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NATURAL HAZARDS – A THREAT FOR IMMOVABLE CULTURAL HERITAGE. A REVIEW

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Abstract

This study presents a review of how natural hazards can impact on immovable cultural heritage (ICH). In the last few decades, the global impact of natural hazards on cultural heritage appears to be growing, which in part, may be a response to the changes in the intensity and frequency of geomorphological processes in the light of climate and environmental change. Research undertaken at present by geographers, geologists, archaeologists, conservationists, and other specialists, shows significant interest in the protection, assessment, and mitigation of natural risk phenomena on ICH. However, attempts of evaluating the present state, and to predict the future degradation of cultural heritage is a real challenge. A review of the published literature indicates that the emergence of studies focused on the degradation of ICH by natural hazards started approximately 40 years ago, with an increasing trend starting from early in the 21st century; Europe is the most studied area globally. These studies demonstrate that conservation measures need to be implemented to protect and prevent further degradation of the world's cultural heritage, to preserve a legacy for future generations.

Keywords: *Immovable cultural heritage, Natural hazards, Mitigation, Conservation.*

Introduction

The impact of natural hazards is a major concern for the safety and development of human society, according to the World Meteorological Organization (WMO) (2002). *Natural hazards* are severe and extreme weather and climate events that occur naturally in all parts of the world; some regions are more vulnerable to certain hazards than others, depending on the local natural conditions. The number of natural hazards is exponentially increasing in the course of the global climatic changes [1]. The increasing human and material losses associated with extreme natural phenomena has led to the emergence of international research agendas focused on the nature and intensity of these phenomena, and the development of possible mitigation strategies to combat their effects, together with protocols for recover after such events. Initially, research was oriented more towards disaster analysis, casualties and material (infrastructure) damage. However, more recently, the effects of extreme events on cultural heritage has been acknowledged and, this has now become an area of significant research activity with a number of case studies focusing attention upon cultural heritage in different parts of the world, including a better understanding of associated geomorphological processes [2].

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UNESCO (United Nations Educational, Scientific and Cultural Organization, 1946) and the Council of Europe represent the key global players concerned with the protection of the tangible heritage across the world. The main focus points of UNESCO are:

- encourage countries to sign the 1972 Convention and to ensure the protection of their natural and cultural heritage;
- encourage States Parties to the Convention to nominate sites within their national territory for inclusion on WHL and to set up reporting systems on the state of the conservation of WH sites
- help State Parties safeguard WH sites by providing technical assistance and professional training;
- provide emergency assistance to WH sites by providing technical assistance and professional training;
- support States Parties' public awareness-building activities for WH conservation;
- encourage participation of the local population in the preservation of their cultural and natural heritage;
- encourage international cooperation in the conservation of cultural and natural heritage.

The term *cultural heritage* was already known since Antiquity [3] and has a very wide meaning, depending on the country, the author's conception, and background. Cultural heritage is an expression of the way in which a community developed and lived, passed on to future generations, including customs, practices, places, objects, artistic expressions, and values. There are several categories of heritage: cultural heritage and natural heritage; cultural heritage can be divided in tangible and intangible. The tangible cultural heritage can be branched in movable cultural heritage (coins, paintings, sculptures, and manuscripts), ICH (archaeological sites, monuments) and underwater cultural heritage (underwater ruins and cities, shipwrecks) (ICOMOS 2002).

Ever since the humans started to evolve and migrate, they had the capability to interact and to adapt to the surrounding environment, using its resources and being under the direct effect of natural hazards. Undoubtedly, there can be no discussion about natural hazards without humans having a direct or indirect influence; the impact of natural hazards on cultural heritage has increased over the last decades [4]. Protecting the diversity of cultural heritage is a constant and difficult issue, which differs from country to country and from region to region. Dealing with management [5-7], preserving [8-10], and rescuing the cultural heritage has become one of the main challenges of the modern times [11-14].

Along the history, there have been many natural hazards that have affected the ICH. A few examples are illustrative: pyroclastic flows from Vesuvius lead to the total destruction of Pompeii and Herculaneum in 79 AD; the Seven Wonders of the World, only one of them – the Great Pyramid Giza – has survived until today. Among the other six, three have been damaged by earthquakes. The Colossus of Rhodes tumbled down around 227 BC, the Pharos Lighthouse in Alexandria in the fourteenth century AD. Mausoleum in Halikarnassos, destroyed by floods and earthquakes and rebuilt several times, disappeared in the fifteenth century [3].

