CROATIA

Management of Earthquake Risk

TAFF Technical Assistance Financing Facility for Disaster Prevention and Preparedness

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ACRYONYMS

AAL	Average Annual Loss
BBB	Build Back Better
BCP	Business Continuity Planning
CPD	Civil Protection Directorate
DG ECHO	Directorate-General for European Civil Protection and Humanitarian Aid Operations
DPPI SEE	Disaster Preparedness and Prevention Initiative for South-Eastern Europe
DRF	Disaster Risk Financing
DRM	Disaster Risk Management
DVD	Voluntary Fire Brigades (Dobrovoljno Vatrogasno Društvo)
EE	Energy Efficiency
EEW	Earthquake Early Warning
EU	European Union
EUSF	EU Solidarity Fund
EWS	early warning system(s)
GDP	Gross Domestic Product
GEM	Global Earthquake Model
GFDRR	Global Facility for Disaster Reduction and Recovery
GoC	Government of the Republic of Croatia
HCK	Croatian Red Cross (Hrvatski Crveni Križ)
HCPI	Croatian Center for Earthquake Engineering
HCPI-IS	HCPI-Intervention Service
HGSS	Croatian Mountain Rescue Service (Hrvatska Gorska Služba Spašavanja)
HVZ	Croatian Firefighting Association (Hrvatska Vatrogasna Zajednica)
LTRS	Long-Term Strategy for National Building Stock Renovation
MMI	modified mercalli intensity
MoC	Ministry of Culture and Media (Ministarstvo Kulture i Medija)
MoI	Ministry of the Interior (Ministarstvo unutarnjih poslova)
MoPPCSA	Ministry of Physical Planning, Construction, and State Assets (Ministarstvo prostornoga uređenja, graditeljstva i državne imovine)
NDRMS	National Disaster Risk Management Strategy
NECP	National Energy and Climate Plan
NGO	Nongovernmental Organization
NRA	National Risk Assessment
NRRP	National Recovery and Resilience Plan
PMF	Faculty of Science at the University of Zagreb (Prirodoslovno-matematički fakultet)
PPP	Public-Private Partnership
PwDs	People with Disabilities
R2R	Ready2Respond
RVS	Rapid Visual Screening
SMEs	Small and Medium Enterprises
UCPM	Union Civil Protection Mechanism

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Disclaimer

KEY TERMS

Earthquake risk is understood as the combination of seismic hazard (e.g., the frequency of earthquake occurrence, the strength of ground shaking given an earthquake), exposure (e.g., the number of people exposed, the value of assets exposed), and vulnerability (e.g., the susceptibility of assets to damage, the ability of populations to cope with earthquake effects).

Hazard: A potentially destructive physical phenomenon, such as a natural hazard (e.g., earthquake, wildfire).

Exposure: The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas.

Vulnerability: The conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards.

Earthquake magnitude is a quantitative measure of the size or energy released by an earthquake at its source. It is determined using seismic data and reflects the amplitude of seismic waves recorded by seismographs. The most common magnitude used today is the moment magnitude scale (Mw), which largely replaced older scales such as the Richter scale. Unlike intensity, which measures the observed effects of an earthquake at specific locations, magnitude provides a standardized measure of an earthquake's overall strength, regardless of where it is measured.

Earthquake shaking intensity measures the strength of ground shaking at a specific location and its effects, such as damage or human perception. Intensity varies with distance from the epicenter and local site conditions. In Europe, a commonly used intensity scale is the European Macroseismic Scale (EMS-98), which ranges from I (not felt) to XII (completely devastating) and is based on observed effects on people, buildings, and infrastructure. Another widely used intensity scale is the Modified Mercalli Intensity (MMI) scale, which is used in the United States and other regions. Quantitative measures like Peak Ground Acceleration and similar parameters are also used in engineering design and seismic assessment and are based on ground motion recorded by instruments.

Secondary perils: Also known as earthquake-triggered perils, are hazards that are triggered by the primary earthquake event. These include landslides, soil liquefaction, tsunamis, and fire following, which can significantly increase the overall damage, losses, and disruption.

Earthquake risk assessment: A process that combines hazard, exposure, and vulnerability information to assess expected infrastructure and human losses after an earthquake. Typically, this involves probabilistic calculations considering a range of hypothetical earthquake scenarios.

Microzonation: Microzonation studies involve geological and geotechnical surveys and analysis, which are used to create detailed maps of seismic hazards in an area. This information can be incorporated into building codes, inform territory and land use management, and guide post-earthquake reconstruction.

Building code: A set of ordinances or regulations and associated standards intended to regulate aspects of the design, construction, materials, alteration, and occupancy of structures necessary to ensure human safety and welfare, including resistance to collapse and damage.

Early warning systems (EWS) are integrated systems that disseminate timely and meaningful information to users threatened by a hazard. These systems can enable protective actions to reduce harm posed by the hazard. Some examples of EWS include sirens, text messages/SMS, and TV or radio broadcasts. Additionally, different hazard types may require different technical capabilities and infrastructure. For earthquakes, EWS typically provide post-event information such as earthquake details and impact estimations, public advisories, and aftershock potential. EWS can also include earthquake early warning (EEW) which are alerts that give imminent notice before shaking begins, but these are not widely implemented.

Earthquake early warning (EEW) involves detecting initial ground shaking and rapidly notifying end users before imminent, stronger ground shaking. The lead time between notification and stronger ground shaking varies by location, depending on factors such as the density of seismic stations in the area, the distance from the epicenter, and the data telemetry/EEW algorithm performance. While EEW can be a part of the EWS, they are highly specialized and location specific and are not widely available.

Coping capacity: The ability of people, organizations, and systems, using available skills and resources, to manage adverse conditions, risks, or disasters.[1]

[1] Mysiak, J., V. Casartelli, and S. Torresan. 2021. Link.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including ensuring the preservation, restoration, or improvement of its essential basic structures and functions.[2]

'Build back better' (BBB) principle: The use of the recovery, rehabilitation, and reconstruction phases after a disaster to increase the resilience of nations and communities by integrating disaster risk reduction measures into the restoration of physical infrastructure and societal[3] systems and into the revitalization of livelihoods, economies, and the environment.

Damage: Total or partial destruction of physical assets existing in the affected area. Damage occurs during and after the disasters and is measured in physical units (that is, square meters of housing, kilometers of roads, and so on).[4]

Losses refer to indirectly quantifiable losses (declines in output or revenue, impact on wellbeing, disruptions to flow of goods and services in an economy), or additional operational costs associated with response and initial repairs.[5]

Reconstruction: The medium- and long-term rebuilding and sustainable restoration of resilient critical infrastructures, services, housing, facilities, and livelihoods required for the full functioning of a community or society affected by a disaster, aligning with the principles of sustainable development and BBB to avoid or reduce future disaster risk.

Rehabilitation: The restoration of basic services and facilities for the functioning of a community or society affected by a disaster.

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[2] World Bank and European Commission. 2021b. Link.
[3] The term 'societal' should not be interpreted as a political system of any country.
[4] World Bank. 2021.
[5] Global Facility for Disaster Reduction and Recovery (GFDRR), website. Link.

EXECUTIVE SUMMARY

Croatia faces significant earthquake risk due to its moderate to high seismic activity and its vulnerable, aging buildings and other infrastructure. Although earthquakes are comparatively rare in Croatia, they nonetheless pose considerable risk.[6] In 2020, amid the COVID-19 pandemic, the country experienced a series of earthquakes, some of the strongest since 1880:[7] earthquakes in March[8] (M5.5) and December[9] (M6.2) caused an estimated €16.1 billion in damage and economic losses, according to the Rapid Damage and Needs Assessments (RDNAs) carried out in their aftermath.[10] The reconstruction and recovery needs were extensive, with estimated costs of €25.9 billion (€17.5 billion for the March earthquake and €8.4 billion for the December earthquake).[11] These recent events highlight the urgent need to proactively manage earthquake risk.

This report summarizes the results of a rapid review of earthquake risk and risk management capacity in Croatia, highlighting potential risk management actions and investment opportunities to inform policy dialogue and future research. The review considers capacity across multiple dimensions, including governance, understanding of earthquake risk, risk reduction and mitigation, early warning and public awareness, preparedness and emergency response, recovery and post-disaster financing, and cross-cutting topics such as social resilience and the role of the private sector. For each of these dimensions, the report draws on available information to review the general context and current situation, including key challenges and opportunities for improvement relevant to Croatia.

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[6] The level of earthquake risk is considered "unacceptable," according to Government of the Republic of Croatia (GoC). 2019a. Link.

[7] Previous significant earthquakes beginning in 1880 include the following: 1880 Zagreb earthquake (local magnitude [ML] 6.2); 1909 Pokuplje earthquake (surface-wave magnitude [MS] 5.8); 1942 Imotski earthquake (ML 6.2); 1962 Makarska earthquake (M 6.1); 1963 Skopje earthquake (ML 6.1); 1969 Banja Luka earthquake (ML 6.4); 1979 Montenegrin coast earthquake ML7.0); and 1996 Ston earthquake (ML 6.0).

[8] This is the "March earthquake" referred to throughout the report; the M 5.5 event occurred on March 22, 2020, with an epicenter located seven km north of Zagreb.

[9] This is the "December earthquake" referred to throughout the report; the M 6.4 event occurred on December 29, 2020, with an epicenter 6 km outside Petrinja.

[10] The March 2020 earthquake (M 5.5) caused €10.7 billion of damage (GoC. 2020b. Link). The December 2020 earthquake (M 6.2) caused €4.1 billion of damage (GoC. 2021a. Link).

[11] GoC. 2020b. Link (March earthquake); GoC. 2021a. Link (December earthquake).

KEY MESSAGES

The following key messages emerge from the review of earthquake risks and risk management capacity in Croatia:

1. Earthquakes are one of the highest-priority risks in Croatia, with the potential to cause significant damage. A key driver of Croatia's earthquake risk is the stock of aged and poorly maintained buildings and infrastructure, much of which was constructed before modern seismic-resistant design provisions were developed and has not been subject to adequate verification for seismic compliance. Before 1964, when seismic provisions were first included in the building code, buildings were constructed with little or no consideration for seismic safety. About one-third of the existing building stock predates the 1964 building code, and new buildings that comply with modern codes represent only a small share (5–10 percent) of the building stock.

2. The legal framework for disaster risk management (DRM) incorporates multi-hazard elements, including seismic risk. Croatia currently does not have a specific seismic risk reduction strategy or roadmap. Institutional arrangements for earthquake risk management are spread across multiple agencies, with no single entity overseeing all phases of seismic risk management. The stock of aged buildings is large and includes critical entities and cultural heritage; thus under the current framework, a strategic approach to planning and implementing risk reduction investments is challenging. There are also some gaps in coordination among the different actors in preparedness and response, and their responsibilities should be clarified.

3. Croatia has several methodologies and processes for risk assessment in place; however, gaps remain in the use and accessibility of risk information. Authorities and academics have an advanced understanding of earthquake risks, including through the National Risk Assessments (NRAs), city-level seismic assessment for Zagreb, and a rapid portfolio analysis of emergency response–related assets.[12] This portfolio assessment shows that Croatia's emergency response buildings are located in areas of high seismic risk, and that many structures are old, vulnerable, and in need of comprehensive interventions to enhance safety, energy efficiency (EE), and functional upgrades. Currently, various authorities hold relevant data on buildings' seismic risk, such as construction materials, age, occupancy, and structural systems, but the data remain fragmented. Efforts are underway to mandate data sharing and clarify institutional roles in order to streamline access, enable rapid damage assessments, and support more strategic, risk-informed decisions. Risk information is not yet fully integrated into land use planning, and information about secondary perils (such as landslides due to earthquakes or aftershocks) may not be readily available.

[12] For information on the portfolio assessment of critical infrastructure, see Box 1.

4. Through the National Recovery and Resilience Plan (NRRP), Croatia invests both in earthquake-linked recovery efforts and EE upgrades. Following the 2020 earthquakes, Croatia introduced rehabilitation and reconstruction investments as part of its recovery programs covering public and private infrastructure. These investments focus on damaged infrastructure. Croatia is making substantial investments to enhance EE in buildings and is promoting integrated solutions through the NRRP. By combining seismic retrofitting with EE upgrades, these initiatives create co-benefits—that is, they make buildings more resilient to earthquakes and more environmentally sustainability, even if an earthquake does not occur for some time. These efforts are further supported by initiatives to enhance technical skills for green and seismically safe investments. Croatia has a Long-Term Renovation Strategy and a framework for integrated investments, which include both climate change mitigation and climate change adaptation initiatives and principles.

5. Public awareness of earthquake risk in Croatia has increased in recent years and has led the country to develop various strategies (e.g., a tourism strategy) that encourage disaster preparedness. The population's increased awareness of earthquakes stems partly from the severity of the 2020 earthquakes and partly from ongoing efforts of authorities, including the Civil Protection Directorate (CPD) of the Ministry of Interior (MoI). These efforts to raise awareness about risk reduction and self-preparedness can be expanded. While earthquake-specific training exercises exist, they are primarily focused on institutional response and do not include the broader public at this point.

6. Croatia has made significant progress in strengthening its disaster preparedness; it carries out comprehensive training and exercises for emergency personnel, such as the Earthquake 2024 exercise, to test readiness for large-scale disasters. In the response to the 2020 Zagreb and Petrinja earthquakes, both civil society and professional emergency services—including the Croatian Firefighters Association (HVZ), CPD, Voluntary Fire Brigades (DVDs), Croatian Red Cross (HCK), and Croatian Mountain Rescue Service (HGSS)—played a role and contributed significantly to relief efforts. Following the 2020 earthquakes, the Croatian Center for Earthquake Engineering (HCPI) was established as an association in an advisory role, and as a center of excellence and research on seismic resilience in Croatia. The HCPI-Intervention Service (IS) is working to ensure engineers are trained in post-earthquake damage assessment and are familiar with improved methods developed following the 2020 earthquakes. While the presence of both professional and volunteer forces is important in disaster response, challenges remain in improving coordination, training, and engagement across entities to enhance earthquake preparedness. Croatia currently does not have a legal requirement for a national earthquake disaster management plan; however, efforts to integrate and streamline existing strategies are needed.

7. Croatia is in the process of improving its damage and loss framework, though for post-disaster recovery Croatia has so far used event-specific measures rather than a pre-agreed post-disaster recovery framework. The experience following the 2020 earthquakes highlighted the reliance on ad hoc approaches for post-disaster recovery. While Croatia publishes an annual Programs of Measures, it has an opportunity to strengthen the strategic underpinnings of its post-earthquake recovery efforts. The CPD is in the process of reviewing the existing damage and loss framework and data collection process; the goal is to propose guidance and preconditions for a robust assessment and data collection system, overseen by responsible stakeholders and a coordinating body.

8. Given the potential macro-fiscal impact from earthquakes, Croatia could face limitations in meeting the financial demands of large-scale seismic events. Croatia has a general budget reserve amounting to 0.5 percent of planned budget revenue in any given year, which is set aside annually for various unforeseen purposes; it is not earmarked for disasters. Croatia can also use dedicated budget lines that may also be used for disaster response. Disaster risks are currently not included in Croatia's fiscal strategy, medium-term forecasts, or annual budgets; nor are disaster-related expenditures tracked. Insurance penetration is low in Croatia (e.g., only 25 percent of homeowners are insured, and only 16 percent are covered for earthquakes).[13] This leaves the financial burden associated with post-disaster recovery largely on individuals. Experience from the 2020 earthquakes shows reliance on international funds—including the European Union Solidarity Fund (EUSF), the NRRP, and other EU funds.

9. Croatia has made efforts to understand social vulnerabilities and proactively improve social resilience—for example, it now has a national Registry of Persons with Disabilities (PwDs); but supporting affected populations remains challenging. While social vulnerability is included in NRAs, the assessment methodology could be improved and made more comprehensive. Moreover, although financial aid programs are in place and efforts are being made to include PwDs, these actions are less than fully effective because of gaps in coordination and limited longer-term planning (that is, limited consideration of social protection in recovery strategies). Croatia should consider developing and implementing emergency adaptive social protection measures to address poverty and inequality exacerbated by disasters. Leveraging social vulnerability and disaster impact data would enable targeted resource allocation, and regular monitoring and evaluation would help ensure the effectiveness of these policies.

10. The private sector does not systematically implement business continuity planning (BCP). Thus businesses, especially small and medium enterprises (SMEs), can be affected by disruptions caused by earthqVuakes and other natural hazards. While few public-private partnerships (PPPs) are currently engaged in disaster or earthquake risk management in Croatia, the country has successfully implemented PPPs in sectors like education, transport, and municipal infrastructure.

[13] World Bank and European Commission. 2024a. Link; World Bank. 2025b. Link.

KEY RECOMMENDATIONS

Croatia should prioritize actions and investments to manage earthquake risk across various dimensions, as outlined in the recommendations below.

1. Review and consider strengthening the governance for earthquake risk management by continuing critical reforms, such as updating building codes to reflect seismic vulnerabilities. Current legislation could be enhanced by adopting a national seismic risk reduction strategy or an action (investment) plan that clarifies roles, streamlines and promotes coordination across stakeholders (public, private, academia, and so on), and thus enables a more systematic approach to risk reduction, preparedness, and recovery. Relevant building codes and regulations for buildings/infrastructure should provide clear requirements and guidance on integrated solutions that consider seismic risk alongside other risks (e.g., floods, fires, extreme heat) as well as functional upgrades, EE, and climate adaptation measures. To enhance capacity and facilitate implementation and enforcement processes, Croatia should foster collaboration among government, academia, engineers, and the private sector through training and upskilling; similar approaches have been applied in countries like Italy and Romania, focusing particularly on targeted risk reduction. Going forward, it will also be important to enhance the governance framework for data sharing and for assessing and mitigating the risk to infrastructure, particularly critical entities and cultural heritage.

2. Continue to conduct national seismic risk assessments, while also strengthening city-level risk assessments (such as those recently conducted for the City of Zagreb) and facilitating stakeholders' use of risk information. Improving seismic risk assessment models by considering more detailed exposure data, updated seismic hazard maps, microzonation studies, and secondary perils can contribute to more robust assessments, which in turn can support planning and implementation of prioritized risk reduction investments. Once the technical work is in place, the analysis should be extended to Croatia's major tourism hotspots, such as Dubrovnik, Split, and other coastal municipalities. The hospitality sector (e.g., hotel and resort operators) should be actively engaged so that the resulting risk information supports preparedness planning for assets that underpin a significant share of national economic activity. This step will require additional research into secondary hazards, interaction with other risks, and social vulnerability.

3. Promote and accelerate seismic retrofit programs targeting critical entities, housing, and cultural heritage to ensure that these programs simultaneously address continuity planning for water, energy, and communication services as integral components of response and recovery efforts. Aged buildings are the key driver of earthquake risk in Croatia and require targeted integrated investments that consider multiple hazards, functionality needs, and sustainability and climate adaptation principles. The housing sector alone accounted for 64 percent of the damage caused by the March 2020 earthquake.[14] Guidance should be provided to help national and local governments prioritize retrofits through cost-effective approaches that maximize various benefits; for example, before prioritization and the detailed assessment required for retrofitting or reconstruction, authorities could carry out an initial rapid screening that also considered how to integrate multiple benefits (that is, through EE programs, inclusive programs, and so on). Integrating seismic upgrades into planned energy upgrade initiatives can help ensure longer-term resilience and optimize investments by providing co-benefits. New incentives could be developed to increase the rehabilitation and reconstruction of private buildings as well as specific critical entities—such as emergency and response infrastructure, public administration buildings, hospitals, and sheltering infrastructure, including schools. The portfolio assessment of critical

[14] GoC. 2021a. Link.

infrastructure serves as a foundational tool that allows the government to evaluate vulnerabilities of critical buildings, such as 112 emergency response centers; however, this tool could be expanded to include more detailed information on water supply systems and other essential infrastructure elements to ensure service continuity during response and recovery efforts.

4. As part of a more strategic approach to seismic risk reduction, consider adopting rapid visual screening (RVS); more specifically, consider leveraging the registry of engineers under the HCPI for pre- and post-earthquake RVS to prioritize buildings in need of intervention. Leveraging the registry of engineers for pre- and post-earthquake RVS could allow (i) exposure data collection and consequently seismic risk assessments and prioritization for retrofitting or reconstruction, and (ii) a quick response for the damage and usability assessment of buildings after an earthquake. This information could feed into an integrated seismic risk management database. Such an approach could potentially be linked to discussions held in 2023 on seismic certification of buildings, but also to governance reforms envisioned by the Ministry of Physical Planning, Construction, and State Assets (MoPPCSA) for 2024–2028 (related to construction, physical planning, and EE). These reforms should be complemented by training and deployment for practical experience. Such information can also feed into regulations to discourage the occupancy of buildings with high earthquake risk that are deemed unsafe.

5. Continue to prioritize public awareness of and preparedness for earthquakes by providing clear guidance on protective actions before and during an earthquake and actively promoting community first-aid training. Various activities could focus on relevant target groups, including the general population, migrants, tourists, and vulnerable populations, using various communication and educational means. To enhance self-preparedness, people should be provided with basic information on immediate actions to take in the event of an earthquake; they should also have more detailed information on the existing early warning system (EWS) and on setting up relevant communication channels to receive emergency notifications.

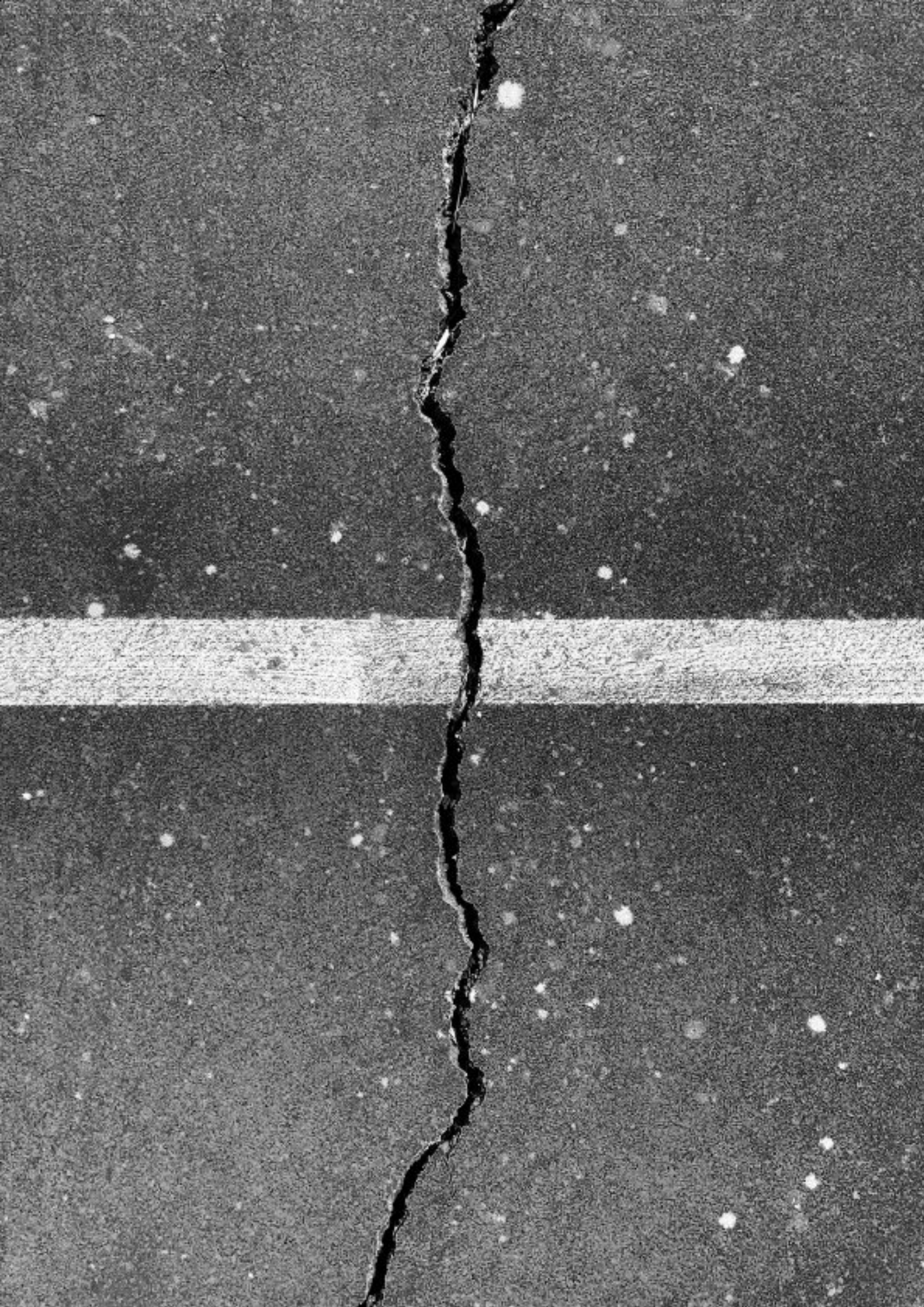
6. Continue to strengthen preparedness and response capacity by rebalancing government human resources in line with the geographic and sectoral distribution of seismic risk, by promoting better coordination among professional actors (such as HVZ), and by engaging volunteers (such as HCK and HGSS) as well as civil society and the private sector. Volunteers and civil society must be engaged in a structured manner to ensure their involvement is well-organized and safe, especially in the aftermath of a disaster. One lesson of the 2020 earthquakes is that clear guidelines and training for volunteers are essential to prevent uncoordinated or unsafe actions. Ongoing training for civil protection teams, emergency personnel, businesses, and community organizations will help maintain readiness for future seismic events. Designated evacuation routes and assembly sites should be widely publicized, and their structural resilience and accessibility should be routinely verified, along with the adequacy of pre-positioned supplies to ensure they are fully operational when needed.

7. **Create an overarching recovery framework and develop the corresponding capacities of key stakeholders.** The experience of the reconstruction following the 2020 earthquakes underscores the value of a systematic recovery model that relies on pre-agreed arrangements and modalities to speed up and simplify recovery efforts. For example, it would be helpful to arrange ahead of time which institution will coordinate damage and loss assessments, which institution will lead medium- to long-term recovery and reconstruction, and what decision-making and financing arrangements will be in place to execute those functions. In particular, Croatia could guide a more sequenced and coordinated recovery process by building on the RDNAs for Zagreb and Petrinja and devising a comprehensive reconstruction strategy, one supported by an action plan and a robust monitoring and evaluation framework. As part of the recovery framework, line ministries should prepare and routinely test business continuity plans, particularly for health, energy, communications, and other critical services, to guarantee functionality immediately after an earthquake. Although the current legal framework provides a basis for more integrated recovery and BBB, it could be further strengthened to promote coordinated and forward-looking actions that reduce exposure and vulnerability to future events. Finally, it is essential to build capacity across all levels—especially for local public administration—in order to improve data management systems; this step makes it possible to implement recovery programs, ranging from damage and loss assessment to investment planning and implementation. As part of this effort, protocols to safeguard cultural heritage in emergencies could also be developed.

