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SCIENTIFIC RESEARCH DIFFICULTIES OF POST-EARTHQUAKE REHABILITATIONS

Abstract

The elimination of the consequences of earthquakes fundamentally differentiates the research of the rehabilitation process depending on the damage that has occurred and the actual value of the rehabilitation. The estimated damage values of the recent earthquakes in Croatia, as well as the built environmental aspects of the actual rehabilitation and reconstruction, also influence the process of performance comparisons and best practice analyses. The authors of the study, in relation to their research areas, are looking for optimized procedures in relation to development opportunities.

Key words: rehabilitation, damage value, earthquake, benchlearning

A FÖLDRENGÉSEKET KÖVETŐ HELYREÁLLÍTÁSOK TUDOMÁNYOS KUTATÁSI NEHÉZSÉGEI

Absztrakt

A földregések következményeinek felszámolása a bekövetkezett károk, valamint a helyreállítás tényleges értékének függvényében a helyreállítás folyamatának kutatását alapvetően differenciálja. A közelmúltban történt horvátországi földrengések eddig becsült kárértékei, valamit a tényleges helyreállítás és újjáépítés épített környezeti vonatkozásaiban a teljesítmény-összehasonlítások és a bevált gyakorlati elemzések folyamatát is befolyásolja. A tanulmány szerzői a kutatási területeik kapcsolatában, optimalizált eljárásokat keresnek a fejlesztési lehetőségek viszonyában.

Kulcsszavak: helyreállítás, kárérték, földrengés, benchlearning

1. INTRODUCTION

The estimated damage values of the recent earthquakes in Croatia (March and December 2020 and January 2021), as well as the large number of stakeholders, highlighted, that in addition to the process of rehabilitations in Hungary previously researched by the authors, it would be worthwhile to examine the neighboring countries. Linked to the idea of benchlearning proposed in Kiss's PhD work [1], which the authors see justified in continuing to study the practice of neighboring countries, in this case Croatia, leaving open the opportunity to promote mutual learning.

In our paper, we first make a brief presentation of the events of the earthquakes in Croatia in March 2020 and December 2020 and January 2021, and then briefly discuss the general characteristics and difficulties of the rehabilitations. Next, we present our applied methods. In the discussion, we address the risk of earthquakes in the affected Zagreb region, and write briefly about the earthquake alarms in Hungary, the definition of vulnerability and the aspects of disaster management. Then we demonstrate briefly the main data and characteristics of the March recovery efforts in Zagreb (since the events of December and January are still very close, there are no real reliable data on the rehabilitation). We then briefly describe the benefits of benchmarking, in terms of rehabilitations. Finally, we formulate our conclusions and suggestions in relation to what has been described.

1.1. Recent earthquakes in Croatia

Amidst the middle of the fight against the COVID-19 pandemic, Zagreb the capital of the Republic of Croatia was stricken with another disaster, an earthquake. On 22 March 2020 at 06:24, Croatia was hit by a strong earthquake of the magnitude of 5.5. The epicenter was at Markuševec, 7 km north of the center of Zagreb, at a depth of only 8 km. At that time, Zagreb was “hub” of the pandemic in the country. With the earthquake causing a huge damage to the entire city center, including major hospitals, leaving over half a million of inhabitants restricted to return to their homes, the situation represented a unique combination of the need to strengthen the measures of physical distancing and humanitarian relief alongside with urgent measures aimed at damage control and assessment.

The March 2020 earthquake had one death toll, 26 injured, and thousands of people were displace. As a consequence of the earthquake, 488 persons were housed in an evacuation center, and an unknown number of people found shelter at friends' and relatives' places. The earthquake caused damage to about 26,000 buildings in the City of Zagreb, Krapina-Zagorje County and Zagreb County. [2; 3]

When the country barely recovered from the damages caused by the March earthquake, another earthquake occurred near the Zagreb region. An earthquake of 6.2 magnitude, with the epicenter close to Petrinja, struck Croatia on 29 December 2020. This earthquake was reported to be the strongest earthquake to hit Croatia for more than 140 years. Eight people were killed and at least 36 persons were injured, ten of whom severely. Between 29 December 2020 and 8 January 2021, additional 379 aftershocks occurred, some of which have been as strong as 5.0 magnitude, additionally damaging buildings and roads in the areas of Sisak-Moslavina, Karlovac and Zagreb Counties. The worst affected areas were the towns of Petrinja, Sisak, Glina and Hrvatska Kostajnica covering a total of 2 802 km^2 of mostly rural area, comprising one medium size town, three smaller rural towns and a total of 482 villages, many of them in hilly remote areas.

