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ASSESSING THE LOSS IN VALUE OF EARTHQUAKE-DAMAGED CULTURAL HERITAGE: AN APPLICATION TO THE 2011 LORCA EARTHQUAKE

X. Romão [1], E. Paupério [2]

[1] Assistant Professor, University of Porto - Faculty of Engineering, xnr@fe.up.pt
[2] Researcher, University of Porto - Construction Institute, pauperio@fe.up.pt
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Abstract

The Sendai Framework for Disaster Risk Reduction (SFDRR) upholds the development and implementation of measures to reduce hazard exposure and vulnerability to disasters. Among other aspects, the SFDRR recognizes the importance of cultural heritage and its irreplaceable value for society, thus emphasizing the need to assess the impact that potential hazards may have on the built cultural heritage. Developing adequate risk assessment and management processes are fundamental towards this end and it is known that systematically collected and robust disaster damage and loss data are essential for such processes. Thus, the development of systems, models and methodologies to collect and handle such data are seen to be a current worldwide priority.

One of the challenges for the disaster risk management sector is to broaden loss assessments to include non-direct losses. For example, non-monetized losses need to be integrated into loss estimation procedures to obtain a sound quantification of disaster impacts. In this context, the losses to cultural heritage and the relation between them and society (e.g. economic losses in tourism resulting from damaged cultural heritage) are particularly important but existing loss and damage databases rarely capture those effects.

The topic of economic valuation of cultural heritage has been the subject of several studies over the past years and several methodologies have been developed to elicit monetary expressions of cultural values. However, most of these methods were not developed to estimate the loss in value of damaged cultural heritage properties. The quantification of the loss in value introduces an additional level of subjectivity due to the difficulty in estimating losses across the multiple types of values that are embodied in a cultural heritage property as a result of a certain amount of physical damage it may have suffered.

In this context, the paper presents a methodology defining an indicator to estimate economic losses that represent the loss in value of cultural heritage properties due to damage caused by hazardous events. The methodology establishes an indicator estimating the loss in value of cultural heritage properties as a function of the (physical) damage they suffered and of the positive estimated economic impact that cultural heritage has in a given country. This indicator is not meant to reflect the true value of economic losses. Instead, it reflects a standardized measure of potential economic losses that is comparable across countries. Details of the methodology are presented along with an illustrative application to the cultural heritage properties damaged by the 2011 Lorca earthquake.

Keywords: cultural heritage, cultural heritage damage, cultural heritage loss, economic loss indicator

1. Introduction

The most widely used measures of disaster impacts are (a) direct losses, meaning the hazard's immediate, physical damage to property, infrastructure, agriculture and human life and (b) insured losses. Direct as well as insured losses are largely reduced to monetary damage, fatalities and injuries. At present, the use of direct losses dominates all other loss measures due to the tangible nature of physical damage. One of the challenges currently faced by the disaster risk management sector is to broaden loss assessments to include other types of losses. For example, the inclusion of indirect costs as well as non-monetized losses into loss estimation is of paramount importance for a sound understanding and quantification of the full impacts of disasters. This relates particularly to the damage of non-monetized resources such as cultural heritage assets and the relationship between them and society (e.g. the economic losses of some sectors such as tourism as a result of damaged cultural heritage). Although disasters adversely affect the cultural sector, those effects are usually not captured in loss estimates and subsequently in loss and damage databases. The lack of this information produces incomplete and skewed risk assessments that are biased toward direct economic and human losses and severely underestimates the effects of hazards.

In light of this, there is a significant potential to advance loss estimation techniques and probabilistic forecasts by including impacts on cultural heritage and by attempting to value (monetize) those impacts. As long as cultural heritage resources are not valued, shocks to these elements will not be reflected in risk assessments and disaster risk management. Based on this discussion, a methodology is outlined in the following for defining an indicator that provides an estimate of economic losses representing the loss in value of cultural heritage properties due to damage caused by hazardous events.

