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How the Italian State Finances Post-seismic Reconstruction: The 2009 Abruzzo Earthquake

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Abstract This paper examines the development of cost estimates for the renovation of buildings damaged by the earthquake that struck the region of Abruzzo in April 2009. The study begins with experience of the authors as the figures responsible for the "Economic Feasibility of Proposed Works" as part of the activities supporting the reconstruction study and project developed by the Architettura Department at the D'Annunzio University of Chieti-Pescara. The analysis concentrates on the main procedures employed to attain the estimate of financial investments necessary for the reconstruction of eleven towns in the provinces of L'Aquila and Pescara. The objectives of producing a trustworthy cost estimate, a transparency of decision-making and rapid schedule of implementation were forced to confront an inevitably incomplete framework of understanding regarding the nature and form of plans for reconstruction. This situation was further aggravated by an articulated and complex system of normative restrictions governing the distribution of financial contributions.

Keywords Preliminary cost estimate · Post-earthquake reconstruction · Abruzzo

1 Introduction

A proper starting point for describing the process of reconstruction initiated following the earthquake that hit the region of Abruzzo in 2009 is offered by two pieces of Italian legislation. They are important because they triggered both the system of ordinances motivating procedural aspects and cost estimates, as well as the obligation to implement the different phases of reconstruction in accordance with specific plans. This does not mean that the legislative structure behind post-earthquake interventions

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is so simple and exemplified; nevertheless, the content of these two measures has—to date—influenced the phases of reconstruction more than any others.

The first is Law n. 225 from 24 February 1992; art. 5 states that following the declaration of a state of emergency in a given territory that has suffered a natural calamity, catastrophe or other event necessitating the use of extraordinary means and powers, it is possible to proceed with measures in derogation to any currently applicable regulation as required to implement the necessary interventions, so long as they continue to respect the general principles of the legal system.

The second reference is the conversion into a law, with modifications, of Decree-Law n. 39 from 28 April 2009. Article 14, comma 5-bis of this law introduced the obligation to prepare *Piani di Ricostruzioni*, or Reconstruction Plans: "Local mayors… together with the president of the Delegated Commissioner of the Abruzzo Regional Government… in conjunction with the president of the Provincial Government for matters of competence, must prepare *Piani di Ricostruzione* (PdR) for historic city centres, as determined by article 2, letter a) of Decree n. 1444 issued by the Ministry of Public Works on 2 April 1968, defining strategic guidelines for ensuring the return of socio-economic activities and requalification of inhabited areas, and facilitating the return of populations displaced from homes damaged by the earthquake of 6 April 2009…".

The successive Decree n. 3/2010, issued by the Delegated Commissioner for the Reconstruction, specified the means for defining the perimeters of these Plans and for their preparation and implementation. More in particular, art. 5, comma 3 (Reconstruction Plans—Objectives and Content) requires a survey of the current condition of sites, taking into account, where possible, the pre-earthquake situation, and providing, among other things, an "estimate of planned intervention costs" (point c).

2 The Area of the Earthquake Crater

During the phase immediately after the earthquake, a total of 49 towns inside the area of the crater were identified. This number successively grew to 57 based on indications provided by the Civil Protection Department, which confirmed that tremors reached and/or surpassed the sixth degree on the Mercalli intensity scale.

The perimeter of the geographic area affected by the earthquake also includes an additional 29 towns that suffered minor damages (Fig. 1).

3 Eligible Subjects and Assets

Article 1, comma 2 of the aforementioned DL 39/2009 specifies that subjects eligible for financial aid for reconstruction from the State are limited to physical per-sons residing in the towns inside the crater, as well as businesses and organisations operating and based here on or prior to 6 April 2009.