There is no final data at the time on the number of houses or residential buildings damaged, since the first screenings and damage assessments of the buildings are still going on. According to the first estimations, there are approximately 15 000 to 20 000 damaged or uninhabitable buildings mainly in Sisak-Moslavina County with the damage value initially estimated at CHF 434.8 million, needed for the reconstruction. [4]

In overall, the Croatian government is currently facing a multifaceted emergency caused by the global pandemic, an economic recession and the earthquakes of 2020 and 2021.

1.2. Post-disaster rehabilitations in general

Due to the large number of natural disasters worldwide each year (hundreds of natural disasters per year) and their volume, there is a significant amount of rehabilitation research at the international level. Due to the rather complex nature of the topic, however, the scientific methods and results are also extremely diverse. Yi –Yang described that in recent years an increasing number of publications on natural disasters and recovery have been published in the international scientific community, however, this field is still a new field of research and no

uniform definition has yet been developed. [5] A research on international rehabilitations focuses on Chile, China, Haiti, India, Italy, Japan, New Zealand, and the United States [6], not surprisingly, as these countries account for most of the natural disasters from year to year. [1]

As per the analysis of the data provided by the International Disaster Database (EM-DAT), the four most frequent types of disasters in Europe and Central Asia are floods, windstorms, earthquakes and extreme temperatures. The response to such disasters requires a high-level of mobilization of people on the site to respond, often exceeding the country's capacity. When it happens, the international community is asked to grant assistance, resulting in international disaster management. Different national and international entities like NGOs, multilateral or international organizations, businesses and the academia, are directly or indirectly involved in disaster management and play various roles. [7]

In order to recover from a disaster, leaders need to make different decisions; however, what makes the post-disaster decision-making peculiar is the lack of time to make the optimal decision. A comprehensive understanding of the limits of recovery can lead to elaboration of policies that help avoid delays in the recovery process and consequently, it results in resiliency. [8]

Rehabilitation absorbs an enormous amount of financial resources [9], and the successful rehabilitation of an affected community can be measured by the extent to which the social and public services are efficiently refurbished. [10] Rehabilitation is a complicated, challenging, and dynamic process, as many responsibilities of rehabilitation are interdependent [11], and have to be assumed at the same time [10; 12]. For example, the recovery of the local economy depends on the restoration of the infrastructure, housing, and public services. [13] After a disaster, the economic recovery is very diverse, requiring the participation of the private sector and it benefits both the private and public sectors. [14] In a long-term rehabilitation process, the disaster-stricken communities require support from different organizations such as NGOs, local and federal governments, etc.. [15]

The reconstruction of the infrastructure is also vital to successful post-disaster rehabilitation. [16] For example, transportation systems play a basic role, facilitating the delivery of resources and materials. Environmental rehabilitation is usually not a high priority following a natural disaster. [10]

1.3. Post-disaster rehabilitations – Hungarian characteristics

In the management of the consequences of natural disasters, the management aspects of rehabilitation are primarily reflected through the leadership functions of the Government, government coordination and the minister responsible for disaster management. The decision-making process takes place through the professional disaster management and the actors assigned to it in the public administration. Due to the earthquakes, the main decision-making tasks can be structured during the processes, taking into account the tasks of the prevention, rescue and rehabilitation period.

In preparation for the occurrence and the prevention of an incident, the development of a procedure for the mechanism and the procedure of decision-making at the government level, the practice of emergency operations, the formulation of the technical and development needs of decision-making and the monitoring of enforcement are stressed.

To achieve partial or full operational readiness, depending on the severity of the expected or developed situation, one needs to immediately assess the situation after the readiness has been reached and develop proposals for measures concerning the rule of conduct to be introduced in case of an earthquake - evacuation and relocation. Elaboration or specification of proposals for the measures - preparedness and reception of requests for international assistance, preparedness for the introduction of a special legal order, raising public awareness, etc., continuous monitoring of the situation and circumstances, review of the proposed measures.

The elimination of the consequences and, in the light of the information provided and the capacity of the available resources, developing proposals for the assessment of subsequent protection measures, including the temporary and permanent accommodation of the population losing their homes, in the period of rehabilitation; the collection, storage and distribution of aid; organizing rescue and decontamination; for the period of resettlement of the population concerned; developing proposals in the event that the criticality of any element of the infrastructure would impede the introduction of subsequent protection measures, endanger the lives of the population, property and the natural environment.