2. An indicator for the economic loss in value of damaged cultural heritage properties

The topic of economic valuation of cultural heritage has been the subject of several studies over the past years and several methodologies have been developed to elicit monetary expressions of cultural values. The most commonly found methodologies are Cost Based Methods (the Replacement Cost Method, the Restoration Cost Method, the Substitute Cost Method or the Preventive Expenditure Method), Revealed Preference Methods (the Hedonic Pricing Method, the Market Price Method or Travel Cost Method), Stated Preference Methods (the Contingent Valuation Method or Multi-Attribute Valuation Methods) and Impact Studies, e.g. see [1-5] among others. Since most of these methods were developed for other areas, they exhibit strengths and weaknesses when applied to cultural heritage assets. Most of these approaches require large amounts of data and many of them also require surveys to be carried out among the population. Moreover, results obtained by these methods are sensitive to the valuation method that is used and are specific to a certain cultural heritage asset with little chance of being extrapolated to other properties. Hence, there is currently no single and entirely reliable approach to estimate the economic value of cultural heritage properties. Finally, it is also referred that most of these methods were not developed to estimate the loss in value of damaged cultural heritage properties. The quantification of the loss in value introduces an additional level of subjectivity due to the difficulty in estimating losses across multiple types of values that are embodied in a cultural heritage property as a result of a certain level of physical damage to the property.

The proposed methodology builds on the valuation method based on Impact Studies and establishes an indicator that estimates the loss in value of cultural heritage properties as a function of the (physical) damage they suffered and of the positive estimated economic impact that cultural heritage has in a given country. It is noted that this indicator is not meant to reflect the true value of economic losses. Instead, it reflects a standardized measure of potential economic losses that is comparable across countries.

2.1 Preliminary data

To establish the proposed indicator, the baseline pre-disaster non-extractive use values and non-use values of each cultural heritage asset considered relevant by a given country must first be defined. It is noted that, within the proposed methodology, the terminology *cultural heritage asset* can refer to:

- **A single unit property**: an immovable cultural heritage property involving only one unit, e.g. a church.
- **A multi-unit property**: a group of multiple immovable units that form a cultural heritage property, e.g. a historical center.
- **A single object**: a movable cultural heritage object or artwork, e.g. a painting.
- **A collection of objects**: a group of movable cultural heritage objects or artworks, e.g. the collection of a museum.
- **An ensemble property:** an immovable cultural heritage property involving only one unit that houses a group of movable cultural heritage objects or artworks, e.g. a historic house.

Given the referred difficulties in valuing cultural heritage, this baseline value *BV* is defined using qualitative descriptors. Although other categories of value could be considered, the following four types of value that are well established by [6] are considered to define the *BV* of a certain asset:

- **Evidential value**: Derives from the potential of the asset to yield evidence about past human activity (physical remains, written records, archaeological deposits, etc.).
- **Historical value**: Derives from the ways in which past people, events and aspects of life can be connected through the asset to the present (divided into (a) illustrative value: the extent to which it illustrates something unique or rare; (b) associative value: the extent to which it is associated with a notable family, person, event or movement).
- **Aesthetic value**: Derives from the ways in which people draw sensory and intellectual stimulation from the asset (either as a result of conscious design or the seemingly fortuitous outcome of the way in which the asset has evolved and has been used over time).
- **Communal value**: Derives from the meanings of the asset for the people who relate to it, or for whom it figures in their collective experience or memory (these can include (a) commemorative and symbolic values: the meanings of the asset for those who draw part of their identity from it, or have emotional links to it; (b) social value: assets that people perceive as a source of identity, distinctiveness, social interaction and coherence; and (c) spiritual value: emanate from the beliefs and teachings of an organized religion, or reflect past or present-day perceptions of the spirit of place).

Although the uniqueness and rarity features are only referred when defining historical value [6], it is assumed that such attributes must also be accounted for in the remaining categories of value. Likewise, authenticity-related aspects of a certain cultural heritage asset can also be associated with any of the referred categories of value. Each category of value is then assigned with a qualitative score *V* according to the following ranks which are based on a proposal from the National Trust of Australia [7]:

- **Exceptional value**: The asset has features of exceptional/international significance or that contain elements with a significance beyond national boundaries (a score of 20 is assigned to this rank).
- **Considerable value**: The asset has features of considerable/national significance, possibly reflected in a statutory designation such as that of a listed building or an equivalent nationally graded asset (a score of 15 is assigned to this rank).
- **Some value**: The asset has features of some significance that are important at a regional level, either individually or for the value as a whole (a score of 10 is assigned to this rank).
- **Limited value**: The asset has features of limited/local significance (a score of 5 is assigned to this rank).
- **Unknown value**: The asset has features of unknown significance resulting from a lack of sufficient information on which to base a sound analysis of its value (a score of 1 is assigned to this rank).
- **No value**: The features of the asset have no significance (a score of 0 is assigned to this rank).