Methodology

The international scientific databases (ISI Web of Science) were consulted in order to make a clear and concise evaluation of studies regarding the degradation of the ICH by natural risk phenomena. Destruction of cultural heritage has a long lasting impact, and damaged or destroyed sites become a loss that cannot be recovered. Capitalizing the archaeological heritage involves collaboration of researchers, combining the information about the data discovered, and conservation policies. With the technological progress and development of new technologies 3D [15-17], remote sensing (GIS, aerial photo, laser scanning, photogrammetry, drone, thermal

method, satellite images, GPR, seismic) [18-36], monitoring [37, 38], and prediction of natural risk phenomena [39], cultural heritage risk assessment [40-45] became easier. A high number of sites were discovered this way, more have been surveyed and a large amount of data was saved, even though the degradation is still ongoing. This can help us and is vital in better understanding the triggering factors and development of natural hazards. In this way, early mitigation measures can be undertaken in order to have a better assessment of the cultural heritage.

Immovable cultural heritage

The main focus of this article is on ICH. Studies regarding the undesired effects of natural hazards on cultural heritage are spread all over the world and can be classified as follows:

1. **Hydrological risks:**
   - **a.** *floods* – one of the most widespread natural hazard, being encountered, especially in coastal areas of oceans, seas, reservoirs, or in the proximity of a flowing water (whether the water course is perennial or temporary); over the past 30 years, floods have been concentrated in Asia (42%), the Americas (23%), Africa (21%), and Europe (14%) [46]. The negative effect on ICH starts when parts of buildings or archaeological sites are under water or they completely disappear, being almost impossible to recover them (Fig. 1) [47-54].

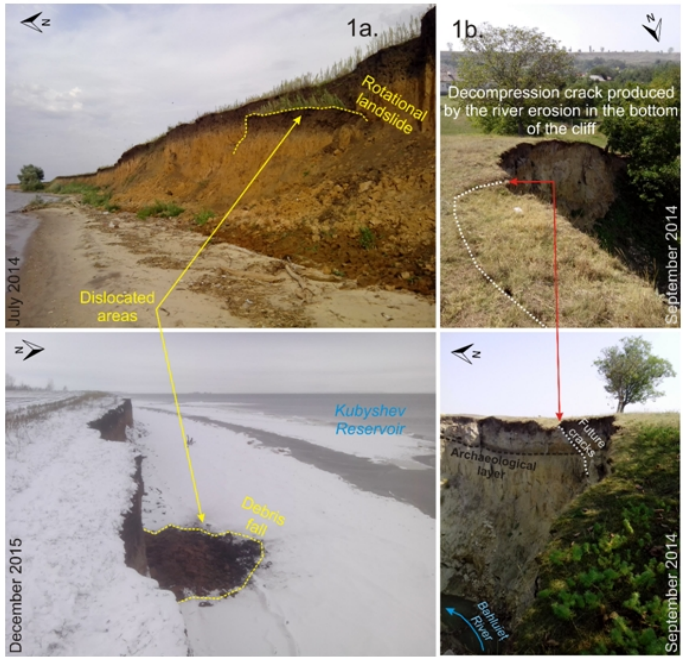

Fig. 1. Erosion process: **a -** affecting the hill fort Devichy Gorodok (upper Palaeolithic-Mesolithic, Imen'kovskaya culture – IV-VI centuries AD, Volga Bulgars – X-XIII centuries AD) from the left bank of Volga River (Kubyshev reservoir, Russian Federation); **b -** affecting a Chalcolithic settlement Costesti – *La Cier* (from the right side of Bahluiet River, North-eastern Romania)

   - **b.** *sea-level rise* – as of April 24, 2016, the NASA listed on its website, sea level rise is caused by two main factors, which are related to global warming: the water coming from the melting land ice and the expansion of sea water as it warms. In this case, the ICH located in coastal areas, which are the most threatened areas globally to sea-

level rise, are most vulnerable; there is only one study regarding the effects of this phenomenon on the global heritage [55].

c. *gully erosion* – one of the few natural hazards from which, once the process affects the ICH it is impossible for the data to be recovered or saved, unless fast anti-erosion and mitigation measures are taken in order to stop the erosion process; the main factor contributing to the gully head retreat and development is the rain and the model tested has shown a high sensitivity to rainfall intensity. In the next years, as a consequence of global climatic changes, these intensities are expected to increase, resulting in increasing the surfaces of eroded land and implicitly the ICH (Fig. 2). Despite the fact that statistical modelling employed to predict the development of gully erosion and gully headcut retreat become widely used on a global level, only a few studies deal with the applicability of these methods to ICH [27, 39, 56-58].