1.4. Benchmarking, benchlearning

The use of benchmarking as a horizontal management tool is becoming more and more valuable nowadays. To explain the concept, we draw from the work of Rónai and Budai. [17; 18] In the wording of Rónai, benchmarking *"means a measure, a level sign, interpreting comparative evaluation"*. In the course of benchmarking, we usually look for practices and procedures in an area similar to our own organization, which prove to be better than the existing one, and we take them as a benchmark for the improvement and development of our own system. Benchmarking can be used as an approach, as an openness again and not just as a stand-alone procedure. In connection with the concept of benchmarking, we also consider it important to mention the method of benchlearning. [17] After all, Budai described already in 2008 that benchlearning is gaining more and more prominence than classical benchmarking, because here we prioritize learning from others. [18] The point is to learn from the strengths of others, collect ideas, review them, and avoid bad practices. [1]

Linking the topic of benchlearning to the present paper, we formulate it as a question whether the rehabilitation in Croatia rehabilitation can provide opportunities for the bordering Hungary, can we learn from Croatian professionals and researchers? A large-scale natural disaster in Hungary has not occurred for a long time, so now in connection with the Croatian events there could be an opportunity for cooperation, more in-depth study of rehabilitations, exploration of national peculiarities, a broader knowledge and understanding of good practices, whether scientific or even practical. Hence, this is the essence of benchlearning. It provides an opportunity to adopt good practices. For these reasons, it is an important question for professionals researching rehabilitation in Hungary what opportunities the practices of neighboring countries may have. Can they provide good practices for us to deal with similar incidents and how to rehabilitate thereafter?

2. METHODS

In this paper, a secondary research was performed by the authors. During this secondary research, literature review and report content analysis were implemented with a focus on the

characteristics of post-disaster rehabilitations and benchlearning opportunities connected to Zagreb's recent earthquakes. Several searches were run on Google, Research Gate, Elsevier ScienceDirect and EM-DAT (Emergency Events Database) databases, with the following queries: "earthquake in Croatia", "reconstruction after the earthquake in Croatia", "post-disaster reconstruction", "seismic risk assessment in Croatia", "reconstruction in Croatia", "Croatian disaster management", "Croatian civil protection", "benchlearning" and their different synonyms. In the following, relevant papers, reports, datasets were scrutinized from the search results and were used for this paper.

3. DISCUSSION

3.1. Earthquake risks in Croatia

Located in Southern Europe, Croatia belongs to the Mediterranean-Trans-Asiatic high seismic activity zone making it one of the most earthquake-prone countries in Europe. These earthquake-prone regions spread over approximately 30% of Croatia and are characterized by a relatively dense population and large urban centers. The urban areas of Zagreb, Split, Dubrovnik and Rijeka are of particular economic and social importance are with about 60% of the country's population. Zagreb itself, as the administrative, cultural, scientific, economic, and traffic center of the country, accounts for almost 20% of the population and about one third of the country's GDP. [19; 20]

The Zagreb epicenter area is the most active one in the continental part of Croatia. [21] The return period of a magnitude 6 earthquake is expected to be 150 years, with magnitude 6.9 being the maximum possible in the nearby system of fault lines. Before the earthquakes of December 2020, the largest known earthquake in the area was the Kasina earthquake in 1880 (*Table 1*). Its magnitude was estimated to be 6.3. [22]

Date	Epicenter (in relation to Zagreb city center)	Magnitude (Mw)	Intensity (MCS)
9 November, 1880	estimated at 12 km	6.3	VIII
17 December, 1901	estimated at 12 km	4.6	VII
17 December 1905	estimated at 12 km	5.6	VII-VIII
2 January, 1906	estimated at 12 km	6.1	VIII
3 September, 1990	10 km north-northwest	4.7	VII
22 March, 2020	7 km north-northeast	5.5	VII-VIII
29 December, 2020	48 km southeast	6.4	

***Table 1*: Major earthquakes in the Zagreb area**

Source: Based on Croatian Government – Word Bank [3] and International Medical Corps [23] Own editing, 2021

Consequently, catastrophic earthquakes have occurred in the past and may hit again and, if not adequately responded to, the losses to life and property can be significant. Yet, there is still not enough public awareness and understanding of the potential seismic risk, although it is indispensable for successful mitigation strategies. [20]

An increasing number of rapidly growing urban areas are becoming more vulnerable to seismic risk in their development process. [24; 25] Nowadays, information on constructions in Croatia that could be used for standard seismic risk assessment studies is very limited. The last census conducted in 2011 provides data such as the date of construction, occupancy category, number of dwellings, and number of people per dwelling. [26] However, other information required for a more comprehensive description of buildings, e.g., construction material, structural type, number of floors, etc., are not available.

