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1010017950 – L2BR – UCMP-2020-KN-AG

Planning

Case study on City of Zagreb in prevention preparedness, and response to earthquakes

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SUMMARY

The aim of the case study on the City of Zagreb in prevention, preparedness and response to earthquakes is to provide insights into these topics directly related to the recent earthquake that occurred in March 2020 during the first COVID -19 lockdown in the country.

The first chapter analyzes the earthquake threat, including the seismic hazard and the general data on the March 2020 earthquake.

The second chapter gives an overview of the pandemics in the vicinity of Zagreb and discusses the response to COVID-19 pandemics in more detail.

The third chapter related to the assessment of the urban resilience is the core of this study. It was performed according to the methodology developed in Task 2.1. of Work Package 2 of the L2BR project. Three indicators of urban disaster risk and resilience were assessed, namely the Urban Disaster Risk Index (UDRi), the Risk Management Index (RMI), and the Disaster Resilience Index (DRI).

The Urban Disaster Risk Index is a composite indicator that measures risk from an integrated perspective and serves as a decision support tool to identify key interdisciplinary vulnerability factors to reduce or address. For the calculation of the UDRi index in the City of Zagreb, data was collected from various official sources and when not available, relevant institutions/persons were contacted and the required data was obtained. Two scenarios were analyzed: Zagreb 22 March 2020 Earthquake (with Covid-19 – real scenario) and Zagreb 22 March 2020 Earthquake without Covid-19 Pandemics (hypothetic scenario). The results were very similar because the earthquake was only of moderate magnitude, so even though the death and injury toll would probably have been higher if the epidemic COVID -19 was not present, it has not much reflected the index value; and the health care system was not yet overloaded with COVID -19 patients in hospitals at the time of the earthquake.

The Risk Management Index (RMI) is a tool that summarizes a group of indicators that measure the performance and effectiveness of a city or country's risk management. These indicators reflect the organizational, developmental, capacity, and institutional actions taken to reduce vulnerability and losses, prepare for crises, and recover effectively from disasters. For the City of Zagreb, all 4 public policies were assessed as below the average. The public policy that had the lowest performance in Zagreb was the financial protection, whereas the policy with the greater performance was the risk identification, followed by the disaster management.

The Disaster Resilience Index (DRI) is a monitoring and evaluation tool for benchmarking and measuring progress (or lack of progress) in incorporating risk reduction and resilience approaches into city development policies and processes.

For the calculation of the RMI and DRI index in the City of Zagreb, data collection was realized through Google Forms sent to the relevant institutions, where each answer was combination of two factors: Valuation level and Confidence level. The individual surveys of the DRI index were grouped by five relevant institutions. For the City of Zagreb almost all disaster resilience indicators are below the average and the strategy aimed at development and strengthening of institutions, polices and capacities, and systematic integration of risk reduction approaches into critical services and infrastructure, and emergency preparedness, response, and recovery need to be adopted very quickly.

All the results point to the fact that the urban resilience in Zagreb is relatively low and further strategic measures need to be implemented as soon as possible. The results are of great importance not only for the city, but also for the whole country and region, as there are many similarities in the building stock, seismotectonic conditions, seismic risk awareness, disaster management system, lack of seismic risk reduction activities, among others.

1 EARTHQUAKE THREAT

1.1 History of Earthquakes in the vicinity of City of Zagreb

According to Herak *et al*. (2008) seismicity in North-Western Croatia can be described as moderate, with rare strong events, both typical features for regions of intraplate seismicity. Although it is not the most earthquake-prone region in Croatia, it is the most seismically vulnerable due to its economic importance and concentration of population centres, including the capital Zagreb. It occupies about 30% of the country's total area, houses 45% of the population and generates over 55% of the national product. Tectonically, it is located in the boundary zone between the Alps, the Dinarides and the Pannonian Basin, at the "triple junction" between the transverse faults of the Periadriatic Mountains, Lake Balaton and the Drava River, all of which play an important role in the Neogene-Quaternary tectonics in this and the surrounding region (e.g. Fodor et al., 1998; Prelogović et al., 1998; Tomljenović and Csontos, 2001; Tomljenović et al., 2008).
All data on earthquakes - the catalogues, macroseismic reports, seismograms and other related documents - come from the archives of the Department of Geophysics of the Faculty of Science and Mathematics of the University of Zagreb. The Croatian Earthquake Catalogue (CEC), covering the period from 373 BC to the present day, is the most important source of information.

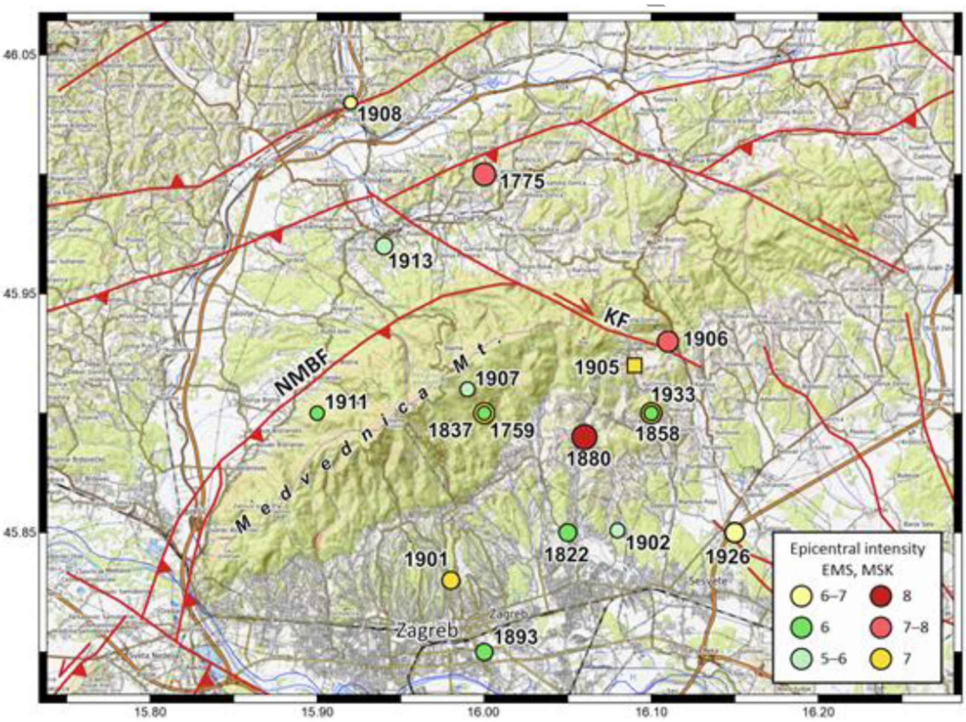


Figure 1.1 Epicentres of historical earthquakes (1700–1920), with epicentral intensity of 5.5 EMS (or MSK) or larger (after CEC). Only mainshocks are shown, except for the 1905 event (yellow square), which has recently been identified by Herak et al. (2021) as the foreshock of the 1906 earthquake. Traces of main faults (red) are modified after Tomljenović and Csontos (2001). NMBF – North Medvednica boundary fault, KF – Kašina fault. Base-map from OpenTopoMap (https://opentopomap.org). (Herak et. al., 2021a)

The Medvednica-Zagreb region experienced strong seismic activity in the 18th, 19th and early 20th centuries. The strongest earthquakes occurred on October 13, 1775 with the epicentric intensity of VII-VIII °MCS (destroyed a church in Bedekovčina), on November 9, 1880 with the intensity VIII °MCS, on December 17, 1905 (Io= VII-VIII °MCS) and on January 2, 1906 (Io= VII - VIII °MCS). The great earthquake of Zagreb in 1880 is very well documented (Torbar, 1882), thanks to the efforts of the Earthquake Committee established by the Academy immediately after the earthquake. This is the first Croatian earthquake for which the focal depth (16 km) was estimated from macroseismic and other observations. Out of 3670 buildings (Zagreb had only 30,000 inhabitants!), all were damaged and about 13% were destroyed. The epicentre of this event was in the village of Planina, about 17 km northeast of Zagreb, where almost all masonry buildings were destroyed. The phenomenon of liquefaction (including mud volcanoes) was observed in the villages located in the valley of the Sava River. The earthquake was felt in a very large area (e.g. in Dubrovnik, 397 km away). This is one of the most important Croatian earthquakes, practically defining the lower hazard limits in the greater Zagreb area. The epicentres of the 1905 and 1906 events most likely coincided with that of the great Zagreb earthquake of 1880. Again, almost all houses in the village of Planina were destroyed (Kišpatić, 1905, 1907). There was also severe damage in Čučerje, Vugrovec and Kašina (about 15 km NE from the centre of Zagreb), where churches and many houses were destroyed (Mohorovičić, 1908). These earthquakes prompted the local authorities to finance the installation of the Vicentini-Konkoly seismograph in Zagreb (Herak and Herak, 2007), thus establishing the Zagreb Seismological Station. Very interesting and comprehensive analysis of the three latest large earthquakes in Zagreb may be found in (Herak et al., 2021b).

According to the recent seismicity, the seismogenic layers extend to a depth of about 16 km. All felt events occurred below 6 km. The calculated and available solutions for the fault planes (FPS No. 5, 10, 12, 14 and 22, Table 1.1) indicate seismogenic activity on (1) reverse ENE-WSW striking faults and (2) along dextral or sinistral NW-SE and ENE-WSW striking faults.

Table 1.1 Earthquakes with available fault-plane solutions (FPS) (Herak et. al. 2009)

No.	Date	Time	Lat °N	Lon °E	h, km	M_L	φ_1°	δ_1°	λ_1°	φ_2°	δ_2°	λ_2°	P_φ°	P_δ°	T_φ°	T_δ°
1	1938-03-27	11:15:59.8	46.105	16.894	03.0	5.6	190	25	142	315	75	70	61	27	200	56
2	1974-06-20	17:08:27.8	46.205	15.506	11.6	5.1	305	58	149	53	64	36	178	4	271	43
3*	1982-03-16	13:52:23.7	46.163	16.210	18.5	4.5	267	38	89	88	52	91	178	7	2	83
4	1984-03-11	11:55:32.3	45.869	15.445	14.2	4.2	326	54	−128	199	50	−49	175	60	82	2
5*	1990-09-03	10:48:32.2	45.911	15.913	13.6	5.0	261	43	94	76	47	86	169	2	302	86
6	1993-05-29	08:43:11.1	45.549	15.289	13.8	4.6	225	43	−7	320	85	−132	194	35	83	27
7*	1993-06-01	19:51:09.8	46.225	16.557	17.8	4.7	93	38	71	296	55	104	16	9	249	76
8	1995-08-25	09:27:20.9	45.407	17.694	18.8	5.0	287	49	71	135	44	111	30	2	129	76
9	1996-09-10	05:09:26.4	45.413	16.271	16.0	4.5	233	49	−8	328	84	−138	199	33	94	23
10	1997-04-30	19:18:18.4	45.930	16.189	15.1	3.8	251	52	13	153	80	141	207	18	105	34
11	1998-06-02	18:02:56.8	46.116	17.109	15.2	4.1	86	45	−165	345	79	−45	294	39	43	22
12	2000-06-16	02:34:58.0	45.924	15.955	14.1	3.7	248	53	52	120	51	129	4	1	96	61
13	2003-08-02	20:31:48.0	45.894	17.215	24.5	3.5	259	61	−28	3	66	−147	223	39	130	3
14	2004-01-08	14:23:31.4	45.873	15.975	13.8	2.4	103	32	34	343	73	117	53	23	287	54
15	2005-12-07	05:22:02.6	46.191	16.501	18.3	3.6	243	43	60	101	54	115	174	6	69	69
16	2006-01-08	15:22:33.8	45.490	16.168	15.9	3.5	91	75	50	344	42	157	210	20	321	45
17	2006-01-23	21:29:04.4	45.776	15.721	12.9	3.6	47	88	5	317	85	178	182	2	272	5
18	2006-04-10	08:35:21.6	46.207	15.441	14.2	2.7	312	64	−155	210	68	−27	170	35	262	2
19	2006-07-19	02:34:05.9	45.695	15.629	14.6	3.5	104	62	−155	2	68	−29	321	37	54	4
20	2006-10-28	13:55:29.8	45.734	15.651	15.0	3.9	22	79	−31	119	60	−166	336	29	74	13
21	2007-04-19	11:18:35.5	46.196	15.518	11.9	2.8	299	57	82	133	34	102	35	12	184	77
22	2008-03-05	19:41:24.6	45.769	15.936	16.6	3.1	145	57	173	239	84	33	7	18	107	27

The hypocenters in the western part of this area are located in a steeply SSE dipping zone, which coincides with the active Quaternary dipping fault mapped along the northern edge of Medvednica Mountain. This fault agrees well in orientation and kinematics with the NE-SW striking and SE dipping nodal plane of FPS No. 5 (Table 1.1), indicating a reverse top-to-NW trending hanging wall movement. Two FPS (nos. 10 and 22; Table 1) associated with earthquakes in the northeastern and southwestern parts of this epicentral area indicate seismogenic structures corresponding to either NW-SE striking dextral or NE-SW striking sinistral faults. In both cases, the first option is more plausible as it matches quite well with the location, orientation and kinematics of two NW-SE striking dextral faults mapped in this area.