8. **Consider adopting a comprehensive disaster risk financing (DRF) and insurance approach, drawing on analysis and considering multiple instruments.** Croatia should continue efforts to deepen the current understanding of potential macro-fiscal risk, and should review and (as relevant) update or develop new DRF and insurance arrangements and instruments, in line with updated legislation. The country should prioritize the promotion and uptake of market-based insurance solutions that reimburse actual damage costs, as these crowd in private capital, encourage accurate risk pricing, and reduce the fiscal burden on the government. This effort should be accompanied by relevant awareness activities to ensure different stakeholders understand the risks they face, the financial mechanisms available, and the residual risks.

9. **Enhance integration of emergency social protection with long-term recovery policies.** Croatia should use social vulnerability and disaster impact data to support targeted resource allocation and programs, promote resilient livelihoods recovery, and strengthen social resilience. Integrating social protection measures—such as shock-responsive scalable approaches—into long-term recovery frameworks could contribute to broader revitalization efforts.

10. **Strengthen BCP and engagement of the private sector in the recovery phase and explore PPPs.** To enhance the private sector's resilience and preparedness, businesses should increase awareness of and capacity for BCP and risk reduction. Exploring possible framework agreements, streamlining arrangements, and strengthening pre-event coordination on recovery planning could facilitate the engagement and contribution of the private sector in recovery and reconstruction processes. Finally, existing models from other sectors or countries could offer lessons for expanding PPPs, potentially involving critical entities, and for exploring targeted incentives.



INTRODUCTION

This report is part of a series aimed at improving the understanding of policy and investment needs and priorities for disaster risk reduction, focusing on two disasters: wildfires and earthquakes. The broader objective is to provide actionable insights and recommendations that can guide the EU and its Member States in making informed, strategic investments to enhance resilience against wildfires and earthquakes.

This report examines earthquake risk in Croatia, providing an overview of risk trends, risk management capacity, investment needs, **and recommended approaches to building seismic resilience.** It is complemented by two other country-specific case studies for Cyprus and Romania as well as an EU-wide policy note on earthquake risk management overview based on existing information and data gathered across EU Member States.[15]

This note provides a high-level rapid overview based on existing information and data. In addition, consultations with national and EU organizations as well as researchers have been conducted to improve understanding of key areas listed above. The note can serve to inform policy dialogue and future research by highlighting key challenges and opportunities for strengthening earthquake resilience in Croatia.

The analysis is structured following the Union Civil Protection Mechanism (UCPM) Peer Review Assessment Framework.[16] The approach considers the following disaster risk management (DRM) elements, with a targeted focus on earthquake risk:

[15] Overseas Countries and Territories are not considered.

[16] Mysiak, Casartelli, Torresan. 2021.

1. **Governance of risk management** examines legal and institutional frameworks, coordination mechanisms, financing strategies, and systemic disaster resilience at the national and subnational levels.

2. **Understanding risk** examines the identification, analysis, evaluation, communication, and capacities associated with assessing disaster risks.

3. **Risk prevention, risk reduction, and mitigation** reviews the regulatory framework for prevention, development and enforcement of building codes, integration of hazard considerations into land planning, retrofitting efforts, and administrative capacities related to disaster risk prevention.

4. **Preparedness, early warning, and awareness** covers preparedness activities, awareness campaigns, EWSs, training and exercises, and the overall development of response capacities in both the population and emergency personnel.

5. **Readiness and response** focus on emergency response planning, operational response measures, capacity building for response, and the framework for actions in the immediate aftermath of an event.

6. **Recovery, reconstruction, and post-disaster financing** covers the processes and actions taken after a disaster event, including damage assessment, restoration efforts, and recovery planning.

7. **Cross-cutting topics:** social resilience and inclusion explores ways to address the disproportionate impact of disasters on vulnerable populations, with special focus on people with disabilities. Meanwhile, private sector covers relevant stakeholders' involvement in the context of earthquake risk management, including building owners and property managers, insurance companies, business owners, utility providers, construction and engineering firms, but also civil society organizations and so on.

EARTHQUAKE RISK PROFILE AND RISK TRENDS

This chapter provides a short overview of risk trends for earthquakes in Croatia. It draws on available data and information and focuses on the tectonic regime and hazard, drivers of risk, and exposure across sectors while also shedding light on locations with high concentrations of risk.

EARTHQUAKE HAZARD AND SECONDARY PERILS

Croatia is in a region of moderate to high seismic hazard. It is situated in a seismically and tectonically active region of the Mediterranean, influenced by the convergent movement of the African plate toward the Eurasian plate, with the Adria microplate positioned between them (see Figure 1).[17] The 2024 NRA and 2022 DRM Strategy further identify earthquakes as one of Croatia's greatest risks, with potentially catastrophic consequences, and classify them as a high-priority, unacceptable risk.

According to the 2024 NRA, the drivers of risk for earthquakes include a combination of physical, social, economic, and institutional factors. Social drivers include demographic trends, such as aging populations and communities with lower income levels, which reduce overall resilience and the capacity for recovery following a seismic event.[18] In high earthquake risk areas, levels of social vulnerability vary: Sisak-Moslavina and counties around Zagreb are rated high, while Zagreb County is classified as very low. Southern regions exposed to seismic risk generally show lower social vulnerability, except for Šibenik-Knin, which is rated very high; though these figures reflect broader social conditions rather than hazard-specific vulnerability. Institutionally, the NRA indicates that capacity in the southern earthquake-prone regions ranges from moderate to very low, while the areas around Zagreb and Sisak-Moslavina County are assessed as having very low institutional capacity to anticipate, respond to, and recover from disasters.[19]

Croatia lies in a seismically active region, with urban areas such as Zagreb and Petrinja particularly vulnerable due to a high concentration of older, unreinforced masonry buildings. Almost one-third of the housing stock was built before the adoption of any regulations that take earthquake action into account. About half was built between 1964, when the first building code with seismic provisions was introduced, and 2013, during which time the values for horizontal seismic forces considered in design were often lower than current Eurocode 8 (EC8) seismic standards. Until then, buildings were constructed with limited consideration for seismic safety. New buildings (that is, those in compliance with modern building codes) represent a small percentage of the building stock in Croatia (estimated between 5 and 10 percent).[20]

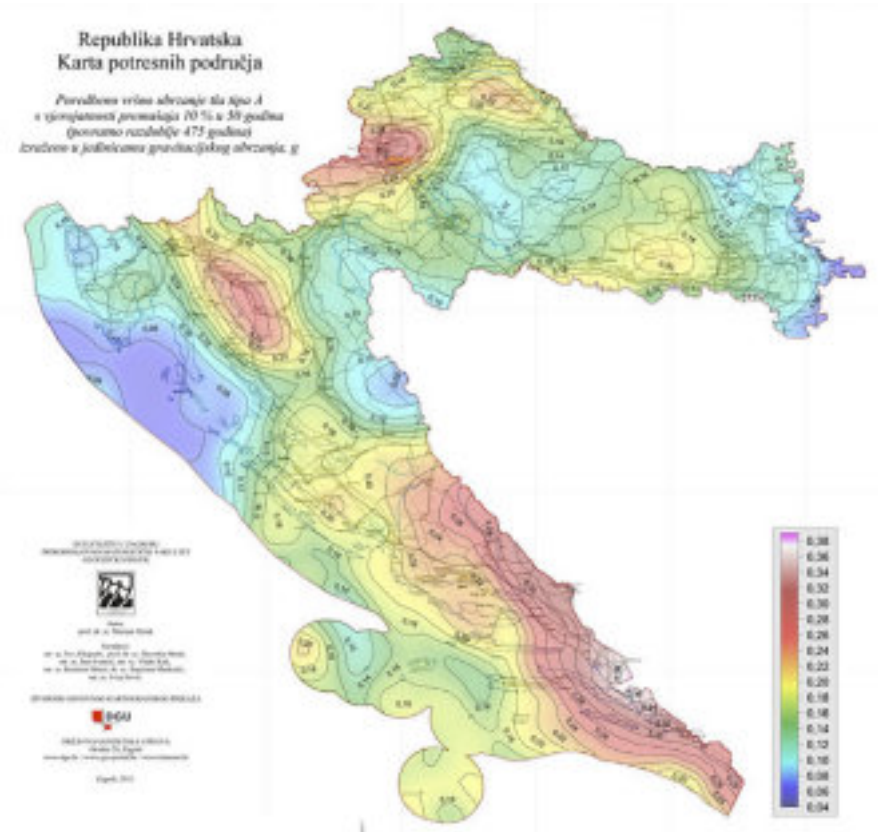
[17] Dasović, I., et al. 2020.

[18] Per the 2024 National Risk Assessment, social vulnerability considers economic and demographic factors such as age, income inequality, disability, household size, and literacy, affecting community's overall resilience and recovery capacity.

[19] The 2024 NRA measures institutional capacity considering risk scenarios, completed local risk assessments, civil protection plans, and the number of emergency personnel per capita. These indicators reflect each region's resilience to disasters.

[20] World Bank and European Commission. 2024d.

Figure 1. Seismic hazard map of Croatia - Peak ground acceleration (PGA) of type soil A for return period (RP) of 475 years (a probability of exceedance of 10 percent in 50 years) in units ag (gravity acceleration)



Source: Herak et al. 2011. *Note:* The hazard map created by Department of Geophysics, Faculty of Science, provides official information on seismic hazard in Croatia; however, it does not include microzonation, which is necessary for detailed seismic hazard assessment.

Another risk driver is that many buildings have not undergone the necessary verification process to ensure they are constructed in accordance with relevant regulations.[21] Many structures were legalized under the Law on the Treatment of Illegally Constructed Buildings,[22] yet their structural stability and earthquake resistance remain unknown. This means that the construction may be inadequate and result in vulnerable buildings that could pose a danger when the next earthquake hits. While rehabilitation/reconstruction is ongoing for recently damaged buildings, a large volume of aged public and private building stock continues to remain vulnerable to the impacts of earthquakes and potentially other hazards as well. Investments in energy-efficient retrofitting, particularly prior to 2021, are increasing but often lack comprehensive consideration of earthquake resilience, fire safety, and other climate-related impacts like heat resilience, flood-proofing, and wildfire.

Several important (and dense) urban areas are at particular risk. About 30 percent of the country, an area that is home to about 60 percent of the population[23] and produces a large percentage of the country's Gross Domestic Product (GDP), is exposed to earthquakes. Over half the residents in Zagreb City and Rijeka City (52 percent and 54 percent, respectively) live in seismically vulnerable multifamily housing built before the year 2000.[24] Unreinforced masonry and reinforced concrete frame buildings pose the highest earthquake risk and are expected to cause the most fatalities in both Zagreb and Rijeka. In Zagreb, which is home to approximately 20 percent of Croatia's population, over two-thirds of residents live in buildings with high earthquake vulnerability. In Rijeka, which is home to approximately 3 percent of the population, one-third of residents live in buildings with high earthquake vulnerability. Another challenge in these dense urban areas is some buildings that come under special cultural protection and require special analysis. Therefore, the poor state of the buildings and the fact that the most densely populated areas are in moderate to high seismic regions make the populations in Zagreb, Split, Dubrovnik, and Rijeka highly exposed to strong earthquakes that could have catastrophic consequences. Additionally, in recent years there has been an increase in urban sprawl, especially in Zagreb, which has exacerbated the density of the population, and, consequently, its exposure to multihazard risks.

In addition, earthquakes result in ground shaking and may also trigger secondary perils such as landslides and liquefaction. These secondary perils often exacerbate damage and loss. In Croatia, the largest area where landslides can occur is in Sisak-Moslavina County, which is 1,804 km^2. However, considering the relative share of areas where landslides are possible in relation to the area of the county, the largest share is in Krapina-Zagorje County, where 67.9 percent of the area is susceptible to landslides. After the December earthquake, several geological processes, including liquefaction, affected the natural environment and land stability of the area. In the area hit by the earthquake, over 100 cover-collapse sinkholes were recorded by authorities. Surface ruptures and landslides also occurred in the epicentral area and throughout the five affected counties.[25] Widespread occurrences of liquefaction were also recorded, with significant damage to structures.

Critical infrastructure in Croatia is exposed to varying levels of seismic risk, including fire stations, police stations, schools (which also serve as emergency shelters), hospitals, roads, and power lines; damage to such infrastructure not only disrupts essential services but also increases the overall risk to the population. According to the 2019 and 2024 NRA, and the 2022 DRM Strategy, critical infrastructures[26] in sectors such as energy, transport, food, public services, and national and cultural heritage are among the most affected.[27] An EU-wide exposure analysis (Figure 2), based on open-source data, shows that Croatia's emergency response infrastructure faces significant exposure

[21] This challenge was recognized in the 'Croatian Disaster Risk Management Strategy until 2030', with the objective to tackle it.

[22] GoC 2019d, Link.

[23] GoC 2013, Link; See also GoC 2019b.

[24] World Bank 2020a, Link. *See also* GoC 2019a, Link.

[25] GoC 2021a.

to seismic hazards,[28] defined as strong ground shaking (MMI ≥ VI) with a 10 percent chance of occurrence in a 50-year period. More than 90 percent of assets are exposed to high seismic risk. Health care facilities are the most vulnerable, with 93 percent (156 buildings) at risk. Similarly, 91 percent of education facilities (414 buildings) and 89 percent of both fire stations (418 buildings) and police stations (212 buildings) are exposed to these hazards. Furthermore, over 2,600 km of roads and 8,000 km of power lines are in areas prone to strong seismic shaking, with 91 and 93 percent, respectively, of these infrastructures at risk. These findings reflect the situation following the 2020 earthquakes, which caused substantial damage to health and education infrastructure, though the analysis does not account for the seismic resilience of individual buildings. Box 1 illustrates how a rapid portfolio assessment can be applied to assess portfolio and investment needs of critical emergency-related infrastructure, supporting more targeted and risk-informed decision-making.

[26] European Union 2022, Link.

[27] GoC 2019d.

[28] Under the exposure assessment, an EU-wide probabilistic seismic hazard map was used from the European Seismic Hazard Model 2020 (ESHM20), providing PGA for each cell, with a probability of ten percent in 50 years (a 1-in-475-year return period), which is used as standard in seismic engineering and hazard analysis. The PGA values were aggregated to seismic intensity values using the corresponding PGA ranges defined by the United States Geological Survey (USGS), to assign each cell a value on the MMI scale.1 This analysis defines high hazard as having a value of MMI VI or above. MMI VI is classified as strong shaking causing light damage and corresponds to PGA of 11.5 percent.

Figure 2. Example map of exposure of assets to seismic hazard

Source: World Bank, as part of EU-wide exposure analysis under World Bank and European Commission. 2024d. *Note:* the analysis uses open-source data, hazard information, and location of assets. It does not include information about the condition of the structures or other information necessary for a full risk assessment.

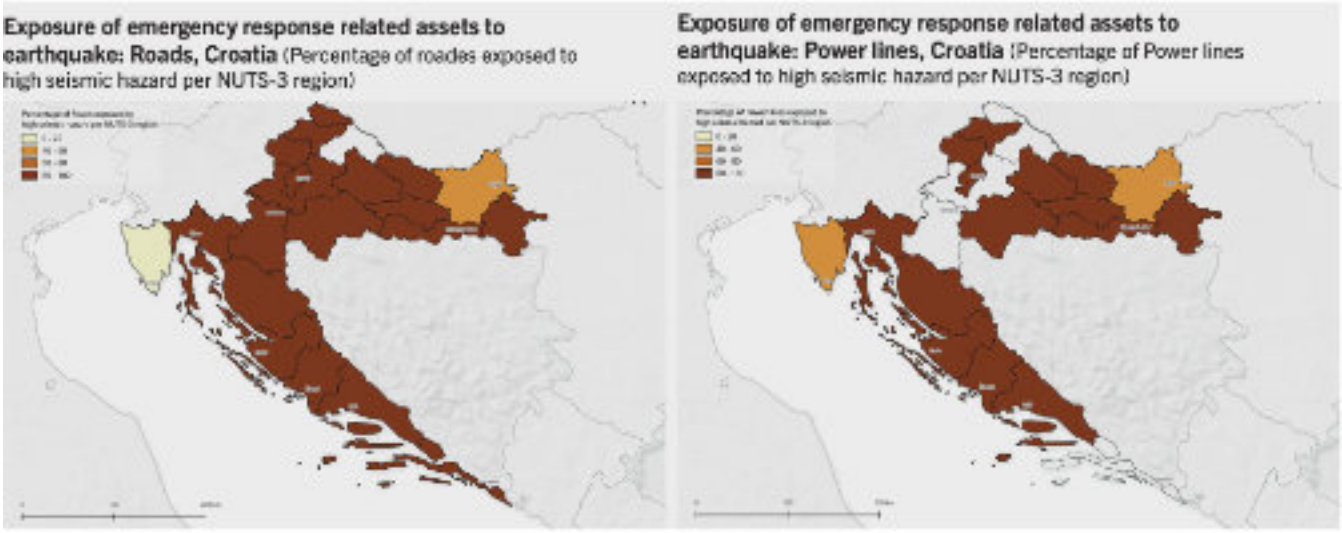


Table 1. Severe earthquakes in Croatia from the seventeenth century to 2019

*Source:*Based on Dasović, I., Herak, M., Prevolnik, S. 2021. About earthquakes and seismology – in general, in M. Uroš, M., Todorić, M., Crnogorac, M., Atalić, J.,M. Šavor Novak, M. i Lakušić, S. (Eds.) Earthquake Engineering – Retrofitting of Masonry Buildings. Zagreb: University of Zagreb Faculty of Civil Engineering.

IMPACTS FROM PAST EARTHQUAKES

Croatia has a history of severe earthquakes. Historically, notable earthquakes include the tragic 1667 Dubrovnik earthquake (estimated M7) and the 1962 Makarska earthquake (M6.1), as shown in Table 1.[29] The most recent major events occurred in 2020, with powerful earthquakes striking Zagreb in March 2020 (M5.5)[30] and Sisak-Moslavina County, Petrinja city, in December 2020 (M6.2),[31] as shown in Table 2.

Historical and instrumental earthquake data for Croatia are compiled in the Croatian Earthquake Catalogue (CEC), maintained by the Department of Geophysics in Zagreb, with records dating back to 373 BC. Figure 3 shows the epicenters of about 60,000 earthquakes in Croatia, of which about 45 are felt on average each year. As shown in the seismic hazard data, the areas around Zagreb, including Sisak-Moslavina County, and the southern coast from Split to Dubrovnik are among the most seismically active in the country.

The series of earthquakes in 2020 highlighted the vulnerability of Croatia's public and private infrastructure, including critical entities such as hospitals and administrative buildings, to earthquakes (Table 2, see further Box 5). In the March 2020 earthquake, most of the infrastructural damage was sustained by the housing sector (64 percent), followed by the culture and cultural heritage sector, which includes historical government buildings (13 percent), education (10 percent), health (8 percent), and business (5 percent). Overall, 78 percent of the damage and losses were in the private sector and 22 percent in the public sector. In the public sector, the damage and losses were mainly in the education sector (513 damaged and destroyed buildings) and health sector (214 damaged buildings), whereas in the private sector, most of the damaged buildings were private houses.[32]

Similarly, the December earthquake caused extensive damage to approximately 43,000 buildings, including over 34,500 in the housing sector (8.2 million m² damaged or destroyed). Cultural heritage also suffered significantly, affecting 510 cultural buildings (199,406 m² damaged or destroyed), including 143 individual immovable properties, 103 of which were deemed temporarily or permanently unusable. In the health sector, 63 primary care facilities were damaged or destroyed, including five classified as temporarily or permanently unusable. Of 274 health buildings in the affected counties, 58 had nonstructural damage, 4 were assessed as temporarily unusable, and 1 was deemed structurally unsafe. The education sector was similarly affected, with 271 buildings affected (430,650 m² damaged or destroyed). The impact on society was equally felt since many pupils had to be relocated to other educational facilities, and many medical procedures had to be postponed due to the damage and losses in the health care sector.

[29] Historical events include the 1667 Dubrovnik earthquake, which caused 5,000 casualties (around one-third of the city's population), and the 1880 Great Zagreb earthquake, which affected almost every building in Zagreb and destroyed 13.

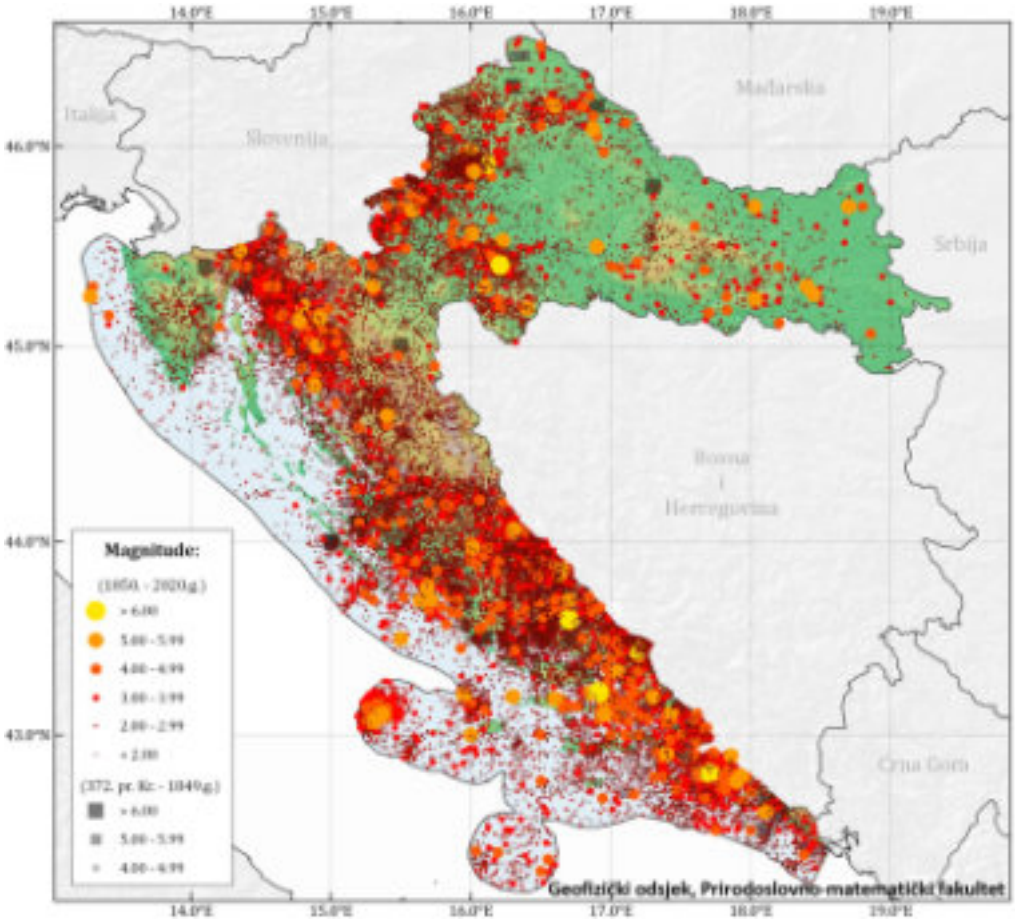
[30] For more information about the Zagreb earthquake, see University of Zagreb 2020, Link. See also Markušić et al. 2020, Link.

[31] University of Zagreb 2020.

[32] GoC 2021a.

Figure 3. Map of epicenters of earthquakes in Croatia

Source: Archives of the Department of Geophysics, Faculty of Science, University of Zagreb. Link. *Note*: Map of earthquake epicenters in Croatia from B.C. to 2020. Each color represents the earthquakes' magnitudes. The yellow dots represent the earthquakes with the highest magnitude (>6.00).



EXPECTED FUTURE IMPACTS

While individual estimates vary across studies, all existing hazard and risk assessments consistently identify earthquakes as one of the greatest risks facing Croatia, with the potential to cause catastrophic consequences. According to the available data, there is a 10 percent chance of a potentially damaging earthquake shaking Croatia in the next 50 years.[33] A major future earthquake could pose an unacceptable level of risk to the country. Such an event could devastate portions of the building stock and workplaces. For example, the City of Zagreb Seismic Risk Assessment revealed that the total economic loss due to the worst-case probabilistic hazard scenario with a return period of 475 years was estimated at approximately €15.5 billion.[34]

While there are various modelled results available, in general, Croatia faces potential high impacts. Croatia is the sixth most earthquake-affected country in the EU (Table 3).[35] Modeling predicts that earthquakes have a 0.2 percent change in any given year to direct losses to residential, commercial, industrial, health care, and education buildings exceeding €6 billion (9.2 percent of GDP); floods have a 1 percent chance in any given year to trigger losses of over €1 billion (1.5 percent GDP). [36]

Increasing urban exposure, aging population and infrastructure, and socioeconomic factors could heighten the human and economic impact of future events. Also, while earthquakes are independent of climate change, climate-induced hazards can amplify earthquake risks; for example, landslides and soil erosion following earthquakes can be worsened by increased heavy rainfall.

[33] ThinkHazard 2020, Link.
[34] Novak, M.S., J. Atalic, M. Uroš, and M. Demsic. 2020.
[35] WB and EC 2021a, Link.
[36] World Bank 2020a.

Table 2. Impacts of the March and December 2020 earthquakes

Source: GoC, 2020b Link.; GoC, 2021a Link.; Croatia Civil Protection System Link. *Note:* additional information on results is discussed in the earthquake recovery, reconstruction, and post-disaster financing section.

	Consequences	Impact	Challenges
March earthquake *Zagreb, 2020*	Injured: 26 Fatalities: 1 Displaced: 30,000 Buildings affected: 26,000	• Damage and losses: €11,301 billion • Impact on access to public services, especially education and health care • Increase in poverty: loss of assets and capital	• The earthquake occurred during the COVID-19, making it more difficult to react and respond efficiently • The earthquake revealed gaps in the country's preparedness for responding to an event of this magnitude • Old and fragile buildings
December earthquake *Petrinja, 2020*	• Injured: 28 • Fatalities: 7 • Displaced: 15,000 • Buildings damaged: 43,000	• Damage and losses: €4.8 billion • Impact on housing, health care, education, transport, and businesses • Affected the access of people to drinking water and, to a lesser extent, electricity • The agriculture sector was significantly affected due to liquefactions, sinkholes, landslides, and damage to the farming infrastructure	• Effects of the March earthquake (Zagreb) • COVID-19 pandemic affected tourism and businesses in the area • Existing socioeconomic challenges and lagging of economic growth in the area

Table 3. Top 10 countries for modelled seismic risk, by AAL as a percentage of exposure

Source: World Bank and European Commission 2021. *Financial Risk and Opportunities to Build Resilience in Europe*.