Preliminary steps towards a standard building inventory database for the City of Zagreb have been assumed within the disaster risk assessments [19; 27] and earthquake risk reduction studies

[28] conducted in collaboration between the Faculty of Civil Engineering and the Zagreb Office for Emergency Management, implemented since 2013.

The fact that a strong earthquake would not only cause damages to the built environment and the population but would also result in the collapse of the country's economy while increasing one of the Croatia's biggest problem, which is depopulation, is far from being generally accepted and recognized. Some efforts for seismic risk reduction, conducted by individual initiatives, are on the agenda, but these efforts are not sufficient for developing the required systematic risk reduction strategy at local and national levels.

The lessons learnt from countries that have already been stricken by earthquakes suggest that it is essential to connect and coordinate the activities of stakeholders (technical experts and scientists involved in the sophisticated research in various fields important for seismic safety). [20]

3.2. Reconstruction after the Zagreb's earthquake

Data and features related to the rehabilitation following the Zagreb earthquake were processed based on the "CROATIA EARTHQUAKE Rapid Damage and Needs Assessment 2020" prepared by the Government of Croatia and the World Bank. [3] This report is a comprehensive and reliable summary of what happened. The government and its external agent worked on based on official data available at the time. No more relevant source is available at the time of writing this paper.

In the weeks following the March 2020 earthquake, the Croatian government launched the preparation of a Rapid Damage and Needs Assessment (RDNA), which was coordinated by the Ministry of Construction and Physical Planning. The damage, loss, reconstruction and rehabilitation estimates were compiled in this report. The RDNA aims to provide a structured and comprehensive account of the earthquake's impacts. The report complements the further planning of an overall post-earthquake rehabilitation strategy and the development of the necessary institutional, legal and financial framework for the reconstruction. This coordinated assessment process has also been used by the Croatian government to prepare its application for the European Union Solidarity Fund.

Most of the damage was suffered by the housing sector (64%), followed by the culture and cultural heritage sector, including historical government buildings (13%), education (10%), health (8%), and business (5%). The sector most affected by total losses is the housing sector (57%), followed by business (29%), health (10%), culture and cultural heritage (3%) and education (1%). Overall 78% of the damage and losses are in the private sector, and 22% in the public sector. In the private sector, damage and losses are mainly in housing and business, while, in the public sector, they are mainly in health and education. For the culture and cultural heritage sector, the ownership distribution of damage and losses is 39.2% public and 61% private.

Housing is the sector most badly hit by the disaster, with approximately 24 000 damaged buildings spread across the whole of the earthquake-stricken area. An estimated 4 600 of them have moderate to severe structural damage (19%), while 1 243 have high structural damage (5%). The total value of damage to the housing sector stands at approximately EUR 6.88 billion, while the assessment of losses amounts to EUR 364 million. The *Table 2.* for losses takes into account the displacement of persons from unsafe buildings, and the disposal of earthquake debris. Ninety-nine percent of all estimated costs relate to the City of Zagreb, as it is here that the density of buildings and population is at its highest.

The needs for reconstruction and rehabilitation (*Table 2*) add up to approximately EUR 17 469 billion. Of this amount, EUR 4,5 billion relates to short-term needs (26%), medium-term needs are estimated at EUR 7,1 billion (41%), while long-term needs stand at EUR 5,8 billion (33%). The reconstruction and rehabilitation needs are higher than damage and losses since they include, first, the application of a build-back better approach to the reconstruction of damaged infrastructure that reduces any future earthquake risks and involves functional improvements including energy efficiency; and second, the resumption of production, service delivery, and access to goods and services.

The cost of rehabilitation is the highest in the housing sector and accounts for more than half of the overall needs (52%), followed by the culture and cultural heritage sector, the health sector, and the education sector (each respectively accounting for 13-14% of overall rehabilitation needs). The large amount of damage done to buildings of cultural heritage value

across all sectors renders the rehabilitation and reconstruction process particularly complex and challenging, both in financial and logistic terms.