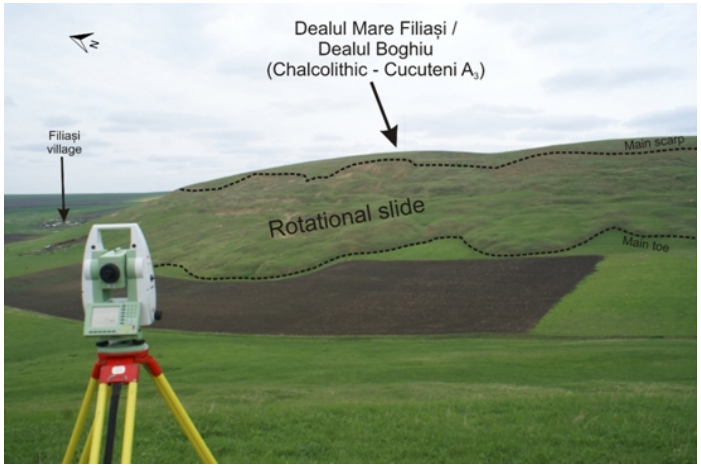

Fig. 2. Landslide affecting the fortified Chalcolithic settlement of Dealul Mare Filiași / Dealul Boghiu (Valea Oii catchment, North-eastern Romania)

2. **Geomorphological risks:**
   d. landslides – (Fig. 3) the most widespread natural hazard, in what concerns the prediction by means of statistical modelling, which has become an increasingly common method in the assessment of landslide hazard [48, 59-73]; the first phase in landslide hazard mitigation is identifying and assessing the hazard [74].
   e. rock fall – represents the falling of a newly detached mass of rock from a cliff or down a very steep slope and occur especially in the mountains or steep areas; this kind of hazard is highly studied in what concerns the negative effects on ICH [75-82].
   f. mudflows – is part of the large spectrum of natural processes which takes the form of a rapid mass movement; when the sediment is rich in clayey materials and poor in coarse particles, the sediment looks like a muddy fluid [83]. Being known for their devastating effects, not only referring to economic activities and human casualties, the ICH can be completely destroyed. No studies have been undertaken regarding this natural hazard and its effects on ICH.
3. **Seismic risks** – seismic hazard is defined by the probability of occurrence, within a specified period of time and in a given area, of a potentially damaging earthquake. Seismic vulnerability of heritage buildings and structures is the probability of occurrence in damage and losses corresponding to a specific level of seismic hazard of building with this character.

g. *earthquakes* – although in the past geological characteristics were taken into consideration in placing a settlement, in present days, because of the earth's crust dynamics these processes can lead to a slow and systematic degradation of the ICH; these are among the most dangerous and unpredictable natural hazards, causing destruction and claiming thousands of human lives throughout the world [84-87].

h. *tsunami* – representing a very sudden and dangerous hazard, as a consequence of earth's crust dynamics; a significant part of the world's heritage is located in coastal areas, thus being in danger of being partially or completely destroyed in a case of such event happening. The most exposed areas are located around the active volcanic areas, especially around the Ring of Fire (Pacific Ocean) [88].