1.2 Zagreb 22 March 2020 Earthquake

1.2.1 Basic earthquake data

The epicenter of the main M_w 5.4 magnitude earthquake was located about 7 km north of the center of Zagreb in the Markusevec and Čučerje districts, at a depth of 10 km below the Medvednica Mountain (Fig. 1.2).

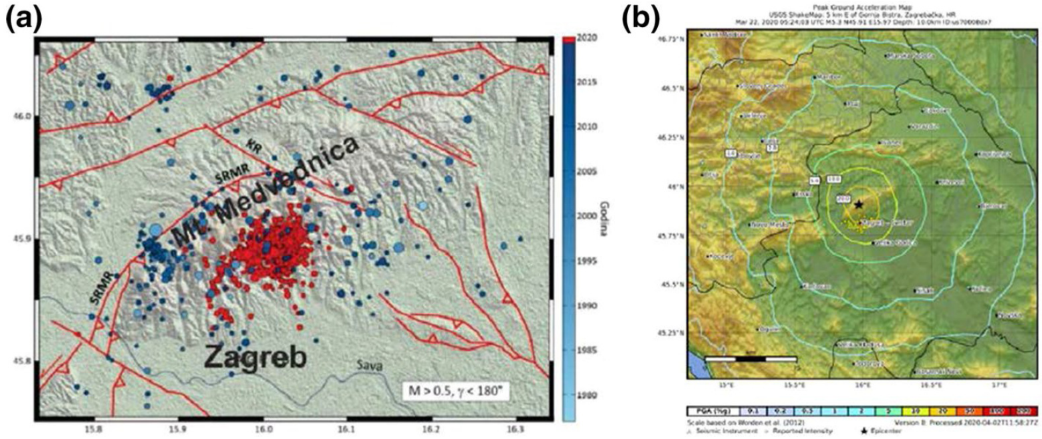


Figure 1.2 2020 Mw5.4 Zagreb earthquake: **a)** major strike-slip and reverse faults in the Zagreb metro region (red lines), epicenters of ML > 0.5 earthquakes since 1975 (blue circles), and epicenters of the series of 2020 earthquakes (red circles). Red arrows indicate direction of the relative slip, triangles indicate fault hanging walls, SRMR is the Northern marginal Medvednica fault, and KR is the Kasina fault (modified from Herak et al. 2016); and **b)** PGA shakemap (USGS url) (Atalić et. al., 2021)

Immediately after the main earthquake, an aftershock sequence started, with more than 1000 tremors recorded within the next month. The strongest aftershock, of magnitude M_w4.7, occurred about 40 minutes after the main shock and was followed by another aftershock of magnitude M_w3.3 at 7:42 am. Before processed earthquake records were available, Stanko (2020) and Markušić et al. (2020) estimated the average peak ground acceleration PGA at the bedrock level in the city center to be approximately 0.16-0.19 g. To account for possible amplification due to local site effects, the corresponding amplification factor for stiff soils was estimated to be 1.4-1.6, resulting in an average PGA of 0.22-0.3 g. Similar values were predicted by the USGS Shakemap (Fig. 5b), which implicitly considers site amplification based on regional topographic slope as a proxy for seismic site conditions. Two seismological stations and four accelerometers were in operation within 20 km of the epicenter, all maintained by the Croatian Seismological Survey. Accelerograms of the main event recorded at the Emergency Management Office station, located about 8 km from the epicenter, are shown in Fig. 1.3. The corresponding 5% damped pseudo-accelerations are presented in Fig. 1.4 together with the Eurocode 8 design response spectra for three different return periods on soil type C for Zagreb (Herak et al. 2011). For comparison purposes, the design response spectrum according to the former Croatian Seismic Code (HRN-ENV 1998-1-1) for a return period of 500 years is also presented. It was derived by converting intensity data from the seismic hazard map of Croatia, with part of Zagreb located in zone IX on the MCS scale. The respective base lateral force was recommended for the design of reinforced concrete structures from 2005 to 2012 and masonry structures from 2007 to 2017.

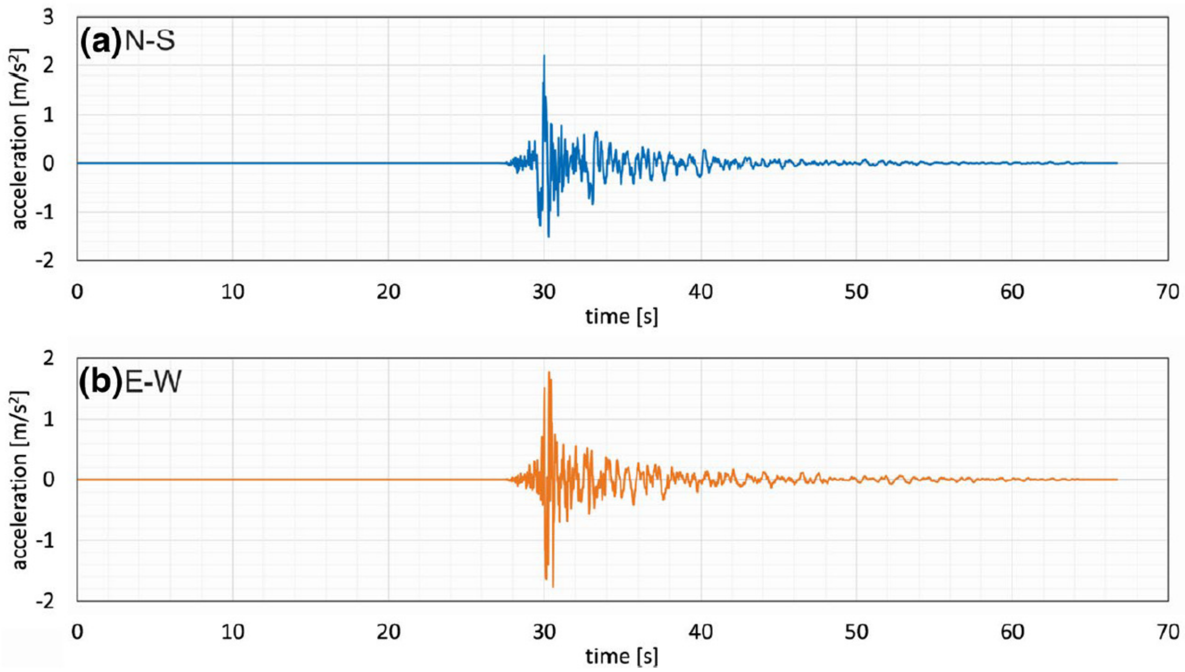


Figure 1.3 Recorded accelerograms at the Zagreb Emergency Management Office (EMO) station (Prevolnik et al. 2020) in horizontal directions: **a** N-S (blue) and **b** E-W (orange) (Atalić et. al., 2021)

Although generated by a moderate magnitude earthquake, these records show a horizontal PGA of about 0.2 g (Fig. 1.3). As expected, the energy content is concentrated in the higher frequency range, 0.1-0.5 s, which is typical for a region close to the epicenter and stiff soils (Fig. 1.4). The record in the east-west direction, perpendicular to the predominant direction of wave propagation, from north to south, generally shows higher oscillations up to 0.4 s, with a maximum spectral acceleration of about 0.6 g at 0.1 s. The record in the east-west direction, perpendicular to the predominant direction of wave propagation, from north to south, generally shows higher oscillations up to 0.6 g at 0.1 s. This maximum spectral acceleration exceeds the EC8 value for 475 years, and the amplitude and frequency content of the earthquake motion (Fig. 1.4) provide useful information about the extent of damage when combined with the fundamental vibration period of the buildings.

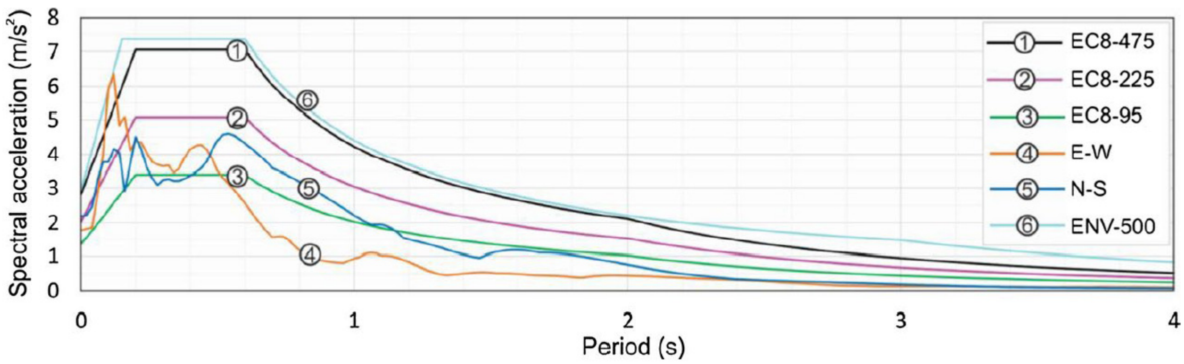


Figure 1.4 Spectral accelerations in horizontal N-S (blue) and E-W (orange) directions at the EMO station (location indicated in Fig. 3), respective Eurocode 8 (EC8) design response spectra for return periods of 95, 225 and 475 years, and the design response spectrum according to the former Croatian Seismic Code ENV- 500 for return period of 500 years (modified from Šavor Novak et al. 2020) (Atalić et. al., 2021)

1.2.2 Losses and damage in the City

Total Damage and Losses and Key Findings

According to the RDNA report (Government of Croatia, 2020) the total cost of the earthquake in the City of Zagreb, Zagreb County and Krapina-Zagorje County is estimated at 11.3 billion EUR, of which 10.7 billion EUR represent the value of destroyed physical assets and 0.6 billion EUR refers to losses. The impact of the disaster on Zagreb's historical center is one of the main reasons for the very high cost of earthquake damage. Buildings classified as cultural heritage are present in all five sectors, and their percentage in each sector is significant. Estimates of damage and losses have been grouped into five main sectors: housing, health, education, culture and cultural heritage, and business.