As revealed by the assessments of damage and losses, the extent of the disaster is so wide-ranging that it is simply not possible to determine a timeframe for rehabilitation at this stage. [3]

The total recovery and rehabilitation needs, which include both reconstruction costs and soft recovery measures, are considerably higher than the estimated damage and losses for all sectors. Several factors have contributed to this; notably the fact that the earthquake severely damaged Zagreb's historical city center, which, as a whole, is classified as cultural heritage; the need to apply build-back better principles and improve functional characteristics of buildings; and the fact that many of the affected hospitals and schools will need to be retrofitted to meet the highest seismic resistance standards.

The legal framework for the reconstruction of damaged buildings, including precise guidelines for construction work, will be set out in the Billy on Reconstruction of Damaged Buildings in Zagreb and the Surrounding Area, which was, at the time of writing the report, undergoing public consultation. The consultations started on 15 May 2020 and the Bill is due to be approved by the new Parliament as a priority action. [3]

The government has already embarked upon the rehabilitation process by preparing the legal framework for a thorough and long-term program of rehabilitation. Building on actions already taken, and using the RDNA process as a basis, a comprehensive Recovery Strategy will be elaborated. The time span for recovery has been divided into short-, medium- and long-term periods, although the exact duration of these periods has not yet been determined. They will be decided during the elaboration of the Recovery Strategy.

The Bill on the Reconstruction of Damaged Buildings in Zagreb and the Surrounding Area: Almost immediately after the earthquake struck on 22 March, the Ministry of Construction and Physical Planning began elaborating a new law to address the specific needs of rehabilitation and reconstruction. The aim of this *lex specialis* is to prescribe the manner and procedures for the removal of debris, and the rehabilitation and reconstruction of damaged buildings on the territories of the City of Zagreb, Krapina-Zagorje County and Zagreb County. The main

purpose of this law is to establish a post-earthquake management system with mid-term and long-term response measures, and designated standards for the carrying out of repairs.

The Bill covers the rehabilitation and upgrading of both public and private buildings. It includes four levels of rehabilitation and reconstruction:

1. repair of non-structural elements of buildings required for legal use and occupancy of a building;
2. repair of structural elements;
3. upgrade of structural elements; and
4. full rehabilitation and reconstruction.

The Bill aims to streamline administrative procedures by prescribing roles and responsibilities among existing central and local agencies, and establishing a coordinating body and Expert Council for the rehabilitation and reconstruction of the damaged infrastructure. The Bill also stresses that the technical and analytical basis for rehabilitation of the urban historic city center will follow the latest EU and international seismic standards. Replacement housing will be provided to those residents whose dwellings have severely suffered and cannot remain there. The Bill also intends to provide indication for the reimbursement of expenses for reconstruction, rehabilitation, dislocation or other actions eligible under this Bill, including actions undertaken before the adoption of the said legislation (*Table 2*).

	Damages and losses by sector (in million EUR)	Damages	Losses	Total	Summary of recovery and reconstruction needs (in million EUR)	Short-term	Medium-term	Long-term	Total
Housing		6 881	364	7 245		2 739	4 102	2 287	9 128
Health		826	61	887		374	210	1 851	2 435
Education		1 071	9	1 080		571	881	909	2 361
Culture and Cultural heritage		1 378	21	1 399		500	1570	447	2 517
Business		505	184	689		338	351	339	1 028
Total		10 661	639	11 300		4 522	7 114	5 833	17 469

Table 2 - Reconstruction after the Zagreb's earthquake – Damages, losses and needs

Source: Based on Croatian Government – Word Bank [3] Own editing (2021)

The report made the following proposals for the rehabilitation, with which also the authors agree:

- A detailed Reconstruction and Recovery Strategy/Framework should be developed
- BBB (Build Back Better) concept [including EE (Energy Efficiency)] and DRR (Disaster Risk Reduction) measures should be integrated in all reconstruction and rehabilitation needs in order to improve future disaster resilience
- Human impact in relation to social vulnerability to disaster (gender, disability, age etc.) should be mainstreamed in all reconstruction and rehabilitation measures
- [3]

3.3. Possible challenges in disaster management – earthquakes

The most important societal expectation regarding seismology, despite the fact that seismology provides a crucial part of the knowledge about the Earth's interior, is related to earthquake prediction. [29]

The development of earthquake alarm systems began in the 1990s in various locations, mainly in the countries affected by earthquakes (Mexico, USA, Japan, Romania, Taiwan, Turkey). The operating costs of forecasting systems are significant.