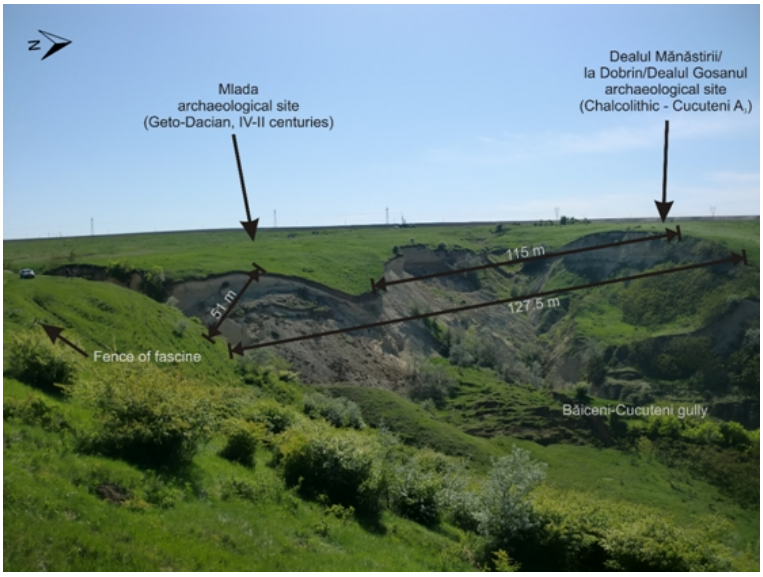

Fig. 3. Gully erosion affecting two archaeological sites
(Chalcolithic and Geto-Dacian period – Valea Oii catchment, North-eastern Romania)

4. **Climatic risks:**
   i. *weathering* – representing a natural process that affects ICH over long periods of time; it can affect the stability of the building (Fig. 4a), paintings (Fig. 4b) or other inscriptions (Fig. 4c) with a significant historical value [89-100].
5. **Biotic processes:**
   j. *root wedging* – occurs when a plant, especially trees, sink roots system into existing joints or fractures, and as a consequence of the root growing it forces the fracture to expand. Studies are lacking in this process affecting ICH. An example is given in Figure 5.

Beyond the loss of information in general terms, undoubtedly the manifestation of natural hazards has undesirable effects on the tourism industry by reducing the number of tourists that travel to these locations [101-107]. Sustainable heritage tourism strategies need to be developed to satisfy the needs of the local population, and to implicate the population directly in the touristic process. The importance of cultural heritage is given by the category classification of the site, whether is listed as a UNESCO heritage [48,108-114] or not; those that are not included in the UNESCO world heritage list are included in different categories of importance that vary from country to country.

Fig. 4. Structural-functional instability, paintings and writings degradation of immovable heritage:
a**.** Instability of the decorated roof at Temple of Bacchus, part of Baalbek Roman Archaeological Site (the largest and most impressive Roman temple complex in the world, part of UNESCO World Heritage since 1984, Beqaa Valley, North-eastern Lebanon);
b. Degradation of Christian paintings from Deir es-Salib, inside the grotto with the same name, Qadisha Valley (The Holy Valley), a UNESCO World Heritage site (ID 850-001), North Lebanon;
c. Degradation of three type of writings from Deir es-Salib (Arabic, Greek, and Syriac)

Fig. 5. Structural-functional instability and deterioration of immovable heritage:
a. Root wedging affecting the walls from the eastern slope of Dacian Fortress – Sarmisegetusa (a UNESCO World Heritage Site, ID 906-001) from the Orăştie Mountains, Hunedoara County, Romania.
b. Basic measures to stop the collapse of the fortress walls

Discussion

The value of cultural heritage goes beyond conservation, monitoring and protection; it can offer significant data that cannot be recovered in the future and insights on human evolution, cultural evolution, evolution of culture, people's behaviour, among other issues. Analysing the published material (Fig. 6a), we can conclude that the most concerned area with cultural heritage studies, management, assessment and mitigation of natural hazards in the world is Europe with 61% of the total studies, followed by Asia with 17%, Americas with 12%, Middle East with 6%, Africa and Australia both with 2%. In Europe, the countries with the highest number of case studies are Italy (54%), Romania (23%), UK (13%) and Greece (10%) (Fig. 6b); this coming from itself, Italy is the country with one of the richest cultural heritage in the world [69].