Therefore, for each cultural heritage asset, a matrix similar to the one presented in Fig. 1 is established to define the *BV* of the asset.

The baseline pre-disaster value *BV* of a certain cultural heritage asset will then correspond to the sum of the scores established for each type of value given by:

$$BV = \sum_{i=1}^{4} V_i \quad (1)$$

where V_i represents the score of the ith category of values. Parameter BV needs to be defined for all the cultural heritage assets a certain country considers relevant for what is termed herein as its cultural heritage capital. The term cultural heritage capital (CHC) is considered to represent what Throsby [8] defines as the part of cultural capital related to tangible assets. A country's CHC aggregates the BV of all the relevant cultural heritage assets according to:

$$CHC = \sum_{i=1}^{NCHA} BV_i \quad (2)$$

where $NCHA$ corresponds to the number of cultural heritage assets a certain country considers relevant for its CHC. The value of CHC is therefore the total pre-disaster qualitative value of the cultural heritage assets in a certain country.

	Exceptional value (20)	Considerable value (15)	Some value (10)	Limited value (5)	Unknown value (1)	No value (0)
Evidential value		x				
Historical value	x					
Aesthetic value			x			
Communal value		x				

Fig. 1 – Example of a matrix with the scores of each category of values of a given asset to establish its BV.

2.2 Estimating economic loss in value due to damaged cultural heritage

Following the occurrence of a disaster, qualitative damage levels need to be collected for each cultural heritage asset affected by the disaster to establish the proposed indicator. Based on the damaged state of a given cultural heritage asset, a qualitative loss or damage level must be assigned to each type of value according to the following four classes of loss/damage D:

- **Undamaged or unaffected** (a score of 0 is assigned to this class).
- **Damaged or partially lost**, but it can be repaired/restored to its initial state (a score of 0.3 is assigned to this class).
- **Damaged or partially lost**, but it cannot be repaired/restored to its initial state (a score of 0.7 is assigned to this class).
- **Destroyed or lost** (a score of 1 is assigned to this class).

For each damaged cultural heritage asset, a matrix similar to the one presented in Fig. 2 is then established to define the damage scores for each type of value of the asset.

	Undamaged or unaffected (0)	Damaged or partially lost, but it can be repaired/restored to its initial state (0.3)	Damaged or partially lost, but it can't be repaired/restored to its initial state (0.7)	Destroyed or lost (1)
Evidential value		x		
Historical value	x			
Aesthetic value			x	
Communal value	x			

Fig. 2 – Example of a matrix of damage scores for each type of value of a given damaged asset.

Based on these damage scores, the qualitative post-disaster loss in value parameter *LV* is then defined for a certain damaged cultural heritage asset as the sum of the damage scores established for each category of value given by:

$$LV = \sum_{i=1}^{4} V_i \times D_i \tag{3}$$

At this point, the following four damage categories of *LV* and subsequent actions need to be defined for the purpose of defining a loss in value parameter that accounts for the effect of the time to recover from the damage sustained by a cultural heritage asset:

- **Damage category 1** - Damaged cultural heritage that will not be repaired, restored or stabilized.
- **Damage category 2** - Damaged cultural heritage that will be repaired, restored or stabilized.
- **Damage category 3** - Destroyed cultural heritage that is expected to be replaced in the future.
- **Damage category 4** - Destroyed cultural heritage that is not expected to be replaced in the future.

Cultural heritage belonging to damage category 1 is assumed to remain usable as it is. Some of its value may be affected but not enough to require repair, conservation or restoration works. Therefore, for cultural heritage assets belonging to this damage category, the expected time to recover (*TTR*) from the disaster is null. As such, the corresponding damage is not considered to have an economic impact and, subsequently, economic losses associated to cultural heritage in this category are considered null. On the other hand, cultural heritage belonging to damage category 2 is expected to remain unusable until the end of the repair, restoration or stabilization works. In this case, economic losses associated to cultural heritage in this category need to account for the time required to carry out those works. To do so, parameter *TTR* is obtained according to:

$$TTR = \frac{NMR}{12} \tag{4}$$

where *NMR* represents the number of months until the possible reuse of the damaged cultural heritage asset and *TTR* is measured in years. For cultural heritage belonging to damage category 3, a similar approach can be established. Parameter *TTR* is also defined according to Eq. (4) but, in this case, *NMR* represents the number of months it will take to replace the destroyed cultural heritage asset by a new asset. For cultural heritage assets belonging to damage category 4, developing a value for parameter *TTR* is conceptually different. Since the heritage asset will not be repaired, restored or replaced, the number of months until its possible reuse in its pre-disaster state is infinite. However, the time length during which the economic impact due to the total loss of a given cultural heritage asset can be felt is expected to be a finite number of years, given that society and socioeconomic activities will adapt over time to cope with this loss. The long-term economic impacts of disasters are known to span across several years (e.g. see [9-11]), however, none of the existing research on this issue has been found to address the specific impact of lost cultural heritage assets. In certain cases where activities of the cultural heritage sector are strongly connected to the tourism sector [12], part of these economic impacts could be captured by considering the recovery time of the tourism sector (e.g. see [13-15]). However, since the duration of these economic effects is not expected to be known immediately following a disaster, a preliminary implementation of the proposed indicator shortly after a disaster (e.g. within the context of a Post Disaster Needs Assessment procedure) requires an expert-based estimate of this duration. On the other hand, given that preliminary estimates of disaster impacts are normally updated over time, the values of the parameters involved in the proposed methodology, namely the *TTR*, can also be revised and updated as more reliable data become available.

After establishing the value of *TTR* for all the affected cultural heritage assets, the total relative post-disaster loss in value of damaged cultural heritage assets in the country (*TRLV*) can then be obtained. This parameter is the sum of the *LV*s obtained for each affected cultural heritage asset factored by their corresponding values of *TTR*, divided by the country's *CHC*:

$$TRLV = \frac{\sum_{i=1}^{NDCHA} LV_i \times TTR_i}{CHC} \tag{5}$$

where *NDCHA* corresponds to the number of cultural heritage assets in the country that were damaged by the disaster. All the *NDCHA* assets must be part of the group of *NCHA* assets previously considered in Eq. (2). Finally, the indicator representing a standardized equivalent economic loss for the damaged cultural heritage assets, I_{LV}, can be defined by:

$$I_{LV} = \frac{TRLV \times GVA + RC}{GDP} \tag{6}$$

where *GVA* represents the country's gross value added associated to the cultural heritage sector resulting from all types of activities related to the cultural heritage assets that are part of *NCHA*, *RC* are post-disaster cultural heritage recovery costs (i.e. repair, restoration, conservation, stabilization, reconstruction costs, as well as other expenditure related with the recovery operations), and *GDP* is the country's gross domestic product. For a given year where a disaster occurs in a country, the considered *GVA* will have to be that of the previous year or an estimate of that year's *GVA* based on available trends.

4.3 Additional considerations regarding the proposed indicator

The underlying reasoning for the development of I_{LV} is that the *CHC* of a given country was contributing to its economy prior to the disaster and that such contribution can be captured by the country's *GVA* associated to the cultural heritage sector. Therefore, when a disaster occurs, the methodology assumes, in a simplified manner, there will be an average loss in the country's *GVA* that is proportional to the global loss in value of the cultural heritage assets damaged by the disaster. Although, in principle, these arguments can be generally accepted, there are caveats in the practical implementation of the proposed indicator and in its ability to reflect the economic losses due to impacts on cultural heritage. For example, in order to determine the proposed indicator in a given country, the country must have a national inventory of its cultural heritage assets, namely those that are expected to contribute to the *CHC*, and their baseline pre-disaster value *BV* should be available (or easily defined based on the availability of pre-set guidelines for this purpose). If this information is not established prior to the disaster, the value of the *CHC* will be more difficult to define.

Another important aspect of the proposed estimator lies in the fact that it assumes that a country's *GVA* is able to capture a wide spectrum of the relevant economic influence of cultural heritage, namely its influence on other sectors as a result of both the use and non-use values of cultural heritage. Even though research has shown that activities related to cultural heritage have a significant impact on economic indicators such as the *GVA*, these impacts are not readily observable in traditional national accounting systems. Therefore, this information needs to be aggregated from the several economic sectors usually defined as industries in national accounting systems. This aggregation is called a Culture Satellite Account (CSA) [13-14] and measures the economic impacts of culture across the multiple productive sectors of an economy. Therefore, if the country where the disaster has occurred did not set up a CSA prior to the disaster, the relevant economic impacts that are expected to be captured by the *GVA* will not be available. Furthermore, it is also noted that, despite the CSA's ability to provide an accounting framework to measure the referred economic impacts of culture, the global structure of a CSA is still not a standard. Therefore, even though CSAs developed by different countries have several common elements, the unavailability of official guidelines on how to develop a CSA allows countries to consider contributions from different sectors [18]. To address this issue and to facilitate the international comparability of culture statistics, the UNESCO Institute for Statistics, in collaboration with the UN Statistics Division, is currently developing international recommendations for compiling CSAs.