There are two possible types of alarm systems. The first one is a regional seismometer or accelerometer network installed in the vicinity of a previously known active geological structure. Their signals must be transmitted to a high-performance computer installed in the study area, analyzing the received signals: determining the position of the epicenter and the magnitude of the resulting earthquake. The latter task is not a simple and clearly automated task for large earthquakes. If a computer has determined the parameters of a quake, it will send an alarm signal if necessary. The definition will be made within a few seconds.

The second option that underpins prevention could be the monitoring of a facility highlighted in terms of a given vulnerability. An alarm signal for the protected facility can be generated based on a comparison of the primary wave arrival recorded by the seismometer(s),

accelerometer(s) and the beginning of the spectrum calculated from the first part of the seismogram.

A potential hazard posed by earthquakes can be characterized by the use of seismic vulnerability and seismic risk. A hazard is an over-time exposure associated with a probability of overshoot. The risk is the probability of failure of a natural structure or equipment. In other words, the risk describes the likely end result of the interaction between hazard and vulnerability. [30]

3.4. The methods of mitigation of losses due to earthquakes and the value of rehabilitation

The mitigation of the damage incurred, i.e., the extent of the compensation, is not regulated in advance. Supporting the owners in need of privately owned residential buildings should also take into account their responsibility to encourage the protection of their property.

Its constructive possibility was also described by Ambrusz in his PhD dissertation, which took into account the possibility provided by an insurance product in claims mitigation. [31] If the owners of the damaged property in need are insured and the owner's insurance is value-based, they should receive a non-refundable subsidy of 100% of the non-recoverable rehabilitation cost, but if the insurance is non-value-added, the 90% of the non-recoverable rehabilitation cost is to be received in form of a non-refundable grant accordingly. If the owners of the damaged properties in need do not have insurance, an owner should receive a 50% non-refundable subsidy for the costs of repair and recovery of the damage and an additional 50% interest-free, reimbursable subsidy in addition to meeting the criteria for taking out insurance. An owner who is not in need and whose income and financial situation do not significantly exceed those in need should be able to receive interest-free repayable assistance.

It is important to emphasize that in the choice of types of mitigation in proportion to the extent and severity of the damages, the validation of quality engineering and construction processes may play a more dominant role in the central mitigation organizational tasks, one of the key features of which also presupposes methods of financing force majeure recovery.

3.5. Opportunities for benchlearning

The difficulties of adapting international “best” practices in Hungary may be due to the fact that Hungary has different characteristics in many areas compared to countries appearing in international research and publications, which are much more often affected by natural disasters. The country's geographical location, population characteristics and economic characteristics also differ from those of the Third World, which is often affected by natural disasters, or even the United States. Probably, rehabilitation in Hungary has not become a key issue in our country either, because the frequency of large-scale natural disasters can be measured in the order of 10 years rather than years. However, this does not mean that it would be of slight importance to resolve the problem in Hungary, as these events, if less often, may burden the domestic budget at unexpected periods, which may trigger further, spill-over processes. [1]

Shifting benchlearning would also be important for countries bordering Hungary. It is presumably easier to overcome compatibility problems due to distance and differences between countries with similar disaster risks and locations. It is probably easier to identify what and how we can learn from each other if implemented in a similar system. Starting from the data collection difficulties experienced during the preparation of the paper, we formulate, as a fundamental problem, that international cooperation needs to be strengthened not “only” from the point of view of assistance, but also from the point of view of scientific experts. After all, in the absence of publications and reports in foreign languages, there is no common language for mapping and adopting best practices.

4. CONCLUSION

One of the clear lessons of the paper is that the management of large-scale emergencies, mainly natural and man-made, also requires a more flexible response system on the part of the EU. The efficiency of the overall response mechanism can be maximized by making capacity available for cases involving several countries at the same time, or the Union as a whole. Mutual European solidarity must be strengthened for the future with regard to rehabilitation, especially

if most or all of the Member States face the same emergency or a disaster of a magnitude beyond the tolerance of the country concerned.

As a continuation of the research, it is possible to develop exact parameters, map rehabilitation practices along them and share them on a common international platform for the organizations and governments concerned in order to learn from and adapt to the strengths of others.

REFERENCES

[1]. Kiss, A. (2020): A természeti katasztrófákat követő helyreállítás-értékelő rendszer fejlesztési lehetőségeinek vizsgálata. Doktori (PhD) értekezés. Debreceni Egyetem, Ihrig Károly Gazdálkodás- és Szervezéstudományok Doktori Iskola, Debrecen, 239 p.