Sectors: Most damage was sustained by the housing sector (64%), followed by the culture and cultural heritage sector, which includes historical government buildings (13%), education (10%), health (8%), and business (5%). The sector most affected by total losses is the housing sector (57%), followed by business (29%), health (10%), culture and cultural heritage (3%) and education (1%). Overall 78% of the damage and losses are in the private sector, and 22% in the public sector. In the private sector, damage and losses are mainly in housing and business, while, in the public sector, they are mainly in health and education. For the culture and cultural heritage sector, the ownership distribution of damage and losses is 39.2% public and 61% private (Table 1.2)

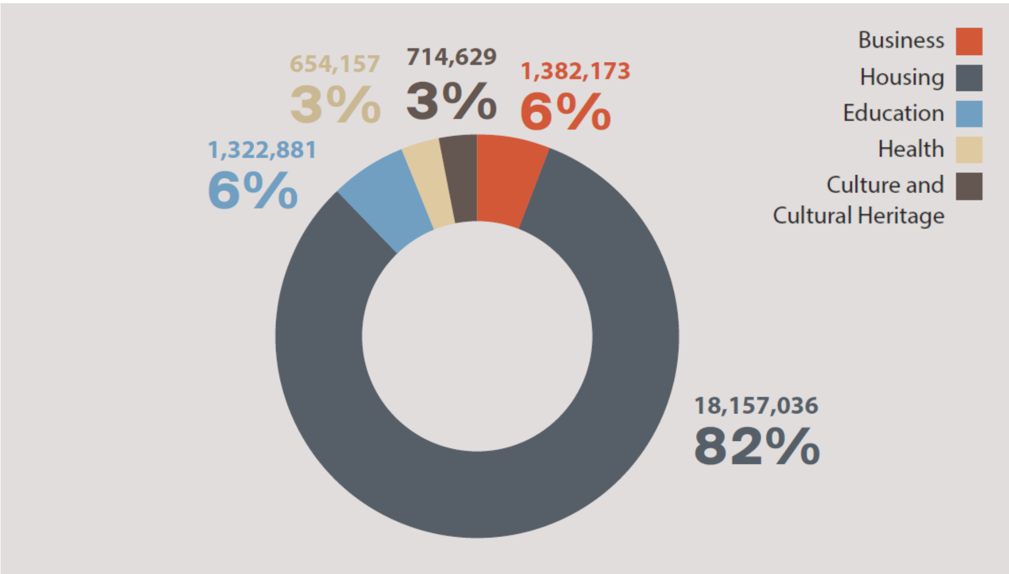


Figure 1.5 Surface area of buildings affected by the earthquake by sector (in m^2) (Croatia Earthquake RDNA, 2020)

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

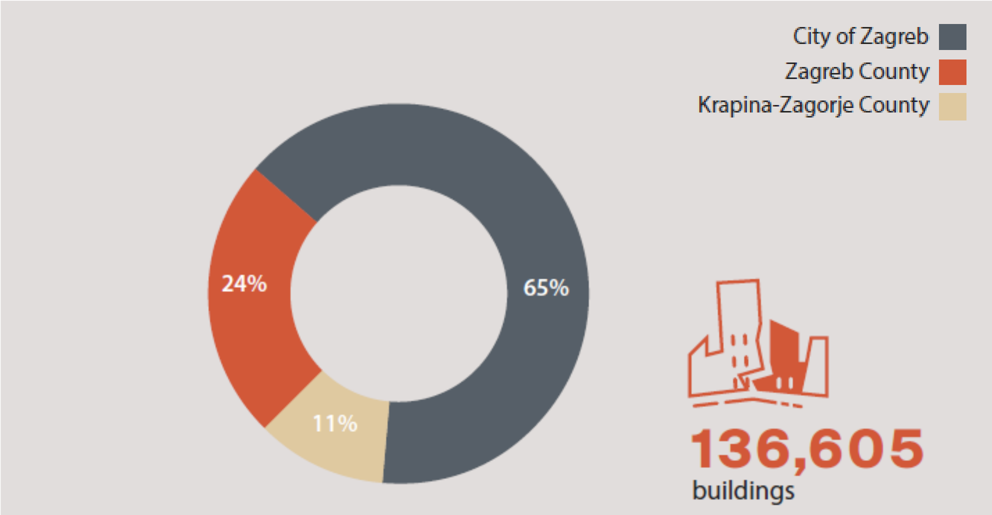


Figure 1.6 Residential building stock in the earthquake affected area (Croatia Earthquake RDNA, 2020)

Health: The total number of affected buildings in the health sector stands at 214, of which 46 are healthcare centers (22%), 125 are hospitals and clinics (58%), 20 are medical institutes (9%) and 23 are pharmacies (11%). Moderate to severe structural damage is reported in a total of 40 buildings (19%), and heavy structural damage in eight buildings (4%). The total cost of damage to physical property is estimated at 826 million EUR. Most of this cost relates to hospitals and clinics (88%). The reported losses amount to 61 million EUR and are mainly linked to the emergency evacuation of patients; and the inability of medical institutions (mainly hospitals and health centers) to provide medical services during the emergency period (due to severe structural damage) and charge their costs to the Croatian Health Institute. As much as 96% of the total costs relate to the City of Zagreb (96%) due to its large concentration of healthcare institutions and its central position in the earthquake-affected area.

Education: A total number of 513 buildings in the education sector recorded damage, of which 484 (94%) are in the City of Zagreb, 23 (5%) in Zagreb County, and 6 (1%) in Krapina-Zagorje County. Moderate to severe structural damage was recorded in 160 buildings (31%), while 12 buildings (2%) suffered heavy structural damage. The total value of damage to buildings and other physical assets is estimated to 1.07 billion EUR. Most of this (98%) relates to educational institutions in the City of Zagreb. Losses are estimated at approximately 9 million EUR, and mainly refer to the short-term countermeasures needed to remove potential hazards to users, and to prevent further degradation of the buildings.

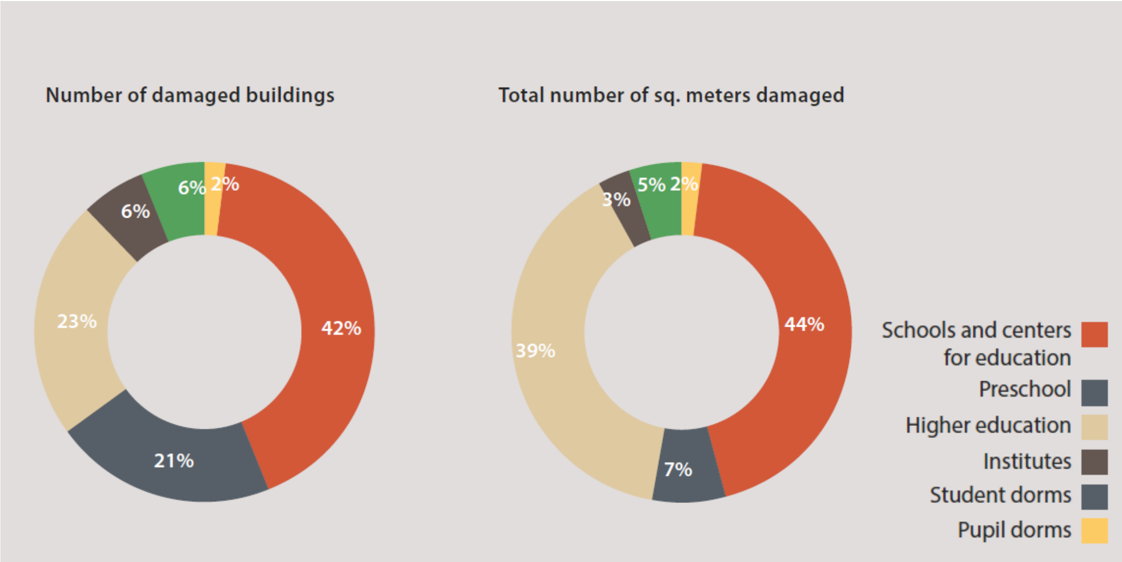


Figure 1.7 Distribution of damaged buildings and of the total number of square meters damaged in the education sector (Croatia Earthquake RDNA, 2020)

Culture and Cultural Heritage: The total number of affected buildings in this sector comprises 192 cultural institutions, 13 state heritage buildings, and 159 religious buildings across the City of Zagreb and the two counties. Since most of the buildings in this sector are very old, moderate to severe structural damage was sustained by 118 buildings (32%), and heavy structural damage was reported in 41 buildings (11%). Total damage to buildings and other physical assets is estimated at 1.38 billion EUR, most of which was incurred in the City of Zagreb. Losses estimated at 21 million EUR mainly relate to emergency measures taken to protect cultural heritage buildings, particularly churches. This sector includes damage and losses to cultural institutions and creative industries, state or government buildings situated in heritage buildings, movable cultural heritage, and churches and other religious facilities. Damage and losses to buildings which qualify as cultural heritage but which fall within other sectors are calculated in the estimates for those sectors.

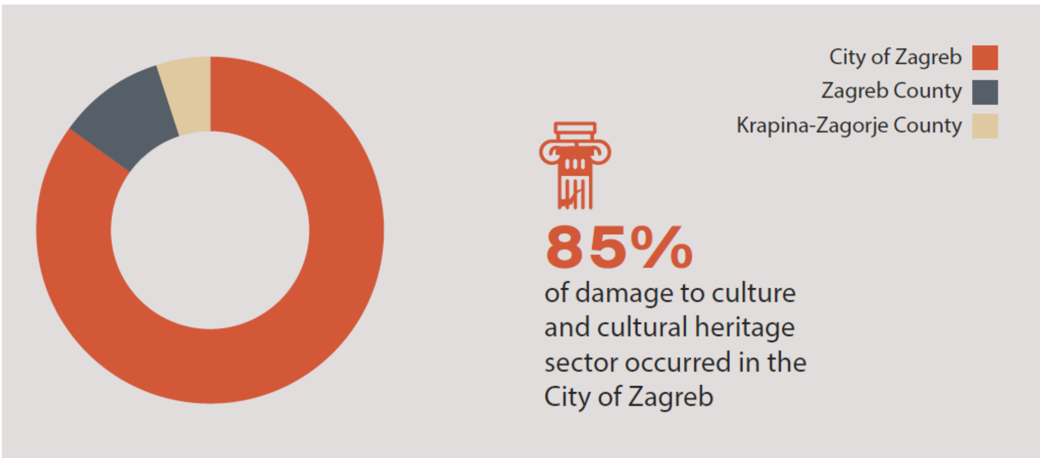


Figure 1.8 Share of total damage by county in the culture and cultural heritage sector (Croatia Earthquake RDNA, 2020)

Business: Based on the data collected, a total of 2,104 business entities have been affected by the earthquake, of which 98.2% are in the City of Zagreb, 1.4% in Zagreb County, and

0.4% in Krapina- Zagorje County. As much as 27% of the surface area occupied by business entities is estimated to have suffered moderate to heavy structural damage, and the total value of damage is estimated at approximately 505 million EUR. The valuation of losses stands at 185 million EUR, caused largely by the reduction of revenue arising from a slowdown or interruption of business activity.

Figure 1.9 Total losses anticipated by businesses through the reduction of revenue resulting from each day of business inactivity. (Croatia Earthquake RDNA, 2020)

As far as the geographical distribution of damage and losses is concerned, the City of Zagreb is most affected with 10,943 million EUR or 96.8% of total damage and losses, while the share of Zagreb County is approximately 219 million EUR (1.9%), followed by Krapina-Zagorje County with 139 million EUR (1.2%). Overall, a total surface area of more than 22.2 million square meters has been affected by the earthquake. Eighty-two percent of the affected surface area is in the housing sector (18.1 million square meters) followed by the business sector with 1.4 million square meters, and the education sector with 1.3 million square meters. The culture and cultural heritage sector accounts for 0.7 million square meters (without the affected area of cultural heritage already accounted for in other sectors), while the health sector accounts for a total of 0.6 million square meters.

The historical center of Zagreb is divided into two zones of protected cultural heritage, of which Zone A denotes the original historical center of the city and Zone B denotes the wider urban complex, mostly built before the mid-20th century. A large share of residential buildings, hospitals, schools, businesses, cultural institutions, and government buildings are housed in cultural heritage buildings located in both Zones A and B. The extent of damage to Zone A, which is protected as cultural heritage as a whole, is proportional to its heritage value. A total of 72% of buildings in Zone A was damaged, which accounts for the high extent of damage across all sectors.

Summary of recovery and reconstruction needs

The needs for reconstruction and recovery add up to approximately 17.469 billion EUR. Of this amount, 4.5 billion EUR relates to short-term needs (26%), medium-term needs are estimated at 7.1 billion EUR (41%), while long-term needs stand at 5.8 billion EUR (33%), as shown in Table 4. The reconstruction and recovery needs are higher than damage and losses since they include, first, the application of a build back better approach to the reconstruction of damaged infrastructure that reduces any future earthquake risks and involves functional improvements including energy efficiency; and, second, the resumption of production, service delivery, and access to goods and services. The cost of recovery is greatest in the housing sector and accounts for more than half of overall needs (52%), followed by the culture and cultural heritage sector, the health sector, and the education sector (each respectively accounting for 13-14% of overall recovery needs). The large amount of damage done to buildings of cultural heritage value across all sectors renders the recovery and reconstruction process particularly complex and challenging, both in financial and logistic terms.