Rank	Country	AAL ratio
1	**Cyprus**	**0.19%**
2	**Greece**	**0.18%**
3	**Romania**	**0.12%**
4	**Italy**	**0.11%**
5	**Bulgaria**	**0.07%**
6	**Croatia**	**0.05%**
7	**Slovenia**	**0.04%**
8	**Austria**	**0.02%**
9	**Portugal**	**0.02%**
10	**Slovakia**	**0.01%**

EARTHQUAKE RISK MANAGEMENT CAPACITY

The following chapters provide an overview of key gaps and vulnerabilities in existing risk management practice relevant to Croatia, along with examples of successful strategies, investments, and approaches. It draws on publicly available information (such as national risk assessments, government reports, and studies) as well as information gathered during consultations.

GOVERNANCE OF EARTHQUAKE RISK MANAGEMENT

This chapter focuses on disaster risk governance, which generally includes the legislative, institutional, strategic, and planning framework. The framework describes mandates, roles and responsibilities, and coordination arrangements among the different stakeholders and their policies, instruments, and investments.

GENERAL CONTEXT

Over the past decades, Croatia's DRM system has evolved to align with the global Sendai Framework for Disaster Risk Reduction (SFDR) 2015–2030, emphasizing prevention and preparedness.[37] The core of this system is the Act on the Civil Protection System, involving policy makers at national, regional, and local levels.[38] The Croatian Platform for Disaster Risk Reduction, established in 2009, fosters knowledge transfer and solutions among various stakeholders.[39] The National Disaster Risk Management Strategy (NDRMS) until 2030, adopted in 2023, addresses unacceptable and tolerated risks, supporting international agreements like the SFDRR 2015–2030 and the Paris Agreement.[40] Croatia is addressing climate change impacts with updated legislation like the Act on Climate Change and the Protection of the Ozone Layer, and the Climate Change Adaptation Strategy.[41] Under the NRRP, €1,978 million is allocated for EE and post-earthquake reconstruction, in line with Croatia's Long-term Strategy for the Reconstruction of the National Building Stock by 2050 supporting long-term EU CO_2 reduction goals to decrease emissions from the building sector by 80–95 percent by 2050, as well as the draft updated Integrated National Energy and Climate Plan (NECP) for 2021–2030 (draft update submitted to the European Commission in June 2023) and with the Strategy for Energy Development until 2030 with a view to 2050 (approved in 2020).[42]

CURRENT ARRANGEMENTS

Institutional earthquake risk management framework

Earthquake risk in Croatia is managed under the broader DRM framework and is a multi-level effort involving national, regional, and local governments. Within this framework, the MoI, through the CPD, *inter alia,* is responsible for coordinating earthquake-related disaster risk reduction and response efforts, including preparing the NRA, mobilizing emergency services, organizing training and simulation exercises, and risk awareness, as well as the National Platform for Disaster Risk Reduction, where earthquakes are represented. The MoPPCSA, *inter alia,* is responsible for coordinating the reconstruction of buildings damaged by earthquakes and the monitoring and evaluation of reconstruction projects, including those related to earthquake recovery. Related to the NRA, pursuant to responsibilities of state bodies to prepare and submit a risk assessment within its scope of work, MoPPCSA coordinates the working group on earthquakes, which includes representatives from the CPD, faculties of civil engineering, the Seismological Survey of Croatia,[43] and the Geophysical Department, both under the Faculty of Science (PMF),[44] the Croatian Geological Institute, the Croatian Firefighting Association, the Croatian Centre for Earthquake Engineering (HCPI), and other relevant institutions.

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[37] Reforms in Croatia's DRM system reflect the legal requirements by the EU (such as the preparation of a national risk assessment [NRA]) and the opportunities for knowledge exchange and international cooperation facilitated by the UCPM. See Zvonko, Radujković, and Atalić 2022, Link. Croatia's DRM strategic documents are in line with the relevant national and EU regulations.

[38] The law stipulates the adoption of a National Disaster Risk Reduction Strategy, a Strategy for the Development of the Civil Protection System, and the State Civil Protection Action Plan, based on the National Risk Assessment. *See* GoC 2022a, Link.

[39] For more information on disaster risk governance in Croatia, see Croatian Conference on Croatian Engineering-Importance of National Platforms in Disaster Risk Governance by Holcinger and Šimac 2021, Link.

[40] The strategy was drafted in accordance with the Act on the System of Strategic Planning and Development Management of the Republic of Croatia (Official Gazette, 123/17). Link.

[41] GoC 2020, Link.

[42] EC 2023a, Link.

[43] Department of Geophysics, Faculty of Science, University of Zagreb, Link.

[44] PMF = Faculty of Science (Prirodoslovno-matematički fakultet) at the University of Zagreb.

The Ministry of Culture (MoC) supports cultural heritage preservation in the context of earthquakes and, since 2015, has strengthened efforts to safeguard cultural heritage from seismic risks. Following the March 2020 earthquake, the MoC, in collaboration with the CPD and joint fieldwork, assessed damage and implemented emergency stabilization measures. The MoC also established the Expert and Advisory Committee for Structural Renovation of Architectural Heritage in Earthquake-Stricken Areas, as well as the Risk Management and Implementation of Cultural Heritage Protection Programs within its Directorate for the Protection of Cultural Heritage, which, while currently focused on post-earthquake recovery, future plans include further strengthening DRM for cultural heritage.[45]

In Croatia, local and regional self-government units hold explicit legal responsibilities for DRM, including for earthquake risk, as outlined in the Civil Protection System Act. These units are tasked with organizing, financing, and maintaining the civil protection system within their jurisdictions. Their obligations encompass the development and regular updating of risk assessments for major disasters, including earthquakes, the adoption of civil protection action plans, the establishment and equipping of civil protection units, and the training of relevant personnel. Executive bodies must also ensure that operational civil protection forces are adequately prepared to respond to seismic risks, supported by a legally mandated process of planning, procurement, and resource management. Despite this broad legal mandate, local and regional authorities face practical challenges in fulfilling these duties without a clear and effective transfer of authority, technical guidance, resource and capacity support, and financial support from national institutions.

While responsibilities for seismic risk management are shared across multiple institutions, a key challenge is ensuring these roles are clearly defined and effectively integrated throughout the DRM cycle. By integrating the expertise of scientific and technical institutions, such as the HCPI, strategic planning, coordination, and the implementation of risk reduction measures can be improved, ensuring that each institution's strengths are fully leveraged. It will be important to ensure that dedicated expertise on seismic resilience is formally mandated within HCPI, with appropriate resources allocated to support this function on a full-time basis.

To further support skills development, Croatia developed the National Action Plan for Green Skills Development in 2021. This includes programs for the development of green infrastructure in urban areas, the development of circular space and building management, and energy renovation program for multi-apartment buildings, renovation of buildings that have cultural heritage status, and a program for combating energy poverty.[46] Further information is provided in the section on earthquake risk prevention, reduction, and mitigation.

[45] Concerning cultural heritage, see Link; Link. ICCROM. *"RIZIK: A Survey on Risk Management in Croatian Museums."* Link. Related to museums, see Radić Štivić, Nataša, Anamarija Batista, and Lucija Šarić. 2022. "RIZIK - A Risk Management Survey for Croatian Museums Geared towards the Better Assessment, Prevention and Reduction of Risk." Museum International. Link.

[46] GoC 2021d, Link.

Legal and strategic earthquake risk management framework

Croatia's seismic code regulations date back to 1948 with the introduction of the Provisional Technical Regulations for Building Loading, the first formal provisions addressing seismic safety. The seismic code evolved significantly after the 1963 Skopje earthquake, which prompted the adoption of the National Provisional Technical Regulations for Construction in Seismic Regions in 1964. This marked a shift toward stricter seismic resilience measures, such as the inclusion of reinforced concrete in construction, by the 1970s. Today, Croatia's seismic regulations continue to align with modern engineering standards, but recent earthquakes, such as those in 2020, have highlighted vulnerabilities in older buildings constructed before these measures were in place.

After 2020, awareness of earthquake risks increased among Croatian decision-makers, leading to the enactment of several new laws on post-earthquake reconstruction.[47] In September 2020, the Law on the Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, and Zagreb County was introduced. In January 2021, it was expanded to include areas affected by the December 2020 earthquakes: Sisak-Moslavina County and Karlovac County (Official Gazette 102/20, 10/21).[48] In February 2023, the current Act on Reconstruction of Earthquake-Damaged Buildings was amended, managed by the MoPPCSA (Official Gazette 21/23).

Additionally, the Program of Measures for the Reconstruction of Earthquake-Damaged Buildings was adopted to facilitate the act's implementation, establishing methods and procedures for the restoration or demolition of structures damaged in the 2020 earthquakes. Since the 2020 earthquakes, several iterations of the program have been adopted, four to date, which have guided annual planning of reconstruction activities.[49] Further regulations and ordinances were enacted by the authorities to oversee the reconstruction process. The mentioned law provides for the rehabilitation and upgrading of both public and private buildings and categorizes the renovation requirements of earthquake-affected buildings according to structural resistance and stability in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County. However, these laws are not harmonized, resulting in many missed opportunities to invest in seismic risk reduction, as each law serves a different purpose, making it harder to incentivize integrated efficient solutions to reduce seismic risk. Moreover, while the Program of Measures serves as a planning tool for annual actions, the absence of a comprehensive ex ante recovery strategy, including clear planning, coordination, and a monitoring and evaluation framework, remains a gap. Similarly, while there is no seismic risk reduction strategy, there are opportunities to increase seismic resilience, particularly in the prioritization of public building maintenance and renovation, as well as critical entities, as noted in the 2022 DRM Strategy, through the Long-Term Strategy for National Building Stock Renovation by 2050 (LTRS).

Although there is no specific seismic risk management strategy, seismic risk priorities are included in various documents, such as the NDRMS, the NRRP, and the NRAs. DRM in Croatia is governed by the DRM Strategy, which outlines key priorities for future action, alongside other relevant laws and legislation, summarized in Table 4. Several projects related to earthquake risk are proposed, including the development of a national platform for the HCPI.

The establishment of the HCPI was realized in 2021 after the 2020 earthquakes, as part of the University of Zagreb's Faculty of Civil Engineering. The HCPI supports authorities in disaster preparedness, reduces seismic vulnerability, and enhances response capacity. It provides expert technical assistance for disaster response and risk mitigation activities. The Croatian Center for Earthquake Engineering – Intervention Service (HCPI-IS) association was formed with the aim of integrating engineering knowledge into systems by bringing together all available capacities from faculties, chambers, institutes, polytechnics and other associations (a total of 20 institutions) and a number of prominent experts.

The HCPI is a voluntary, humanitarian and non-profit organization that performs emergency and professional engineering activities within the state system (primarily civil protection). Over time,

[47] More information about the new laws on post-earthquake reconstruction can be found in Annex 3.

[48] GoC 2021b, Link; See the reconstruction section for more details.

[49] *See* GoC. n.d. Area for the reconstruction of buildings damaged by the earthquake [*Područje obnove zgrada oštećenih potresom*]. Link.

the HCPI is expected to expand its role, aligning with the civil protection system's needs, and become a center of excellence in seismic risk reduction. During the response phase, HCPI's Intervention Service (HCPI-IS) conducts field inspections of damage and usability of buildings (based on AEDES methodology whereas this assessment is then used for damage estimates as part of RDNA process),[50] supervises disaster response facilities, and collaborates with the Civil Protection Headquarters. It also provides its data and platforms to relevant institutions for risk management and mitigation activities.

Beyond operational tasks, HCPI-IS works to raise public awareness of earthquakes and other risks, connecting experts in earthquake engineering to enhance the profession through unified methodologies, knowledge sharing, and digitalization. The benefits of integrating expertise are already evident in new developments, where the government plans to introduce a seismic certificate, as the HCPI is helping create a database of building structures in Zagreb and Sisak-Moslavina County. The proposal is to introduce a seismic certificate to assess the mechanical stability and resistance of public buildings, similar to the existing energy certificate, as part of the new Construction Act expected 2025-2026.[51]

The protection of cultural heritage from seismic risks is highlighted as a need in the NDRMS, emphasizing improved response capacity and damage assessment systems (see Table 4 with highlighted areas and measures). However, given the vulnerable building stock and specific needs of cultural heritage sites, there is room for example for greater integration of cultural heritage protection into the broader DRM framework.

An existing gap in the DRM governance framework is the absence of a comprehensive recovery framework, which is crucial for effective post-disaster management. This gap is discussed further below in the chapter on earthquake recovery, reconstruction, and post-disaster financing. Even further, it should be noted that efforts are underway to propose guidance and the enabling conditions for a dedicated law to formalize and institutionalize the DLD collection and assessment process.[52]

[50] Baggio, C., et al. 2007. Link.
[51] GoC 2024, Link.
[52] European Union 2024b, Link.

Table 4. Extract from the Croatia National DRM Strategy

Source: World Bank team (design). *Note:* Information extracted from Croatia's DRM Strategy.

Area	Measure
Prevention and risk reduction	Encourage comprehensive renovation of buildings. Additional measures include the following: improve buildings' existing condition, increase safety in case of fire, ensure healthy indoor climate conditions, and improve the mechanical resistance and stability of the building.
Preparedness	Strengthen seismological station networks.
Post-disaster response and recovery	Strengthen the operational forces of the civil protection system for search and rescue, involve more experts in activities defined by earthquake risk needs, and undertake seismic strengthening of structures and comprehensive renovation of buildings.
Overall operational readiness and awareness	Increase professional capacities and equipment for earthquake risk management, forming intervention teams and teams of experts to eliminate consequences/damage, raising awareness, and educating the population about behavioral procedures before, during, and after the earthquake. Establish an interdisciplinary and cross-sectoral earthquake relief center and develop and modernize seismological affairs.
Cultural heritage protection	Enhance the resilience of Croatia's rich cultural heritage and building stock.

KEY OPPORTUNITIES

With respect to the earthquake governance framework, the following five key opportunities have been identified: (1) enhance governance mechanisms for assessing and implementing seismic risk reduction strategies, particularly for critical entities, (2) harmonize existing laws regarding seismic risk reduction in buildings to enable integrated risk-informed investments, (3) mandate and promote collaboration between different stakeholders, and (4) strengthen the integration of cultural heritage protection into DRM strategies, and (5) develop a recovery framework (discussed further below in Earthquake recovery, reconstruction, and post-disaster financing).

Enhance governance mechanisms for assessing and implementing seismic risk reduction strategies

To effectively manage seismic risks, Croatia should prioritize enhancing its governance mechanisms for assessing and mitigating the risk to infrastructure, particularly critical entities. A key opportunity lies in clearly defining and integrating the roles of various institutions throughout the DRM cycle, ensuring a coordinated approach. This could be streamlined through the creation of a specific earthquake risk management strategy or action plan, which would enable Croatia to systematically address earthquake risks, ensuring risk reduction across all critical sectors and assigning responsible coordinating authorities. Increasing resilience against earthquakes requires that planning and prioritization frameworks be applied systematically across all critical sectors (e.g., emergency response, health care, education, transportation, energy). Accompanying the strategy with specific implementation and investment plans would facilitate long-term financing, ensuring resources are dedicated to seismic risk mitigation, infrastructure reinforcement, and public education. By integrating the expertise of scientific and technical institutions, such as the HCPI, as an advisory service, strategic planning and the implementation of risk reduction measures can be strengthened, maximizing the contributions of each institution. These efforts can also be aligned with the implementation of the LTRS, expanding and linking existing initiatives under the NRRP into the broader legal and governance framework.

Harmonize existing laws regarding seismic risk reduction in buildings to enable integrated risk-informed investments

Harmonizing existing laws provides the foundation for integrated investment planning that systematically addresses seismic and climate risks across sectors and scales, while unlocking multiple benefits such as safer housing, greener energy use, and more efficient reconstruction processes. Currently, this regulatory inconsistency leads to missed opportunities for promoting integrated interventions, coordinating financing, and maximizing resilience outcomes. Better alignment across the Reconstruction Law, Building Code, Ordinance for Simple Buildings, and Energy Efficiency Law would not only improve seismic safety but also support climate adaptation efforts, especially through renovation strategies that enhance structural safety, energy performance, and environmental sustainability. Therefore, to mitigate risk derived from seismic events, Croatia should work on the harmonization of existing laws that could be applied during pre- and post-seismic events. Envisioned reforms related to construction, physical planning, and EE planned by the MoPPCSA under its Program for 2024-2028 could also be a practical opportunity to improve the governance framework on seismic risk reduction.[53] The LTRS provides an opportunity to integrate comprehensive building renovations that go beyond EE to include seismic safety improvements. This includes enhancing fire safety, ensuring healthy indoor environments, and improving mechanical stability. Seismic retrofitting efforts should focus on upgrading critical entities, eliminating hazards from gas installations and chimneys, and promoting earthquake-resilient energy solutions.

Mandate and promote collaboration between different stakeholders

To respond more efficiently to disasters, there should be strong collaboration between national, regional, and local governments; civil society organizations; and other stakeholders in Croatia. For example, there is also an opportunity to develop joint frameworks for risk communication and public awareness campaigns, ensuring consistent messaging and leveraging diverse expertise per mandated DRM institutions. It is equally important to ensure that dedicated expertise, such as for seismic

[53] GoC 2024, Link.

resilience within HCPI, is formally mandated and supported with adequate resources to carry out this function on a full-time basis. It is also important to promote coordinated planning and execution of strategies. Such efforts could be promoted through the NDRRP.

Strengthen the integration of cultural heritage protection into DRM strategies

Continued investments in risk assessments, capacity building, and the integration of cultural heritage considerations into national and local DRM strategies are essential for safeguarding Croatia's invaluable historical and architectural legacy. There is an opportunity to increase cultural heritage protection in the national and local DRM strategies, particularly in areas of high earthquake risk and high concentration of cultural heritage. The MoC should play a key role, as most protected buildings require earthquake upgrades, and its involvement in future reconstruction projects will be crucial, because the structural systems of historic buildings often differ significantly from those of modern structures (e.g., in Split or Dubrovnik, as compared to Zagreb).

UNDERSTANDING EARTHQUAKE RISKS

This chapter focuses on the current understanding of earthquake risks in Croatia, which is informed by various sources of data and analysis, research and innovation, NRAs, and subnational risk evaluations. Earthquake risk is understood as the combination of seismic hazard (e.g., the frequency of earthquake occurrence, the strength of ground shaking given an earthquake), exposure (e.g., the number of people exposed, the value of assets exposed), and vulnerability (e.g., the susceptibility of assets to damage, the ability of populations to cope with earthquake effects).

GENERAL CONTEXT

The NRA process in Croatia, governed by the Civil Protection System Act, requires ministries and government institutions to develop risk assessments at the national, regional, and local levels. The process adheres to EU and ISO guidelines and has produced NRAs in 2015, 2019, and 2024. The risk assessment framework involves a main working group and hazard-specific working groups composed of scientific and academic experts. The assessments include hazard identification, scenario analysis (most probable and worst-case), risk matrix evaluations, and capacity assessments for prevention and response. Key hazards include earthquakes, floods, forest fires, extreme temperatures, and industrial accidents. Risks are categorized as unacceptable, tolerated, or acceptable based on likelihood, impact, and mitigation capacity. The 2022 risk assessment introduces updated guidelines emphasizing economic and social vulnerability, direct damage, and broader considerations like public infrastructure and critical services. Vulnerability metrics such as poverty, unemployment, and literacy rates are factored into evaluations. Hazard-specific risk maps and matrices are developed by ministries in collaboration with scientific institutions, supported by the National Platform.

CURRENT ARRANGEMENTS

National risk assessments 2015, 2019, and 2024

Croatia has conducted several NRAs (2015,[54] 2019,[55] and 2024[56]), coordinated by the MoI CPD, in compliance with UCPM (Decision 1313/12), which includes earthquakes as a key focus. In 2024, as the country prepared for the next update of the NRA, the CPD developed a draft of new guidelines for disaster risk assessment.[57] The initial and updated NRAs consider the country's seismic risk as 'unacceptable' under various earthquake-related scenarios. The 2024 NRA highlights the increasing need for investment in mitigation and resilience, particularly against high-risk hazards such as floods, earthquakes, and wildfires. It aligns with international frameworks like the SFDRR, reflecting Croatia's commitment to improving disaster preparedness, response, and recovery capacities. In addition, the 2024 assessment emphasizes categorizing these risks to better define investment priorities across all segments of DRM to determine which risks require immediate attention and resources.[58]

Prior to 2020, an earthquake in Zagreb was included as a scenario in the NRA, and following the 2020 earthquakes, Croatia has taken steps to localize the NRA to better reflect the specific seismic risk of the City of Zagreb.[59] This assessment aggregated existing hazard data, constructed a detailed exposure database for buildings by conducting a building-by-building data collection and assessment, and performed advanced risk calculations to aid strategic planning. The City of Zagreb Seismic Risk Assessment assessed seismic risks for

[54] This was in line with Decision No. 1313/2013/EU of the European Parliament and of the Council of 17 December 2013 on the Union Civil Protection Mechanism and EU Decision 2019/420 of the European Parliament and of the Council of 13 March 2019 amending Decision No. 1313/2013/EU, with the obligation to provide risk data in accordance with the recommended Guidelines of the European Commission SEC(2010) 1626. *See* 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, Croatia.; Atalić, J.,M. 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, Croatia.

[55] GoC 2019a, Link.

[56] GoC 2024c, Link.

[57] GoC 2024d, Link.

[58] GoC 2024c, Link.

[59] World Bank 2020a.

buildings and human lives in the city, which is located in a seismically active area. It focused on categorizing risks to different types of buildings (residential, commercial, cultural heritage, other infrastructure) and evaluated the potential impacts on people, such as casualties, injuries, and housing needs. The City of Zagreb was the pilot area for this project, chosen due to its dense population, economic importance, and vulnerability to seismic activity, and has developed a methodology for seismic risk assessment that can be applied to other major cities in Croatia. The City of Zagreb Seismic Risk Assessment was implemented as a sub-project within the broader project 'Multisensory Aerial Survey of the Republic of Croatia for the Purposes of Disaster Risk Assessment and Reduction,' which supported the development of high-quality spatial datasets using aerial LiDAR (Light Detection and Ranging) scanning and photogrammetry, creating Digital Terrain Models, Digital Surface Models, and a digital orthophoto map.[60] These datasets provide valuable data for disaster risk analysis, including earthquake and flood risks, and are accessible through a WEB-GIS portal for stakeholders in DRM.

Secondary hazard map

Landslide risk following an earthquake has been identified under the NRA. After a disaster occurs, there is a possibility that the risk map of the area changes since disasters like floods and earthquakes can create other risks such as landslides and liquefaction. The frequency of triggered landslides depends on the frequency and intensity of the events that trigger them, such as precipitation (intensive precipitation, melting of snow cover), seismic activity (earthquake), volcanic activity, and human interventions. The Croatian NRAs in 2019 and 2024 categorize landslides as disastrous situations that can exacerbate the risk in areas previously damaged by a disaster. However, none of them directly correlate earthquakes to landslides but focus mainly on precipitation. In 2023, the MoPPCSA presented the Decision on the adoption of the Landslide Mitigation Program in the Republic of Croatia, which would enhance Croatia's preparedness to face this peril.[61] Additionally, Croatia has developed and EWS for landslides called the SRUK to provide the most relevant and updated information on landslide preparedness and protection, as well as maps depicting the location of the peril.[62] Besides landslides, other secondary perils, such as liquefaction, should be considered. After the December 2020 earthquake, widespread occurrences of liquefaction were recorded, which affected the natural and built environment and land stability of the area.

Microzonation

Seismic microzonation, currently conducted at some localities in Croatia, helps determine the influence of soil layers on the intensity of the seismic shaking and provides a better understanding of the local-level seismic shaking potential on the ground surface.[63] As a result, the quality of the ensuing risk assessment at the local level and eventual mitigation actions will be increased. For example, in 2023, the field team of Component 2 of the CRONOS project conducted geophysical field research in Sinj (Croatia) as part of the city's

[60] City of Zagreb. "Multisenzorsko zračno snimanje Republike Hrvatske za potrebe procjene i smanjenja rizika od katastrofa – KK.05.2.1.10.0001." Link.

[61] GoC 2023; GoC 2024.

[62] Sustav za rano upozoravanje za klizišta (SRUK). Link.

[63] Ibid.

microzonation effort.[64] The research involved measurements of ambient seismic noise and tremors, also known as microseisms, at approximately 90 locations across the city, spaced 200–300 meters apart, using the HVSR (Horizontal to Vertical Spectral Ratio) method with Tromino devices funded by the CRONOS project. Field measurements aimed to determine relevant ground properties (such as resonance frequencies, $V_{S,30}$ and H_{800} values) providing critical data for understanding local soil and rock properties. The findings will support the development of a seismic basemap essential for urban planning and improving the understanding of the area's seismic characteristics.[65]

Availability of risk data

Data on disaster risks are currently being collected by different entities, and Croatia is taking efforts to streamline this data. There are efforts to streamline data collection, including through the Drafting Disaster Risk Reduction Awareness Raising Guidelines and Disaster Loss Data & Assessment System (DrawData) project.[66] Through these efforts, Croatia aims to improve reporting to the Sendai Monitor and DesInventar. In parallel, efforts have also been made to strengthen institutional capacity, notably through the training of national and local authorities in the Post-Disaster Needs Assessment (PDNA) methodology. However, information sharing is still limited due to the sensitivity of the data.

Information on earthquake hazard and risk in Croatia is accessible via the CPD platform, which has several educational materials and documents on this topic. The platform has documents such as the earthquake brochure, which informs citizens of what an earthquake is, what can be affected by an earthquake, how to respond to an earthquake as a citizen, and so on.[67] The portal also offers tools/maps, which allow users to review of identified threats, developed scenarios and the adoption/updating of major accident risk assessments for local and regional self-government units, and review of the adoption of Civil Protection Action Plans of LGUs (Regional) and approvals of External Civil Protection Plans, view county risk maps (i.e., the available seismic risk map considers a return period of 100 years), and risk factors, such as social vulnerability and exposure, access land cover data, among others.

KEY CHALLENGES

One critical issue in Croatia is the lack of a comprehensive building inventory and structural data, which are essential for understanding earthquake risk and effective risk reduction planning and can support risk-informed decision-making. Like in many other countries, there is no official inventory database in Croatia that includes building material, age, floor area, structural system, and occupancy category of buildings, which are parameters critical for seismic risk assessments. There is also no inventory database for the public sector that includes emergency facilities in Croatia, which is crucial for efficiently responding to seismic disasters. However, Croatia is aware of this problem and is participating in different efforts to leverage its potential. One of these initiatives is the Global Earthquake Model (GEM), in which different Croatian experts have participated.[68] This initiative has developed advanced and widely applicable databases, tools, and programs for seismic risk assessment. Continuous updates to these databases and models, driven by collaboration and the exchange of expertise, are vital. Therefore, Croatian experts should continue to actively participate in these efforts to ensure the methodologies remain relevant and effective for the country's needs.[69]

Efforts to improve disaster-related data are progressing but remain fragmented. There are efforts to address such challenges, particularly in relation to systems of collecting damage and loss data following an earthquake or other disaster events.[70] There are also efforts under the MoI, specifically within the CPD, to create a singular database to consolidate currently scattered available disaster data across multiple stakeholders. Such efforts are also bolstered by efforts to create a new law.