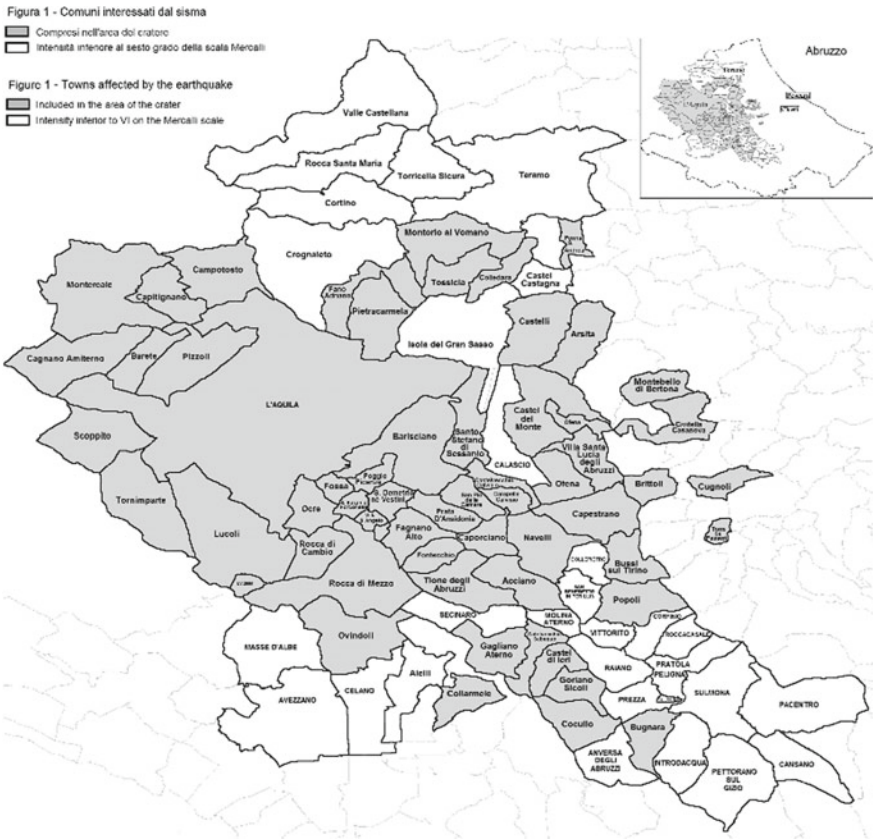

Fig. 1 Towns affected by the earthquake

The successive art. 3 specifies that the awarding of financing, for immobile assets, is extended to properties used as primary homes that have been destroyed or declared inaccessible or for the purchase of new homes to substitute destroyed primary homes (comma 1a); however, it also includes buildings other than those used as primary homes, as well as buildings for non-residential uses either destroyed or declared inaccessible (comma 1e).

4 The Damage Surveying Charts

The emergency management interventions activated in the wake of an earthquake and, successively, during the different phases of reconstruction, were sub-ordinated to a survey of damages suffered by buildings, which produced an evaluation of their accessibility [1].

Accessibility defines the boundary between the possibility to return to one's home and the time spent in a temporary shelter; between the permanence of administrative functions, services, the economy and the slowing of activities in an entire social context [2].

A rapid survey was made during site visits after the earthquake by a team of technicians accredited by the Civil Protection Department. Special surveying charts were developed for ordinary buildings known as AeDES *(Agibilità e Danno nell'Emergenza Sismica*, Accessibility and Damage during a Seismic Emergency). Models of charts with different structures were instead used for specialised or monumental buildings: for listed buildings the compilation of the charts was man-aged by the *Soprintendenza*, and religious buildings directly by the Curia.

The AeDES charts, each containing specific data and information: 1 Building Identification; 2 Building Description; 3 Typology; 4 Damages to structural elements and emergency interventions carried out; 5 Damages to non-structural elements and emergency interventions carried out; 6 External risks from other constructions and emergency interventions carried out; 7 Ground and Foundations; 8 Accessibility Rating; 9 Other observations.

The verification of damages and the consequent accessibility rating was linked to the following categories:

- *A. Accessible Building: The building can be utilised in all of its parts with no risk to the lives of its occupants, without the need for any emergency measures.*
- *B. Temporarily Inaccessible Building (total or partial) though accessible following emergency intervention measures.*
- *C. Partially Inaccessible Building: the condition of limited portions of the building are considered to pose a serious risk to inhabitants and thus influence the assessment of inaccessibility.*
- *D. Temporarily Inaccessible Building to be studied in more detail: the building presents characteristics sufficient to render uncertain the verdict of accessibility by the technician. An additional and more de-tailed site visit and/or a visit by more expert technicians is request-ed. The building is considered inaccessible until this new visit has been completed…*
- *E/F. Inaccessible Building: for organisational purposes a distinction is made between the effective inaccessibility of the building owing to structural, non-structural or geotechnical risks (E), and inaccessibility due to serious external risks (F), even in the absence of consistent damages to the building. The building cannot be utilised in some of its parts, even after the completion of emergency interventions.*

Leaving aside those cases in which the verdict on accessibility remains uncertain after the first site visit (rating D) and those in which the situations of risk are not linked to damages suffered by the inspected building, but derive from situations determined by adjacent buildings or constructions (rating F), the range of possible situations varies substantially from A to E, passing through the intermediate results B and C.

5 The Methodology

In extreme synthesis, the work can be summarised in three principal phases:

- identification of the area of each *unità immobiliare urbana* (u.i.u., urban real estate unit) inside the perimeter of the plan;
- assignment of an area to each accessibility rating;
- application of parametric costs to areas in relation to their accessibility rating to quantify the costs of recovering the buildings, as defined in the OPCM[1] and opportunely modulated in accordance with specific situations and the guidelines issued by the Delegated Commissioner for Reconstruction.

5.1 Association of the Area of Each U.I.U. with the Results of the Accessibility Survey

Given these conditions, it is evident that the methods for calculating building areas was decisive to the estimate, as it could signify a variation in the value based on the approach adopted [3].

Four approaches were potentially feasible.