Table 1.2 Summary of recovery and reconstruction need (in million EUR) (Croatia Earthquake RDNA, 2020)

	Short-term	Medium-term	Long-term	Total
Sectors				
Housing	2,739	4,102	2,287	9,128
Health	374	210	1,851	2,435
Education	571	881	909	2,361
Culture and Cultural Heritage	500	1,570	447	2,517
Business	338	351	339	1,028
TOTAL	**4,522**	**7,114**	**5,833**	**17,469**

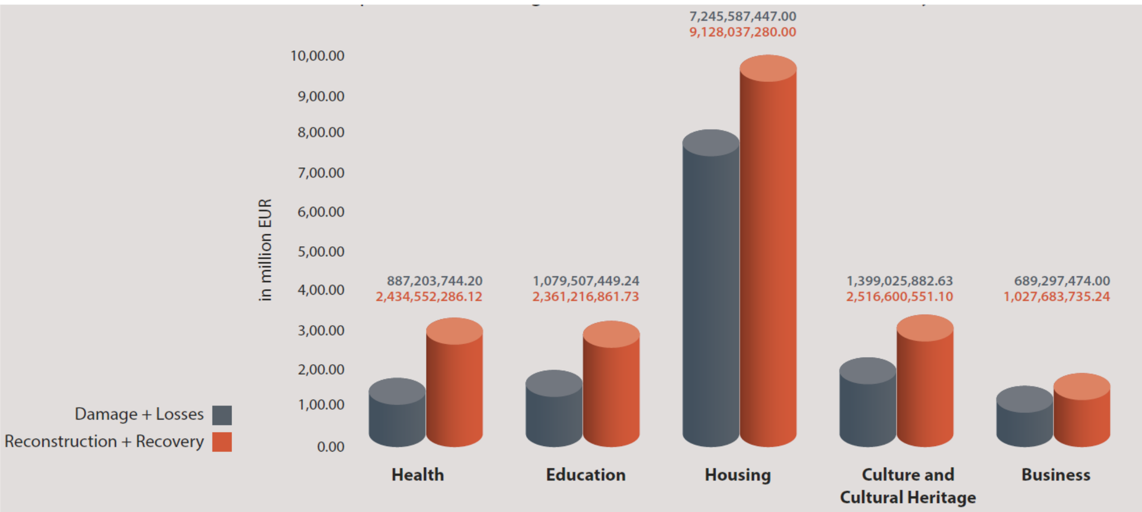


Figure 1.10 Relationship between Damage + Losses and Reconstruction + Recovery (Croatia Earthquake RDNA, 2020)

1.2.3 Earthquake response

Zagreb was much deserted on that early Sunday morning, a fortunate circumstance given the aftermath of the earthquake. Immediately after the main shock, the Civil protection services were activated for emergency action. The members of the Zagreb EMO, the Directorate of Civil Protection of the Ministry of the Interior and of the Zagreb Faculty of Civil Engineering convened establishing the Crisis headquarters for operational management at the EMO. Fire and communal services together with units of the Croatian army were called upon to maintain order and start clearing the city center and surrounding streets. Fortunately, the earthquake did not cause any major collapse of buildings or transportation facilities that would fully occupy the emergency services. The focus was therefore put on the assessment of damage and usability of affected buildings and infrastructure. Since there was no previously established damage assessment plan at city level, the technical experts self-organized using their experience and previous collaborations and under the guidance of experts from the Faculty of Civil Engineering. As the scale of the destruction was unknown in the first hours, all engineers who had undergone exercises and training for post-earthquake inspection of buildings were called upon by private calls. One of the first actions was to send them to lead the inspection of hospital buildings in the historic downtown, already identified as critical for post-earthquake recovery (Šavor Novak et al. 2020).

In parallel, at the EMO headquarters was initiated the fine adjustment of the initial safety and usability assessment methodology. Promptly, a general call was sent for mobilization of all engineers with expertise in the (1991–1995) post-war reconstruction or with knowledge related to traditional masonry structures. The Croatian Chamber of Civil Engineers was instrumental in providing the necessary support. On the first day alone, over 150 engineers voluntary responded to the call and started the inspection and assessment of building damage. The protective equipment (helmets, vests, etc.) required for safety during entry into damaged buildings together with masks, disposable gloves and disinfectants for Covid-19 were distributed to all first responders in the field. Programming of a mobile application (Collector for ArcGIS) for acquisition of field observations was initiated at the end of the first day; it was then tested the next day and put into operation a day later. The form was created according to the Italian (Baggio et al. 2007) and Greek (Anagnostopoulos et al. 2004) experience taking into account local building features and observed characteristic damage to gable walls, roofs and chimneys. The applied procedure for the post-earthquake damage assessment of buildings is described in detail in (Uroš et al., 2020).

All data was stored in a GIS based database for efficient information flow in both directions. For example, experts in the field could also retrieve data on the sick and self-isolated people due to Covid 19, important regarding the safety and limiting the epidemics spread.

In the first week, the number of volunteers rose to over 500 including volunteers climbers for work at heights (e.g., roofs, chimneys). The emergency calls were monitored to ensure timely response and inspection in the order of arrival of requests. Requests for inspection were received also by e-mails and via the web page promptly established by the City for that purpose. Being rapidly overwhelmed, the frontline workers had to be reorganized, having in mind Covid-19 crisis, thereby responding on emergency basis and depending on the importance of the observed damage; it was already known that the hardest hit areas were the historic downtown and the epicentral neighborhoods of Markuševec and Čučerje. The damage assessment teams consisted of at least two structural engineers and/or architects with the number increasing with the size and occupancy of the building. Creating teams of experienced engineers, especially those who had undergone education and exercises, with younger fellows contributed to knowledge transfer and an increased inspection rate.

The inspection of residential buildings was conducted visually and it was more detailed in case of older masonry buildings and buildings that suffered apparent structural damage. Decisions on the short-term usability were made in discussion between the team members based on the current damage state and considering potential behavior of the structure in case a stronger shaking should have occurred during the still ongoing aftershock sequence. Decisions on usability of critical infrastructure (e.g., bridges) and of essential facilities (e.g., hospitals, schools) were made in agreement with the headquarters and people responsible for the institution. In both cases, the engineering experience and intuition were decisive for the evaluation of the safety and accessibility.

The first objective of the assessment was to identify and implement urgent measures to reduce to a maximum any potential risk of debris falling on neighboring buildings, sidewalks or driveways and other threats to human lives (e.g., collapsed chimneys, damaged façades and architectural finishing). The municipal representatives immediately warned people to beware of this potential threat and not to walk close to buildings. It was then important to restrain access to damaged buildings, to temporarily take care of people in need and to obtain as soon as possible a preliminary insight into the extent of the damage. Data collected in the field was practically immediately available to the fire and communal services (using GIS maps), which then took appropriate measures of clearing and removal of debris. In addition, access to the database and insight to the buildings damage and usability reports was allowed to all relevant City services, e.g., firefighters, communal service, city offices, etc., and governmental departments depending on the level of authority. This allowed smooth exchange of information and transparency through daily briefings via public media.

The training given to a number of civil engineering experts with focus on the typical damages observed in the field, proved to be crucial for the quality of inspections. Firstly organized in-person at the EMO headquarters, given the pandemic circumstances, the training was later offered via internet together with accompanying handbook and webinars (CCEE url). The Croatian Centre for Earthquake Engineering CCEE website was intended to provide the necessary information to inspection teams in the field, to allow for a live monitoring of the status of inspected applications and was also used to prepare and educate citizens on the methods of building inspections. In addition, three WhatsApp communication groups (up to 250 members) proved effective for sharing essential information between field teams, including further training of younger engineers.

The site inspections encountered a number of unexpected difficulties. Some of the challenges faced by the field teams and crisis headquarters were frequent double-requests for inspection on the same address (Fig. 1.11), reaction of residents that were not familiar with the methods of inspections, residents that choose to stay home even when the building was red-tagged, conflicting and confusing information reported by the media, etc. Given the shortage of protective equipment on the market, it had to be obtained in different ways, e.g., through numerous donations. Occasional shortages of protective equipment left frontline workers ill-equipped rising concerns among the population. Due to closed borders and a ban on movement outside the place of residence, many engineers and specialists from other parts of Croatia and neighboring countries were unable to come to Zagreb to provide assistance. In addition, with the exception of external damage observations to roof structures and chimneys, modern reconnaissance technologies (drones, satellite images, etc.) could not be applied to the full extent, since most of the damage occurred inside the buildings.

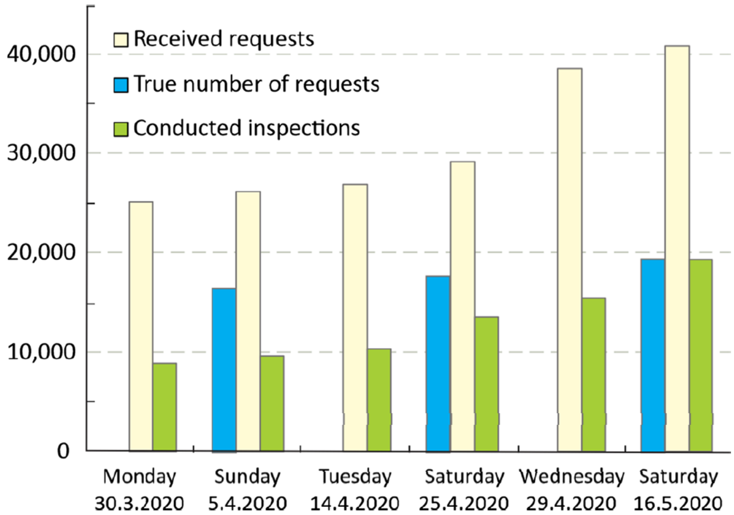


Figure 1.11 Number of received requests for inspection, the assessed number of “true” requests for inspection and conducted inspections (courtesy of the City Office for Strategic Planning and Development of Zagreb) (Atalić et. al., 2021)

The successful development and implementation of a feasible action plan for post-earthquake inspections was a challenge from the engineering point of view. Such plan did not exist before the earthquake (existing plan were only related to search and rescue teams) and timely communication between the relevant institutions was particularly challenging in the first days of the post-earthquake activities. This also required a numerous adaptations of the GIS database to be able to respond to various needs (e.g., addition of necessary attributes, allowing access of different institutions to different attributes, etc.). The permanent communication between government and municipal representatives with citizens also revealed to be important for fine adjustments of the inspection activities.

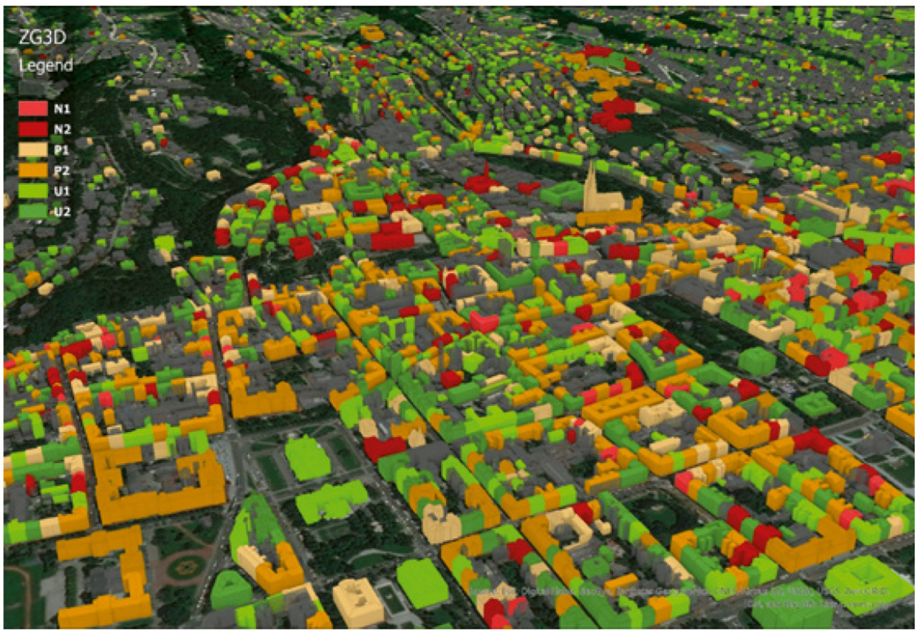


Figure 1.12 3D view of the Lower and Upper Towns of the City of Zagreb based on the usability classifications (Croatia Earthquake RDNA, 2020)

1.2.4 Prevention and preparedness pre-earthquake measures

Numerous activities related to post-earthquake emergency response and recovery situations, organization and education of intervention units, formation of urban search and rescue teams, field exercises, etc., contribute to increased resilience in case of natural disasters. The Croatian Platform for Disaster Risk Reduction within the Directorate of Civil Protection of the Ministry of Interior can be highlighted as a positive example. Its main objective is to foster continued cooperation between political, operational and scientific stakeholders to enable transfer and harmonization of knowledge, propose informed solutions, and adopt and ensure implementation of guidelines aiming at overall disaster risk reduction. Within this comprehensive system, the Zagreb Faculty of Civil Engineering was assigned as the lead scientific institution for activities related to seismic risk assessment. Experts from the faculty participated in training and civil protection exercises within various European projects and exercises (e.g., Matilda project, Cascade'19 exercise, etc.). As part of the Croatian technical-tactical support team, a few experts also participated in inspections of buildings safety following the 2019 Albania earthquake (Atalić et al., 2020). The acquired expertise and knowledge proved essential during the March 2020 post-earthquake damage reconnaissance phase in Zagreb.