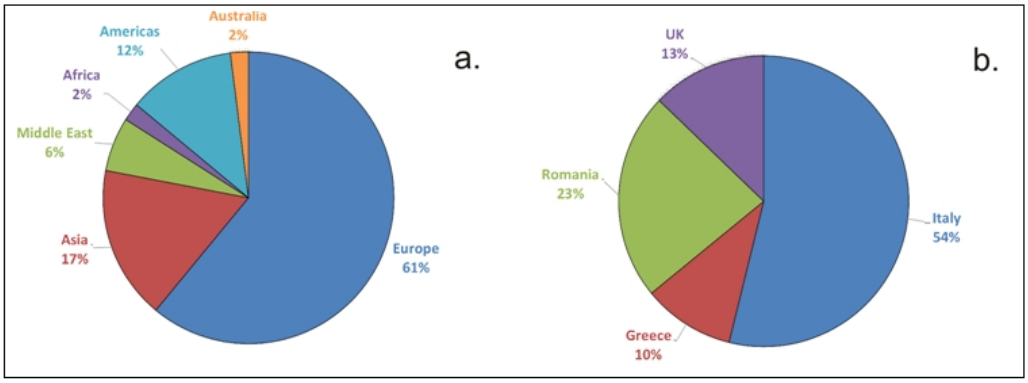

Fig. 6a. Percentage distribution of studies worldwide. **Fig. 6b.** Percentage of studies in Europe

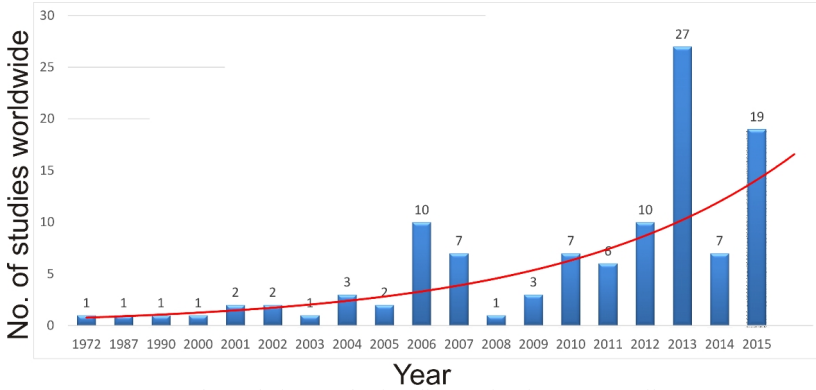

Fig. 7. The evolution graph of studies starting from 1972 until 2015

Conclusions

Analysing years of emerging studies, the early 70's revealed the beginning of such academic work by the North American's conservationists employed by the U.S. Army. To date, 2013 highlighted an increase in the number of conducted research of this type. The growing trend (Fig. 7) is identified starting with 2006, with a total of 10 studies, up to 2013 and 2015, with a total of 27, respectively 19 studies. Slowly, important steps are being undertaken every year in order to save as much data-related degradation of sites. The high number of studies from 2013 is associated with the publication of a special issue following an international conference Landslide Science and Practice. Vol. 6: Risk Assessment, Management and Mitigation.

Regarding Romania, the number of studies has grown over the last two years, thanks to a research project funded by Romanian National Research Council; the research is focused on developing and implementing a functional model of applied research based on integrating and improving of non-destructive approaches, while understanding and valuing the complexity of prehistoric archaeological sites, evaluating the present state in which the site is regarding the natural hazards and anthropic interventions, assessment, and proposing different management plans to diminish the negative effects for the future.

The appreciation and economic gain from cultural heritage sites are growing from year to year, according to natural conditions in which the site is found. The importance of cultural heritage and the opportunities that this sector can create for both professionals in the field and for communities is of great value. The most common natural hazard approached are mass movements, erosion and rock fall. Given the high number of sites located in prone areas of landslides, this is a necessity; saving as much spatial data as possible will lead to a better

understanding for local authorities and stakeholders to plan economic activities, minimize the damages costs, improve environmental protection, and the most important aspect, cultural heritage protection. However, the research must be converted into policy action, with the differences among countries addressed through international collaboration and knowledge transfer, in order to avoid recourse to inappropriate strategies and experiences. States with experience of the effects of a certain type of natural hazard effects on ICH, could thus share their knowledge with those newly affected by similar conditions, or states with a poor economy.

The prevention and protection [115] of ICH from natural hazards is a very difficult task, because of the sites location in the proximity of earthquake or sea-level change areas, along coasts, areas with landslides, areas threatened by floods. The impacts of natural hazards can be mitigated by reinforcing buildings to protect them against earthquakes, stabilising unstable slopes to protect them against landslides and gully erosion, and fixing banks, managing watercourses, and building dams to protect areas against floods; however, the destruction cannot be completely prevented [3]. More attention should be given in the study and assessment of natural hazards on ICH such as wildfires, mudflows, sea-level rise and root wedging.

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