento della Protezione Civile e l'Università dell'Aquila, è stata elaborata una metodologia per la valutazione della vulnerabilità di un centro urbano (Ferlito et al., 2010). In seguito all'evento sismico che il 6 aprile 2009 ha colpito la città abruzzese, utilizzando l'esito del rilievo del danno e della valutazione dell'agibilità post sisma, è stato possibile verificare la validità di quella parte del modello che valuta il contributo alla vulnerabilità della componente edifici prospicienti la viabilità d'emergenza (Zucconi, 2010). Successivamente vengono illustrati i risultati di una prima sperimentazione sulle potenzialità di riconoscimento dei danni sismici da immagini satellitari monoscopiche ad alta risoluzione. Infine si riportano alcune considerazioni sulle possibilità di inserire tali informazioni nei *data model* Plan4all dell'iniziativa *Inspire*.

Parole chiave

L'Aquila, EROS B, GIS, sisma, vulnerabilità.

Résumé - Validation cartographique d'un modèle de vulnérabilité sismique et ses possibles implémentations avec les formats Plan4all

En 2002, dans le cadre d'une collaboration entre le Département de la Protection Civile et l'Université de L'Aquila, a été élaborée une méthodologie pour l'évaluation de la vulnérabilité d'un centre urbain (Ferlito et al., 2010). Suite à l'événement sismique qui le 6 avril 2009 a frappé la ville des Abruzzes, et en utilisant les évaluations de l'importance du dommage et de la praticabilité post-séisme, on a pu vérifier la validité d'une partie du modèle qui évalue la contribution à la vulnérabilité du centre-ville de la composante édifices qui donnent sur la viabilité d'émergence (Zucconi, 2010). L'article illustre ensuite les résultats d'une première expérimentation sur les potentialités de reconnaissance des dommages sismiques à partir d'images satellitaires monoscopiques à haute résolution. Enfin, on développe quelques considérations sur les possibilités d'insérer des telles informations dans donnée model Plan4all de l'initiative *Inspire*.

Mots-clés

L'Aquila, EROS B, SIG, tremblement de terre, vulnérabilité.