The public safety framework in Croatia is relatively well set, yet its capacity to cope in an emergency or disaster of higher proportions revealed insufficient. The Zagreb 2020 earthquake has helped identify certain gaps and needs for improvement in the response capacity and in the communication and synchronization between the state and municipal command chains. In the scope of their natural hazards risk assessment study, Atalić and Hak (2014) evaluated the impacts from a series of potential disasters in Croatia with the objective to prepare a common ground for comparison of respective risk management policies. The impacts from seismic scenarios exceeded by far potential losses from other disasters. The potentially disastrous consequences of strong earthquakes, beyond the criteria adopted by the European Commission, were further emphasized by Atalić et al. (2018). All these analyses recognized that Croatia lags behind countries with similar seismic settings, e.g., Italy, and that it should strengthen the organization of the emergency system. The authors recommended that the focus should be on activities that can be achieved relatively rapidly and without significant investments, e.g., implementation of operational policies and practices such as training exercises, development of methods for long-term and near-real time prediction of potential impacts and techniques for post-earthquake damage inspections. The ultimate goal would be to help reduce seismic risk by identification and application of feasible retrofit strategies for older buildings and strengthening of bridges, utility systems and other essential infrastructure components. The need of a centralized comprehensive building and infrastructure database with linkages to the existing scattered databases and information was also pointed out as a major enabler to a more efficient emergency planning system. The Croatian Bureau of Statistics was invited to play important role in planning and acquisition of this strategic information.

2 PANDEMIC THREAT

2.1 History of pandemics in the vicinity of the City of Zagreb

According to Petrić (2020), there is not much information on the earliest epidemics and pandemics on the territory of present-day Croatia. One of the first major documented **plague epidemics** was the so-called Justinian's Plague in the 6th century. It also affected the territory of present-day Croatia. In response to the later plague epidemics, it is interesting to mention that Dubrovnik was the first city in the world to introduce quarantine in 1377.

The northern regions were also affected by plague epidemics, for example Zagreb in the 15th century. In the middle of the 16th century, the plague epidemic spread from the Ottoman Empire to Croatian territories, including Zagreb. The high mortality rate weakened the Ottoman defense forces. It is known that in the 17th century the plague hit the wider Danube region, affecting Zagreb as well.

In addition to quarantine in the 14th century, another measure to control epidemics that is important for global health history was introduced in Croatian countries in the 18th century. Although there are several examples of the establishment of sanitary corridors in different parts of the world, the most comprehensive and one of the most permanent land quarantine protection systems in human history was created at the Croatian-Slavonian military border in the 18th century. Known as the sanitary cordon, it was established between the Habsburg monarchy and the Ottoman Empire, and included more than 10,000 guards along a 1,900-kilometer line. Petrić (2020) also notes that various measures to control epidemics on the border with the Ottoman Empire were undertaken from the end of the late 17th century and that the basis for the development of continuous protection was the imperial patent for protection against the plague of 1709, which had been created in response to the plague epidemic that had broken out two years earlier and provided for quarantine measures at specific locations on the border. The sanitary cordon consisted not only of quarantines, but also of permanent cordon guards and a system for collecting health information. The sanitary cordon did not provide complete protection against epidemics. Since the middle of the 18th century the plague spread five times in the Habsburg monarchy, and in 1795 the epidemic had alarming proportions.

In the 19th century, the transmission of plague was no longer a problem, but it was necessary to protect against **cholera**, but the strict measures of sanitary cordons were unable to prevent the spread. According to Jeren (2005) cholera was brought from India and the first recorded case in Europe was in 1829. At that time Austria built Pula, as its war-port, and as traffic was markedly intensified cholera began to spread throughout Istria, then to Rijeka, then to Dalmatia, Zagreb, Vojna Krajina, Slavonia and Srijem. For decades, cholera ravaged our region. In 1855, it is estimated that approximately 2 % of the population in Croatia contracted cholera. In 1883, R. Koch detected the cholera bacillus in stool and contaminated water, and as early as August 5, 1886, the Municipality of Zagreb the pamphlet "Lessons on cholera and measures against it", which contains the latest knowledge in the world about cholera at that time. In 1893, the first cholera hospital was founded in Zagreb, which later developed into the hospital for infectious diseases.

The influenza could be related to the fever epidemic of 1784-178,6 which was also recorded in Croatia. It was followed by a pandemic of Russian influenza (1889-1890) and Spanish influenza (1918-1919). The **Spanish influenza** epidemic was considered the most serious pandemic of modern times. It began in the spring of 1918 and spread across the globe. By all accounts, it was the greatest natural disaster of the early twentieth century. The first pandemic wave began in the spring of 1918 as a mild form of the disease, deaths were rare and therefore did not attract much attention. The second wave was extremely deadly and began in the fall of 1918, affecting more than 30 % of the world's population (about 500 million people) and estimated to have claimed between 50 and 100 million lives. According to Fatović and Šain (2020), the first patients with Spanish influenza in the area of the city of Zagreb appeared in July 1918. In the period from 1 September to the end of 1918, a total of 861 persons died because of Spanish influenza and complications caused by pneumonia. The analysis of autopsy data shows that during the period from September 30, 1916, to October 16, 1918 influenza gradually emerged as one of the most frequent causes of death in autopsies in the Public Prosecutor's Office of the City of Zagreb Health Offices. During this period, autopsies in the City of Zagreb Public Health Offices also revealed the following infectious diseases: **Tuberculosis, Dysenteria bacillaris, Syphilis, Malaria, Enterocolitis, Typhus abdominalis** and other less common diseases.

After the Spanish influenza, no major pandemic or epidemic (such as Asian influenza, Hong Kong influenza, AIDS, SARS among others) has affected Croatia to any significant extent, until **COVID-19 pandemics**.

2.2 Covid-19 Pandemics

Coronavirus is a new strain of the virus that has not been detected in humans so far. The World Health Organization called it SARS-CoV-2, and the disease caused by COVID-19. It was discovered in China at the end of 2019. The first case in the Republic of Croatia was reported in Zagreb on February 25, 2020. Since the start, 604,347 cases of coronavirus infection have been recorded in Croatia (with 2021, November 29), 563,630 people have recovered from the infection and 10,826 have died because of the infection (Government of Croatia, 2021).

2.2.1 Epidemiological situation in Zagreb

According to the latest census (31 August 2021), there are 4,047,687 inhabitants in the country, with 20.0% of the total population (809,268 inhabitants) living in Zagreb, the capital and most populous city of Croatia.

During the COVID-19 pandemic in Zagreb (information on November 29, 2021) 129,943 coronavirus infection cases were recorded, 21.5% of the total number of infected people in the Republic of Croatia. A total of 3,339 inhabitants (with 2021, November 29) of the City of Zagreb died as a result of the infection (30.8% of the total number of dead people in Croatia as a result of the infection).

The figure below shows the number of cases from March to July 2020, the period during which the post-earthquake usability assessments were conducted. It can be concluded that civil engineers did not spread the infection as the number of cases stagnated, nor was there a significant increase in the number of cases as a result of the earthquake.

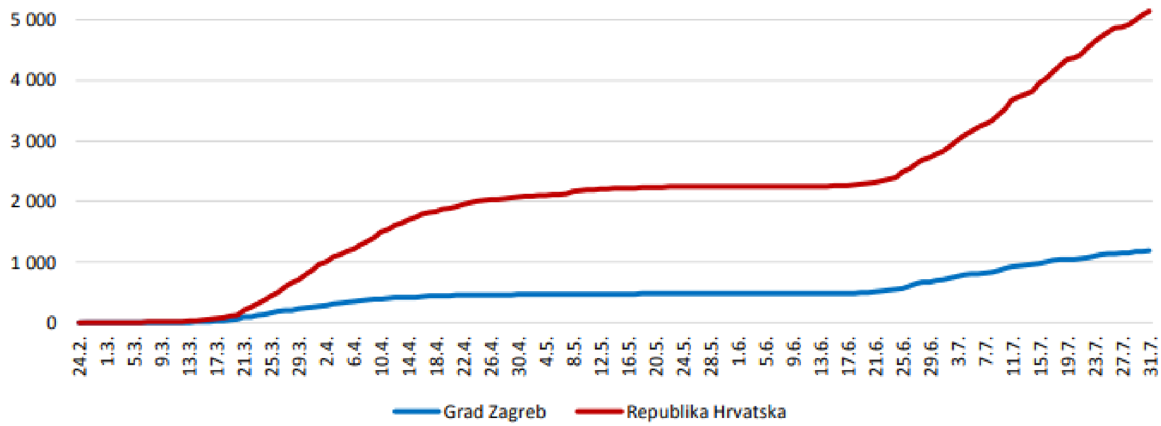


Figure 2.1 Total number of infected people (City of Zagreb/Croatia)

2.2.2 Losses and economic impact to Croatia and the city of Zagreb

The COVID-19 epidemic left strong negative consequences on the economy, which directly affected the business of most entrepreneurs in Croatia and consequently the unemployment rate. Therefore, the Government of the Republic of Croatia has adopted a number of measures to preserve economic activities, in order to make it easier for entrepreneurs to do business in the new circumstances and enable them to continue working and provide salaries for employees (Government of Croatia, 2021). Despite government support, COVID - 19 had a significant impact on economic parameters in the Republic of Croatia. The measures for restricting the movement of people and conducting the economic activities have affected the aggregates of quarterly national accounts as well as the quality and availability of many data sources that are commonly used in estimating the gross domestic product (GDP). Data show that the pandemic has largely led to a slowdown in Croatian economy since mid-March 2020. Although the spread of the disease did not significantly affect economic indicators in January and February 2020, the impact of the pandemic has been present since March 2020, that is, since the first quarter of 2020 (Croatian Bureau of Statistics, 2021).

Figure 2.2 shows that quarterly GDP decreased in real terms by 14.5 % in the second quarter of 2020, as compared to the same quarter of 2019. It is the largest decline in quarterly GDP in real terms since 1995, when quarterly GDP started being estimated. The real decline was recorded in all components of GDP on the expenditure side, except in the general government consumption, which recorded a slight increase.

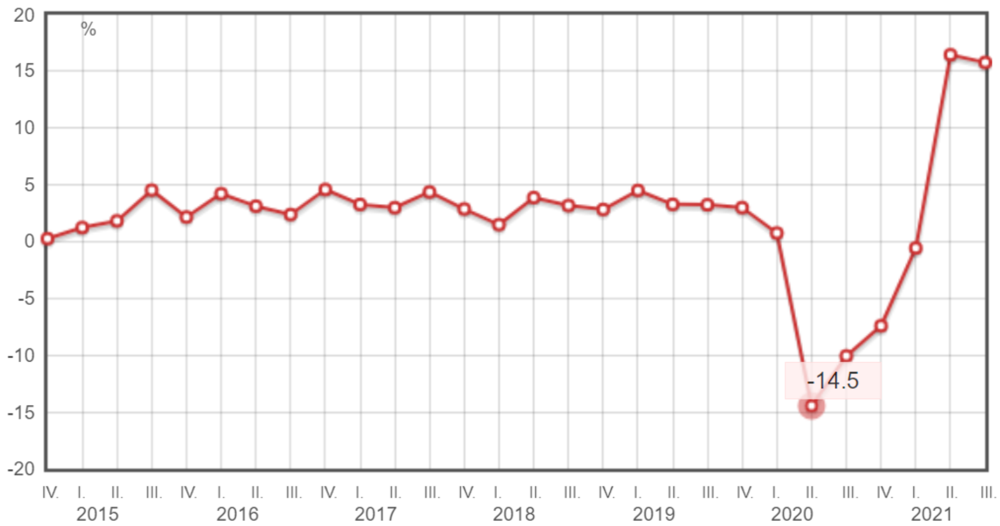


Figure 2.2 Gross domestic product, GDP (real grow rates) (Croatian Bureau of Statistics, 2021)

The impact of the COVID-19 pandemic on global economy has led to a large decline in trade flows between the Republic of Croatia and other countries. As regards the export of services, a significant decline was recorded in travels, traffic and other business-related services. Travel restrictions implemented globally have also significantly reduced tourist traffic. Due to the closure of world economies and a fall in demand, the import of goods has been reduced significantly, especially the import from the most important foreign trade partners from the European Union. The decline in total investment was mostly due to the decline in investment in the business sector, especially in the investment in equipment (Croatian Bureau of Statistics, 2021).