Finally, it is noted that damaged cultural heritage has also non-economic impacts on several domains of society, namely on social cohesion and community participation, education and knowledge, social identity, well-being and quality of life, environmental sustainability (e.g. see [19] and references cited therein). For

example, losing the recreational value of a given cultural heritage asset because it was destroyed or cannot be accessed for some time can have impacts on the well-being of people. Similarly, the loss of the social or spiritual value associated to the cultural heritage asset can have deep social impacts, namely in the sense of identity, continuity and belonging of people. Given the difficulty to relate these impacts with economic indicators, the proposed indicator is unable to capture them. Still, quantifying non-economic losses is not an issue solely for the cultural heritage sector since it recently became a component of international climate change policy [20-22]. Therefore, developments in this domain may become relevant and applicable to cultural heritage in the future and may be used to enlarge the scope of the proposed indicator.

In light of these issues, the proposed indicator is seen as a first attempt to tackle the problem of widening the scope of post-disaster economic loss evaluation associated to damaged cultural heritage assets. Nevertheless, to highlight the potential of this indicator, a case study application is presented in the following that provides insights on its practical implementation even if the necessary pre-disaster information is not fully available.

3. Case study application of the proposed indicator: the 2011 Lorca earthquake

The case study involving the cultural heritage assets damaged by the 2011 Lorca earthquake in Spain is selected due to the limited number of assets that were affected, therefore enabling the presentation of a short illustrative application of the proposed indicator. Furthermore, this particular event is also selected due to the information that is publicly available about the event and its consequences in the cultural heritage sector, as well as about Spanish cultural heritage statistics in general.

3.1 The 2011 earthquake and its overall impacts

On May 11, 2011, at 18:47 (local time), an earthquake of magnitude Mw 5.1 hit the city of Lorca in the region of Murcia, Spain. Lorca is a moderate size city that had a population of about 93000 in 2011. The city, which sits on both banks of the Guadalentín river and on the hillside of a 9th century castle, is rich in both tangible (e.g. churches, Roman villas, palaces, a castle and several other monuments) and intangible cultural heritage (e.g. the Holy Week and the Easter festivities, the San Clemente festivities, the art of embroidery in silk and gold). The earthquake caused extensive damage to both recent and older constructions in Lorca, along with 9 casualties and 324 injured. Although earthquakes of such magnitude are expected to cause limited damage, it is believed that both the shallow depth of the hypocenter and its close distance to the city are the main reasons for the significant damage that occurred [23]. The main earthquake was preceded by another event of magnitude Mw 4.5, at 17:05 (local time). Although this foreshock was relatively weak, damage to some structures was also reported.

Overall, nearly 80% of the buildings were damaged at different levels from this event. The inspection of 7876 buildings in the city showed that 5383 suffered minor or no damage (green-tagged), 1569 suffered moderate damage (yellow-tagged), 664 suffered moderate to serious damage (red-tagged), and 260 had to be demolished (black-tagged). Of the red-tagged buildings, 164 were later also demolished since their repair was either economically or technically unfeasible [24]. The insured losses due to this earthquake were close to 511M€ [25], of which 83.5% are related to residential buildings and 13.5% are related to commercial buildings, but estimates of the overall direct and indirect losses are in the range of 1200M€ [26].

3.2 Earthquake impacts in the cultural heritage sector

The earthquakes damaged several monuments and historical constructions, as well as movable heritage assets. Detailed data on the damage in 74 monuments and historical constructions was made publicly available in the "*Plan Director para la Recuperación del Patrimonio Cultural de Lorca*" (Master Plan for the Recovery of the Cultural Heritage of Lorca) commissioned by the *Instituto de Patrimonio Cultural de España* (Spanish Cultural Heritage Institute) of the Spanish Ministry of Culture and published on November 2011 [27]. The prompt development of this Master Plan indicates clearly how significant this cultural

heritage was for the city's recovery and sustainability and for the well-being of citizens. These 74 heritage assets that were damaged by the earthquake include 17 assets listed as BIC ("*Bien de Interés Cultural"*), 19 assets listed as Grade 1 and 38 assets listed as Grade 2. In addition to this detailed information, the Master Plan also includes cost estimates for the emergency stabilization and the repair of the 74 heritage assets and for one item referring to damaged movable heritage. The overall cost of immediate protection measures and repair of cultural heritage was estimated to be 47.87M€ for the immovable assets and 2.10M€ for the movable assets [27].