[2]. Curkovic, M. – Svetina, L. – Košec, A. (2021): Double jeopardy; What happens when an epidemic is followed by an earthquake? Spatial and Spatio-temporal Epidemiology Vol. 36., February 2021, pp. 100402

[3]. Croatian Government – Word Bank (2020): Croatia Earthquake, Rapid Damage and Needs Assessment 2020. 102 p., WEB: https://mgipu.gov.hr/UserDocsImages/dokumenti/Potres/RDNA_web_04082020.pdf Downloaded: 25.01.2021

[4]. International Federation of Red Cross (IFRC) (2021): Croatia: Petrinja Earthquake Response - Emergency appeal. WEB: https://reliefweb.int/report/croatia/croatia-petrinja-earthquake-response-emergency-appeal-n-mdrhr004-15-january-2021 Downloaded: 19.01.2021

[5]. Yi, H. – Yang, J. (2014): Research trends of post disaster reconstruction: The past and the future. Habitat International. 2014. Iss. 42. pp. 21-29.

[6]. Peacock, W. G. – Dash, N. – Zhang, Y. – Van Zandt, S. (2018): Post-Disaster Sheltering, Temporary Housing and Permanent Housing Recovery. pp. 569-587. In: Rodríguez, H. – Donner, W. – Trainor, J. E. (2018): Handbook of Disaster Research. In: Handbooks of

Sociology and Social Research. 2nd Edition. (Ed. DeLamater, J.) 635 p. ISBN 978-3-319-63253-7

[7]. Macapayag, N. – Amisic, G. (2015): Trends and Patterns in Natural Disaster Management in Europe and Central Asia 1993-2014. Policy Lab Research Report. Vol.3. 2015, 56 p. WEB: https://cps.ceu.edu/sites/cps.ceu.edu/files/attachment/basicpage/143/ceu-policy-lab-ifrc-natural-disaster-mgmt-europe-and-central-asia-2015.pdf Downloaded: 25.01.2021

[8]. Rouhanizadeh, B. –Kermanshachi, S. –Nipa, T. J. (2020): Exploratory analysis of barriers to effective post-disaster recovery. International Journal of Disaster Risk Reduction. Vol. 50, 2020, 101735

[9]. Orabi, W. – El-Rayes, K-. – Senouci, A.B. – Al-Derham, H. (2009): Optimizing post-disaster reconstruction planning for damaged transportation networks, J. Construct. Eng. Manag. Vol. 135, Iss. 10. pp. 1039–1048.

[10]. Schwab, J. –Topping, K.C. – Eadie, C. – Deyle, R.E. – Smith, R.A. (2014): "Planning for Postdisaster recovery." PAS Rep, American Planning Association, Washington, D.C., 2014. No. 576.

[11]. Miles, S.B. – Green, R.A. – Svekl, W. (2012): Disaster risk reduction capacity assessment for precarious settlements in Guatemala City, Disasters Vol.36, Iss. 3., pp. 365–381.

[12]. Lam, N.S.N. – Reams, M. – Li, K. – Li, C. – Mata, L. (2015): Measuring community resilience to coastal hazards along the Northern Gulf of Mexico. Nat. Hazards Rev. Vol. 17., Iss. 1., 04015013.

[13]. Lyons, M. (2009): Building back better: the large-scale impact of small-scale approaches to reconstruction. World Dev. Vol. 37., Iss. 2., pp. 385–398.

[14]. Chang, Y. – Wilkinson, S. – Potangaroa, R. – Seville, E. (2010): Interpreting resourcing bottlenecks of post-wenchuan earthquake reconstruction in China, Int. J. Strat. Property Manag. Vol. 14., Iss. 4., pp. 314–331.

[15]. Islam, R. – Walkerden, G. –Amati, M. (2017): Households' experience of local government during recovery from cyclones in coastal Bangladesh: resilience, equity, and corruption, Nat. Hazards. Vol. 85. Iss. 1 pp. 361–378.

[16]. Jordan, E. – Javernick-Will, A. (2013): Indicators of community recovery: content analysis and Delphi approach, Nat. Hazards Rev. Vol. 14. Iss. 1., pp. 21–28.