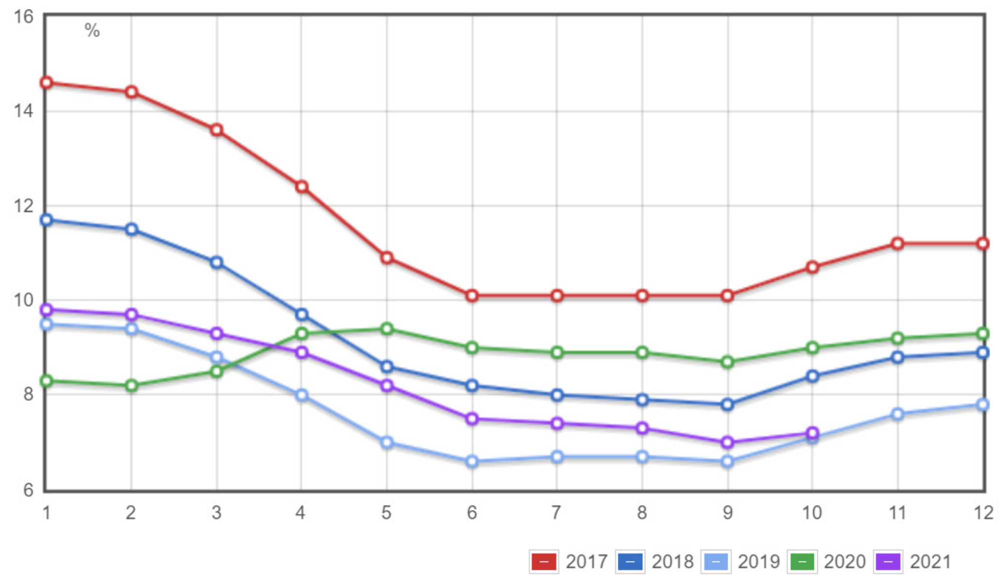


Figure 2.3 Unemployment rate (Croatian Bureau of Statistics, 2021)

Despite the Government's measures, the unemployment rate (Figure 2.3) expanded sharply due to the uncertainty of the situation due to the beginning of the COVID-19 crisis. From the beginning of 2021, the trend of decreasing unemployment and stabilization of the global economic picture is noticeable in the Republic of Croatia and consequently in the City of Zagreb.

2.2.3 Response to the Covid-19 Pandemics

Following the example of the other countries in the world and the European Union, Croatia has tried and is still trying to prevent the spread of coronavirus through a series of measures. The Civil Protection Headquarters of the Republic of Croatia issued a Decision temporary prohibiting and restricting the crossing of persons across all border crossing points of the Republic of Croatia (NN 3/21). However, in accordance with the guidelines of the competent authorities, exceptions have been made for the passengers with valid (European Union) EU Digital COVID Certificate (Government of Croatia, 2021).

The EU and its member states are working together to reinforce national healthcare systems and contain the spread of the virus. At the same time, the EU and its member countries are taking action to mitigate the socio-economic impact of COVID-19 and support the recovery. The main actions taken at EU level to coordinate the fight against the pandemic:

1) Supporting healthcare systems and protecting public health,
2) Providing safe and effective COVID – 19 vaccines,
3) Responding to the economic fallout caused by the pandemic and fostering recovery,
4) Coordinating on travel measures within the EU during the pandemic,
5) Helping partners around the world (European Council, 2021).

Vaccination is envisioned as one the main measures against the COVID – 19. Until the November 29, 2021 in The Republic of Croatia total number of vaccine doses consumed is 4,115,040 (Vaccinated with one dose: 2,176,068, Vaccinated with two doses: 1,931,878) (Government of Croatia, 2021).

2.2.4 Prevention and Preparedness Pre-Covid-19 Measures

The Croatian National Platform for Disaster Risk Reduction is a body that connects the political, operational and scientific levels by enabling the transfer and harmonization of knowledge, proposing solutions, adopting documents and encouraging their implementation in order to reduce disaster risk. One of its major tasks is coordinating the activities of several ministries responsible for individual hazard. National Disaster Risk Assessment is one of the results of multisectoral cooperation in the National Platform. Among other risks, the risk of epidemics and pandemics was assessed in the Disaster Risk Assessment for the Republic of Croatia (Government of Croatia, 2019). It was concluded that the risk of epidemics and pandemics is high in the whole country (Fig. 2.4).

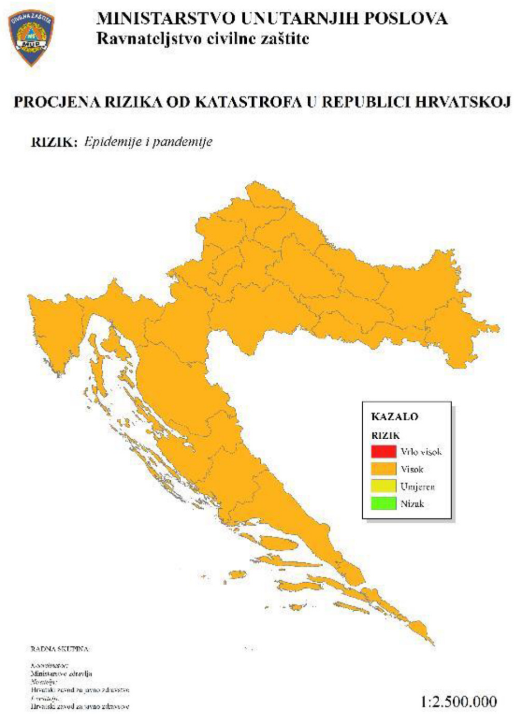


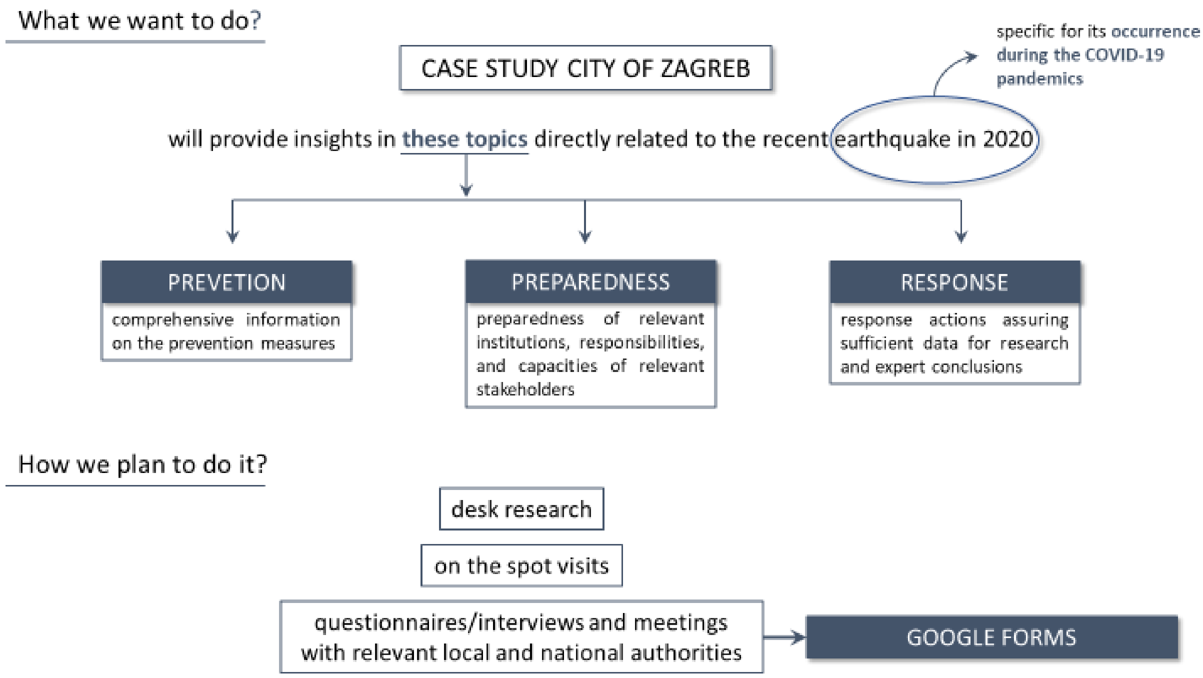
Figure 2.4 Disaster Risk Assessment for the Republic of Croatia – risk of epidemics and pandemics

In Croatia, Croatian Institute of Public Health (CIPH) is a central public health institute, which promotes health and welfare of the population. CIPH deals with public health, health promotion and education, disease prevention, microbiology, environmental health, school medicine, mental health care and addiction prevention. Among other activities, it carries out epidemiological surveillance and proposes, organizes and undertakes preventive and counter-epidemic measures. It also plays a crucial role in planning, supervision and evaluation of immunization. The Service for Epidemiology of Infectious Diseases of the Croatian Institute of Public Health issues the yearly report on infectious diseases, based on the national system of reporting individual infectious diseases, the system of reporting epidemics of infectious diseases and population vaccination. In the years before COVID-19, the epidemiological situation in Croatia was assessed as quite favorable due to the fact that diseases associated with poverty, poor sanitation and low levels of education are rare or sporadic.

It may be stated that the risk of epidemics and pandemics was analyzed and that relevant institutions were aware of it and had to prepare the system for coping with it. However, the measures for prevention of the infectious diseases were not enough for tackling with the proportions of the COVID-19 pandemic, as was the case in almost every other country in the world.

3 MEASURING URBAN RESILIENCE

The study is set to provide comprehensive information on the prevention measures, preparedness of relevant institutions, responsibilities, and capacities of relevant stakeholders as well as response actions assuring sufficient data for research and expert conclusions.



The methodology has three urban disaster risk and resilience indicator systems, developed as complementary tools to communicate risk and promote discussion around appropriate level risk and resilience strategies:

1 Urban Disaster Risk Index (UDRi)

A risk communication tool which provides a holistic view of disaster risk by capturing through indices, both the direct physical damages of buildings and infrastructure. It also considers social vulnerability and lack of resilience that can aggravate the physical effects.

2 Risk Management Index (RMI)

A risk management tool which measures a city's risk management performance, reflecting organizational, development, capacity and institutional actions taken to reduce risk, to prepare for crisis and to recover efficiently from disasters.

3 Disaster Resilience Index (DRI)

A monitoring and evaluation tool for benchmarking and measuring progress or lack thereof, along a city's key development policies and processes for mainstreaming risk reduction and increasing resilience.

Proper data collection is essential in order to reliably evaluate the related indices, which will enable estimation and direct comparison of prevention, preparedness and response of the selected case-study cities due to recent earthquakes and Covid-19 pandemics. Data collection related to this estimation mostly is depended on the governmental, public, academic and other institutions data basis, which requires direct involvement of considerable number of stakeholders.

Data collection depends on for which type of urban disaster risk and resilience indicator system calculation was made.

- For the calculation of the UDRi index, data was collected from various official sources (e.g. Statistical yearbook of the City of Zagreb 2020, City of Zagreb; Health statistical yearbook of the City of Zagreb for 2020, Croatian Institute of Public Health; Population census 2011, Croatian Bureau for Statistics; COVID and crime in 2020 - Commentary on security indicators in the Republic of Croatia, Ministry of the Interior, etc.). When not available, relevant institutions/persons were contacted and the required data was obtained.
- For the calculation of the RMI and DRI index, data collection was realized through Google Forms where each answer was combination of two factors: Valuation level and Confidence level, based on five performance levels corresponding to a range from 1 to 5, where 1 is the lowest level and 5 the highest. Valuation level is personal assessment of the answer that the respondent considers to be the closest to the correct one. Confidence level is factor that takes into account the confidence of the respondent when evaluating the Valuation level, in other words factor that considers the fact that not every respondent can be equally competent in each field, therefore not every question can be answered with an equal level of reliability. All the answers for which the confidence level was assessed as very low (CF= 1.0) were not accounted for in the calculation of the corresponding index.
- the individual surveys of the DRI index were grouped by relevant institutions:
  - Faculty of Civil Engineering University of Zagreb - FCE_ZGB
  - other faculties of Civil Engineering in Croatia (Osijek, Rijeka, Split) - FCE_CRO
  - Ministry of Interior, Civil Protection Directorate – CPD
  - City Offices of the City of Zagreb – CoZ
  - Croatian Centre for Earthquake Engineering - CCEE

Calculation of each urban disaster risk and resilience indicator system is based on methodology given in *Task 2.1 (2. Case study methodology)*.