Aside from managing the recovery of heritage assets, the Master Plan also included several supporting activities under the section Auxiliary Programmes. One of these activities involved the development of a database to document and collect all the relevant data on the repair actions performed across the different heritage assets. Other activities of the Auxiliary Programmes involved dissemination actions of the heritage recovery process throughout its development across different media, as well as special publications targeting different sectors of the local population on topics related to the effects of the earthquake and to the heritage recovery operations. The Auxiliary Programmes also included activities that were specifically designed to preserve the engagement of the citizens with their cultural heritage during the recovery and to involve them with the recovery process. Among others, reference is made to activities such as exhibitions related to the recovery and repair processes, workshops discussing these processes with invited talks and practical in situ demonstrations, and guided tours to sites of heritage assets being repaired. The costs of these additional components of the recovery process were estimated to be 1.32M€.

3.3 Economic loss estimate of the earthquake impacts on the cultural heritage sector

The implementation of the proposed indicator is based on the data and estimates for the recovery costs published in the Master Plan [27]. Updates of this information were carried out recently (e.g. see [28]), but full details of the data are not publicly available. Therefore, the 2011 data are considered herein, namely to enhance the replicability of the presented results. Since the list of cultural heritage assets that are expected to contribute to the *CHC*, as well as their baseline pre-disaster value *BV*, are not established, several assumptions are made regarding these classifications. These and other issues related to aspects for which information is not fully available are presented next to detail the implementation of the proposed indicator.

Since country-level statistics regarding the quantity of each type of listed heritage asset (i.e. BIC, Grade 1 and Grade 2) in Spain are only publicly available for BICs, the following assumptions are made for the implementation of the proposed indicator:

- The *CHC* is considered to be defined by the total number of BICs in Spain, which comprised 14088 cultural heritage assets in 2011 [29]. Given the inability to classify each BIC individually using the scores defined in Figure 2 to establish the value of *BV*, each BIC was considered to be an asset of national significance. Therefore, each BIC was assigned a *BV* of 60, which corresponds to a score of 15 for each type of value.

- Cultural heritage assets listed as World Heritage Sites were also considered when defining the *CHC* according to the following criteria:

  a) In case the World Heritage Site is comprised of one or more clearly defined units (e.g. the Works of Antoni Gaudí, which involve 7 units, or the Tower of Hercules which is only one unit), each of these units is assumed to be listed also as a BIC and their *BV* is increased from 60 to 80 to reflect their international significance (which corresponds to a score of 20 assigned to each type of value).

  b) In case the World Heritage Site is a multi-unit property that was classified mostly due to the value of the whole ensemble instead of that of its individual units (e.g. the Historic Centre of Córdoba or the Rock Art of the Mediterranean Basin on the Iberian Peninsula), each of these sites is also added to the *CHC* with a *BV* of 80 to reflect their international significance.

In light of these considerations, the value of *CHC* is found to be 848180.

As defined in Section 2.2, the value of parameter *LV* is defined by only considering the contribution of cultural heritage assets that are part of the *CHC*. Based on the data found in the Master Plan, the list of BICs damaged by the earthquake has 17 components. However, since the referred list has 3 separate entries referring to the castle and 2 separate entries referring to Teatro Guerra, which means these 5 entries only involve 2 BICs, the value of *LV* was defined by considering 14 cultural heritage assets. Furthermore, according to the repair and recovery operations defined by the Master Plan, and given the simplified approach followed to establish *BV*, a damage category 2 was assigned to all the 14 damaged BICs and a damage score of 0.3 was assigned to each type of value. Therefore, the value of parameter *LV* for each BIC is 60×0.3 = 18 (see Eq. (3)). The value considered for the *TTR* of each BICs is based on the planning of the recovery operations presented in the Master Plan. Table 1 presents the list of the 14 BICs damaged by the earthquake along with their corresponding values of *LV* and *TTR*. Based on these, the value of *TRLV* given by Eq. (5) is 576.