In theory, the area of the u.i.u.'s, and thus of the buildings, could have been inferred from the AeDES charts, under Sect. 2 containing a description of the building. The dimensions found in the charts were characterised by a more or less elevated degree of imprecision that, for the most part, was justified by the approximation—rather important—allowed during the surveying of damages. In fact, point 2.5 *Building Description*, found in the manual for filling out the 1st level charts,[2] suggested surveying the *average values of heights and floor areas in groups and the guideline criteria for making a selection, in the case of important variations between floors, was to consider average values that best describe the total volume (for height indicate that closest to the average height of all floors; for floor areas indicate the range that best describes the average area of all levels).* This meant it was not a question of whether or not to consider eventual errors in the surveys (highly probable), but instead one of evaluating their order of magnitude.

A second hypothesis could have involved the building surveying operations, effectively capable of providing specific information about floor areas. In this specific case, it was merely a theoretical possibility, considering that the time allowed to complete the surveys, in the majority of the towns involved, was far longer than that during which the estimates were developed.

A third expeditious hypothesis, apparently without any difficulty, could have considered the "footprint" of a building and its number of floors. This method would hot have been without glaring imprecisions, given the topography and building

[1] In particular 3778/2009, 3779/2009, 3790/2009.

[2] Presidency of the Council of Ministers and Civil Protection Department [2] (op. cit.).

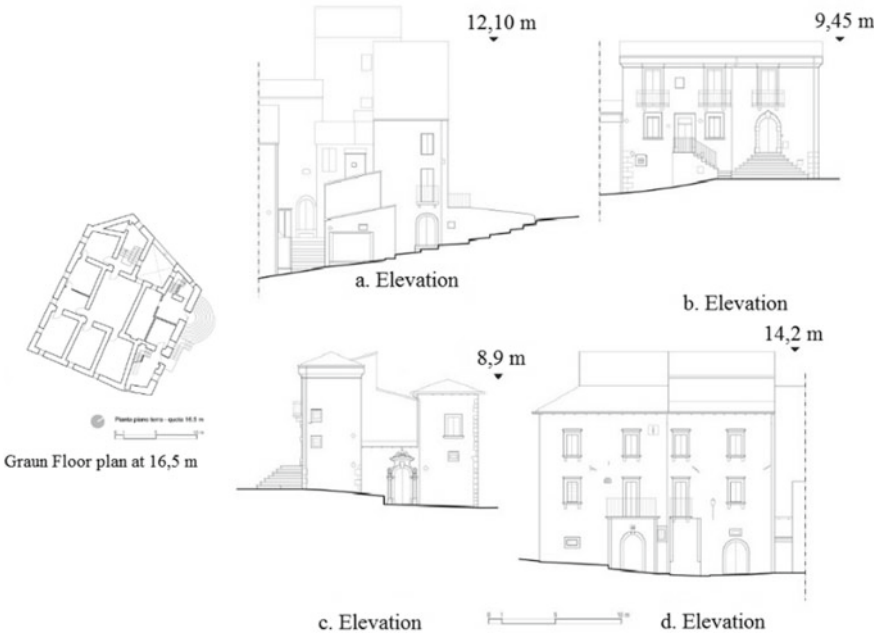

Fig. 2 Survey of a building damaged by the earthquake

typologies of the different towns. As an example, Figs. 2 and 3 illustrate frequently encountered situations. The comparison between the footprint of a building and the dimensions of its façade clearly demonstrates that—at least in the example considered—the calculation of the area produced by multiplying the footprint by the number of floors would produce an evident distortion (Fig. 2). The situation was repeated also for entire structural aggregates such as those illustrated in Fig. 3.

In any case, all three hypotheses are characterised by a common defect that is impossible to ignore: they provide no indications about the use of the spaces inside the building; instead they indistinctly consider primary and accessory spaces, producing a gross floor area that, for buildings with an E rating, cannot be considered in this manner when calculating the financing available, which is subject to a maximum limit. This is anything but a small problem, considering that it refers to buildings with seriously compromised structures, of which there are e great many in the areas affected by the earthquake,[3] and thus with a greater incidence on the total cost of reconstruction.

[3]The total costs of reconstruction will depend for the most part on E rated properties: in the towns analysed in the province of Pescara, the percentage ratios between the number of sub-parcels distinguished by accessibility rating were slightly less than 40% for rating A, 20% for B/C, and slightly more than 40% for rating E. In terms of area, the gap between results B/C and E grows. In the towns analysed in the province of L'Aquila, closer to the epicentres of the earthquake, in some cases these ratios were 2% for ratings B/C and 90% for rating E.

Fig. 3 Example of a structural aggregation: representation of floor levels

Regarding this issue, it is worth recalling a few sections of legislation related to the concept of the maximum limit.