3.1 Urban Disaster Risk Index (UDRi)

The general evaluation of risk by means of indices is achieved by affecting the physical risk with an intensifying coefficient/impact factor (F), obtained by considering related conditions, such as the socioeconomic fragility and lack of resilience, that intensify initial physical losses.
The total risk represented by UDRi depends on the direct effect, or physical risk, and the indirect effects expressed as a factor of the direct effects.
The physical risk, R_F and the impact factor F is evaluated using transformation functions given in *Task 2.1 (2.2.2.4. Methodology for Assessment)*.
The procedure for calculation of the total risk or UDRi is graphically presented in Fig. 3.1. The weighting factors proposed by Carreño et al. (2007) were adopted for the calculation.

Physical risk

Indicator	Name	F_{RFi}	W_{RFi}
F_{RF1}	Damaged area		0.31
F_{RF2}	Death people		0.1
F_{RF3}	Injured people		0.1
F_{RF4}	Rupture in water mains		0.19
F_{RF5}	Rupture in gas network		0.11
F_{RF6}	Fallen length in HT power lines		0.11
F_{RF7}	Telephone exchange affected		0.04
F_{RF8}	Electricity substations affected		0.04

R_F Physical risk

$$R_F = \sum_{i=1}^{p} w_{RFi} \times F_{RFi}$$

UDRi = R_F (1+F)

Social vulnerability

Indicator	Name	F_{FRi}	W_{FRi}
F_{FS1}	Slums-squatter (poor) neighbourhoods		0.18
F_{FS2}	Mortality rate		0.04
F_{FS3}	Delinquency rate		0.04
F_{FS4}	Social disparity index		0.18
F_{FS5}	Population density		0.18

Lack of resilience

	Name	F_{FSi}	W_{FSi}
F_{FR1}	Hospital beds		0.06
F_{FR2}	Health human resources		0.06
F_{FR3}	Public space/shelter facilities		0.04
F_{FR4}	Rescue and fireman power		0.03
F_{FR5}	Development level		0.09
F_{FR6}	Preparedness/emergency planning		0.09

F Impact factor

$$F = \sum_{i=1}^{m} w_{FSi} \times F_{FSi} + \sum_{i=1}^{n} w_{FRi} \times F_{FRi}$$

Figure 3.1 Factors of physical risk, social fragility and lack of resilience and their weights based on Carreño et al. (2007)

3.1.1 Zagreb 22 March 2020 Earthquake (with Covid-19 – real scenario)

Although the earthquake occurred in March 2020, not much later than the first COVID-19 cases appeared in Croatia and the country was in the first lockdown phase, the healthcare system was not yet overloaded with COVID -19 patients in hospitals. It is important to note that COVID -19 saved many lives, as very few people were outdoors due to restrictions related to the COVID -19 pandemic. Gatherings were banned, which was especially important for centuries-old churches that suffered heavy damage and where mass services would have been held under normal circumstances. Furthermore, there were only few people in the streets as otherwise many lives might have been lost due to collapses of numerous chimneys, gable walls, and other unsupported parts of buildings (Šavor Novak et al., 2020).

As already mentioned at the beginning of the chapter, the data required for the calculation of the UDR index were gathered from various official sources (e.g. Statistical yearbook of the City of Zagreb 2020, City of Zagreb; Health statistical yearbook of the City of Zagreb for 2020, Croatian Institute of Public Health; Population census 2011, Croatian Bureau for Statistics; COVID and crime in 2020 - Commentary on security indicators in the Republic of Croatia, Ministry of the Interior, etc.). When not available, the relevant institutions/persons were contacted and the necessary data was obtained. The transformation functions used to standardize the factors of physical risk, social vulnerability and the lack of resilience are shown in the following figure (red line marks the adopted value for the calculation).

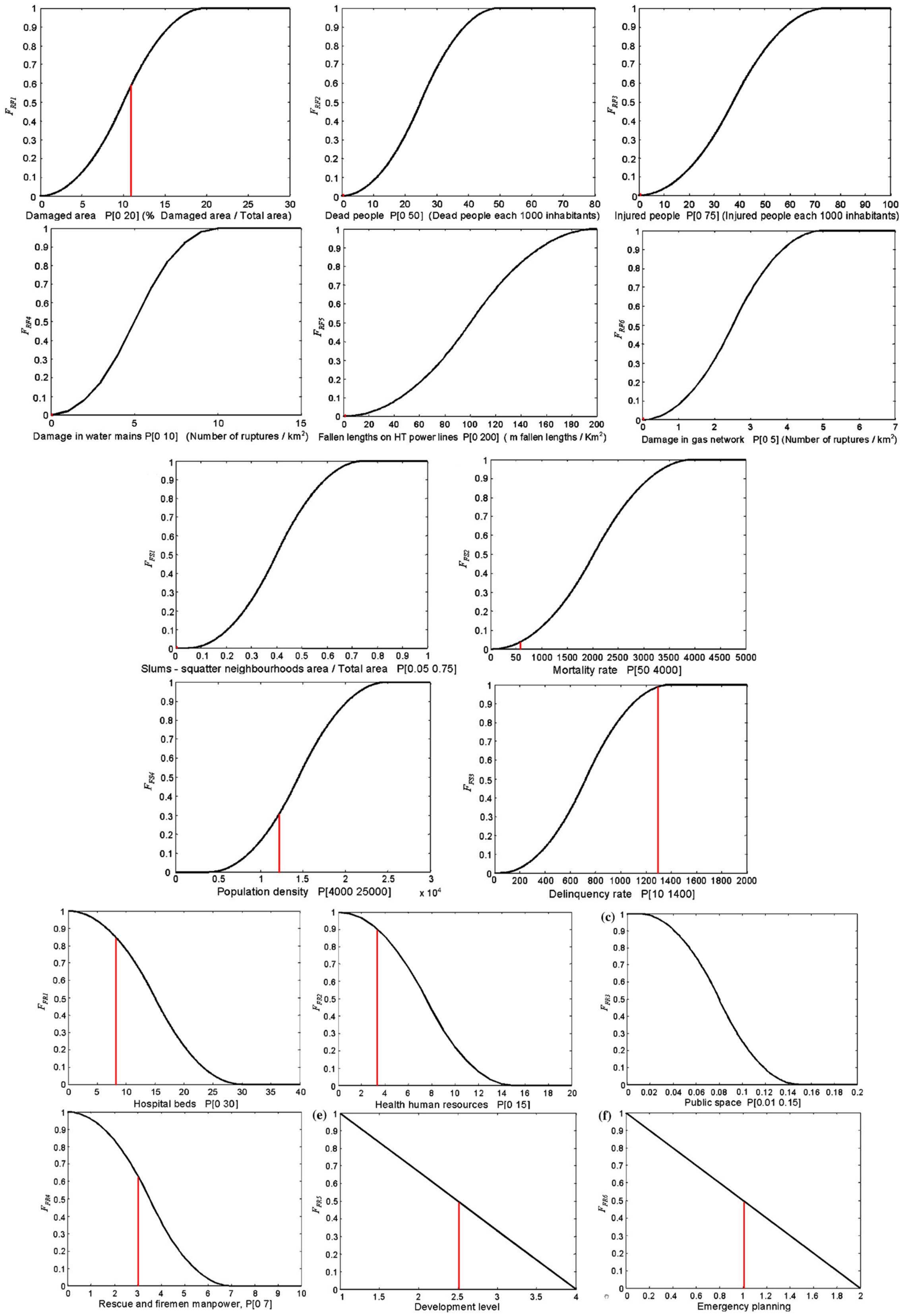


Figure 3.2 Transformation functions used to standardize the factors of physical risk, social vulnerability and the lack of resilience (Carreño et al. 2007)

The following table shows the adopted values of the indicators. It may be noted that the number of fatalities was low (1 dead and 26 injured in total), while the damaged area was high. The calculation of the damaged area was performed by taking into account the area of buildings that were marked with red (unusable) and yellow (temporarily unusable) usability tag, excluding those with the green tag although they also suffered minor damage. Unfortunately, there is no official data on the ruptures in water supply system. However, it should be mentioned that there were many water pipe breaks in the year following the earthquake. It can only be assumed that the already poor condition of the city's aged water supply system, which has approximately 50 % of the water losses, was worsened by earthquakes in 2020. Regarding the other indicators of the physical risk, no data on affected gas network, HT power lines, telephone exchange and electricity substations was recorded.

The social vulnerability and lack of resilience indices were based on the official data.

Table 3.1 UDR index for the Zagreb 22 March 2020 earthquake

	Indicator	Name	F_{RFi}	W_{RFi}	$F_{RFi}\times W_{RFi}$
Physical risk	F_{RF1}	Damaged area	0.6	0.31	0.186
	F_{RF2}	Death people	0.001	0.1	0.0001
	F_{RF3}	Injured people	0.03	0.1	0.003
	F_{RF4}	Rupture in water mains	0.05	0.19	0.0095
	F_{RF5}	Rupture in gas network	0	0.11	0
	F_{RF6}	Fallen length in HT power lines	0	0.11	0
	F_{RF7}	Telephone exchange affected	0	0.04	0
	F_{RF8}	Electricity substations affected	0	0.04	0
				R_F=	**0.1986**
	Indicator	Name	F_{FSi}	W_{FSi}	$F_{FSi}\times W_{FSi}$
Social vulnerability	F_{FS1}	Slums-squatter neighbourhoods	0	0.18	0
	F_{FS2}	Mortality rate	0.04	0.04	0.0016
	F_{FS3}	Delinquency rate	0.98	0.04	0.0392
	F_{FS4}	Social disparity index	0.5	0.18	0.09
	F_{FS5}	Population density	0.3	0.18	0.054
	Indicator	Name	F_{FRi}	W_{FRi}	$F_{FRi}\times W_{FRi}$
lack of resilience	F_{FR1}	Hospital beds	0.85	0.06	0.051
	F_{FR2}	Health human resources	0.9	0.06	0.054
	F_{FR3}	Public space/shelter facilities	0	0.04	0
	F_{FR4}	Rescue and fireman power	0.62	0.03	0.0186
	F_{FR5}	Development level	0.6	0.09	0.054
	F_{FR6}	Preparedness/emergency planning	0.5	0.09	0.045
				F=	**0.4074**

$UDRi=R_F\times(1+F)=0.28$

3.1.2 Zagreb 22 March 2020 Earthquake without Covid-19 Pandemics (hypothetic scenario)

Had the earthquake occurred during the period when the epidemic COVID -19 was not present, the death and injury toll would probably have been higher. However, since the earthquake was only of moderate magnitude, it can be assumed that the relevant physical risk indicators would also be very low. Other indices would not have changed either because, as mentioned earlier, the health care system was not yet overloaded with COVID -19 patients in hospitals at the time of the earthquake.

In conclusion, for this scenario UDRI would change very slightly due to minor change in the F_{RF2} and F_{RF3} (it is assumed that F_{RF2}= 0.002 and F_{RF3}= 0.06) and its value would be UDRI=0.284.

3.2 Risk Management Index (RMI) for the City of Zagreb

For RMI formulation, four components or public policies are considered: Risk identification (RI), risk reduction (RR), disaster management (DM) and Governance and financial protection (FP).