Table 1 – List of the 14 BICs damaged by the Lorca 2011 earthquake, along with their values of *LV* and *TTR*.

BIC	*LV*	*TTR* (years)
Castillo (Torre del espolón y tramos de muralla. Torre Alfonsina. San Clemente. Parador. Derrumbe rocoso basamento muralla) (10th-16th centuries)	18	3.5
Porche de San Antonio (13th-14th centuries)	18	0.5
Muralla manzana 7 (14th-15th centuries)	18	0.5
Palacio de Guevara (17th-18th centuries)	18	1.5
Colegiata de San Patricio (16th-18th centuries)	18	5.5
Iglesia y convento de San Francisco (16th-18th centuries)	18	2.5
Colegio de San Francisco (16th-18th centuries)	18	1.5
Iglesia de Nuestra Señora del Carmen (18th century)	18	2.5
Iglesia de San Mateo (18th-19th centuries)	18	1.5
Casino Artístico y Literario (19th century)	18	2.5
Palacio de los Condes de San Julián (17th-18th centuries)	18	2.5
Torre de Mena. La Hoya (12th-13th centuries)	18	5.5
Teatro Guerra including Casa Privada (14th century)	18	1.5
Palacio Huerto Ruano (19th century)	18	0.5

The value considered for the Spanish *GVA* associated to the cultural heritage sector is obtained from the CSA of 2011 [30] and for the compound category "*heritage, archives and libraries*". The value of the *GVA* for this category is 2216M€. However, for the purpose of the current analysis, only the contribution of the *heritage* component is needed. Since that *GVA* values were defined separately for *heritage* and for *archives and libraries* prior to 2010 (e.g. see [31]), a proportion was defined for each component based on the available data from earlier years. Based on the data from 2005 to 2010, the *heritage* component was seen to represent, on average, 2/3 of the total *GVA* while the *archives and libraries* component represents only 1/3. Therefore, the value of the *GVA* is considered to be 1477.33M€.

Finally, to implement the proposed indicator, the total value of the recovery costs *RC* are considered to be 51.29M€, according to the Master Plan, and the Spanish *GDP* of 2011 is found to be 1070449M€ [32]. Based on the values of the components necessary for the proposed indicator I_{LV}, its value is found to be 0.0049%. Given the scale of the Lorca 2011 earthquake and the low number of damaged cultural heritage assets that are involved in the quantification of the proposed indicator (only 15), the value of I_{LV} is, as expected, small. Furthermore, the contribution of the losses in the economic impact that cultural heritage has

in the country to I_{LV}, i.e. the component $TRLV \times GVA$ of I_{LV}, is only about 1.02M€, which roughly represents 2% of the GVA. Likewise, that component also represents an increase of roughly 2% in the economic losses to the cultural heritage sector with respect to the situation where only the value of RC is considered.

4. Conclusions

International frameworks and programmes for disaster risk reduction are clear in their objectives of reducing hazard exposure and vulnerability to disasters. Furthermore, the importance of cultural heritage and its irreplaceable value for society is also clearly acknowledged in these objectives. Currently, it is clear that existing disaster loss accounting systems underestimate the true cost of disasters as a result of several factors. One of these factors is the inability to account for disaster impacts on the cultural heritage sector in a more realistic way.

In this context, one of the challenges of cultural heritage disaster loss analysis is to broaden the quantification of economic losses associated to the damage sustained by cultural heritage assets to include other correlated impacts. To address this issue, a new indicator is proposed that provides an estimate of economic losses representing the loss in value of cultural heritage assets due to disaster damage and the associated recovery costs. The steps needed to implement the proposed indicator are described in detail, as well as difficulties and limitations of its application. This indicator is not meant to reflect the true value of economic losses. Instead, it reflects a standardized measure of potential economic losses that is comparable across countries and that is expected to provide useful information, for example, when developing a PDNA procedure where information is required in a short amount of time.

The proposed indicator is a first attempt at widening the scope of post-disaster economic loss evaluation associated to damaged cultural heritage assets and is expected to provide the starting point for further developments on this issue. To further highlight the potential of the proposed indicator, a case study application is presented which addresses the losses to cultural heritage assets damaged by the 2011 Lorca earthquake. The case study details all the steps of the implementation of the indicator and provides insights for its practical application when the necessary pre-disaster information is not fully available.

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