Art. 5, comma 4, of OPCM 3881/2010 establishes a ceiling on financing for interventions to recover and repair buildings with an accessibility rating of E; the reference is represented by the cost forecast for subsidised housing: *Admissible financing for the reconstruction of primary residences and the common areas of condominiums must not exceed the cost of construction of a building of equal volume calculated using the cost of construction for subsidised housing determined by the Abruzzo Regional Government, increased by 20% to account for the costs allowed for in applicable legislation governing energy efficiency and acoustic insulation….*

This means that, for the Abruzzo earthquake, the State Government offered financing for the recovery of significantly damaged buildings up to but not in excess of the hypothetical cost of their substitution, based on the structure outlined in the Deliberation of the Abruzzo Regional Government n. 615/2010 in matters of *Updates to the cost of subsidised residential construction.*

In light of the specific items expressed with regards to Decree 27/2010 issued by the Delegated Commissioner for the Reconstruction, the following line items were to be considered (Table 1).

This calculation provides the maximum admissible unit cost for the recovery and/or substitution of buildings with an E rating, net of charges and technical fees. That said, art. 6 of the aforementioned Abruzzo Regional Government Deliberation

Table 1 Maximum admissible unit cost for the recovery and/or substitution of buildings with an E rating

Basic cost for new construction (CNB) €/sq. m	808,00
Health and Safety costs pursuant to D.Lgs 494/96, n. 81/2008 (up to 5% CNB) €/sq. m	40,40
Application of D.Lgs. 192/2005 and D.Lgs. 311/2006 on matters of energy efficiency (up to 20% CNB) €/sq. m	161,60
Incorporation of earthquake design legislation (up to 7% CNB) €/sq. m	56,56
Total Basic Technical Cost (per square metre of total area (T.A.)	1.066,56
Insurance policies (3% CNB)) €/sq. m	24,24
Improvements to environmental comfort offered by acoustic and temperature-humidity conditions (5% CNB)) €/sq. m	40,40
Use of earthquake protection devices (base isolators) (3% CNB) €/sq. m	24,24
Particular local conditions (3% CNB) €/sq. m	24,24
For building typologies up to or equal to 4 floors (8% CNB) €/sq. m	64,64
For a prevalent number of units with an net floor area that does not exceed 65 sq. m (4% CNB) €/sq. m	32.32
Increased cost differential for particular technical conditions (€/sq. m)	210,80
CNR base tender cost (A + B) per unit of total area	**1.276,64**

n. 615/2010 specifies that that the Total Area (*Superficie Complessiva* S_C) to be used to verify the congruity of residential construction costs is defined as follows:

$$S_c = S_u + \left(S_{nr} + S_p\right) \times 0,6$$

where:

- S_c Total Area (Superficie Complessiva);
- S_u represents the useful inhabitable area, in other words the paved surface of a home, net of the perimeter and interior walls, thresholds, splayed door and window jambs, internal stairs and built-in closets;
- S_{nr} indicates instead the non-residential area to be intended as the sum of the *areas annexed to a home* (loggias, balconies, small cellars, attics) and *areas annexed to a building* (foyers, lobbies, open porticoes, technical volumes, heating plants and other spaces serving a home), net of perimeter and internal walls; in addition, the area of stairwells connecting different residential units, including stair landings, is calculated as a horizontal projection only once; Snr does not consider inspection-only attic spaces and/or attics with a ceiling height inferior to 2.40 m; the S_{nr} of an elevator shaft is calculation in projection only once;
- S_p indicates parking areas, in other words garages or covered parking spaces annexed to residential buildings.

For example, we can consider the case of a structural aggregate consisting of 3 u.i.u. with an E rating, and with a total inhabitable floor area of 233.60 sq. m, plus 206.30 sq. m of storage areas and cellars, considered accessory spaces indirectly serving principal spaces. The total area is thus 439.90 sq. m that, net of accessory charges and technical fees, considered as primary homes, produces a total estimated value of €561,312.

If, instead, we more correctly evaluate the total area (useful area plus opportunely reduced non-residential area), we arrive at an area of 285.90 sq. m, with an estimated value of €364,813.

A considerable difference.

To introduce a fourth hypothesis, we can compare the area calculations in the example with the corresponding values from cadastral maps for the three residential units:

– gross area: 439.90 sq. m
– total area (SC): 285.90 sq. m
– cadastral area: 285.18 sq. m.

The example presents an almost total correlation between the S_C and the cadastral area; this is not always the case, though the two values are generally very similar.

With the intention of obviating these problems, the area was inferred from the cadastral maps, whose calculation appears to be in line with the criteria listed in Deliberation n. 615/2010, which produced a substantial equivalency between the two values.

5.2 Assignment to Each Area of the Accessibility Ratings

Having defined the area of each u.i.u., it was possible to assign the accessibility ratings found in the AeDES charts, though only after verifying and resolving dubious situations.

For u.i.u. without an AeDES chart, in some specific cases an “intrinsic rating” was assigned after conferring with the structural engineering team working on the PdR.

The product of this first phase concluded with the creation of a list of all u.i.u. inside the PdR perimeter, each with its own area for each sub-parcel, parcel, aggregate or zone in which it was located and its accessibility rating.