[64] The CRONOS Project refers to the "investigation of seismically vulnerable areas in Croatia and seismic ground motion assessment."
[65] CRONOS 2023, Link.
[66] EC 2024b, Link.
[67] GoC, Ministry of Interior and Civil Protection. n.d. *Educational Corner- Earthquake Brochure*. Link.
[68] EFEHR. n.d. *Earthquake Risk across Europe*. Link.
[69] Atalić, J., M. Šavor, and M. Uroš. 2019. Link.
[70] United Nations for Disaster Risk Reduction (UNDRR). DesInventar for Sendai Framework and SDG Indicators. Link.

Seismic risk data are not widely shared with the public, and public awareness could be strengthened. For example, citizens are unaware of how much earthquakes can affect their lives (please see more under Preparedness).

There is a limited understanding of the risk of critical entities and infrastructure in high earthquake risk areas that require seismic assessment. In addition, the NRA does not include an earthquake risk assessment of critical entities, which may be necessary under the CER (Critical Entities Resilience) and NIS2 Directives.

The risk modeling of earthquake-induced secondary perils, such as landslides and liquefaction, has received little attention in the NRA. Although the probabilities of their occurrence seem to be high, there is limited risk information and understanding of these hazards in the NRA. Thus, it would be beneficial to better integrate them into hazard and risk modeling.

KEY OPPORTUNITIES

With respect to understanding earthquake risk and data, the following six key opportunities have been identified: (1) enhance risk data collection and accessibility, (2) understand the risk of critical entities, (3) improve risk assessment models, (4) implement regular updates to seismic hazard maps, (5) invest in seismic microzonation and localized assessments, (6) strengthen city-level risk assessment programs, and (7) increase public information sharing on seismic risk.

Enhancing risk data collection and accessibility

Croatia should invest in developing consistent, comprehensive building and infrastructure databases, including critical parameters for seismic assessments, such as building materials, age, and structural systems, which could be achieved through a combination of existing inventories, automated and AI-based methods, and the application of a standardized RVS procedure. RVS can serve as a cost-effective tool to collect preliminary data on building exposure and vulnerability, identify assets that may require further assessment or retrofitting, and support prioritization for risk reduction investment. Accurate seismic risk assessments are crucial for targeted disaster preparedness efforts, as they help predict damage to buildings, threats to human life, and financial losses. Current models must incorporate not only seismic hazards but also the vulnerability of the built environment, including outdated and poorly maintained structures, many of which were not designed to withstand earthquakes. The data would improve the accuracy of risk assessments and enable more effective planning and resource allocation and should be made available across relevant agencies.

Once the technical and institutional capacities are in place, Croatia may consider extending the analysis to Croatia's major tourism hotspots, such as Dubrovnik, Split, and other coastal municipalities. Engaging the hospitality sector (e.g., hotel and resort operators) could support preparedness and continuity planning for assets that underpin a significant share of national economic activity, especially in coastal areas highly exposed to seismic and climate risks.

Understanding the risk to critical entities

Efforts should be made to collect data on public sector infrastructure and emergency facilities to ensure a timely response during seismic events. A country or asset-type specific portfolio assessment can be applied to systematically evaluate the condition, vulnerability, and investment needs of critical infrastructure, enabling more targeted and risk-informed decision-making. The results of such an assessment are displayed in Box 1.

Box 1. Portfolio assessment of critical infrastructure

A rapid portfolio analysis shows that a large number of emergency response buildings are highly vulnerable to seismic risk, some of them in the regions of high-seismic hazard. This example shows how a rapid seismic safety analysis, in combination with EE and simple cost/benefit can provide valuable information for future prioritization of investments.

Data across 60+ buildings of emergency response services (county firefighting centers, national/county CP centers, firefighting stations in the City of Zagreb, and CP headquarter buildings in the City of Zagreb) was collected and analyzed. Information was collected on key building attributes, functional and occupational data, photos, and other documentation which can help inform future investments.

The analysis found that reinforced concrete (48 percent) is the most used type of material, followed by unreinforced masonry (40 percent), confined masonry (10 percent), and steel (2 percent). Three percent were built in the 18th and 19th century, 18 percent were built between 1880 and 1918, and 18 percent built between 1945 and 1964), all of these not designed for earthquake loads. With respect to county firefighting centers, the analysis shows that over half of the buildings analyzed were built prior to 1964, and out of these, the large majority (82 percent) is built from unreinforced masonry. Of the 21 buildings analyzed, 14 buildings would likely suffer moderate-extensive damage – this is more than two thirds of the population. Related to Firefighting stations in the City of Zagreb, 1/3 (30 percent) of the buildings analyzed were built prior to 1964, and out of these, all are built from unreinforced masonry. Of the 10 buildings analyzed, 4 buildings would likely *suffer* moderate-extensive damage. This means that in the case of a major earthquake, there may be significant impact on the operational capacities of critical infrastructure, as well as substantial indirect impacts on the communities. A depiction of the results from the portfolio assessment can be found in Figure 4.

Also, EE and cost/benefit analysis were carried out for 35 buildings in the CP portfolio. The findings indicate that many buildings currently fall short of EU and national energy performance benchmarks, with an average annual consumption of 125.6 kWh/m² (2018–2022). For the purpose of the analysis, it was assumed that buildings constructed before 1981, representing over 80 percent of the sample, would benefit from comprehensive renovation, while others may require more targeted upgrades. A subsequent cost-benefit analysis using the Triple Dividend of Resilience (TDR) approach found positive benefit-cost ratios for combined seismic and energy upgrades, particularly over a 50-year asset lifecycle, showing that integrated investments in infrastructure can bring economic and socio-environmental benefits and that these benefits will outweigh costs in the longer term.

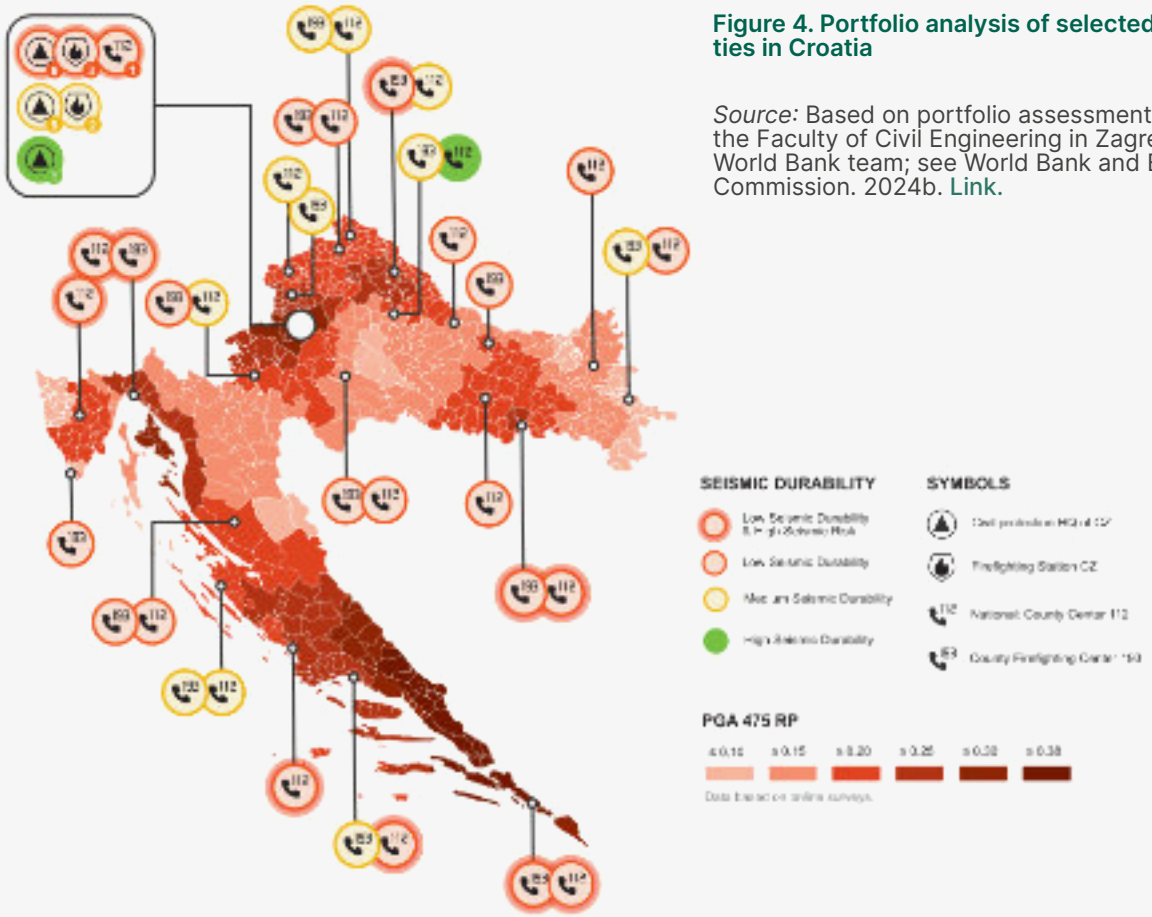

Figure 4. Portfolio analysis of selected critical entities in Croatia

Source: Based on portfolio assessment conducted by the Faculty of Civil Engineering in Zagreb and the World Bank team; see World Bank and European Commission. 2024b. Link.

Improve risk assessment models

Croatia has an opportunity to improve its existing risk assessment models through the processing of available hazard data and the development of an exposure database for vulnerable assets, which should be included in the current legislation (e.g. by considering secondary perils and aftershocks, integrating additional exposure information, and results of localized assessments). Before the 2020 earthquake, areas like Split and Osijek had individual initiatives, but these lacked a comprehensive approach. However, the 2020 earthquakes spurred the launch of a pilot project, the City of Zagreb Seismic Risk Assessment, which has advanced seismic risk knowledge in Croatia and developed a methodology that can be applied to other major cities in Croatia. This project has processed all available hazard data and developing an exposure database for buildings. The project has also delivered advanced risk calculations, which can be used to guide strategic decisions, resource allocation for emergency response, and the reinforcement of critical buildings.

Implement regular updates to seismic hazard maps

The Croatian authorities should implement a system for periodic updates to seismic hazard maps, leveraging new earthquake data to maintain accurate, up-to-date maps. This will help ensure that future assessments reflect the most current seismic activity and provide reliable guidance for risk management strategies.

Invest in seismic microzonation and localized assessments

Although seismic microzonation is already in practice in Croatia, it should be expanded and enhanced, as it was done in the CRONOS project in Sinj. This will improve the understanding of seismic hazards at the local level, as seismic microzonation studies can determine the local soil effects on earthquake risk, allowing for more targeted mitigation strategies that consider soil conditions and other site-specific factors.

Strengthen city-level risk assessment programs

Linked to improving risk assessment models, Croatia has the opportunity to expand city-level risk assessment initiatives, like the City of Zagreb Seismic Risk Assessment project,[71] to other major cities across the country, particularly in areas of high earthquake risk. These programs should assess risks to various building types, infrastructure, and populations while also improving emergency response and recovery capabilities. Detailed spatial datasets and GIS tools should be integrated to support effective DRM.

Increase public information sharing to seismic risk

Croatia should work to disseminate seismic risk information to the public, including enhancing the availability of educational materials, hazard maps, and preparedness guides. To respond efficiently to disasters, it is crucial to improve transparency and access to risk data while ensuring that sensitive information is appropriately managed. Croatia should enhance the use of the CPD web platform and make it more accessible to citizens. Also, it should improve and generate more educational campaigns for different groups (children, teenagers, PwDs, and so on) on understanding seismic risk information in order to implement seismic risk reduction and preparedness measures. Croatia should strengthen hazard maps and make them more accessible and useful for the population, for instance, by allowing individuals to look up hazards in their locations, such as the "SeizKarta" or Maps of earthquake zones of the Republic of Croatia.[72]

[71] For more information, see Link.

[72] Department of Geophysics, Faculty of Science, University of Zagreb. "Seismic Hazard Map of Croatia." Link.

EARTHQUAKE RISK PREVENTION, REDUCTION, AND MITIGATION

This chapter focuses on earthquake risk prevention, reduction, and mitigation. Earthquakes occur with minimal warning times that limit the ability to remove people and property in advance; therefore, most earthquake risk reduction efforts focus on mitigation by reducing exposure and vulnerability. This includes the development and enforcement of building codes with earthquake-resistant design requirements, land use planning to avoid high-risk areas near faults or unstable soil and retrofitting existing buildings and infrastructure.

GENERAL CONTEXT

In line with the governance framework, planning and prevention activities in Croatia fall under the jurisdiction of the MoI and the CPD, relevant line ministries (depending on the hazard), and sub-national authorities. In 2023, Croatia approved the NDRMS for 2030, which provides a comprehensive strategic framework for enhancing disaster resilience across all hazards identified in the NRA. The strategy reinforces the principle that "disasters are everyone's business" and underscores the importance of a collaborative approach to risk reduction. On the other hand, DRM funding in Croatia is sourced primarily from the state budget and local budgets, complemented by EU and other international funding. These funding resources have been utilized for various purposes, including enhancing operational readiness and capacity, raising public disaster risk awareness, and, more recently, integrating EE measures and seismic retrofitting. While a comprehensive overview of existing public and private, national and international funding opportunities and synergies is not available, it is estimated that between 2014 and 2024, Croatia has made several investments in DRM through national programs funded by the state budget, alongside various programs from EU investments, including from Cohesion Funds, NRRP, and UCPM, among others.

CURRENT ARRANGEMENTS

Earthquake recovery/seismic risk reduction initiatives

The government has introduced financial assistance programs to support the reconstruction process, including grants for structural reinforcements and incentives for homeowners to enhance building resilience. Through the NRRP, Croatia was also allocated €5.8 billion in grants and €4.2 billion in loans from the NRRP, of which approximately 39 percent was designated for the green transition. The GoC also finances the post-earthquake reconstruction and energy upgrade of buildings damaged in the devastating earthquakes that hit Croatia in 2020, with €1,978 million for earthquake reconstruction through the NRRP.[73] Programs under the Renovation Building Initiative encourage comprehensive building renovation and high-performance alternative systems, and they will ensure healthy indoor climate conditions, fire protection, and understanding of risks associated with increased seismic activity. The renovation includes residential and non-residential buildings, as well as public purpose buildings, while respecting the importance of public interest for health and educational buildings. The plan is to renovate 45,000 m^2 of private buildings and 274,000 m^2 of public buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County. Besides increasing buildings' seismic resilience (under the BBB principle), the NRRP also seeks at least 30 percent energy savings for all buildings compared to their pre-renovation state, thereby contributing to a cleaner and safer environment.[74] Such investments under the NPPR contribute to more effective post-earthquake reconstruction and seismic safety of buildings.[75] Other measures include improving efficiency and digitizing the reconstruction process; modernizing seismic data integration for reconstruction and infrastructure planning; and establishing systematic energy management and a new financing model. Measures for conducting energy renovations in both earthquake-damaged and culturally significant buildings are included in the NRRP as well.

[73] EC 2023a, Link.
[74] GoC 2021c.
[75] GoC. n.d. Recovery Plan, "Initiative: Renovation of Buildings" [*Inicijativa: Obnova zgrada*]. Link.

The NRRP includes the following planned reforms and measures with respect to building renovation: energy renovation of buildings (€133 million);[76] disaster risk reduction program (€158 million);[77] seismological data network development (€11 million);[78] introduction of a new model of green urban renewal strategies and the implementation of a pilot project for the development of green infrastructure and circular management of space and buildings (€2.1 million);[79] and introduction of vouchers for developing green and digital skills (€40 million for programs related to green skills, including development of a framework for skills necessary to green jobs in post-earthquake reconstruction).[80]

Additionally, Croatia has introduced various programs to address energy poverty and promote efficiency in different sectors:

- *Multi-Apartment Buildings*: These programs focus on energy renovation, including buildings damaged in the earthquake, EE loans, and other measures.
- *Single Family Houses:* Programs target EE for both single-family houses and those at risk of energy poverty.
- *Public Buildings:* These programs focus on energy renovation, including the energy renovation of earthquake-damaged buildings, as well as those with cultural heritage status.
- *Business:* Entrepreneurs can benefit from EE programs.

The EU Semester and Croatia's green skills

Croatia's 2024 Country Report found that the management of climate risks and the quality and availability of environmental infrastructure need improving.[81] The report found that support for EE measures in businesses and the residential sector was not sufficient in 2023. Since Croatia relies on grant-based funding schemes implemented via centralized calls for proposals on building renovation, increased transparency and timely information on future calls would help the potential beneficiaries and the construction sector. Under the RRP, Croatia implemented reforms and investments addressing the skills gap noted in 2023, improving productivity and promoting inclusiveness. Croatia's innovative, nation-wide voucher scheme to provide training in skills in response to labor market needs, particularly skills related to the green and digital transition, was met with strong demand and has been further developed by complementary ESF+ investments. In addition, a national plan for developing green skills in the building sector was prepared, to provide skills in the context of EE renovation, post-earthquake reconstruction and application of green infrastructure solutions.[82] Lastly, water management and infrastructure need to be further improved and made more sustainable to optimize water use and address vulnerabilities from water-related climate risks. This also includes addressing institutional challenges. Damages from floods

[76] EC. n.d. *Energy Renovation of Buildings*. Link.

[77] EC. n.d. *Disaster Risk Reduction Program*. Link.

[78] EC. n.d. *Seismological Data Network Development*. Link.

[79] GoC, "Pilot Project for the Development of Green Infrastructure and/or Circular Management of Space and Buildings" [*Pilot projekt razvoja zelene infrastrukture i/ili kružnog gospodarenja prostorom i zgradama*], Link.

[80] EC. n.d. *Introduction of Vouchers for Developing Green and Digital Skills*. Link.

[81] EC 2024, Link.

[82] Croatia's REPowerEU chapter, €2.9 billion, includes a new reform to enhance green skills and competences in the construction sector, with a focus on non-EU workers.

could be alleviated by improving availability and affordability of insurance policies to cover climate hazards.

Croatia's 2023 Country Report found that the lack of relevant green skills created bottlenecks in the reconstruction and renovation process following the 2020 earthquakes, and more generally in the transition to a net-zero economy.[83] According to the report, Croatia is facing labor shortages, particularly in 31 green transition–related occupations, causing constraints in the industry and construction sectors. Construction and manufacturing experienced a shortage of professional and skilled workers, and the construction sector performed below the EU average. Croatia is investing in developing green skills through the European Social Fund (2.6 percent contributes to green skills and jobs) and through the Just Transition Fund. The latter includes Sisak-Moslavina, which suffered significant damage following the 2020 earthquakes.[84] The NRRP is also seeking to develop green skills by introducing vouchers that finance participation in relevant educational programs, which are based on the Croatian Qualifications Framework (CROQF) and are implemented through accredited institutions in accordance with the new Adult Education Act.[85]

Residential buildings

Croatia's NRRP places an emphasis on the renovation of private buildings, particularly multi-apartment residential structures, focusing on reconstructing and making EE buildings based on the EU Green Deal 'Renovation Wave'. The plan aims to renovate at least 180,000 m^2 of multi-apartment buildings by the end of June 2026. This initiative seeks to reduce energy consumption for heating, increase the use of renewable energy sources, and alleviate energy poverty among residents. To support these objectives, the NRRP includes support schemes that encourage private investment in energy-efficient renovations. These schemes are designed to incentivize building owners to undertake comprehensive upgrades, thereby contributing to the decarbonization of the building sector and promoting the development of green infrastructure. To support these renovations, the NRRP allocates €133 million in grants. Projects are co-financed by 60 percent or 80 percent, depending on the depth of the energy renovation undertaken. By the end of 2022, contracts worth €40 million had been signed for the energy renovation of 91 multi-apartment buildings, covering over 390,000 m^2. These efforts are expected to achieve significant energy savings, with calculated average annual heating energy savings around 70 percent and primary energy savings around 60 percent.[86] However, it is essential to mention that the 2020 earthquakes have shown that investments in energy renovation of buildings without sufficient seismic resistance can be wasted resources; covering walls with new layers to upgrade the building's energy performance ultimately makes it difficult to inspect damaged buildings (as they hide cracks) and to retrofit them afterward.[87]

Buildings of public interest

In addition to private residences, the NRRP focuses on the renovation of public buildings, including health care and educational facilities. The goal is to renovate at least 288,000 m^2 of public buildings by the same deadline (and 180,00 m^2 of multi-apartment buildings). These renovations aim to improve EE, enhance seismic safety and promote the development of green infrastructure.[88] The NRRP includes comprehensive plans to renovate educational facilities, focusing on improving energy performance and structural integrity. The initiative encompasses both energy renovation and seismic strengthening, ensuring that educational institutions provide safe and efficient learning environments. By upgrading these facilities, the plan aims to create healthier indoor climates, enhance fire safety, and mitigate risks associated with increased seismic activity. Similarly, the plan targets health care buildings for renovation, aiming to improve their EE and structural resilience. The focus is on ensuring that health care facilities can operate efficiently while providing safe environments for patients and staff. The renovations are designed to enhance the mechanical resistance and stability of these

[83] Ibid.
[84] EC 2022, Link.
[85] EC. n.d. *Introduction of Vouchers for Developing Green and Digital Skills*. Link.; GoC, HZZ. n.d. Knowledge Voucher [*Vaučer za Obrazovanje*]. Link.
[86] Ibid.
[87] GFDRR and University of Zagreb 2023.
[88] GoC, MoPPCSA. n.d. *National Recovery and Resilience Plan (Initiative: Building Reconstruction)*. Link.

structures, particularly in response to seismic risks, thereby ensuring the continuity of essential health care services during and after potential natural disasters.

KEY CHALLENGES

Institutional arrangements for earthquake risk management are spread across multiple agencies, with no single entity overseeing all phases of seismic risk management. Given the substantial stock of aged buildings, including critical entities and cultural heritage, the current arrangements pose limitations for adopting a strategic approach to planning and implementing risk reduction investments. Seismic risk assessments, as the first step toward mitigation, can serve as a basis for the implementation of policies, such as estimation of capacities and capabilities and implementation of strategies. There are also gaps in coordination among different actors in preparedness and response, requiring clarification of responsibilities. Following the 2020 earthquakes, the Croatian Center for Earthquake Engineering (HCPI) was established as a center of excellence and research on seismic resilience in Croatia. All the knowledge and expertise from past earthquakes and future directions should be incorporated under a centralized leadership and management body (devoted to earthquake risk) that would facilitate challenges and enable systematic work on both seismic risk assessments and mitigation of consequences.

All existing hazard and risk assessment studies point to earthquakes as one of the biggest risks for Croatia, with possible catastrophic consequences; thus, more emphasis should be given to seismic retrofit programs, at a minimum for critical entities, but potentially also for public and private buildings. A destructive earthquake in Croatia could affect part of the building stock and workplaces, further impair the fragile economic stability of the country, and jeopardize the social and political fabric of the country.[89]

While investments in Croatia have focused on enhancing EE, there is limited dedicated financing or incentives for integrated investments, such as seismic strengthening, retrofitting, and application of climate adaptation principles – while the enabling conditions exist within the legal and strategic framework (albeit not explicitly). In addition, given that earthquakes are not a climate risk, they are typically not addressed by large climate and EE investment programs. When a building's EE is enhanced, the building is subject to significant interventions, and it would be logical to ensure resilience to other potential hazards such as earthquakes. Uncoordinated and individual energy and seismic upgrading measures are not a good approach to building. It is worth taking several actions at once, but it is critical to be proactive and include both seismic retrofits and EE improvements in the strategic plans for a single building that has been identified as essential. An intervention strategy aimed at mitigating the risk must be developed as soon as possible, identifying representative retrofits for various building typologies, including EE improvements. In addition, there are opportunities to make broader investments, considering all relevant disaster and climate risks, integrating opportunities through CCA measures, as well as considering inclusive measures.

At the same time, there is a gap between regulations and compliance across all infrastructure in Croatia. Efforts should be made to facilitate the application of regulations and incentivize integrated investments. To improve the seismic resilience of structures, the next generation of regulations will need to address practical problems in the field. A synchronized approach should be pursued that combines research and professional communities and continually seeks to raise the level of knowledge. This will eventually bridge the gap and facilitate the application of regulations. In addition, such efforts will contribute to Croatia's efforts to transpose the revised Eurocodes once adopted.

Although Croatia has made progress in flood resilience through investments in flood prevention, earthquake resilience has lagged. The flood prevention project included investments to achieve a high level of protection for the target civilian population in priority river basins in Croatia, thus reducing flood occurrence and its adverse social and economic impacts. While there are similar initiatives to build resilience to earthquakes, these efforts can be strengthened through lessons learned from the 2020 earthquakes and the flood protection initiatives.

In Croatia, there are some barriers when developing green skills, as well as the skills to conduct integrated investments – including seismic retrofits and EE upgrades. Some of the barriers to developing green skills include high regulatory

[89] Atalić et al. 2019.

restrictions for some relevant occupations, such as engineering.[90] The 2023 Country Report found that competitiveness across engineering professions is restricted by a combination of challenges.[91]

KEY OPPORTUNITIES

With respect to earthquake risk prevention, reduction, and mitigation, the following nine key opportunities have been identified: (1) develop a prioritized approach to earthquake risk prevention, reduction, and mitigation, (2) integrate seismic retrofits into planned energy upgrade initiatives, (3) promote a holistic approach to resilience of public and private infrastructure, (4) establishing a registry of engineers for pre- and post-earthquake RVS, (5) bridge the gap between existing regulations and reality, (6) develop a standardized multi-tier approach to seismic safety assessment of buildings, (7) raise awareness on securing nonstructural elements, (8) enhance collaboration between different stakeholders, (9) target investments in disaster resilience for the most vulnerable sectors and infrastructures.

Develop a prioritized approach to earthquake risk prevention, reduction, and mitigation

Croatia has an opportunity to establish a prioritized approach to risk reduction through pre-earthquake RVS and initial assessment that makes its efforts both effective and cost-efficient and considers risk and other socioeconomic and environmental information. As many existing buildings are old and vulnerable, an approach to prioritize seismic retrofits to critical entities and housing could include guidance to help national and local governments prioritize retrofits and reconstruction through pre-earthquake RVS and initial assessment before conducting the detailed assessment required to design retrofits.