[17]. Rónai, M. (2014): Szervezetfejlesztés a közszolgálatban (ÁROP 2.2.21 Tudásalapú közszolgálati előmenetel, Magyary Program). Nemzeti Közszolgálati Egyetem, Budapest, 46 p. (ISBN 978-615-5491-30-6) http://vtki.uni-nke.hu/uploads/media_items/szervezetfejlesztes-a-kozszolgalatban.original.pdf, download: 01.03.2017

[18]. Budai, B. B. (2008): E-közigazgatás axiomatikus megközelítésben. Doktori PhD értekezés. Pécsi Tudományegyetem, Állam- és Jogtudományi Kar Doktori Iskola, Pécs, 359 p. http://ajk.pte.hu/files/file/doktori-iskola/budai-balazs-benjamin/budai-balazs-benjamin-vedes-ertekezes.pdf, letöltés dátuma: 2017. november 22.

[19]. Atalić, J. – Hak, S. (2014): National disaster risk assessment in the Republic of Croatia – seismic risk (in Croatian), Faculty of Civil Engineering in collaboration with Ministry of Construction and Physical Planning and National Protection and Rescue Directorate

[20]. Novak, M. Š. –Atalic, J. –Uroš, M. –Prevolnik, S –Nastev, M. (2019): Seismic risk reduction in Croatia: mitigating the challenges and grasping the opportunities. Scientific Symposium FUTURE TRENDS IN CIVIL ENGINEERING Zagreb, Croatia, 17 October 2019, pp. 72-109. DOI: https://doi.org/10.5592/CO/FTCE.2019.04

[21]. Markusic, S. – Herak, M. (1999): Seizmic zonation of Croatia. Natural Hazards. Vol. 18. 1999. pp. 85-269.

[22]. Lokmer, I. – Herak, M. – Panza, G. F. – Vaccari, F. (2002): Amplification of strong ground motion in the city of Zagreb, Croatia estimated by computation of syntetic seizmograms. Soil Dynamics and Earthquake Engineering. Vol. 22. 2002, pp. 105-113.

[23]. International Medical Corps (2020): Croatia Earthquake Situation Report #1. WEB: https://reliefweb.int/report/croatia/croatia-earthquake-situation-report-1-december-31-2020 Downloaded: 19.01.2021

[24]. Hung, H.C. –Ho, M.C. –Chen, Y.J. – Chian, C.Y. –Chen, S.Y. (2013): Integrating long-term seismic risk changes into improving emergency response and land-use planning: a case study for the Hsinchu City, Taiwan, Nat. Hazards Vol. 69., 2013, pp. 491–508.

[25]. Šipoš, T. K. – Hadzima-Nyarko, M. (2017): Rapid seismic risk assessment. International Journal of Disaster Risk Reduction Vol. 24., 2017, pp. 348–360.

[26]. Croatian Bureau of Statistics (2011): Census 2011, Occupied dwellings by period of construction, type of building and number of households in dwelling, WEB: www.dzs.hr

[27]. Atalić, J. – Šavor Novak, M. – Uroš, M. (2018): Updated risk assessment of natural disasters in Republic of Croatia – seismic risk assessment (in Croatian), Faculty of Civil Engineering in collaboration with Ministry of Construction and Physical Planning and National Protection and Rescue Directorate, 2018.

[28]. Atalić, J. – Krolo, J. – Damjanović, D. – Uroš, M. – Sigmund, Z. – Šavor Novak, M., Hak, S. – Korlaet, L. – Košćak, J. – Duvnjak, I. – Bartolac, M. – Serdar, M. – Dokoza, I. – Prekupec, F. – Oreb, J. – Mušterić, B. (2013): Study on earthquake risk reduction in the City of Zagreb, Phase 1–6 (in Croatian), Faculty of Civil Engineering, Department of Engineering Mechanics, 2013-2018.

[29]. Varga, P. – Grafarend, E. (2019): Influence of Tidal Forces on the Triggering of Seismic Events In: Geodynamics and Earth Tides Editor; Rossi, Giuliana; Braitenberg, Carla Geodynamics and Earth Tides Observations from Global to Micro Scale Springer International Publishing pp. 55-63.

[30]. Bondár, I. –Galsa, A. – Gráczer, Z. –Gribovszki, K. – Győri, E. – Kiss, J. – Kiszely, M. –Lenkey, L. – Süle, B. – Szanyi, Gy. (2018): Hungarian national report on IASPEI (2015-2018) Geomatikai Közlemények / Publications In Geomatics. Vol. 21., pp. 127-143.

[31]. Ambrusz J. (2019): Katasztrófák következményeinek felszámolása, valamint a helyreállítás, újjáépítés vezetés-irányítási, műszaki feladatainak lehetséges megoldásai. Doktori (PhD) értekezés. Nemzeti Közszolgálati Egyetem, Katonai Műszaki Doktori Iskola, Budapest, 171 p.

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