5.3 Application of Parametric Costs to Surfaces in Relationship to Damage

The cost value, per u.i.u. (parcel or sub-parcel) and expressed by zone, aggregate, use and accessibility rating, was calculated in accordance with the instructions contained in specific ordinances and—in the event of a lack of direct normative and/or design indications—using parametric costs indicated/agreed upon by/with the STM.

The first step was to identify primary homes using the indications received from municipal offices.

This was followed by a summary examination of specific situations relative to each of the accessibility ratings and a description of the criteria used in the estimate.

5.3.1 Buildings with an Accessibility Rating A

OPCM 3778/09 considers a maximum contribution of €10,000 for the repair of damages only for *unità immobiliari urbane* (u.i.u.) used as "primary homes", to which it is possible to add an additional maximum sum of €2,500/u.i.u. for repairs to common areas.

The framework defined for A rated buildings is completed by the content of art. 7 of OPCM 3820/09, which deals specifically with buildings that are part of aggregates. Comma 6 foresees that *interventions of reinforcement or seismic retrofit are financed up to a maximum sum for the entire aggregate equivalent to the eligible sum for each building. In the case of buildings with different ratings, including those with an E rating, financing for buildings with B and C ratings may be increased by 30% and those for A rated buildings may be considered as B rated, however without the… increase of 30%.* This means it is possible to foresee an additional contribution of up to 150 €/sq. m also for A rated buildings[4] [4].

In general, all u.i.u. with an A rating/*primary homes* were assigned the maximum allowable sum, also in consideration of the fact that financing which had already provided, in the majority of cases, was just under the threshold of €10,000. Following indications from the STM, the additional sum of €2,500 for common areas was always assigned.

Furthermore, all u.i.u. with an A rating (primary homes and non-primary homes) were always assigned a sum of €150/sq. m when they were part of an aggregate containing E rated buildings.

[4]Civil Protection Department—Delegated Commissioner [4] (op cit.).

Table 2 Comparison between the two methods

Floor area	sq. m	Unit cost (€/sq. m)	Estimated Financing (€)
Gross total	439.90	200–290	87,980–127,571
Cadastral	285.18	450 + 150	171,105

5.3.2 Buildings with an Accessibility Rating B/C[5]

OPCM 3779/09 and the successive guideline measure connected with it, foresees the awarding of financing to cover all repair costs for "primary homes".[6] For non-residential properties or homes that are not primary homes, coverage is guaranteed up to 80% and in any case capped at €80,000; all the same, unlike E ratings, there is no indication of any reference unit cost. Admissible costs include design fees and technical assistance by licensed professionals, including VAT.

Unit costs for B/C rated u.i.u. were calculated beginning with a base unit cost of €450/sq. m (net of fees and technical expenses), and an eventual additional contribution of €150/sq. m for local reinforcement works of structural elements[7] extendable to €195/sq. m (in the presence of E ratings).

The base unit cost of €450/sq. m + €150/195/sq. m, while still related to cadastral areas, provides ample guarantees supporting the hypothesis that excludes the underestimation of costs for these ratings [5–7]; if we return to the previously proposed example of the aggregate, with a hypothetical rating of B/C for three homes, the comparison between the two methods gives the following results (Table 2).

For primary homes, the applied cost integrally covers interventions of local reinforcement (€150/sq. m or 195), and repairs (€450/sq. m).

The total cost of properties not used as primary homes or used for other purposes, was instead obtained by integrally recognising a rate of €150–195/sq. m for local reinforcement works, while repairs were evaluated at €450/sq. m and reducing the product with the area calculated at 20%,[8] in any case never exceeding the limit of €80,000.

[5] All costs indicated are net of accessory fees and technical expenses.

[6] In order to favour the rapid return to homes in the territories of towns identified pursuant to art. 1 of Decree-Law 39/2009, that had suffered damages sufficient to make them temporarily inaccessible, either totally or partially (with a B rating) and whose accessibility can be restored following emergency measures, of those that are partially inaccessible (C rating), are eligible for direct financing of the costs of costs relative to the repair of non-structural elements and building systems, as well as repairs or local interventions to single structural elements or parts thereof, in any case suitable to ensuring increased conditions of safety… (OPCM 3779/09, art. 1, comma 1).

[7] Civil Protection Department, Delegated Commissioner [4], Guidelines for the implementation of interventions pursuant to OPCM n. 3779 dated 6.6.2009 (repairs to damaged non structural elements and building systems, repair or local reinforcement of structural elements or parts thereof).

[8] The corresponding 20% is the responsibility of the property owner, who is obliged to offer proof of the total effective cost.

5.3.3 Buildings with an Accessibility Rating E[9]

OPCM 3790/09 provides financing for repairs, including seismic retrofit, of damaged buildings or the reconstruction of collapsed buildings that have been declared totally inaccessible (E). Financing covers all costs for primary homes, but must not exceed 80% for non-primary homes or non-residential properties with a ceiling of €80,000. Admissible costs include design fees and technical assistance by licensed professionals, including VAT.