Based on the data, Croatia could consider establishing and financing dedicated programs for phased improvements in infrastructure at different administrative and societal levels, focusing initially on critical entities and services (such as emergency response, health care, education, transportation, energy, and telecommunications) and addressing multiple hazards, including earthquakes, landslides, wildfires, and extreme heat. Such programs would also consider the need to adapt to and mitigate climate change impacts. Especially important to mitigating current and future risks is to provide incentives to support seismic resilience in high-risk areas. Novel incentives may additionally be required to increase the uptake of retrofit of private buildings. This requires strong technical capacity and the development of skills through alliances across society, including academia and the private sector. Risk reduction must also be accompanied by efforts to enhance preparedness (see further Governance of earthquake risk management).

Integrate seismic retrofits into planned energy upgrade initiatives

Croatia has an opportunity to integrate seismic retrofits into planned energy upgrades and renovation initiatives for its building stock, addressing both structural resilience and EE, also addressing climate adaptation principles, which would allow for an integrated investment. Preventive investments in resilient infrastructure make economic sense and deliver many benefits by protecting lives and assets, avoiding disruption of services, and creating various developmental and climate change–related co-benefits. Given that existing structures tend to have inadequacies beyond their vulnerability to earthquakes, retrofitting programs that enhance both seismic resistance and EE could yield multiple co-benefits. Integrating upgrades for earthquake resilience with energy improvements aligns with European and international goals to reduce greenhouse gas emissions while extending the lifespan of buildings, enhancing safety, and lowering life-cycle costs.

Promote a holistic approach to resilience of public and private infrastructure

To meet the challenges of seismic and disaster risks, Croatia needs to promote a holistic approach to resilience (green, resilient, and inclusive) that includes a comprehensive regulatory framework, as mentioned in the Governance of earthquake risk management section, and a focus on public and private infrastructure exposed and vulnerable to different hazards. While the country has taken significant steps to build resilience to floods by investing in flood protection,

[90] Croatia is one of the most restrictive EU countries in terms of access to and exercise of the profession of engineering. *See* EC 2021, Link.

[91] EC 2023, Link.

earthquakes have received considerably less attention, and public awareness of risks and appropriate courses of action is still limited. An important part of a holistic approach to disaster resilience is an adequate framework for prevention and preparedness that facilitates the reduction of risk, avoids the creation of new risks, and enhances preparedness to manage disaster impacts and recovery needs.

Maintain a registry of engineers for pre- and post-earthquake RVS

Croatia can build on its existing damage assessment training programs to maintain a national registry of trained and certified inspector-engineers for pre-earthquake RVS through the HCPI, enabling swift deployment in emergencies.[92] These engineers could be deployed not only to promptly assess the structural safety of buildings but also to conduct pre-earthquake RVS of all public buildings to prioritize them for seismic safety interventions. As a result, buildings could be prioritized, with some needing immediate repair and others requiring further seismic assessment. Providing specialized training and tools would enable this main pool of structural engineers to preliminarily assess the structural safety of buildings and support decision-making for risk reduction efforts. The HCPI-IS is currently implementing the Strengthening the Capacities and Equipping of the Croatian Center for Earthquake Engineering - Emergency Services project, which addresses the problem of lack of capacity and coordination for emergency engineering activities in the event of earthquakes and other crisis situations in Croatia.[93] The same training could be expanded to certify engineers for conducting pre-earthquake RVS of public buildings to support risk-informed investment planning. This training could also be made mandatory within university civil engineering curricula to ensure future cohorts of engineers are certified. This registry would help classify buildings by risk and prioritize retrofitting needs.

Bridge the gap between existing regulations and infrastructure compliance

To mitigate risks, Croatia needs to bridge the gap between existing regulations and actual infrastructure compliance — currently estimated at only 5 to 10 percent of the building stock, corresponding to buildings constructed after 2012 that fully meet current seismic standards. In Zagreb, nearly one-third of the housing stock was built before 1964 without seismic considerations, making it particularly vulnerable, while more than half of the housing stock built between 1964 and 2013 was designed to significantly lower seismic standards than those required today. Additionally, numerous buildings legalized under special laws lack verified earthquake resilience. The process was rounded off by the adoption of the Act on the Treatment of Illegally Constructed Buildings (Official Gazette 90/11, 86/12, 143/13, 65/17, 14/19). However, the actual safety status of buildings constructed during that period is unknown for up to 30 percent of the building stock, mostly residential. Therefore, strong earthquakes and landslides could result in an unexpected collapse or severe damage to building structures that should have been built according to the prescribed seismic construction standards since 1964[94]. To address this, Croatia should: develop a more accessible and enforceable regulatory framework for existing buildings, including differentiated safety requirements for retrofits and energy renovations; promote collaboration between research institutions, engineering associations, and local authorities to systematically assess and strengthen structural performance; and invest in national-level monitoring systems to track compliance and risk exposure across the building stock. These efforts will also prepare Croatia to adopt future revisions of Eurocodes, aligning with European standards.

Complementing these regulatory enhancements, improving training and technical skills in the construction market is crucial. By integrating state-of-the-art research into continuous education and training programs, including green upskilling, Croatia can build capacity for energy-efficient and resilient construction. This dual approach ensures that both the regulatory framework and the technical expertise of professionals are aligned, thereby enhancing the country's ability to implement effective interventions and maintain compliance with evolving standards.

[92] While there is a registry of certified engineers managed by the Croatian Chamber of Civil Engineers, under HCPI, this registry would cover trained and certified inspectors/engineers for pre-earthquake RVS, and also for integrated infrastructure solutions.

[93] HCPI. Strategic Project: Strengthening the Capacities and Equipping the Croatian Centre for Earthquake Engineering [Strateški projekt: Osnaživanje kapaciteta i opremanje Hrvatskog centra za potresno inženjerstvo]. Link.

[94] GoC 2019a.

Develop a standardized multi-tier approach to seismic safety assessment of buildings

To further strengthen earthquake risk prevention and support ongoing and future risk reduction programs, Croatia needs to build institutional capacity by developing a standardized multi-tier approach to seismic safety assessment of buildings. This will also help improve exposure data collection mechanisms and prioritization of risk reduction in a large building portfolio. Given the Croatian context, this seismic safety assessment framework should consider the risks posed by nonstructural elements such as facade and balconies.[95] The responsible government authorities and departments, as well as building owners, can use the results from this assessment to prioritize the buildings that need retrofitting. As there are many vulnerable buildings, prioritizing data collection and collecting key structural vulnerability data could help reduce the list of candidate buildings. In addition, the absence of a comprehensive building database hinders seismic risk assessments; thus, Croatia should prioritize the development of a national inventory for building materials, age, structural system, and occupancy category. This would facilitate risk assessments and more targeted investments in seismic resilience. Additionally, the government should explore partnerships with local authorities and private sector stakeholders to improve exposure data collection and integration.

Raising awareness on securing the nonstructural elements

Securing the nonstructural elements is a low-cost measure that improves safety during an earthquake and saves lives. This is especially helpful with low-magnitude earthquakes, which may result in many injuries. Nonstructural components of buildings include all those components that are not part of the structural system, namely the architectural (e.g., facade, balconies, partitions, cladding, ceilings, and chimneys), the electrical and mechanical (e.g., distribution panels, plumbing, piping), and the contents (such as bookcases, other furniture, and desktop equipment). In Croatia, the 2020 earthquakes in Zagreb and Petrinja underscored the risk posed by unsecured nonstructural elements, including chimneys, roof tiles, and decorative façades, which generated hazardous debris that caused life-threatening injuries and material damage, even in buildings that remained structurally sound.[96] A good initiative was the European project KnowRISK[97] which aimed to guide people in the first steps of prevention in a straightforward manner, minimizing or avoiding injuries, damage, and long-term financial consequences. The concept was that anyone can mitigate seismic risk in his or her own environment by adopting simple and low-cost measures, such as seismic mitigation solutions for nonstructural components.

Enhance collaboration between different stakeholders

To advance earthquake risk prevention, Croatia should deepen research integration into policy and investment strategies. Following the 2020 earthquakes, collaboration between the research and engineering communities highlighted the value of knowledge sharing and a unified approach to applying regulations. Establishing partnerships with academia and research institutions would also support cost-effective investment in disaster risk reduction by targeting resources more efficiently. The HCPI could be further strengthened as a national center of excellence for seismic risk, with an interdisciplinary and cross-sectoral approach modeled after those in Italy and New Zealand, could further enhance knowledge transfer, risk awareness, and the development of mitigation strategies.

Target investments in earthquake resilience most vulnerable sectors and infrastructures

Targeting investments in resilience in Croatia's most vulnerable sectors and infrastructures would greatly benefit the society, culture, and environmental preservation of the region. First, it would help preserve infrastructure and cultural heritage by retrofitting buildings that are important for the communities they serve and boost the sense of belonging and identity in those areas. Also, it would provide environmental improvements, such as ensuring the accessibility and availability of green areas and their integration with urban surroundings. Regarding the social aspect, providing the community with a greater sense of resilience and data related to DRM in the area and civil protection activities and risks would develop greater awareness and engagement within society. Therefore, investing in improving critical entities, including a substantial share of emergency response buildings that will not be able to stay operational if another disaster occurs, will bring economic and socio-environmental benefits that will outweigh costs in the longer term and save lives.

[95] Oliveira, C., et al. 2016. Link.
[96] Markušić, S. 2020, Link.
[97] O'Neill, H., et al. 2019, Link.

EARTHQUAKE EARLY WARNING AND PUBLIC AWARENESS

This chapter focuses on EWSs, EEW, and public awareness. While long-lead time forecasting of earthquakes is not possible, short-term warnings of several seconds can be feasible, enabling protective actions that can reduce casualties or damage. Earthquake-triggered tsunamis can have longer lead times, allowing further protective action to be taken. However, timely alerts must be combined with adequate training and an educated public to successfully enhance societal resilience against earthquake risks.

GENERAL CONTEXT

Croatia's risk communication and awareness initiatives are implemented at the national and local levels, focusing on continuous DRM education and practical skills for all age groups, from kindergarten to university. Through the National Platform geared by CPD, awareness-raising activities include workshops, seminars, evacuation exercises, and creative initiatives like literary and art projects. They also include a specific 'action' brochure for every hazard that might affect Croatia, explaining the hazard and how to respond to it. Additionally, they provide different learning materials for children, such as animated videos explaining how to reduce disaster risk and how to respond to different catastrophes[98]. Online resources, such as dashboards with hazard and risk assessment data, complement these activities. Furthermore, disaster risk reduction workshops and training events, often in collaboration with the Disaster Preparedness and Prevention Initiative for South-Eastern Europe (DPPI SEE) and United Nations Office for Disaster Risk Reduction (UNDRR), promote a holistic, regional approach to resilience building and provide tailored education for school principals and local governments, fostering capacity development at all levels. In August 2023, Croatia established the SRUUK EWS, co-financed by the EU, to notify citizens and civil protection participants about imminent dangers like natural disasters, epidemics, or other crises.

Moreover, in Croatia, public alerts are issued through sirens, public address systems, electronic media, and mobile device messages. Each warning signal is accompanied by public communication that provides timely and essential information for effective protective action. Residents and visitors in specific areas of Croatia receive warning messages on their mobile devices in cases of extraordinary events that pose potential threats to life, health, property, or the environment. Such events include natural disasters, technological accidents, or human-induced incidents, such as floods, fires, hazardous material accidents, dam failures, or epidemics. Finally, surveys have been conducted in Croatia to assess citizens' disaster awareness. A 2024 report by the EC revealed that Croatian citizens feel most vulnerable to extreme weather events (43 percent), followed by geological disasters (39 percent) and human health emergencies (33 percent).

CURRENT ARRANGEMENTS

Strengthening public awareness and preparedness remains a national priority, with ongoing efforts to enhance disaster communication and build a more risk-informed society in Croatia. According to the Croatian National Platform for Disaster Risk Reduction,[99] to lower the risk and damage earthquakes pose, it is necessary to lower the exposure by informing the population of the existing risks and warning them about potential hazards. Additionally, Croatia has developed an EWS to enhance its preparedness when a crisis hits, known as SRUUK.[100] However, in Croatia, given the context, there are no specific EWS for earthquakes. Finally, the civil protection unit has organized several national and international trainings and workshops to stay up-to-date and improve their preparedness and response to disasters, including earthquakes.

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[98] GoC. n.d. *Reducing Disaster Risk Portal- Educational Materials*. Link.

[99] Croatian National Platform for Disaster Risk Reduction. *What Is Disaster Risk Reduction and Why Is It Important?* [Što je smanjenje rizika od katastrofa i zašto je važno?] Link.

[100] GoC, Ministry of Interior and Civil Protection. n.d. *SRUUK - Sustav za rano upozoravanje i upravljanje krizama*. Link.

Public awareness and preparedness

In addition to the aforementioned measures, the government has made efforts to make the population more aware and conscious of seismic hazards, with targeted activities for youth and guidance on how to overcome an earthquake. These include the "On the Road to Disaster Risk Reduction" government-led, EU-funded project that strengthened earthquake and disaster preparedness through school-based education, public awareness campaigns, and a mobile earthquake simulator, reaching thousands of students, teachers, and citizens nationwide. The earthquake simulator bus is a mobile earthquake simulator designed to provide a tangible and physical experience of seismic events. By simulating the shaking of an earthquake, it allows individuals to understand the physical sensations and potential impacts of such events. This hands-on experience is crucial for raising awareness about earthquake preparedness and the importance of building resilience. In addition, in partnership with the United Nations Children's Fund (UNICEF), 'Riskland' was developed as an educational board game aimed at teaching children about disaster prevention and risk reduction. Players advance along a winding path by answering questions related to disaster preparedness, learning how certain actions can mitigate the impacts of disasters.[101]

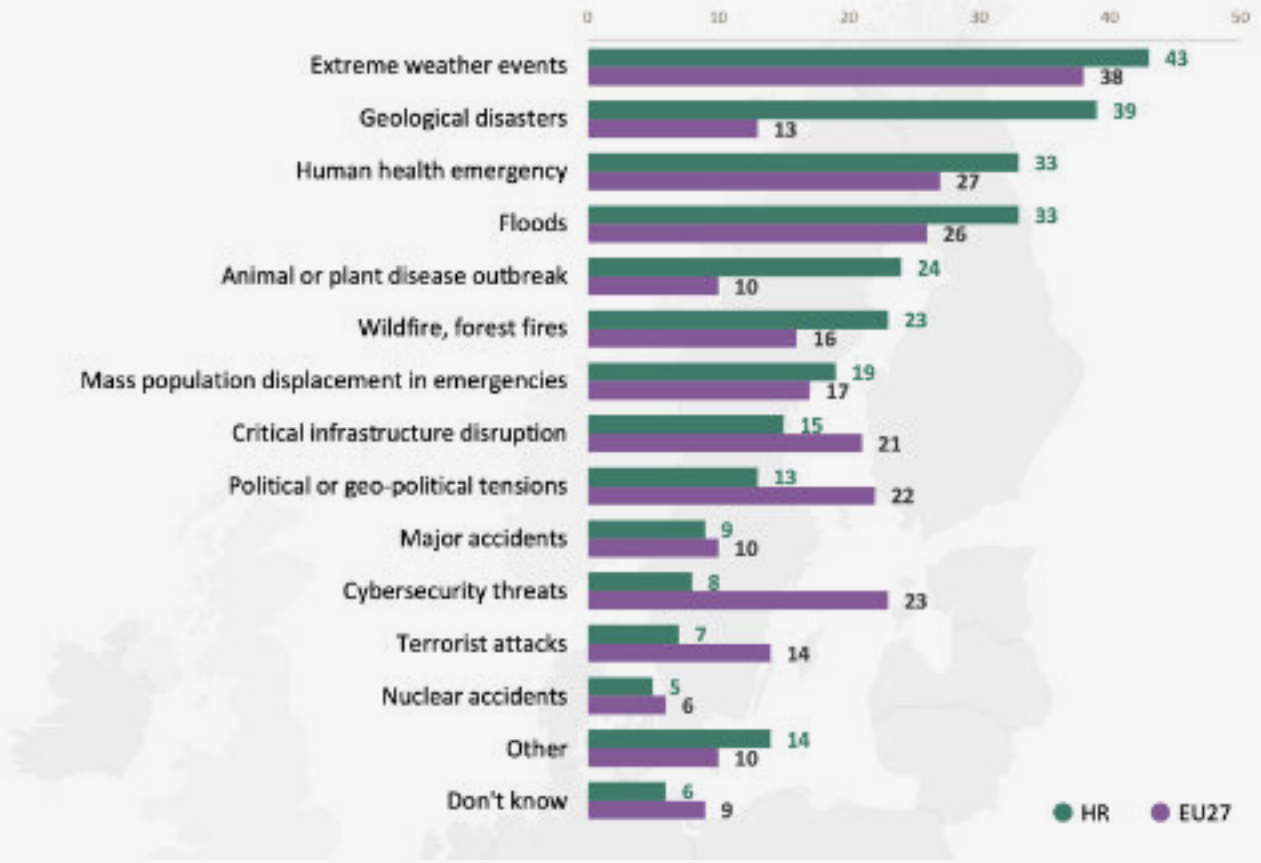
Following the 2020 earthquakes, Croatia has taken further steps to support citizens in ensuring that their homes are safe from earthquakes, especially in densely populated areas that have the highest earthquake risk. The CPD hosts an "Educational Corner" on its disaster risk reduction portal, offering a variety of materials such as brochures, videos, and other educational resources. For example, the leaflet on seismic risk advises creating an emergency action plan and taking preventive measures, such as securing wardrobes and shelves against walls and preparing an emergency kit. It also provides guidance on how to act before, during, and after an earthquake. Additionally, the platform features educational videos for children, available in both Croatian and English.[102] After the 2020 earthquakes, residents were notified on the usability of the affected buildings, following a colored-coded system, which helped them assess which buildings were safe and unsafe for residents. However, Croatia should keep making efforts to develop systems to notify residents and potential buyers of the seismic risk of their property/land, which would greatly benefit seismic risk prevention and preparedness in urban planning.

The 2024 Eurobarometer on disaster risk awareness and preparedness revealed that Croatian citizens feel most exposed to extreme weather event and geological events, and that a large part of the population trust the information provided by the government and other authorities Box 2.

[101] UNICEF. *Croatia disaster risk reduction*. Link; UNDRR 2019, Link.
[102] Civil Protection Directorate. 'Earthquake. What does it do?' [*Potres – što učiniti?*] YouTube video. Link.

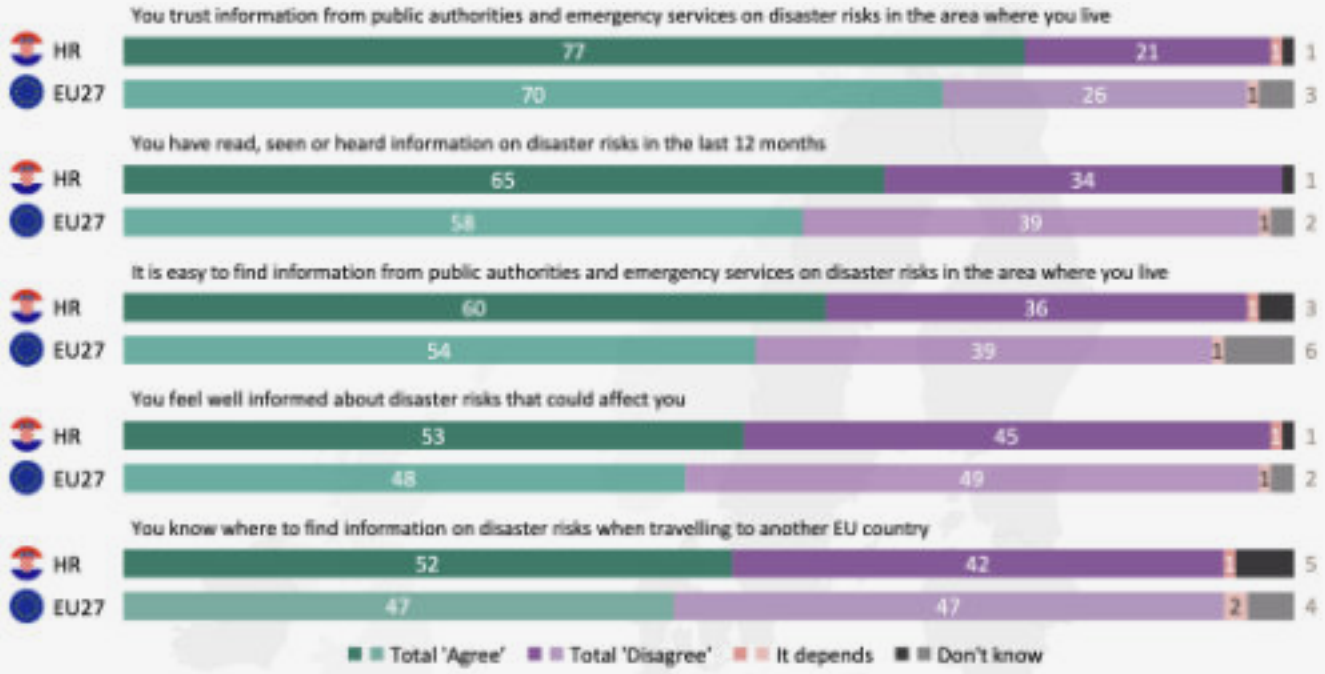
Box 2. Eurobarometer disaster risk awareness and preparedness of the EU population: Croatia

A 2024 Eurobarometer report by the European Commission revealed that Croatian citizens feel most exposed to extreme weather events (43 percent), followed by geological disasters (39 percent) and human health emergencies (33 percent).



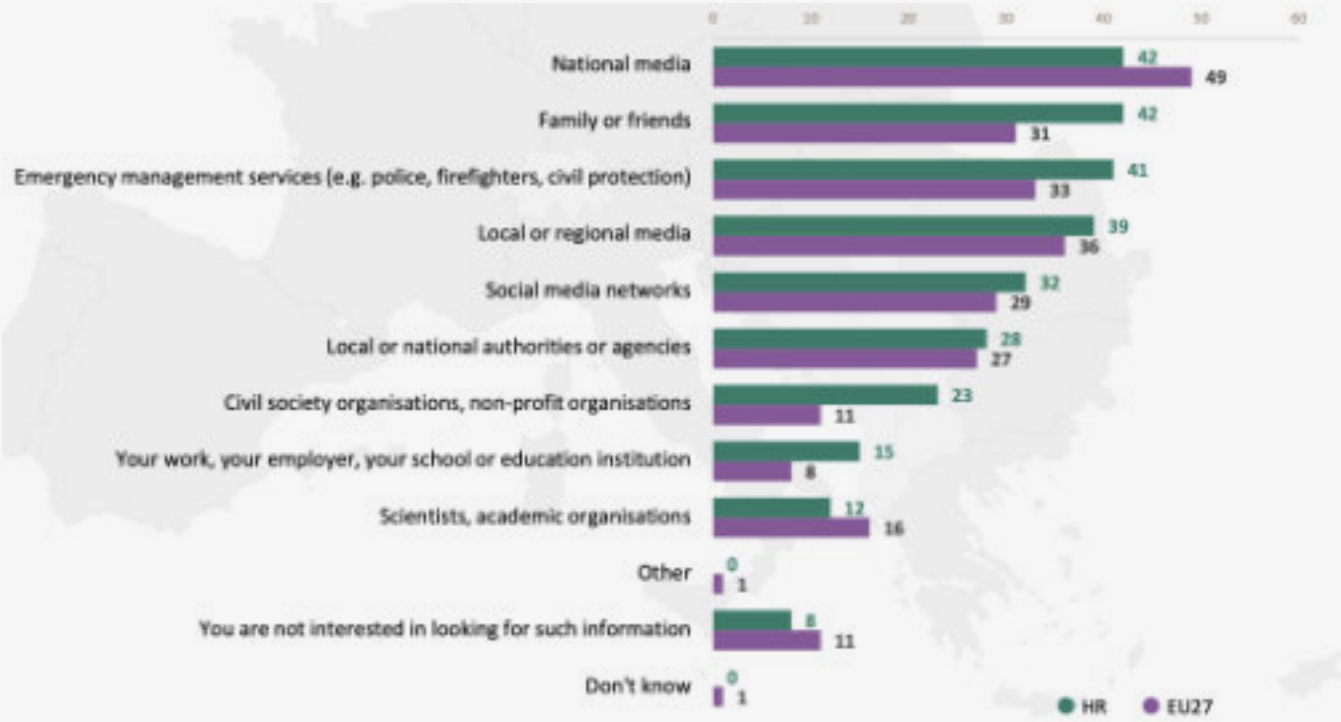
Source: Eurobarometer

Regarding the level of information and trust in disaster risk information, 77 percent of the people in Croatia trust information from public authorities and emergency services on disaster risk, which is higher than the EU average of 70 percent. Also, in Croatia, 65 percent of the people confirm that they have read, seen, or heard information on disaster risk in the last 12 months, in contrast with the 58 percent EU average. Similarly, 60 percent of the people in Croatia believe that it is easy to find information from public authorities and emergency services on disaster risks in their area, whereas the EU average is 54 percent. However, only half of the population (53 percent) believe they are well informed about the disaster risk that could affect them, a value much closer to the 48 percent EU average.



Source: Eurobarometer

When asked which sources of information they would use to learn about disaster risk, 42 percent of the respondents said, "National Media" and "Family and Friends;" 41 percent said, "emergency management services;" and 39 percent mentioned "local and regional media." The lowest value (not considering the "Other," "You are not interested in looking for such information," and "Don't know" sections) was for "Scientists and academic organizations."



Source: Eurobarometer

EWS

SRUUK, the Early Warning and Crisis Management System, is a unique tool that, since August 2023, has been used in Croatia to quickly and effectively inform citizens and civil protection participants about impending dangers and measures that need to be taken to reduce human casualties and material damage, via messages via mobile phones.[103] This EWS, created in August 2023, enables the quick and efficient notification of citizens and civil protection participants about imminent dangers and the measures that need to be taken to reduce human casualties and material damage, through messages sent to mobile phones. Residents of a specific area in the Republic of Croatia, as well as its visitors, will receive a warning message on their mobile devices during a crisis situation. The message will inform them of extraordinary events in the area that pose potential threats to human lives, health, property, or the environment, such as natural disasters, large-scale accidents, epidemics, or other types of crises. Alongside the notification of the imminent dangers, the message will include measures that must be urgently undertaken to minimize negative consequences. In addition to residents and visitors, participants in the civil protection system in the affected area will also receive the notification, enabling a faster response to the crisis and mitigation of its effects.

An alerts and communication mechanism is available in Croatia for prompt earthquake notifications.[104] This system is known as the Automatic Earthquake Location System. When an earthquake takes place, the data and information regarding that event are sent to the main center of the Croatian Seismological Service in Zagreb almost in real time (1–2 seconds delay). Then, the data are processed automatically, and within less than two minutes, the system provides the automatic location of the earthquake and its main parameters (magnitude, time of occurrence, and hypocenter depth). However, before publicizing any of the results, a manual verification of the solution is required. It is important to note that the precision of the parameters increases with the magnitude of the earthquake, meaning that some smaller magnitude earthquakes may not be detected at all.

Following the 2020 earthquakes, there was an increase in public awareness and use of such systems through information portals like 'potresi.hr'. These platforms provide real-time updates and detailed information about seismic activities, enabling individuals to take necessary precautions. Additionally, educational resources and safety guidelines are often shared to help communities better prepare for potential emergencies. The accessibility and reliability of these systems have contributed significantly to enhancing public safety and disaster preparedness.

[103] GoC, Ministry of Interior and Civil Protection. n.d. *SRUUK - Sustav za rano upozoravanje i upravljanje krizama.* Link.
[104] Seizmološka služba Hrvatske 2016, Link.

KEY CHALLENGES

In Croatia, information on the earthquake risk of buildings or location are not easily accessible. It would be very useful if people could easily find preliminary information about the seismic risk of their building, for example, about which materials were used in the construction of their building. Such information could incentivize solutions and increase risk awareness, including for selecting house insurance.

More workshops or materials (e.g., brochures) should be made available for the population to understand how the existing EWS works as well as to know how to set up their phones to receive emergency notifications when a disaster occurs. There are segments of the population (older people, people who live in rural/isolated areas) that do not have the means (e.g., social media) to understand how to set up these notifications or how they work when a disaster occurs.

Given Croatia's seismic context, where earthquakes strike close to densely populated areas with little to no warning, efforts are best focused on strengthening post-event alerting systems and aftershock warnings. Unlike in Japan or regions in South America, where earthquakes occur many kilometers away with the epicenters or underground foci of the earthquakes allowing at least about 30 seconds of time for detection, in Croatia earthquakes happen in densely populated areas, where, whether it is a stronger or weaker earthquake, the area shakes immediately, leaving too little time to respond effectively. Therefore, establishing an EEW system in Croatia remains a challenge. An EEW system consists of a seismic network of accelerometers and seismometers at various seismic stations in a region, as well as algorithms capable of detecting and analyzing seismic events a few seconds after initiating the fault rupture, providing real-time data on ongoing earthquakes. However, earthquakes in Croatia happen very close to populated areas, which complicates the development of a seismic-specific EWS. Thus, a feasibility study of an EEW system could determine whether such a system could be effective in Croatia.

The feasibility of an EEW system hinges on having a dense network of seismic stations to ensure rapid detection and sufficient lead times. Depending on the lead time (i.e., the time between the alert and the onset of strong shaking), EEW systems can trigger automated protective actions—such as shutting off critical systems (e.g., gas pipelines). When combined with public awareness and training, such systems can also enable individuals to take context-appropriate protective actions, such as "drop, cover, and hold on" or moving to a safer location. In the same vein, the NDRMS focuses on strengthening Croatia's seismological monitoring capacity through the expansion and modernization of the seismic station network, including advanced instrumentation and fault zone monitoring, to support real-time data collection and improved earthquake risk assessment. As such, efforts may be better directed at enhancing post-event alerting, including for aftershocks, and ensuring robust public communication systems.

Since Croatia is a tourist destination, it should work on developing a system to keep tourists and visitors aware and informed if an earthquake occurs. It should be a system that complies with data protection regulations and is also accessible for those who are not accommodated in a hotel (easier to implement) but in a private house (e.g., Airbnb).

There is not enough earthquake risk awareness in Croatia. The results of the Eurobarometer survey[105] indicate that Croatians do not consider building earthquake resilience as the biggest EU priority, which, considering the several vulnerabilities the country faces regarding earthquakes, should be a number one priority and concern for its citizens. These results show that the population is not properly informed about the earthquake risk the country faces.

The present level of public awareness about the exposure and vulnerability to earthquakes in Croatia is not sufficiently developed to serve as a basis for compelling efforts to foster institutionalized seismic risk assessment, mitigation, and preparedness activities. The relatively low probability of occurrence of strong earthquakes in Croatia, compared to other natural disaster hazards, contributes to a pervasive ignorance of the fact that earthquakes are an unacceptable risk. Hence, it is crucial to act without delay and raise public awareness of earthquakes by organizing related campaigns and webinars that can also be promoted via social media or TV, as there is still time to react before another potentially disastrous earthquake strikes in Croatia.

[105] EC 2023c, Link.

KEY OPPORTUNITIES

With respect to earthquake preparedness and public awareness, the following three key opportunities have been identified: (1) increase public education on protective actions and general earthquake risk, (2) incorporate earthquake-specific considerations into the existing EWS, and (3) continue to invest in the development of a modern seismic monitoring network.

Increase public education on protective actions and general earthquake risk

Although Croatia is already working on developing various activities to raise awareness, it should strengthen its national and regional campaigns aimed at educating citizens on earthquake risks, safety measures, and the importance of preparedness. These campaigns could focus on two strategies: raising awareness of earthquake risk within the home and creating an educational campaign to prepare the population. The former could include developing a web platform where citizens could check whether their homes are prepared to withstand an earthquake, building on the disaster risk reduction web portal and available earthquake information.[106] These activities should include information about the types of buildings most susceptible to damage during an earthquake and how to identify risks in one's own home. Additionally, the government could develop guidelines on how to secure one's home in the event of an earthquake, including information on bolting furniture, storing water, and communicating during a power outage. The information available on this web platform would be based on the results of risk assessments. The second strategy should focus on creating an educational campaign to boost the population's earthquake preparedness. It should work on increasing the use of existing tools like the earthquake simulator bus and educational games like 'Riskland' to engage the population, especially children, in disaster preparedness. These hands-on experiences can enhance understanding of the physical sensations of earthquakes and teach actions to reduce risks. Such campaigns should also be expanded to support tourists, migrants, and vulnerable groups. For example, government agencies should invest in comprehensive public education efforts, building on tools like the CPD's earthquake brochure, ensuring they are available in multiple languages and disability-inclusive formats, such as braille or audio versions.

Incorporate earthquake-specific considerations into the existing EWS

While significant lead times from EEW to alert the public before imminent ground shaking are not feasible in Croatia, the feasibility of other near-real-time alerting for critical infrastructure could be further explored (e.g., automatic slowing of trains, shutoff of gas pipelines). Additionally, post-event messaging to affected populations can alert the public about potential aftershocks and remind them of which protective actions to take before, during, and after an earthquake. These earthquake-specific considerations can be integrated into the existing EWS in Croatia.

Continue to invest in the development of a modern seismic monitoring network

A higher density of seismic stations and seismic station networks can help advance scientific understanding and are the backbone of all EWS potential. In Croatia, higher coverage of seismic stations, especially near populated areas, could enable automated protective actions for critical infrastructure or inform near-real-time damage assessment, which may be useful in the response phase. Additional studies investigating the strategic placement of seismic stations may be beneficial.

[106] See, for example, GoC. N.d. Potres Letak. Link.

EARTHQUAKE PREPAREDNESS AND EMERGENCY RESPONSE

This chapter focuses on earthquake preparedness and emergency response. Earthquake preparedness includes training and exercises, as well as rescue and response capacity. Earthquake emergency response encompasses actions taken in the immediate aftermath to days or weeks after an event: search and rescue missions to assist trapped survivors, first aid provision, establishment of temporary shelters, restoration of basic services, mobilization of community volunteers, and building safety inspections.

GENERAL CONTEXT

The Civil Protection Headquarters functions as both an operational and coordinating body, and its CPD aims to minimize risks, prevent consequences of risks, organize activities related to DRM, oversee the civil protection operational forces, and ensure smooth coordination among all the participants of the civil protection system. In times of disaster, it is responsible for overseeing and coordinating the activities of civil protection operational forces, both during the preparatory phase and throughout the implementation of civil protection measures. The headquarters operates at both the national level and within units of local and county (regional) self-governments. It is composed of representatives from relevant public administration bodies, operational forces of the civil protection system, and other key legal entities that play an important role in civil protection in Croatia. At the regional level, county civil protection headquarters have been established, with a total of 21, representing 20 counties and the City of Zagreb. There are three main voluntary emergency services: the DVD,[107] the HCK,[108] and the HGSS.[109] In the Ready2Respond (R2R).[110] Diagnostic conducted in 2022, emergency response, specifically search and rescue, was an area identified as very strong for Croatia.

CURRENT ARRANGEMENTS

Training and exercises for emergency personnel

Croatia is working on providing efficient and up-to-date exercises and training for its operational forces and participants in the civil protection system, to test the readiness, equipment, planning documents, and actions of operational forces and participants in the civil protection system. Based on objectives and participants, the Croatian civil protection unit distinguishes between field exercises, command-staff exercises, simulation-communication exercises, and demonstration exercises. The civil protection unit has organized several national and international training sessions and workshops to stay up-to-date and improve their preparedness and response to disasters. In December 2024, the civil protection field exercise titled 'Earthquake 2024' was successfully organized and conducted.[111] The exercise simulated the consequences of a strong earthquake with a magnitude of 6.0 on the Richter scale, including building damage, outbreak of fires, evacuation, and the rescue of the injured. This exercise, organized by the City of Zagreb in cooperation with Croatian Telekom and key operational forces, aimed to test the readiness of the civil protection system and operational forces in the event of major disasters such as earthquakes and accompanying fires.

The HCPI[112] ensures the training of engineers on post-earthquake damage and usability assessment, as well as the acquisition of the necessary equipment to increase the level of preparedness. The HCPI contains training materials for engineers, which aim at a thorough understanding of the procedure and the acquisition of specific skills necessary to perform inspections quickly and efficiently and to

[107] Voluntary Fire Brigades. See GoC 2019b.

[108] Croatian Red Cross. See GoC 2023b.

[109] Croatian Mountain Rescue Service. See GoC 2015a; GoC 2023a.

[110] The Ready2Respond (R2R) framework is a methodology that provides an understanding of existing EP&R capacities in a municipality, country or region and assesses 360 data points related to facilities, personnel, equipment, information and legal frameworks. See GFDRR and World Bank 2017, Link.

[111] City of Zagreb 2024, Link.

[112] HCPI 2025

evaluate buildings in emergency situations. Before the March 2020 earthquake, no systematic training of experts who could take part in post-earthquake inspection of buildings had been organized. During the first days after the earthquake, training sessions were organized at the Emergency Management Office premises, in the form of discussions, to educate engineers. Afterwards, considering epidemiological requirements banning personal contacts, the training material was posted in digital format, together with appropriate webinars. The manual and webinars were inspired by the Matilda project,[113] numerous exercises, and especially by experience gained in the assessment of earthquake-damaged buildings in Albania in 2019.[114] Training sessions were simultaneously conducted for the installation and use of the mobile application. Considering potential problems, direct communication with engineers was achieved within three WhatsApp groups that were initially conceived for communication between experts, namely for on-site consultation between inspectors (harmonization of assessments), but also for directing questions to headquarters (to solve difficult issues). In addition, these groups were used to forward significant new information to engineers every morning. It is noted that after the Zagreb 2020 earthquake, the training of engineers for the damage assessment process was conducted spontaneously (during the assessment process) as it took place during COVID-19, and the situation was difficult, while after the December earthquake, the engineers were better trained, and the form and mobile app used were upgraded.

Civil society engagement and volunteer emergency services

Volunteer emergency services are a crucial part of the response when a disaster occurs in Croatia, with several entities mandated to support. They work closely with the pertinent authorities to try to lower the negative outcomes by providing medical aid, among others. Croatia has three official volunteer emergency services, including the DVD: these brigades are organized within the HVZ[115]; the HCK; and the HGSS.

Volunteer emergency services in Croatia, such as the DVDs, HGSS, and HCK played a critical role in Croatia's emergency response system during the 2020 earthquakes. Also, during the 2020 earthquake, many volunteer emergency services and civilians helped in the rescue missions. The HGSS was engaged in the search and rescue missions, helping locate and rescue people trapped under rubble. It used specialized equipment and highly trained rescue dogs to assist with operations. DVD from across Croatia mobilized to assist with extinguishing fires caused by structural damage, rescuing people, and clearing debris. They provided support alongside professional firefighting units. The HCK played a key humanitarian role, providing emergency shelters; distributing food, water, and essential supplies; and offering psychological support to affected families. There was also significant civil society engagement. In the December earthquake, local residents and citizens from across Croatia spontaneously organized to provide aid. Volunteer groups delivered food, blankets, and other necessities to affected areas.

[113] EC 2014, Link.
[114] Atalić, J., M. Šavor Novak, M. Uroš, and M. Baniček. 2020.
[115] Croatian Firefighting Association.

Emergency evacuation

In Croatia, the Civil Protection Act ensures that to reduce the possible consequences of a major accident or disaster, the head of civil protection staff can issue a verbal order or make a decision for the preventive implementation of a forced evacuation.[116] This decision must contain provisions on the implementing authority, measures, time, and place where the forced evacuation measure is implemented. In an attempt to improve preparedness and response to disasters, the Rijeka Regional Civil Protection Office organized an evacuation exercise. The exercise focused on coordinated action by the operational forces of the civil protection system in response to an earthquake scenario that occurred in the Rijeka area. The exercise demonstrated the capacities and capabilities of the operational forces of the civil protection system of Primorje-Gorski Kotar County, as well as their coordination with the State Civil Protection Intervention Unit in Rijeka, as additional assistance in carrying out the evacuation.[117] Additionally, it is central to widely publicize designated evacuation routes and assembly sites, and routinely verify their structural resilience, accessibility, and adequacy of pre-positioned supplies to ensure they are fully operational when needed.

KEY CHALLENGES

According to the R2R assessment conducted following the 2020 earthquakes, capacity-building efforts in Croatia, especially in training and knowledge management, are areas for further development. The assessment confirms that it is essential for Croatia to have sufficient capacity and continuous training, based on state-of-the-art research, to implement green, resilient, and inclusive considerations swiftly and effectively, as well as address infrastructural deficiencies in terms of aged buildings.

One of the biggest challenges in Croatia is to establish a legally prescribed preparedness and emergency response procedure for the next earthquakes, using the available risk information as well as the knowledge and expertise from past earthquakes and clearly assigning the responsibilities of each authority. A national plan for earthquake disaster management with a focus on preparedness and emergency response could be developed to provide a comprehensive framework for cross-governmental preparedness. The role of each institution should be defined, and exercises should be carried out to practice implementation.

There is a lack of civil society engagement in earthquake training and drills. While earthquake-specific training exercises exist, they are primarily focused on institutional response and do not include the public.

KEY OPPORTUNITIES

With respect to enhancing earthquake readiness, the following three key opportunities have been identified: (1) strengthen volunteer and civil society engagement, (2) develop emergency evacuation protocols, (3) enhance training and exercises, (4) strengthen the training and capacity building of emergency personnel and the broader public, and (5) maintain a registry of trained and certified inspector-engineers.

Strengthen volunteer and civil society engagement

Croatia should expand its volunteer capacities by strengthening funding, equipment, and training. It should increase its operational forces of the civil protection system, like the HCK, the HVZ, and the HGSS by providing better funding, equipment, and training. It should also foster closer collaboration between civil society organizations and official emergency services to strengthen grassroots disaster response capabilities. Finally, it could establish mechanisms to channel spontaneous citizen-led aid efforts into structured response strategies, ensuring efficiency and coordination during disasters.

Develop emergency evacuation protocols

Croatia should standardize its evacuation plans by ensuring that those plans at the national and regional levels include clear roles, responsibilities, and communication strategies for all operational forces and civil protection units. Additionally, it

[116] Art. 26 retrieved from GoC 2023b, Link.

[117] GoC, Ministry of Interior and Civil Protection. n.d. An Evacuation Exercise Was Held in Rijeka on the Occasion of the International Disaster Risk Reduction Day [*Održana vježba evakuacije u Rijeci povodom Međunarodnog dana smanjenja rizika od katastrofa*]. Link.

should replicate and expand regional evacuation exercises, like the Rijeka scenario, to test coordination between local, regional, and state-level civil protection forces.

Enhance training and exercises

Croatia should organize more national and international disaster simulations, like the 'Earthquake 2024' exercise, to test and refine operational readiness for multiple disaster scenarios. It could also be a good opportunity to partner with businesses to enhance training exercises by leveraging private sector resources, such as telecommunications technology used during exercises like 'Earthquake 2024'.

Strengthen the training and capacity building of emergency personnel and the broader public

Croatia should continue to provide ongoing training for civil protection teams and emergency personnel, but it should also include the broader public, businesses, and community organizations. Training should focus on earthquake-specific scenarios, preparedness measures, and post-disaster recovery efforts, and it should be frequently organized at the local, regional, and national levels. These exercises should involve various stakeholders, including government agencies, emergency services, and the public, to ensure readiness in the face of a seismic disaster. Integrate a nationwide public-education and outreach program on earthquake preparedness, providing clear guidance on protective actions and promoting community-level first-aid training, to strengthen household readiness and complement technical risk-reduction measures.

Maintain a registry of trained and certified inspectors-engineers

The HCPI-IS should maintain a registry of trained and certified inspector-engineers for immediate deployment in post-earthquake damage and usability assessment of buildings (see also Earthquake risk prevention, reduction, and mitigation). To ensure a sustainable pipeline of qualified professionals, damage assessment training should be embedded in university-level civil and earthquake engineering programs, such as the University of Zagreb's specialist study in Earthquake Engineering.[118] While formal certification as damage inspectors is not yet established, integrating such training into academic curricula can lay the groundwork for future certification frameworks. The same registry could also be used for engineers conducting pre-earthquake RVS of all public buildings for their prioritization as a risk reduction opportunity.

[118] Faculty of Civil Engineering, University of Zagreb. *University Specialist Programme in Earthquake Engineering*. Link.

EARTHQUAKE RECOVERY, RECONSTRUCTION, AND POST-DISASTER FINANCING

This chapter covers earthquake recovery, reconstruction, and post-disaster financing. It refers to actions taken after the response phase when priorities shift toward restoring affected areas, rebuilding buildings and infrastructure, and helping communities return to normal.

GENERAL CONTEXT

Assistance after a disaster is regulated by the Act on Mitigation and Elimination of Consequences of Natural Disasters (OG 16/19) and the Ordinance on the Register of Damages of Natural Disasters (OG 65/19). Also, the Ministry of Finance uses budget reallocations to finance unplanned needs, as the Amendment of the Public Financial Management Act (Articles 58 and 59) removes restrictions on the use of budget reallocations after a disaster. Budget reallocations, including identification of the original account and the redesignated account, are reported twice a year. Additionally, Croatia is advancing its efforts to enhance damage and loss assessment as a critical component of post-disaster recovery and reconstruction planning. A key initiative involves the development of a bottom-up disaster loss data (DLD) collection and damage and loss assessment system. This system will be created through collaboration with local and national stakeholders, who will also receive targeted education and training to ensure effective implementation. The renewed disaster loss and damage assessment system will establish clear roles for responsible stakeholders and a coordinating body to oversee its operation. The collected data will not only guide recovery and reconstruction efforts but also be integrated into localized awareness-raising activities and materials to make the information more relevant and relatable for citizens in the pilot areas. Additionally, efforts are underway to provide recommendations for a dedicated law is being planned to formalize and institutionalize the DLD collection and assessment process.[119] On the other hand, banks currently recommend that those seeking a home loan should purchase a household insurance policy. However, insurance is only required to cover fire risks and not natural hazards in general. For multi-apartement buildings, all owners have to pay for a reserve fund called *pričuva*. The reserve is used for general repairs but can also be used for repairs resulting from natural hazards. A new law is being introduced in Croatia that requires landlords to have property catastrophe insurance for their buildings. This step will help ensure protection against disasters.

CURRENT ARRANGEMENTS

After the 2020 earthquake, Croatia received support for recovery and reconstruction from various international organizations.[120] The RDNAs estimated the damage and losses from both 2020 earthquakes at €16.1 billion (€11.3 billion for Zagreb[121] and €4.8 billion for Sisak-Moslavina County[122]). The EUSF granted €1 billion—€684 million for the March earthquake and €319 million for the December earthquake, [123] among other EU funds, such as the NRRP.[124] Through the €183.9 million (US$200 million) Earthquake Recovery and Public Health Preparedness Project, the World Bank is supporting Croatia with earthquake reconstruction efforts in Zagreb and the surrounding areas, improving institutional capacity for reconstruction, and strengthening national systems for public health preparedness.[125] To further support localized and evidence-based decision-making, a localized Post-Disaster Needs Assessment (PDNA) and a Municipal Finance Assessment

[119] EU 2024b, Link.

[120] *See* GoC. n.d. Financial resources for reconstruction [*Financijska sredstva za obnovu]*.Link.

[121] Of the €11.3 billion, €10.661 billion is the value of destroyed physical assets, and €0.640 billion are losses; see GoC 2020a.

[122] Of the €4.8 billion, €4.12 billion is the value of damaged physical assets, and €714 million refers to losses; see GoC 2021a.

[123] GoC 2023a, Link.

[124] EC 2023a, Link.

[125] Information on the Earthquake Recovery and Public Health Preparedness Project (P173998) is available at Link.

(MFA) were also undertaken. These tools helped identify local recovery priorities and fiscal needs, strengthening the capacity of municipalities to plan and implement resilient recovery investments.[126]

Following the earthquakes, several laws, such as the Reconstruction Act, were passed to simplify reconstruction procedures in earthquake-affected areas; however, these were developed ad hoc and act as temporary recovery framework. Together with the NRRP, the most recent amendment (NN21/23) incorporates BBB elements, including a focus on seismic resilience, energy-efficiency targets, and the option of complete replacement. while also expediting approvals by simplifying administrative procedures, warranting continued attention to keep speed and resilience in balance.[127] Following the government's post-earthquake plan, the completion of the reconstruction of public buildings is expected by June 2026; meanwhile, the reconstruction of private properties should be completed by 2030.[128] Although the process of rehabilitation/reconstruction is ongoing for recently damaged buildings, a large number of aged public and private buildings remain vulnerable to earthquakes.

Budgetary instruments

In Croatia, Article 56 of the Budget Act allows for a budget reserve dedicated to covering costs from natural disasters, epidemics, environmental incidents, or other unforeseen events. The government can utilize this reserve but must report its usage to the Croatian Parliament (Sabor). However, the amount drawn from the reserve is capped at 0.5 percent of the planned budget revenues (excluding non-tax revenues, like fees). Dedicated budget lines that may also be used for disaster response include item A539025 (compensation for damage caused by natural disasters) and item A539020 ('assessment of damage from natural disasters'). Croatia has also benefited from the EUSF, receiving €683.7 million after the major earthquakes in 2020 (with a total of €706 million provided to Croatia from the EUSF).

Post-disaster assistance is governed by the Act on Mitigation and Elimination of Consequences of Natural Disasters (OG 16/19) and the Ordinance on the Register of Damages of Natural Disasters (OG 65/19). Funding for these activities comes from both the budget reserve and specific budget allocations, including funds designated for natural disaster compensation and damage assessment. For example, in response to floods and wildfires in previous years, budget reserves were allocated for reconstruction and equipment replacement. At the local level, subnational governments also use budget lines and reallocations to address disaster recovery. They can request additional state support if the disaster's damage exceeds 20 percent of their original income from the previous year or if property values in their area decline by at least 30 percent.[129]

[126] World Bank 2022, Link.

[127] In April 2022, the Minister of Physical Planning, Construction and State Assets presented a five-point plan to speed up reconstruction in earthquake-affected areas. This included organizational restructuring, streamlined procurement, regulatory amendments, improved communication with beneficiaries, and a ramp-up in both structural and non-structural reconstruction activities, with a target of starting works on over 1,000 homes within 2023. See: MoPPCSA, "Plan for Expediting Reconstruction," April 2022, Link.

[128] GoC 2024a, Link.

[129] GoC. Act on Mitigation and Elimination of Consequences of Natural Disasters (OG 16/19). [*Zakon o ublažavanju i uklanjanju posljedica prirodnih nepogoda*]. Link.

Evolution of legislation

The evolution of the legislation on recovery and reconstruction after the 2020 earthquakes resulted in a rapid increase in the rate of investments in reconstruction. Before the March earthquake, the only law to regulate recovery was the Law on Mitigation and Elimination of the Consequences of Natural Disasters. As soon as the first earthquake struck Zagreb, it was clear at the governmental level that the Croatian legal framework could not be kept as it was. The first recovery and reconstruction law was created to support the affected areas of the first earthquake. The law was revised following the December earthquake to orient toward creating emergency housing capacities for people whose homes were destroyed or severely damaged. The law was further amended to improve definition of the tasks of governmental bodies involved in the process of reconstruction, including the definition of the maximum allowed time for decision-making in the process of project approval and the definition of requested conditions that must be obeyed (e.g., preservation measures for cultural heritage buildings).

Other changes were also implemented after the 2020 earthquakes. Some included (a) the increase from 80 to 100 percent of the construction and reconstruction cost of the governmental financial support for reconstruction, with the possibility to receive the governmental subsidies in advance (only in cases where the buildings had a legal and official representative) or request a full refund for the applicable reconstruction costs (for cases where owners finance the recovery works by themselves); (b) the financing of the demolition of heavily damaged buildings completely by the government, and in cases where a building is endangering the surroundings or persons, the building demolition through a shortened administrative procedure (with a duration of up to 5 days), where the owners of a demolished real estate have the possibility to receive financial reimbursement for their real estate or they can request a replacement house (only for real estate where owners were living at the time of the earthquake).[130] Thus, a large number of reconstruction investments were approved and finally completed.

EU disaster funding

After the 2020 earthquakes, Croatia received post-disaster funds from different EU funding options such as the EUSF,[131] the Recovery and Resilience Fund (RRF), and the EU UCPM, among others. The country received €683.7 million after the March earthquake and €319 million after the December earthquake from the EUSF (*see* Figure 5). Almost €22 million of EUSF assistance and €35 million of the RFF were used to restore the damaged infrastructure at the Merkur Clinical Hospital in Zagreb.[132] Although Croatia faced challenges in implementing the EUSF within a short time frame—particularly as the earthquake highlighted gaps and limitations of the EUSF's focus on returning to the pre-disaster state—it ultimately succeeded in completing implementation on time. The Croatian authorities managed to fully spend the EUSF assistance in May 2023, several weeks before the end of the eligibility period. Ensuring complementarity of the funded operations was crucial since several EU funds were being used for reconstruction after the earthquakes with different eligibility rules and procedures. Another EU instrument, the UCPM, offered assistance to Croatia after the 2020 earthquakes. Additionally, through the UCPM, 15 countries sent immediate assistance, including housing containers, winter tents, sleeping bags, beds, and electric heaters.[133] Under the RRF, Croatia received close to €600 million, with the goal to BBB, dedicating specific measures to integrated seismic and EE investments, an example relevant for other countries interested in smart investments that yield multiple benefits (*see* Earthquake risk prevention, reduction, and mitigation).