An increase in this limit is allowed up to a maximum of 60% for buildings "of particular historic artistic value" and up to 100% for listed buildings (OPCM 3917/10).

The level of safety of buildings can be increased by up to 80% of seismic retrofit works and in any case beyond 60%.

More in detail, the part of each intervention relative solely to structural components, in relation to the damage surveyed, activates a specific quota of unit costs that vary from €250/sq. m (light damages to less than one third of the structure, in the presence of a safety level of 60% of seismic retrofit works) solely for *local reinforcement*; up to €600/sq. m when it is possible to demonstrate the need to use particular technical solutions to achieve a level of safety of at least 60% through seismic retrofit works.

That said, it is necessary to consider that retrofit and repair works involving common areas, following the constitution of consortia between property owners, for obvious reasons create a different flow of financing with respect to the distinction between primary homes and non-primary homes considered singularly.

For this reason, ordinary u.i.u. with an E rating were always associated with a max unit cost of €1,267/sq. m (net of fees and technical expenses) referred only to primary homes.

For non-primary homes and properties with other uses, the estimated value was obtained by integrally recognising a cost of €700/sq. m for interventions involving common areas (including additional financing for energy efficiency), while those for non-structural interior works were calculated at €576/sq. m, with a reduction of 20%, within the limit of €80,000.

Finally, the increases foreseen for buildings "of particular historic artistic value" (up to + 60% of the "base" cost used for ordinary u.i.u. E: €2,041/sq. m), and for listed buildings (up to +100%: €2,553/sq. m), were applied only to primary homes. On the contrary, the scheme developed for ordinary non-primary homes was applied.[10]

[9] Also in this case, costs are to be considered net of all accessory expenses and technical fees, which are instead considered in the QTE.

[10] OPCM 3917/2010, art. 21. Regarding this issue, the STM adopted the binding position of limiting additional financing to primary homes.

5.3.4 Specialised or Monumental Buildings

Public buildings (strategic and non strategic, listed or not), religious buildings, as well as the network of underground services, were treated based on interventions already completed and/or underway, suggested by the STM and in any case within the interval listed in Table 3.

Special mention must be reserved for religious buildings, whose accessibility ratings were classified in different terms than those used in the AeDES charts: light damage (D1); medium-serious damage (D2–D3); serious damage D4–D5).

Below is a summary table of the cost ranges considered in the estimate, distinguished by building typology, nature and accessibility rating.

5.3.5 Expenses and Technical Fees

The incidence of expenses and technical fees—including those to be paid to *Presidents of Consortia* and the costs of *geotechnical services* (studies and professional fees), both subject to specific modulations—was estimated at between 35.7% of the cost of works for aggregates with E rated buildings, and 28.8% for single B rated buildings outside of an aggregate.

6 Summary Table of Estimated Costs

The estimated costs for the eleven PdR contained in the QTE developed and submitted to municipal governments are summarised in Table 4.[11] The total value of approximately 444 million Euro[12] is relative to an area that, solely for A, B/C and E rated buildings, is slightly less than 372,000 square metres. The total number of cadastral sub-parcels was 5,441: more than 42.6% characterised by E ratings; B/C ratings account for 12.6%, A ratings for 24.7%, F ratings for 1.2%. The situation is completed by properties with no rating (8.4%) those with recovery projects that had already been financed (6.2%) and, finally, linked, suppressed or uninhabitable properties that, together, account for 4.2%.

One element worthy of emphasis, and which emerges clearly from the numbers in the table, regards the ratio between the *costs of private construction/total cost of*

[11] The approval of the PdR for Brittoli, Bussi, Civitella, Cugnoli, Montebello, Ofena and Popoli, as per Decree 3/2010 issued by the Delegated Commissioner for Reconstruction, was completed in the summer of 2012, when the municipal governments formalised an agreement with the President of the Region of Abruzzo and the specific Provinces. More recently, the PdR for Goriano Sicoli was also approved, according to the methods outlined in applicable ordinary reconstruction management. The towns of Castelvecchio Subequo, Poggio Picenze and Caporciano, to date, have only adopted their respective plans.

[12] This value does not include projects financed during the period preceding the procedure to develop the PdR.

Table 3 Indicative costs for public and religious buildings and underground utilities