Croatia received funds from the RRF, the European Regional Development Fund, the European Social Fund, and the European Agricultural Fund. It received €98 million from the European Regional Development Fund to provide additional support for

[130] Sigmund, Z., M. Radujković, and J. Atalić. 2022.

[131] From 2014 to 2025, Croatia requested EUSF support seven times for flooding and, earthquake recovery. From 2010 to 2014, it requested support five times for ice storms and flooding. In 2020, it submitted two requests: for the Zagreb earthquake (March) and another one for Petrinja earthquake (December). For the March earthquake Croatia was provided €684 million in EUSF funds, and for the December earthquake €319 million in EUSF funds. In total, Croatia received €1,025,69 million in EUSF funds.

[132] An example of blended EUSF and RRF funds is the reconstruction of the Sisak Secondary School, which received €5.4 million; €3.5 million from the EUSF and €1.8 million from the RRF to renovate the structure and improve the energy efficiency.

[133] European Parliament 2021, Link.

earthquake damage resilience, €2.6 million from the European Social Fund to support non-governmental organizations (NGOs) in providing aid to local communities, and €30 million from the European Agricultural Fund for Rural Development to restore agricultural production.[134] In 2025, five years after the earthquakes, 3,800 reconstructions with 37,000 housing units have been completed. Currently, the financial amount invested in the areas affected by the earthquakes is €3.5 billion, for both the reconstructions and construction of public and private buildings.[135]

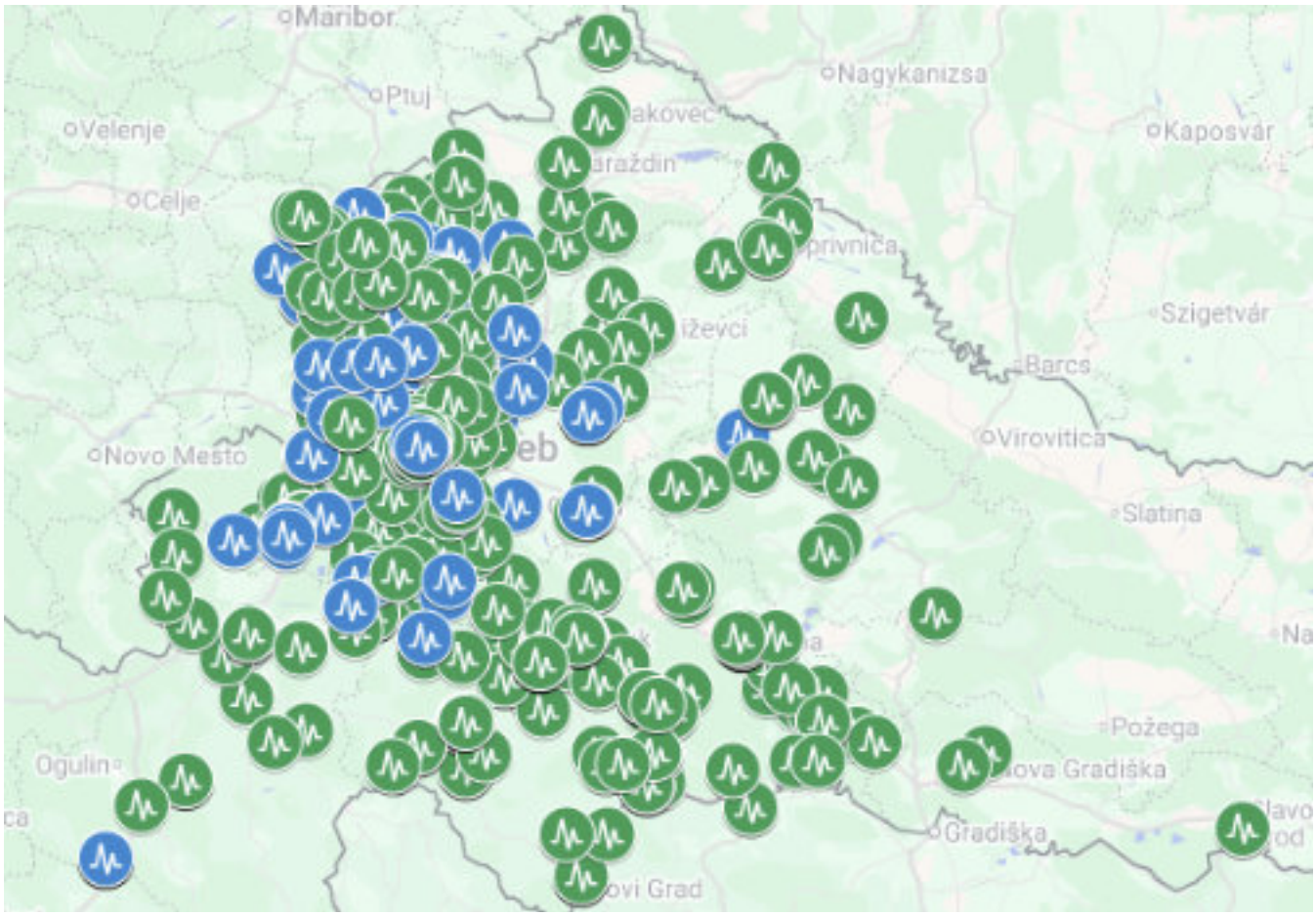
Progress of post-earthquake inspections procedure and recovery

After the 2020 earthquake in Zagreb, significant progress was made in post-earthquake inspections and damage assessment of different structures such as buildings, cultural heritage assets, and bridges (Box 3). RVS inspections of buildings were immediately initiated on a voluntary basis, focusing primarily on the safety and usability of the buildings. Details on the progress of post-earthquake inspections for the damage assessment of buildings in Croatia and anecdotes after the 2020 earthquakes can be found in Box 3. Organizing inspections on damage and usability of buildings in earthquake-struck areas is of paramount importance for ensuring the safety of the local population and should be conducted as soon as possible after a destructive earthquake.[136] Soon after the earthquake, the MoC established a parallel system for the inspection of cultural heritage assets based on separate detailed forms. The system for the financial damage assessment, required by law, was established three months after the earthquake but needed to be adjusted before implementation. The bridge inspection forms, which would be used during specialist inspections, were developed in the scope of the Study on Seismic Risk Mitigation. Moreover, the new Law on Reconstruction included additional steps for detailed engineering inspections required for the assessment methodology applied for RVS inspections.

[134] EC 2023b, Link.
[135] NoviList 2025, Link.
[136] M. Uroš et al. 2020.

Figure 5. The EU Solidarity Fund following the March and December 2020 Earthquakes

Source: Government of Croatia. Overview Of Infrastructure and Public Building Renewal Locations Financed from the EU Solidarity Fund. Link. *Note:* Blue = March 2020 earthquake; Green = December 2020 earthquake.



Damage and loss assessment

After the 2020 earthquake, to understand Zagreb's risk level and prioritize recovery efforts, authorities conducted damage assessments immediately after the seismic event, and teams of engineers conducted preliminary assessments and categorized buildings according to their usability. The earthquake highlighted the city's vulnerability to seismic risks, especially in its historic urban core, where construction often predates modern building codes. Teams of engineers and experts were deployed to inspect buildings, categorizing them as safe, restricted use, or unsafe based on their structural condition (see also Box 3). The response consisted of conducting preliminary assessments of the buildings; setting up a hotline and a web-based application for registering damaged buildings; clearing debris, damaged roofs and chimneys, and other potential hazards to safety; and ensuring accommodation and food for people whose homes were damaged in the earthquake.

Buildings were inspected and categorized according to the damage, which helped prioritize repairs. In the first phase of inspections, buildings were rated according to the following categories: green (usable: without limitations U1 or with a recommendation for short-term countermeasure U2), yellow (temporarily unusable and requiring a more detailed inspection PN1, or can become usable with suggested short-term countermeasures PN2), and red (unusable: due to external risks N1 or due to damage N2) (Figure 6). The aim was to commence emergency risk mitigation measures as soon as possible; reduce the danger of damaged buildings collapsing onto other buildings, sidewalks, or people; and determine whether people needed to be temporarily re-housed. In the first month following the earthquake, that is, by April 22, 2020, more than 13,000 buildings had been inspected, amounting to approximately 75 percent of all reported buildings. The progress could be followed through a 3D map showing the lower and upper town of the City of Zagreb (Figure 6). The classification system helped prioritize buildings for repairs and ensured safety for residents. Authorities also utilized geospatial mapping and historical data to identify high-risk areas and analyze them.[137] Box 3 explains the details on the progress of post-earthquake inspections for the damage assessment of buildings in Croatia and it shares some anecdotes after the 2020 earthquakes.

[137] GoC 2020b.

Figure 6. Damage and building usability assessment level

Source: Croatia 2020 Rapid Damage and Risk Assessment

Damage states determined based on the conducted post-earthquake field surveys and the usability assessment	Level
Slight structural damage	
Moderate structural damage	
Heavy structural damage	

Figure 7. 3D view of City of Zagreb buildings based on usability classifications

Source: Croatia 2020 Rapid Damage and Needs Assessment. Notes: View of Lower and Upper Town.

Box 3. Details on the progress of post-earthquake inspections for the damage assessment of buildings in Croatia and anecdotes after the 2020 earthquakes

In the first hours after the 2020 earthquake in Zagreb, experts trained for such inspections, that is, engineers experienced in damage assessment or who had undergone relevant training, were invited first. They immediately initiated inspections of buildings on a voluntary basis, focusing primarily on the safety and usability of the buildings. As the number of calls by citizens reporting damage increased with every passing hour, the CPD of the MoI, in cooperation with the Croatian Chamber of Civil Engineers, invited structural engineers to assist in these efforts. Within the first days after the earthquake, more than 150 engineers responded to volunteer in the rapid damage assessment of buildings. All of them were provided with necessary protective equipment (hardhats, vests, and so on) at the Emergency Management Office, so that they could safely enter the damaged buildings—and with gloves, masks, and hand sanitizers because of the pandemic. A major issue was that there was no official form for post-earthquake damage assessment. The engineers used the one from the Matilda project,[138] which focused on the design and implementation of a multinational macro-module for post-earthquake building safety assessment and countermeasures in international emergencies. Based on feedback from inspection teams on typical damage, the form was adapted, and a mobile application for building inspections was created. Special care was taken to cover, in the form, specific features of the building types and construction methods widely used in Croatia. It was then that the HCPI was established,[139] where over 20 institutions participated in making strategic decisions, aiming to become a center of excellence dedicated to seismic risk reduction. Training sessions, also inspired by the Matilda project, were organized and provided to engineers, so that they could properly inspect damaged buildings and estimate their usability as well as install the mobile app, for which appropriate instructions were also created. After conducting the post-earthquake damage assessment, the buildings were finally classified in one of the offered categories of building usability. Buildings can be classified as temporarily unusable when a detailed inspection by specialized engineers is required, or when a satisfactory level of safety can be achieved by short-term countermeasures (urgent interventions) after which the building can be declared usable.[140] Later, a database of engineers for post-earthquake damage assessment was created, where almost 400 engineers volunteered to participate. There were also many anecdotes in the response of the population. For example, engineers were threatened. Some people did not want to leave their houses because they claimed that everything they had was there. In some cases, engineers were shocked, so they were offered psychological support. Thus, the need for engineers to be trained in how to approach people was identified.

In preparation for the request for EUSF support, Croatia prepared an RDNA (results shown in Box 4); however, efforts are underway to improve and institutionalize this system based on lessons learned from the 2020 earthquake, under the DrawData project. As part of this process, technical assistance and training were provided to Croatian authorities involved in damage and loss assessment, as well as DRM data, using the 2020 earthquakes a basis.

[138] EC 2014, Link.
[139] Atalić et al. 2022.
[140] Uroš, M., et al. 2020.

Box 4. Findings of the 2020 post-earthquake rapid damage and needs assessments in Croatia

On March 22, 2020, Zagreb was hit by a magnitude 5.5 earthquake, the strongest earthquake recorded in 140 years. The event occurred in the middle of a nationwide lockdown due to the COVID-19 outbreak, and it affected COVID-19 testing centers and health facilities specializing in respiratory diseases. The earthquake-affected large sections of the population in Zagreb and the surrounding area. There was one fatality and 26 people were injured (18 severely). According to CPD data, 791,038 people were directly exposed to 7.0 magnitude earthquakes. The earthquake caused damage to 26,000 public and private buildings, including health and education infrastructure. A total of 5,816 buildings were declared unusable (1,236 permanently unusable and 4,580 temporarily unusable), while 18,065 remained in usable condition. By the end of February 2021, following the December earthquakes, approximately 43,000 buildings were reported as damaged.

On December 29, 2020, Sisak-Moslavina County, specifically Petrinja city was hit by a 6.2 magnitude earthquake with the epicenter near the town of Petrinja. This earthquake was preceded by a strong 5.0 magnitude foreshock a day earlier. Numerous aftershocks followed the December 29 main shock. The earthquake resulted in seven fatalities; 15 persons sustained severe injuries, and dozens sustained minor injuries. Apart from Sisak-Moslavina, several other areas were affected, including Karlovac, Zagreb, and Krapina-Zagorje Counties and the City of Zagreb. In the immediate aftermath of the earthquake, it was estimated that the houses of almost 15,000 Sisak-Moslavina County residents were unusable or temporarily unusable. Some of the affected people were housed in evacuation centers and temporary shelters, some were displaced to other parts of Croatia, and some decided to stay near their homes and were eventually provided mobile homes or housing containers. Overall, the earthquake resulted in damage to about 40,000 buildings, predominantly in Sisak-Moslavina County but also in the other abovementioned counties. The total cost of the December earthquake across 13 sectors and five counties was estimated at €4.8 billion, of which €4.2 billion refers to destroyed physical assets and €687 million refers to losses. Most of the cost (80 percent) refers to Sisak-Moslavina County, followed by Zagreb County (10 percent), Karlovac County (6 percent), Krapina-Zagorje County (2 percent), and the City of Zagreb (2 percent). Overall, a total area of more than 11.2 million m^2 was affected by the December earthquake. By sector, most of the damage was to housing (73 percent), followed by the business sector, agriculture, education, and others.

Earthquake insurance

In Croatia, there is no specific earthquake insurance but household insurances that landlords can opt to have or not. Namely, insurance companies offer specific policies for earthquakes, but uptake is not incentivized. As DRF is a priority for the government, a new law has introduced in Croatia that requires landlords to have property insurance for buildings, namely the Act on Management and Maintenance of Buildings.[141] Specifically, pursuant to Article 30, The community of co-owners, through the building manager, is required to insure the common parts of the building against basic risks, namely fire, storm, lightning strike, water leakage from plumbing and sewage pipes, as well as liability for damages to third parties. Public infrastructure in Croatia is insured at the discretion of local governments and state-owned infrastructure enterprises, and the amount of financial protection varies. Currently, there is no law that regulates such a situation. Also, the exposure is very difficult to quantify, as the data are fragmented and there is no single risk catalogue. One solution for this could be to catalogue public infrastructure. Metrics such as usage and concentration of exposure (e.g., the number of people) could be established. Then, if the concentration of exposure was in excess of a certain threshold, these properties would have to be assessed, and protection measures implemented.

As coverage for natural disasters is not mandatory, banks often advise home loan seekers to only purchase household insurance. However, State-owned enterprises, especially larger companies that own roads, ports, and airports, are more likely to purchase insurance that includes catastrophe cover. Nevertheless, the choice to buy insurance is up to the commercial entity, and for this reason, the level of protection can vary by type of asset and sector. Due to this variation and inconsistency, new legislation is being introduced that mandates property catastrophe insurance for landlords, but household insurance penetration remains low, with only 25 percent of homeowners insured and just 16 percent covered for earthquakes.[142] Since many homeowners rely on government support for recovery, the incentive to purchase private insurance decreases. This situation is unlikely to change unless the government invests in public awareness or offers incentives to encourage the purchase of insurance (e.g., tax relief on property insurance premiums to incentivize people to insure their first home). Increased insurance penetration would likely benefit the state's finances, as it would minimize the additional funding required after an event. Young

[141] GoC 2024, Link.

[142] WB and EC 2024a, Link. ; WB 2025b, Link.

citizens could be introduced to the principles of DRM and shown that protecting their assets makes sense financially. In addition, the government could establish an earthquake certificate for public buildings, especially those with high life accumulation like schools and hospitals. Along with helping to catalogue risks, the earthquake certificate could incentivize the necessary discipline to protect assets.

KEY CHALLENGES

Given the potential macro-fiscal impact from earthquakes, Croatia could face limitations in meeting the financial demands of large-scale seismic events. Despite the resources, Croatia's fiscal planning currently lacks a comprehensive approach to integrate disaster risks into the medium-term and annual budgets. Line ministries and local governments are not required to account for these risks in their budget submissions. While there are requirements to report damage, the Ministry of Finance does not systematically track disaster expenditures, although the auditor general conducts audits and has recommended improvements for clearer guidance on reserve usage.

Croatia does not have a systematic post-disaster recovery framework. As in other EU countries such as Italy, the government issues some ordinances after earthquakes, specific to the earthquake. It is important to note that the regulatory framework needs to accommodate real case issues, mainly focusing on removing the main barriers to successful implementation of the disaster relief regulatory framework, which is the main aim of the law on the reconstruction of buildings damaged by earthquakes.

Croatia is continuously building on the existing preparedness structure; **however, there is an opportunity to further integrate BBB element.** The Croatian Platform for Disaster Risk Reduction also focused its work mainly on immediate post-disaster relief and rescue. The March 2020 earthquake added emphasis to the development of the regulatory framework focusing more on long-term recovery and BBB.

A need is also identified to harmonize and systematically define comprehensive methodologies that would include all necessary inspections and corresponding forms for the different structures. Thus, easier education and maximum use of available experts would be achieved. It is also of paramount importance to inform engineers about the characteristic structural types in each location, the nature of the inspections, and so on, which would be greatly facilitated by a comprehensive system. The system should also cover other critical entities such as roads, railways, dams, power lines, pipelines, and all other utilities necessary for the functioning of the affected area.

It would be highly beneficial for damage inspections to be coordinated by an institution that does not need to adapt to new conditions and divert staff who are normally occupied with other professional activities. It is essential to have experts ready to assist with post-earthquake activities, organize and link all systems for continuous monitoring of global efforts to develop inspection forms and methods, that is, professionals who are constantly prepared for a disaster that can strike Croatia at any time.

There is a need for experts who are specially trained to provide psychological support. Engineers could also be trained in how to approach people in affected areas. These actions would allow for better service to citizens and undoubtedly speed up inspections. Organizing the building usability assessment system is a highly sensitive task that, although it greatly contributes to mitigating the consequences of earthquakes, also entails significant responsibility. The competent command unit, which is responsible for registering engineers and deploying them to specific affected areas according to the needs identified at a given time, should consider the above and incorporate these elements into the entire process.

KEY OPPORTUNITIES

With respect to earthquake recovery, reconstruction, and post-disaster financing, the following six key opportunities have been identified: (1) develop a recovery framework based on lessons learned, (2) prioritize DRF and advancing laws regarding household insurance, (3) delve into risk transfers and contingency financing options, (4) increase the penetration rate of disaster insurance for households and public assets, (5) conduct assessments of its financial exposure and available resources, and (6) establish a DRF and insurance strategy.

Develop a recovery framework based on lessons learned

Develop an overarching recovery framework and corresponding capacities of key stakeholders. The experience of the reconstruction following the 2020 earthquakes underscores the value of a systematic recovery model that could rely on certain pre-agreed arrangements and modalities, such as determining which institution will coordinate damage and loss assessments, which entity will lead medium- to long-term recovery and reconstruction, and through what decision-making and financing arrangements those functions will be executed, which could expedite and simplify recovery efforts. Line ministries must, in turn, prepare and routinely test business continuity plans, particularly for health, energy, communications, and other critical services, to ensure functionality immediately after an earthquake.

There are many lessons that could be integrated into the recovery framework. In particular, building on the RDNA for Zagreb and Petrinja through a comprehensive reconstruction strategy, supported by an action plan and a robust monitoring and evaluation framework, could help guide a more sequenced and coordinated recovery process. There is also an opportunity to build on the implementation experience of the NRRP and the use of the EUSF, drawing on operational, institutional, and financial lessons to inform the design of a more robust and integrated recovery framework going forward. Although the current legal framework provides a basis for more integrated recovery and BBB, it could be further strengthened to promote coordinated and forward-looking actions, reducing exposure and vulnerability to future events.

While improving data management systems, it is essential to build capacity across all levels, especially for local public administration, to implement recovery programs, starting from damage and loss assessment to investment planning and implementation. As part of this, protocols to safeguard cultural heritage in emergencies could also be developed.

Prioritize DRF and advance related laws

To strengthen disaster resilience, the government should prioritize DRF and advance the proposed law mandating property catastrophe insurance for landlords. This legislation marks a positive step, and moving forward, there is an opportunity to create a structured financing plan that proactively prepares and funds disaster response while reducing the government's financial exposure. Currently, the government faces high financial risks from disasters, affecting national fiscal planning, economic stability, and public well-being. A structured financing approach, ensuring prearranged funding for immediate post-disaster needs, is crucial, as the costs of response, recovery, and reconstruction place a significant burden on both national and local government finances, in line also with ongoing efforts under Article 14 of Council Directive 2024/1265/EU on requirements for budgetary frameworks of the Member States.

Delve into risk transfers and contingency financing options

Based on detailed financial risk assessment and gap analysis, specific risk transfer or contingency financing options could be explored. For example, Croatia could consider the establishment of a national catastrophe insurance pool, such as those in place in California, Taiwan, or New Zealand, which could provide rapid liquidity to different layers of the government in case of an emergency.

Increase the penetration rate of disaster insurance for households and public assets

To reduce the funding gap, the government could investigate the option of increasing the penetration rate of catastrophe insurance for households or public asset insurance. It could also explore alternative sources of funds, such as cash loans and housing loans. Access to alternative capital markets could decrease government liabilities and allow better management of the funding gap.

Conduct assessments on financial exposure and available resources

To improve understanding of gaps and needs, Croatia could conduct a detailed assessment of its financial exposure and available resources and then incorporate the results into its future fiscal and budgetary strategies. The findings could inform the development of a more comprehensive DRF and insurance strategy to establish the overarching principles, objectives, and methods for financing the response and recovery costs associated with damage-causing events. A well-considered split between risk retention (that is, budgetary reserves) and risk transfer (that is, insurance), as well as the inclusion of other complementary risk financing sources, ensures that funding

is diverse and not subject to a single point of failure. The strategy could also outline ways to deepen or adjust existing financial mechanisms and consider the feasibility of expanding agriculture insurance as well as public asset insurance.

Establish a DRF and insurance strategy

To ensure consistency, a DRF and insurance strategy should be established and coordinated by a single entity. Going forward, there is an opportunity to develop a structured financing approach that anticipates and funds disaster response and takes steps to decrease the government's liabilities. The government remains substantially exposed to large financial losses from disasters, which can affect fiscal planning, economic stability, and the population's well-being. The financial cost of response, recovery, and reconstruction is a significant burden on government finances, both at the national and subnational levels. Therefore, a structured financing approach, which would help ensure the availability of prearranged funding to cover immediate liquidity needs following disasters and crises, is paramount.

CROSS-CUTTING TOPIC: SOCIAL RESILIENCE AND INCLUSION

SOCIAL RESILIENCE, SOCIAL PROTECTION, AND INCLUSION

This chapter covers social resilience and inclusion in the context of earthquakes. Beyond physical damage, earthquakes induce multidimensional impacts on people that affect their livelihoods and personal well-being and can have ripple effects on the economy. The degree of impact on a given household depends on both physical and socioeconomic characteristics. For example, a wealthier household may be able to access financial savings and housing insurance to afford repairs to its dwelling, while a less wealthy household may not have access to resources and face obstacles in accessing financing in a timely manner, hindering recovery.

CURRENT ARRANGEMENTS

Earthquakes disproportionalities affect the most vulnerable populations in Croatia, as recognized within the NRAs. In Croatia, the poorest 20 percent of the population are disproportionately affected by disasters.[143] The consumption losses caused by this type of event have a 5 percent chance of occurring in the next 10 years and are expected to push some 50,100 individuals into consumption poverty (1.2 percent of the local population) and displace some 110,000 individuals under the middle-class consumption level (representing a 4.4 percent decrease compared to pre-disaster levels). Also, according to the mentioned study, Croatia has the lowest socioeconomic resilience to earthquakes in comparison to other countries such as Albania, Georgia, Greece, and Romania. The Petrinja area, one of the poorest regions in the country, was strongly affected by the earthquake and its aftermath since it had vulnerable infrastructure. When the earthquake hit the area, people in Croatia showed support and helped those who had lost everything after the disaster. For example, social groups such as football clubs helped during the aftermath of the 2020 earthquakes in Croatia, by providing blankets and supplies to the most vulnerable groups and helping move part of the maternity ward in the Clinic for Women's Diseases and Obstetrics in Petrova Street to a new location after having to reallocate due to the earthquake damage. The widespread volunteering effort was such that a bridge over the Petrinjčica River in Petrinja was renamed the 'Volunteers' Bridge'.[144]

Additionally, the government mobilized funds to help those in need and worked closely on the rehabilitation and reconstruction of damaged buildings. In this regard, several laws and decisions were adopted as part of the program of measures introduced after the 2020 earthquakes, which are displayed in Box 7.

Mitigation measures implemented by the government are expected to alleviate the impact of the earthquake on poverty. The Ministry of Labour, Pension System, Family, and Social Policy developed a one-time assistance aid intended for all those affected by the 2020 earthquake and invited everyone whose buildings were damaged in the earthquake to request this financial aid.[145] Together with the need for the preparation of a comprehensive recovery strategy, there is a need for stronger integration of emergency social protection with long-term recovery policies, which could improve the management and allocation of post-disaster mechanisms and resources to those that need them the most.

Croatia is also taking targeted measures to support vulnerable groups, such as PwDs, which are heavily affected by disasters in Croatia. After the 2020 earthquake, Croatia's authorities developed the 'See Me' project (2022–2023) aimed at improving the safety and inclusion of PwDs in emergencies by raising awareness, developing guidelines, and providing training for responders. It included workshops, awareness campaigns, and GIS tools for rescuers. The follow-up project (2024–2025) continues these efforts, focusing on training emergency operators and first responders and expanding the GIS database to enhance emergency responses for PwDs, and improving the usability of the national Registry of Persons with Disabil-

[143] World Bank. 2020b. *Overlooked: Reexamining the Impact of Disasters and Climate Shocks on Poverty in the Europe and Central Asia region.* The study uses the WB poverty and middle-class thresholds for upper-middle-income countries ($5.50 and $15.00 per day per person, respectively) to calculate poverty impacts and recovery dynamics based on a given disaster scenario (earthquake or floods).

[144] See Atalić, Josip, and Marta Šavor Novak. 2022.; Also see "*Petrinja Bridge Renamed in Honour of Volunteers Who Helped 2020 Quake Victims.*" *N1*, August 10, 2022. Link.

[145] GoC, Ministry of Labour, Pension System, Family and Social Policy. n.d. Link.

ities to support targeted emergency assistance. As part of this effort, PwDs are encouraged to update personal data, such as location, communication preferences, and assistance needs, via the eCitizens platform or through direct contact with the Croatian Institute of Public Health, enabling 112 operators to better coordinate evacuation and rescue operations during disasters. Additional social inclusion measures can be integrated into the recovery and reconstruction process, and broader legal revisions, to consider inclusive building design, by including PwD organizations.

Lastly, traumatic events such as devastating earthquakes can lead to long-term emigration (a trend that had been observed in Croatia even before the earthquake). Unfortunately, after the earthquake in Zagreb, limited psychological assistance was provided to the victims of affected houses. It would be meaningful to anticipate the provision of such a service in the future.

KEY OPPORTUNITIES

With respect to social resilience, protection, and inclusion, the following four key opportunities have been identified: (1) integrate social protection with recovery policies, (2) enhance disaster risk reduction measures, (3) strengthen public service resilience, and (4) address and monitoring the economic impact.

Integrate social protection with recovery policies

Develop and implement emergency adaptive social protection measures alongside long-term recovery and reconstruction policies to address poverty and inequality exacerbated by disasters. Such measures should align with an analysis of potential socioeconomic impacts of earthquakes on vulnerable populations. Leveraging social vulnerability and disaster impact data enables targeted resource allocation, and regular monitoring and evaluation ensure the effectiveness of these policies. This integrated approach reduces poverty, supports resilient livelihoods, promotes social cohesion, and strengthens preparedness for future disasters.

Enhance disaster risk reduction measures with a focus on protecting the assets of vulnerable populations

Croatia can strengthen social resilience to earthquakes through targeted investments to support vulnerable populations. It should utilize social vulnerability data to prioritize pre-disaster planning, resource pre-positioning, and targeted interventions in the most at-risk areas. Considering social vulnerability data can reinforce pre-disaster planning efforts such as resource pre-positioning, identification of areas with the greatest needs, training, and targeted communication campaigns. This comprehensive perspective allows policy makers to prioritize regions most prone to certain disasters with significant consequences, enabling more efficient resource allocation.[146]

Strengthen public service resilience

Croatia should work on restoring its critical services post-disaster to ensure that everyone, even the most vulnerable, gets access to those services as soon as possible. It should focus on rapidly restoring health, education, and social welfare services in affected areas to ensure access for vulnerable populations.

[146] World Bank and EC 2024b.

Address and monitor the economic impact

Croatia could benefit from supporting income restoration by developing programs to restore livelihoods and employment opportunities, especially in sectors affected by disasters. This involves developing comprehensive programs that provide financial assistance to individuals and businesses, such as grants, low-interest loans, and tax relief, to help restart operations and maintain employment.

CROSS-CUTTING TOPIC: PRIVATE SECTOR

This chapter covers private sector involvement in the context of earthquake risk management. Relevant stakeholders might include building owners and property managers, insurance companies, business owners, utility providers, construction and engineering firms, NGOs, and nonprofits.

CURRENT ARRANGEMENTS

The Croatian private sector, especially SMEs, is facing several climate and disaster vulnerabilities due to the country's exposure to natural hazards and the critical role SMEs play in the economy. In fact, 6 in 10 Croatian firms have reported negative impacts from adverse weather events affecting their business.[147] The country's susceptibility to hazards like floods, droughts, and heatwaves poses substantial risks to sectors critical to SMEs, including agriculture, water, and energy. These challenges are compounded by financial constraints, as 10 percent of Croatian firms face difficulties accessing finance, a rate higher than the EU average of 6 percent. This financial limitation hinders their ability to invest in resilience measures against climate-induced disruptions. However, 1 in 3 firms have invested in measures to build resilience against the physical risks caused by climate change.

In the context of disaster resilience, PPPs in Croatia remain largely untapped. PPPs have been applied in selected sectors such as education, transport, and municipal infrastructure, including EE, there are currently around 17 contracted projects listed in the Ministry of Economy's official PPP registry, with a total value of approximately €620 million.[148] To date, PPPs have not been widely used for seismic risk reduction or broader disaster resilience efforts, as post-earthquake reconstruction has primarily relied on public financing. Croatia has a clear legal and institutional framework in place to support expansion through the Public-Private Partnership Act (OG 78/12, OG 152/14 and OG 114/18) and there is clear potential to adapt and expand existing PPP models to enable more strategic, long-term investments in resilient infrastructure and essential public services.

The significant impact of the 2020 series of earthquakes on the private sector, particularly SMEs, is evident, as highlighted in the March 2020 earthquake RDNA findings detailed in Box 5**.** A lesson learned from the 2020 earthquakes was that lagging regions in Croatia face significant disaster resilience challenges, particularly in relation to weak private sector participation. The scale and duration of the risks necessitate a long-term perspective. There is room in this space for both public and private sector funding, as well as for citizens' initiatives. Addressing systemic risks and fighting climate change requires having decision-makers on board—they need to do the heavy lifting. Allocation of public funding will then be the key to unlocking the much-needed private finance. Key sectors, such as tourism and agriculture, are also facing significant vulnerabilities to disaster risks, as recently witnessed by the 2020 series of earthquakes. Tourism-dependent SMEs are especially at risk, as disasters such as the 2020 earthquakes can result in substantial revenue losses. Similarly, agriculture-based SMEs were also highly exposed to the 2020 earthquakes, especially to the secondary risks that were generated, such as liquefactions and sinkholes. In addition to sector-specific challenges, some SMEs operate in older buildings or rented facilities that lack modern, disaster-resilient standards. Financial constraints, such as limited access to disaster insurance, hinder their ability to invest in necessary measures. However, some opportunities are available through EE funds, even though these are not always linked to seismic interventions. Furthermore, gaps in knowledge and capacity mean that many SMEs are not adequately aware of their specific risks or prepared to integrate disaster resilience into their business strategies. While EU funding mechanisms offer potential support, the complex application processes and limited targeted initiatives create barriers to effective access and

[147] European Investment Bank 2023, Link.
[148] GoC 2025, Link.

utilization for SMEs. Therefore, it is of utmost importance to work on and implement initiatives that can directly help SMEs and local organizations build resilience and effective recovery mechanisms. This is the case of "DM", a German cosmetics brand, that selected 32 projects to help the earthquake-affected areas, where it invested more than 4 million kuna. This project will enable faster recovery from the consequences of the earthquake and the entrepreneurial, cultural, and social development of the Sisak-Moslavina County. Seven of these projects provided an incentive for the development of entrepreneurship, as part of which DM will include products from selected local producers from the Sisak-Moslavina County in its offer.[149]

The EU provided support for private sector disaster resilience. For example, through the NRRP, €542 million will be invested in supporting businesses for green transition and EE, supporting their projects aimed at boosting the green economy, sustainable tourism, and investing in green technologies. However, there is a missed opportunity to integrate seismic considerations in this support for businesses.

[149] DM. 32 projects selected to help earthquake-affected areas [*Odabrana 32 projekta za pomoć potresom pogođenim područjima*]. Link.

Box 5. March 2020 earthquake - Impacts on the business sector

The total damage to the business sector amounts to €505 million. The earthquake significantly affected Croatia's business sector, with 2,104 economic operators and their premises affected, predominantly in Zagreb. Damaged commercial buildings span 1,382,173 m^2, with 58,742 m^2 deemed unsafe and 322,155 m^2 temporarily unusable, requiring urgent reconstruction. Businesses in older, mixed-use buildings in Zagreb's center suffered the greatest damage. Additional costs include €9 million for debris removal, mostly in Zagreb, and €190 million in public and private building losses, bringing the total damage to €690 million.

Daily revenue losses for affected enterprises are estimated at €689.3 million. Unemployment is rising, exacerbated by the COVID-19 pandemic, with tourism—a key economic driver—particularly hard hit due to its concentration in heavily damaged areas of Zagreb. Recovery in construction-related sectors is expected to offset some losses. Unemployment is rising, exacerbated by the COVID-19 pandemic, with tourism—a key economic driver—particularly hard hit due to its concentration in heavily damaged areas of Zagreb. Recovery in construction-related sectors is expected to offset some losses.

The recovery and reconstruction needs in Croatia's business sector are nearly double the estimated €505 million in damage, totaling approximately €937 million due to added costs for seismic retrofitting and EE upgrades. Including recovery activities like demolition, debris removal, and working capital restoration, total recovery needs are estimated at €1 billion. Immediate support is essential to sustain businesses, retain workers, and address liquidity challenges exacerbated by the earthquake and COVID-19.

Recovery strategies should focus on rebuilding resilient infrastructure, providing financial and technical support, and fostering productivity-led growth. Short-term efforts must prioritize reopening businesses, offering grants, micro-loans, and wage subsidies, while medium-term measures include improving managerial skills, digitalizing services, and promoting disaster-resilient business practices. Adopting the BBB approach and prioritizing preventive measures will help mitigate future risks and support long-term recovery.

Figure 8. March 2020 RDNA – Interruption of service - Public and private sectors

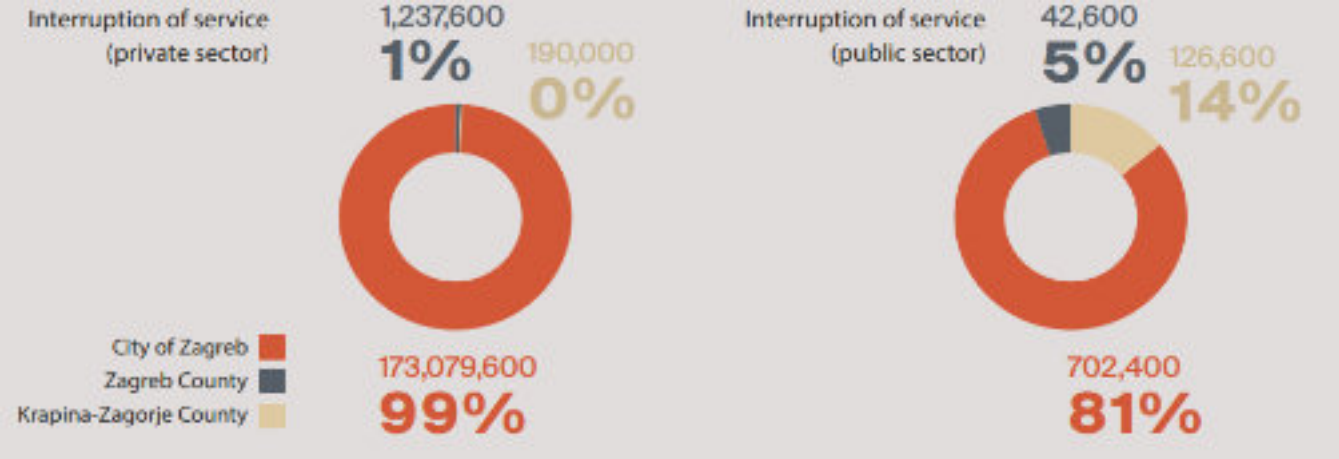


Table 5. March 2020 RDNA – Economic operators and area affected in the City of Zagreb, Krapina-Zagorje County, and Zagreb County

Counties	Number of economic operators	Total damaged area in square meters
City of Zagreb	2,067	1,308,960
Zagreb County	29	66,665
Krapina-Zagorje County	8	6,846
TOTAL	**2,104**	**1,382,471**

Table 6. March 2020 RDNA – Total damage and losses by ownership and county in the business sector (€, million)

County	Damage			Losses			Total		
	Private	Public	Total	Private	Public	Total	Private	Public	Total
City of Zagreb	470.13	19.08	489.21	181.42	1.04	182.46	651.55	20.12	671.67
Zagreb County	13.28	0.46	13.74	1.61	0.06	1.67	14.90	0.51	15.41
Krapina -Zagorje County	1.11	0.74	1.85	0.22	0.14	0.36	1.33	0.89	2.22
TOTAL	**484.52**	**20.28**	**504.80**	**183.25**	**1.24**	**184.49**	**667.78**	**21.52**	**689.30**

Table 7. March 2020 RDNA – Total recovery and reconstruction needs in the business sector (€, million)

	Short-term	Medium-term	Long-term	Total
Reconstruction	281.16	328.01	328.01	937.18
Recovery	57.00	22.05	11.00	90.50
TOTAL	**338.16**	**350.51**	**339.01**	**1,027.68**

Source: GoC, 2020b.

Private disaster insurance market

In Croatia, there is no compulsory disaster insurance. If a state of emergency is declared at the local or regional levels, the state will provide some compensation, but there is no government fund in case of a disaster; rather, there is a budgetary reserve. It is obligatory for the national, regional, and local levels to have 0.5 percent of the budget set aside for an emergency, which is used for unplanned expenses, not just for damage compensation. However, disaster insurance coverage among SMEs is relatively limited. In Croatia, all insurance is provided by private companies (which insure against fire, storm, hail; however, uptake on earthquakes is limited) for houses and companies; companies also offer agricultural insurance. The demand for private disaster insurance is influenced by various factors, including economic conditions, risk awareness, and the perceived value of insurance products.

KEY CHALLENGES

The adoption of BCP has not picked up in Croatia. There are currently no laws or mandatory regulations requiring private companies to develop BCP, leaving businesses, especially SMEs, vulnerable to disruptions from natural hazards and other risks. While NDRMS emphasizes the importance of PPPs in DRM, further engagement on business resilience is needed.

KEY OPPORTUNITIES

The lesson learned from the 2020 series of earthquakes is that the largest part of the reconstruction costs will be borne by the private sector, and it is crucial to ensure that private sector actors have access to affordable financing schemes.[150] With respect to private sector, the following four key opportunities have been identified: The key opportunities for Croatia include (1) strengthen SME resilience through BCP, (2) improve PPPs, (3) promote 'BBB' principles and initiatives, and (4) address specific vulnerabilities depending on the sector.

Strengthen SME resilience through BCPs

Croatia should develop targeted programs to provide financial assistance for SMEs to adopt and reinforce their disaster resilience practices. Additionally, Croatia could encourage these businesses to conduct risk assessments and integrate risk and disaster resilience into their business strategies. Finally, enhancing risk awareness and promoting the benefits of disaster insurance are crucial steps toward building greater resilience within the SME sector.

Improve PPPs

There are significant opportunities to encourage PPPs, such as drawing on existing examples like the collaboration between the business incubator PISMO and telecom company A1, which could be scaled up for broader impact. Environmental, socioeconomic, and financial sustainability should be integral to these efforts. Sustainability requires fostering growth through public and private sector investments that minimize or mitigate adverse impacts on future development. A recovery approach that leaves no one behind can help reduce disparities in opportunities and outcomes, ensuring that marginalized groups share the benefits. Actively including diverse perspectives and involving communities in the design of policies and investment projects will not only promote equity but also ease implementation challenges for both public and private sector entities.

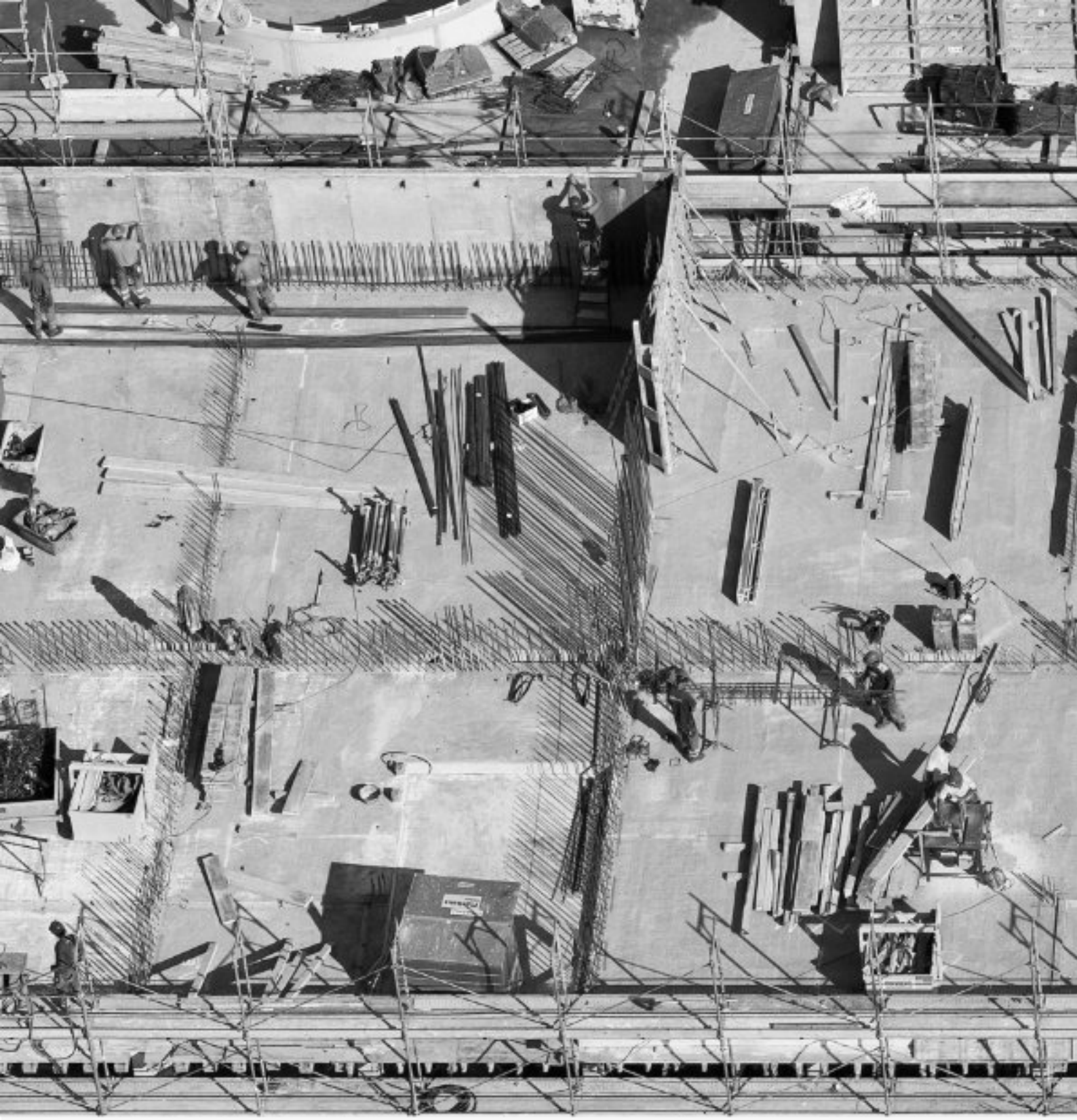
Promote BBB principles and initiatives

There is an opportunity for Croatia to focus on reconstruction efforts that prioritize disaster-resilient and energy-efficient infrastructure. It could also link the already-existing EE funds to seismic retrofitting for a comprehensive approach to resilience. This way, the country would become more resilient to future seismic events and invest in more robust and energy-efficient infrastructure.

Address sector-specific vulnerabilities

As discussed, sectors such as tourism and agriculture have severely suffered from the consequences of the seismic events, which should encourage the Croatian government to tailor specific response and resilience-building initiatives. For example, it could develop disaster preparedness plans for tourism-dependent SMEs in high-risk areas and invest in diversifying tourism offerings to reduce dependency on a single geographic area. Regarding the agriculture sector, Croatia could encourage crop diversification to reduce reliance on single crops that are highly sensitive to climate fluctuations and create contingency plans for agricultural operations. It would also be beneficial to introduce subsidized disaster insurance tailored to agricultural risks, covering crop failure, floods, and droughts.

[150] GoC 2020b.



INVESTMENT NEEDS AND RECOMMENDATIONS

This chapter proposes key priorities for reforms and investment areas, which may be considered as part of technical assistance, policies, or instruments. It is informed by desk research and consultations.

RECOMMENDED AREAS OF INVESTMENT

As Croatia continues to suffer from seismic vulnerabilities, some key areas of investment in earthquake risk management should be considered to alleviate the impact of future seismic events:

Invest in seismic risk reduction through prioritized approaches. The key driver of seismic risk in Croatia is the vulnerable and aging building stock. Prioritizing the seismic rehabilitation and reconstruction of public infrastructure, such as emergency response facilities, schools, and hospitals, is critical to minimize damage and ensure functionality during and after a disaster. A prioritized approach can be facilitated by conducting rapid visual screening/ surveys, supported by a pool of trained engineers, and analyzing EE costs/benefits to ensure the application of integrated solutions and maximize various benefits. At the same time, there is a need to raise awareness and incentivize private property owners and businesses to improve buildings. Targeted attention could also be given to cultural heritage buildings. Additionally, strengthening laws for construction and seismic risk reduction, ensuring integration of multi-hazard and integrated solutions, and reflecting risk information in urban planning and land use regulations can contribute to enhancing the underlying framework for seismic resilience.

Continue improving the understanding of seismic risk, accessibility, and use of risk information. Croatian authorities and academia have advanced the understanding of seismic risk in Croatia through NRAs and localized assessments, such as in the City of Zagreb. Building on these efforts, this understanding can be further improved by considering secondary perils and aftershocks, integrating additional exposure information, and results of localized assessments. Data should be made accessible to relevant stakeholders by strengthening databases that catalogue critical parameters, like building materials, age, and structural systems. Regularly updating this data on damage, loss, and vulnerability can also enhance decision-making capabilities. In parallel, fostering multi-stakeholder coordination and exchange among government, academia, engineers, including leveraging the knowledge under the HCPI, and the private sector could help streamline data processes and investments. Relevant information should be available to the public to support their own decisions and self-preparedness actions.

Continue no-regret investments in preparedness and enhance recovery planning. Investing in community preparedness through inclusive training programs, educational resources, and awareness campaigns can strengthen social resilience and self-preparedness. Continuing to modernize EWSs and enhancing their accessibility for at-risk populations is a no-regret multi-hazard investment. Strengthening preparedness and response capacity involves effective coordination among professional actors, such as HVZ, and engaging volunteers and civil society in a structured manner to ensure safe and organized involvement during disasters. Financial instruments like insurance for households, businesses, and high-risk industries, or contingency financing, as part of a comprehensive DRF approach, can help ensure resources are quickly available and well-targeted for recovery and reconstruction. Developing an overarching recovery framework, which includes BBB principles, can also support more effective and speedy reconstruction. Such a framework could be supported by capacity building at all levels, particularly within local public administration, to facilitate impact assessments, investment planning, and implementation. With respect to the private sector, it is important to strengthen BCP and enhance the private sector's role in risk reduction as well as recovery frameworks and processes. Integrating emergency social protection with long-term recovery can support resilient livelihoods and revitalization efforts.

A list of key recommendations is provided in Table 8.

Table 8. Key investment recommendations for Croatia in earthquake risk management

Risk governance	Enhance governance mechanisms for assessing and implementing seismic risk reduction strategies. Harmonize existing laws regarding seismic risk reduction in buildings to enable integrated risk-informed investments. Mandate and promote collaboration among different stakeholders. Strengthen the integration of cultural heritage protection into DRM strategies.
Understanding risk	Enhance risk data collection and accessibility. Understand the risk to critical entities. Improve risk assessment models. Implement regular updates to seismic hazard maps. Invest in seismic microzonation and localized assessments. Strengthen city-level risk assessment programs. Increase public information sharing on seismic risk.
Risk prevention, reduction, and mitigation	Develop a prioritized approach to earthquake risk prevention, reduction, and mitigation. Integrate seismic retrofits into planned energy upgrade initiatives. Promote a holistic approach to resilience of public and private infrastructure. Establish a registry of engineers for pre- and post-earthquake RVS. Bridge the gap between existing regulations and infrastructure compliance. Develop a standardized multi-tier approach to seismic safety assessment of buildings. Raise awareness on securing the nonstructural elements. Enhance collaboration between different stakeholders. Target investments in earthquake resilience in the most vulnerable sectors and infrastructures.
EWSs and public awareness	Increase public education on protective actions and general earthquake risk. Incorporate earthquake-specific considerations into the existing EWS. Continue to invest in the development of a modern seismic monitoring network.
Preparedness and emergency response	Strengthen volunteer and civil society engagement. Develop emergency evacuation protocols. Enhance training and exercises. Strengthening the training and capacity building of emergency personnel and the broader public. Maintain a registry of trained certified inspectors-engineers.
Recovery, reconstruction, and post-disaster financing	Develop a recovery framework based on lessons learned. Prioritize DRF and advance laws regarding household insurance. Delve into risk transfers and contingency financing options. Increase the penetration rate of disaster insurance for households and public assets. Conduct assessments of its financial exposure and available resources. Establish a DRF and insurance strategy.
Social resilience and inclusion	Integrate social protection into recovery policies. Enhance disaster risk reduction measures with a focus on protecting the assets of vulnerable populations. Strengthen public service resilience. Address and monitor the economic impact.
Private sector	Strengthen SMEs / business resilience through BCP. Improve PPPs. Promote “BBB” principles and initiatives. Address specific vulnerabilities depending on the sector.

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ANNEX 2. ADDITIONAL INFORMATION

Box 6. List of key seismic regulations in Croatia

The following laws, among others, are key legal instruments related to seismic risk reduction in Croatia:

- Croatian Building Code [Zakon o gradnji] (Official Gazette 153/13, 20/17, 39/19, 125/19)
- Technical Regulation on Amendments to the Technical Regulation for Building Structures (Official Gazette NN 7/2022)
- Law on Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County (Official Gazette 102/20, 10/21, 117/21)
- Program of Measures for the Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County (Official Gazette 28/23)
- Regulation on the content and technical elements of the renovation project documentation, the project for the removal of the building, and the project for the construction of a replacement family house damaged by the earthquake in the area of the City of Zagreb, the County of Krapina-Zagorje, and the County of Zagreb (Official Gazette 127/20)

Source: World Bank team.

Box 7. Overview of Legislative Measures following 2020 earthquakes

The following laws and decisions were adopted as part of the program of measures introduced after the 2020 earthquakes:

- Law on the reconstruction of buildings damaged by an earthquake in the area of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (NN21/23);
- Program of measures to restore buildings damaged by the earthquake in the area of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (NN154/24);
- Decision on providing financial aid for temporary and necessary protection and repair of buildings damaged by the earthquake in the area of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (NN 34/21; 138/22);
- Decision on providing financial assistance for the purchase of condensing water heaters and condensing boilers in buildings damaged by the earthquake (NN 49/21);
- Decision on the financing of rent for temporary housing care for persons whose real estate was damaged or destroyed in the earthquakes in the area of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County on March 22, 2020 and December 28 and 29, 2020 (NN 51/23);
- Decision on co-financing utility costs for beneficiaries of temporary housing care (NN 87/23);
- Decision on organized temporary accommodation of earthquake victims in the area of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County on March 22, 2020 and December 28 and 29, 2020 (NN 33/24).

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