Typology	Result/intervention		Unit cost	
Public buildings of strategic interest	A	Ordinary	300–400	€/sq. m
Public buildings of strategic interest	A	Listed	500–1400	€/sq. m
Public buildings of strategic interest	B/C	Ordinary	700–1100	€/sq. m
Public buildings of strategic interest	B/C	Listed	1800–2100	€/sq. m
Public buildings of strategic interest	E	Ordinary	1500–2000	€/sq. m
Public buildings of strategic interest	E	Listed	2100–3000	€/sq. m
Public buildings not of strategic interest	A	Ordinary	150–250	€/sq. m
Public buildings not of strategic interest	A	Listed	400–1000	€/sq. m
Public buildings not of strategic interest	B/C	Ordinary	550–750	€/sq. m
Public buildings not of strategic interest	B/C	Listed	1300–1500	€/sq. m
Public buildings not of strategic interest	E	Ordinary	1100–1400	€/sq. m
Public buildings not of strategic interest	E	Listed	1800–2500	€/sq. m
Religious buildings	D1		Up to 200	€/cu. m
Religious buildings	D2–D3		200–300	€/cu. m
Religious buildings	D4–D5		300–500	€/mc
Water network—independent path		Maintenance	42–54	€/m
Water network—independent path		Total substitution	140–180	€/m
Gas network—independent path		Maintenance	36–45	€/m
Gas network—independent path		Total substitution	120–150	€/m
Sewer network—independent path		Maintenance	90–108	€/m
Sewer network—independent path		Total substitution	300–360	€/m
Electrical network—independent path		Maintenance	24–33	€/m

(continued)

Table 3 (continued)

Typology	Result/intervention		Unit cost	
Public buildings of strategic interest	A	Ordinary	300–400	€/sq. m
Electrical network—independent path		Total substitution	80–110	€/m
Telephone network—independent path		maintenance	21–30	€/m
Telephone network—independent path		Total substitution	70–100	€/m
Pub. light. network—independent path		Maintenance	48–60	€/m
Pub. light. network—independent path		Total substitution	160–200	€/m
Excavations and reinf. conc. works—inaccessible tunnel			1000–1800	€/m
Water network—inaccessible tunnel			110–150	€/m
Gas network—inaccessible tunnel			90–120	€/m
Sewer network—inaccessible tunnel			150–190	€/m
Electrical network—inaccessible tunnel			50–80	€/m
Telephone network—inaccessible tunnel			40–70	€/m
Pub. light. network—inaccessible tunnel			130–170	€/m
Paved public spaces			230–280	€/sq. m
Public landscaping			70–85	€/sq. m

the PdR, which is approximately 78%, ranging from the minimum value in Ofena of just under 51% (the only town among those considered where the estimated cost for religious buildings has a notable impact) and more than 84% in the town of Bussi.

Thus the costs of recovering private buildings, and above all E rated units, have a very significant impact on the overall costs of reconstruction; this consideration can be extended to all of the towns in the area of the crater, including the city of L'Aquila, as clearly demonstrated by the PdR presented thus far.

Something that is not shown in the tables, but found among the information requested of the documentation accompanying the QTE, regards the indicator that expresses the relationship between the overall cost of each PdR and the resident population of the *Ambiti* (zones) located inside the perimeter of the plans: from the minimum value in the towns of Civitella C. and Montebello di B., with a cost per inhabitant of roughly €50,000, we reach the maximum cost in Ofena, which

Table 4 Summary of economic and technical conditions in the eleven towns

Typology	Brittoli	Bussi sul Tirino	Civitella Casanova	Cugnoli	Montebello di Bertona	Ofena	Popoli	Poggio Picenze	Goriano Sicoli	Castelvecchio Subequo	Caporciano	TOTAL of 11 MUNICIPA-LITIES
	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	
	PP-B	PP-A-B-C3	PP-A-B	unico e PP	PP-B-C	PP-1-2-3-4-6-7-8	PP-A-B-C	1-2-3-4-5	PP-Le Pagliare, Nucleo Centro Storico	1-2-3-4-5-6-7-8-9-10	PP-A-B-C-Bominaco	
Private constructions	**5.430.897**	**57.576.343**	**16.121.513**	**9.950.983**	**11.255.796**	**13.300.087**	**50.887.568**	**91.293.841**	**22.627.947**	**26.963.018**	**41.784.365**	**347.192.358**
Public housing										**155.363**		**155.363**
Public buildings and religious buildings *of which*	**2.079.885**	**6.096.193**	**4.034.726**	**2.281.130**	**2.525.110**	**12.029.781**	**10.793.038**	**15.130.592**	**5.161.791**	**3.549.120**	**7.764.741**	**71.446.109**
Public buildings of strategic interest			202.905	587.872				660.488		91.170		1.542.435
Public buildings not of strategic interest		3.942.568	3.011.821	1.693.259	192.360	4.894.375	7.188.585	3.385.777	305.280	112.010	200.207	24.926.243
Religious buildings	2.079.885	2.153.625	820.000		2.332.750	7.135.405	3.604.454	11.084.327	4.856.511	3.345.940	7.564.534	44.977.430
Technological networks and public spaces *of which*	**115.250**	**4.873.737**	**1.824.268**		**45.000**	**558.714**	**118.020**	**7.115.480**	**2.523.329**	**5.727.750**	**2.293.609**	**25.195.156**
Technological services network		1.878.647						1.333.530	946.741		1.350.609	5.509.526

(continued)

Table 4 (continued)

Typology	Brittoli	Bussi sul Tirino	Civitella Casanova	Cugnoli	Montebello di Bertona	Ofena	Popoli	Poggio Picenze	Goriano Sicoli	Castelvecchio Subequo	Caporciano	TOTAL of 11 MUNICIPA-LITIES
	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	Zone	
	PP-B	PP-A-B-C3	PP-A-B	unico e PP	PP-B-C	PP-1-2-3-4-6-7-8	PP-A-B-C	1-2-3-4-5	PP-Le Pagliare, Nucleo Centro Storico	1-2-3-4-5-6-7-8-9-10	PP-A-B-C-Bominaco	
Road network			124.000									124.000
Public spaces	115.250	2.995.090	1.700.268		45.000	558.714	118.020	5.781.950	1.576.589	5.727.750	943.000	19.561.630
TOTAL AMOUNTS	**7.626.032**	**68.546.273**	**21.980.506**	**12.232.113**	**13.825.906**	**25.888.581**	**61.798.626**	**113.539.913**	**30.313.067**	**36.395.251**	**51.842.715**	**443.988.985**
Other costs *of which*	**1.449.954**	**4.296.913**	**3.770.524**	**2.472.226**	**7.685.945**	**10.635.233**	**890.344**	**2.584.710**	**1.877.458**	**918.950**	**2.153.420**	**38.735676**
Escape route safety	**294.355**	**3.033.669**	**940.324**	**774.806**	**1.930.080**	**483.468**	**890.344**		**1.414.800**		**930.572**	**10.692.418**
Other network of technological services	**494.578**	**883.244**	**265.200**	**817.120**	**1.498.865**	**17.206**		**2.584.710**	**462.658**	**918.950**	**1.222.848**	**9.165.380**
Public spaces	**661.020**			**756.300**	**2.977.000**	**349.978**						**4.744.298**
Road netwok				**124.000**								**124.000**
Landslide areas		**380.000**	**2.565.000**		**1.280.000**							**4.225.000**
Other interventions						**9.784.580**						**9.784.580**

exceeds €1.4 million/res. Between these two extremes are the values for Castelvecchio Subequo (over €600,000/*res.*) and Goriano Sicoli, Caporciano and Brittoli (slightly more than €400,000/*res.*). For all of the other towns, a range of between €100,000 and €225.000/residents was calculated.

While this is a simple indicator, it nonetheless lends itself to different interpretations and must be comparatively analysed not only in terms of pure accounting, but also in relationship to the restoration of a stable urban structure for these settlements, prospects of development for local manufacturing systems, the importance of architectural heritage and, more in general, the meaning that can be attributed to the notion of the cultural good that, *tangible or intangible, a testimonial to the historic or artistic or environmental value, the cell of the suitable space or fabric of a territory, is always and also an economic good* [8].

7 Conclusions

The structure of the summary calculation of the cost of the PdR began with the objective of defining the maximum theoretical costs admissible based on the criteria expressed in the Ordinances issued by the President of the Council of Ministers.

This means that, with respect to the variability of possible, or simply imaginable situations, choices that generated the highest financial coverage were always preferred.

In other words, within the "cage" of restrictions imposed by legislation, the hypotheses assumed always tended toward the highest values.

All the same, two points remained fixed: naturally the accessibility ratings (acquired) and the areas to which the costing structure was applied.

The entire project was based on the cadastral areas and pursued the result of reconstructing the estimate based on individual urban properties. This made it possible to provide municipal governments and controlling institutional bodies a set of documentation that contains a highly detailed and transparent recounting of the genesis of the potential costs for each sub-parcel, parcel, aggregate and zone.

That said, a question was raised in any case about the entity of financing effectively necessary for the reconstruction. In other words, it is justifiable to ponder the percentage shift between the estimated costs and the actual financing that will be provided: while hypotheses can be advanced, they would require further study before being presented.

From this point of view, it would have been preferable to utilise other procedures of mass appraisal, for example multi-parameter linear regression, based on the observation of costs inferred from interventions that had already been financed.

What is more, an approach of this type could have been further improved and offer a higher level of rigour and transparency, if the Technical Offices working on behalf of the Government had prepared the final recovery projects with the same rapidity as the site visits used to define the physical conditions of properties. Costs could have been analytically estimated based on a sample of buildings (150–200), opportunely

defined based on their accessibility ratings, location, building and structural typology, function and dimensional class, to define a more robust regression model. Estimates defined in this way would have referred to the effective characteristics of different buildings, both in terms of their construction and level and percentage of damage, based on relations between the two categories of aspects.

In any case, once the QTE had been developed and the PdR approved, this initial idea was never again considered.

Not without some difficulty, little more than one hundred estimates of private recovery projects that had already been financed (results B, C and E) were acquired. They made it possible to define a model of multiple linear regression that allowed for the use of the mass of information contained in the AeDES charts, transformed into independent variables (building typology, level and percentage of damage to vertical structures, infill and stairs, floor slab typology, etc.) [9].

The results of this calculation, now complete, are extremely comforting, even if, as one would hope, it would be opportune to test the model against a more important number of observations, expanded to the towns closer to the epicentres of the seismic events.

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