The indicators that represent risk identification, RI, are the following:
- RI1. Systematic disaster and loss inventory
- RI2. Hazard monitoring and forecasting
- RI3. Hazard evaluation and mapping
- RI4. Vulnerability and risk assessment
- RI5. Public information and community participation
- RI6. Training and education on risk management

The indicators that represent risk reduction, RR, are the following:
- RR1. Risk consideration in land use and urban planning
- RR2. Hydrological basin intervention and environmental protection
- RR3. Implementation of hazard-event control and protection techniques
- RR4. Housing improvement and human settlement relocation from prone-areas
- RR5. Updating and enforcement of safety standards and construction codes
- RR6. Reinforcement and retrofitting of public and private assets

The indicators that represent the capacity for disaster management, DM, are the following:
- DM1. Organization and coordination of emergency operations
- DM2. Emergency response planning and implementation of warning systems
- DM3. Endowment of equipments, tools and infrastructure
- DM4. Simulation, updating and testing of inter institutional response
- DM5. Community preparedness and training
- DM6. Rehabilitation and reconstruction planning

The indicators that represent the governance and financial protection are the following:
- FP1. Interinstitutional, multisectoral and decentralizing organization
- FP2. Reserve funds for institutional strengthening
- FP3. Budget allocation and mobilization
- FP4. Implementation of social safety nets and funds response
- FP5. Insurance coverage and loss transfer strategies of public assets.
- FP6. Housing and private sector insurance and reinsurance coverage

As seen, estimation of each public policy takes into account 6 subindicators that characterize the performance of management in the country. Assessment of each subindicator is made using five performance levels: low, incipient, significant, outstanding and optimal, that corresponds to a range from 1 to 5, where 1 is the lowest level and 5 the highest. In this methodological focus each reference level is equivalent to a “performance objective”, thus, it allows the comparison and identification of results or achievements towards which governments should direct the efforts of formulation, implementation and evaluation of policies in risk management.

Once performance levels of each subindicator have been evaluated, the value of each component of RMI is determined. The value of each composed element is between 0 and 100, where 0 is the minimum performance level and 100 is the maximum level. Total RMI is the average of the four composed indicators that represent each public policy. When value of RMI is high, performance of risk management in the country is better.

Detailed description and explanation of each of four components or public policies with belonging six subindicators is given in *Task 2.1 (2.2.2.3. Methodology for Assessment)*.

As already mentioned, data required for the calculation of the RMI index was collected through Google Forms where each answer was combination of two factors: Valuation level and Confidence level, based on five performance levels corresponding to a range from 1 to 5, where 1 is the lowest level and 5 the highest. Valuation level is personal assessment of the answer that the respondent considers to be the closest to the correct one. Confidence level is factor that takes into account the confidence of the respondent when evaluating the Valuation level, in other words factor that considers the fact that not every respondent can be equally competent in each field, therefore not every question can be answered with an equal level of reliability. All the answers for which the confidence level was assessed as very low (CF= 1.0) were not accounted for in the calculation of the corresponding index. The employees of the following institutions were asked to fill-in the form: Faculty of Civil Engineering University of Zagreb - FCE_ZGB, other faculties of Civil Engineering in Croatia (Osijek, Rijeka, Split) - FCE_CRO, Ministry of Interior, Civil Protection Directorate – CPD, City Offices of the City of Zagreb – CoZ and Croatian Centre for Earthquake Engineering - CCEE

The following table and figure present the average values of the performance levels and weights of each risk management indicator evaluated by local officials and researchers.

Table 3.2 Risk management indicators for the City of Zagreb

	Indicators of RI	**Performance Levels**	**Weights**	**Σ (PL x W)**	**Total RMI**
RI	RI1. Systematic disaster and loss inventory	2.75	0.15	**2.72**	**2.58**
	RI2. Hazard monitoring and forecasting	2.70	0.1		
	RI3. Hazard evaluation and mapping	3.00	0.15		
	RI4. Vulnerability and risk assessment	2.90	0.35		
	RI5. Public information and community participation	2.45	0.1		
	RI6. Training and education on risk management	2.15	0.15		
	Indicators of RR				
RR	RR1. Risk consideration in land use and urban planning	2.44	0.1	**2.56**	
	RR2. Hydrological basin intervention and environmental protection	3.06	0.1		
	RR3. Implementation of hazard-event control and protection techniques	2.53	0.1		
	RR4. Housing improvement and human settlement relocation from prone-areas	2.42	0.25		
	RR5. Updating and enforcement of safety standards and construction codes	3.15	0.2		
	RR6. Reinforcement and retrofitting of public and private assets	2.10	0.25		
	Indicators of DM				
DM	DM1. Organization and coordination of emergency operations	3.21	0.3	**2.71**	
	DM2. Emergency response planning and implementation of warning systems	2.85	0.1		
	DM3. Endowment of equipments, tools and infrastructure	2.50	0.15		
	DM4. Simulation, updating and testing of inter institutional response	2.72	0.1		
	DM5. Community preparedness and training	2.47	0.15		
	DM6. Rehabilitation and reconstruction planning	2.21	0.2		
	Indicators of FP				
FP	FP1. Interinstitutional, multisectoral and decentralizing organization	2.28	0.3	**2.32**	
	FP2. Reserve funds for institutional strengthening	2.61	0.25		
	FP3. Budget allocation and mobilization	2.59	0.15		
	FP4. Implementation of social safety nets and funds response	2.39	0.1		
	FP5. Insurance coverage and loss transfer strategies of public assets.	2.00	0.1		
	FP6. Housing and private sector insurance and reinsurance coverage	1.53	0.1		

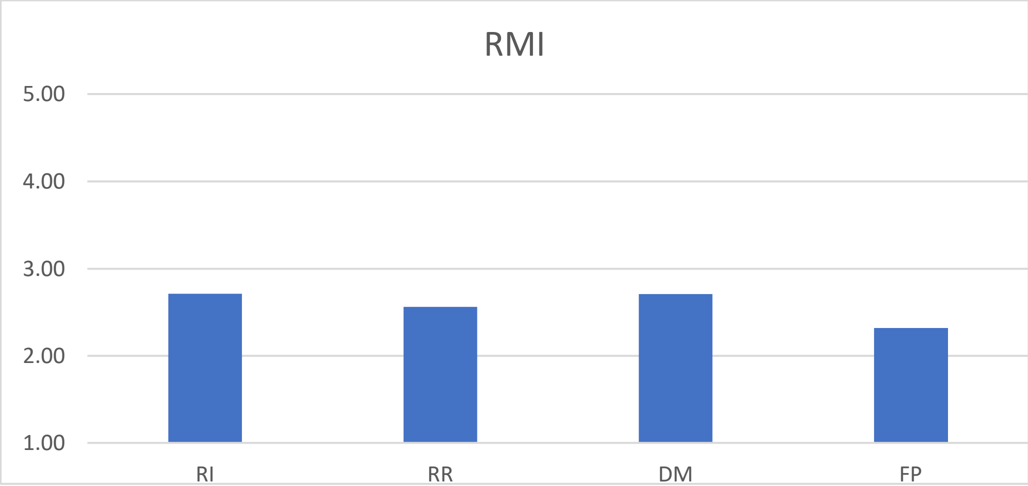


Figure 3.3 Risk Management Index for the Zagreb 22 March 2020 earthquake

It may be observed that all 4 public policies are assessed as below the average. The public policy that had the lowest performance in Zagreb is the financial protection, whereas the policy with the greater performance is the risk identification, followed by the disaster management.

Estimation of the total RMI

$$RMI = \frac{(RMI_{RI} + RMI_{RR} + RMI_{DM} + RMI_{FP})}{4}$$

Risk management indices for Zagreb: The total RMI is estimated as 2.58 (the lowest performance level being 1.0 and the highest 5.0).

3.3 Disaster Resilience Index (DRI) for the City of Zagreb

The DRI is a self-assessment tool which aims to establish an initial benchmark and obtain consistent and objective evaluations around 10 indicators grouped along five thematic areas i.e., DRMMP sectors (Fig. 3.4).

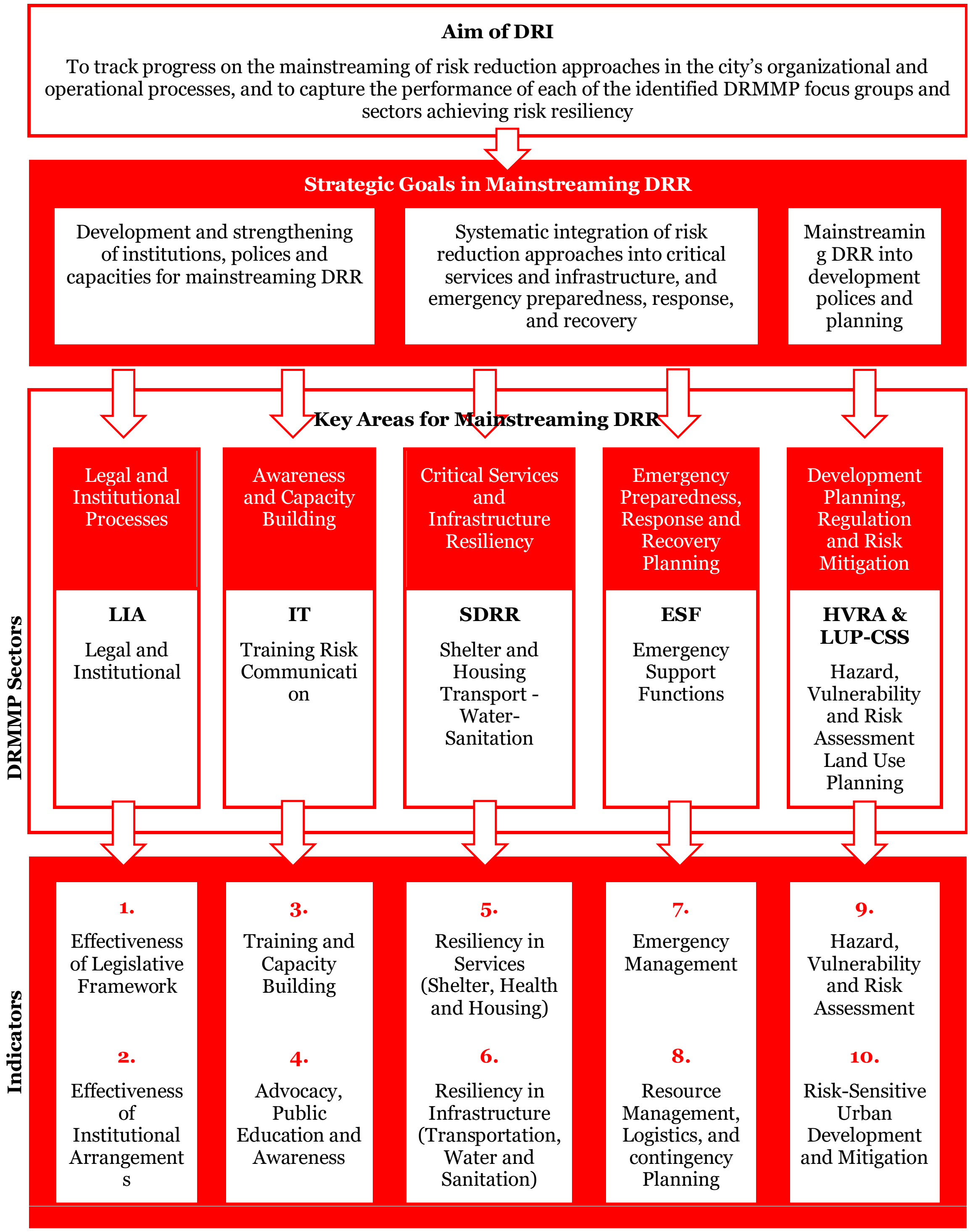


Figure 3.4 DRI Methodological Concept Scheme

For each indicator relevant stakeholders should give assessment in 5 levels of attainment i.e., performance target levels:

	Level 1:	Little or no awareness
	Level 2:	Awareness of needs
	Level 3:	Engagement and Commitment
	Level 4:	Policy Engagement and Solution Development
	Level 5:	Full Integration

For the assessment of each indicator given are template questionaries, presented in *Task 2.1 (Appendix A).*

Detailed description and explanation of each of 10 indicators is given in *Task 2.1 (2.2.3.4. Methodology for Assessment).*

As already mentioned, data required for the calculation of the DRI index was collected through Google Forms where each answer was combination of two factors: Valuation level and Confidence level, based on five performance levels corresponding to a range from 1 to 5, where 1 is the lowest level and 5 the highest. Valuation level is personal assessment of the answer that the respondent considers to be the closest to the correct one. Confidence level is factor that takes into account the confidence of the respondent when evaluating the Valuation level, in other words factor that considers the fact that not every respondent can be equally competent in each field, therefore not every question can be answered with an equal level of reliability. All the answers for which the confidence level was assessed as very low (CF= 1.0) were not accounted for in the calculation of the corresponding index. The employees of the following institutions were asked to fill-in the form: Faculty of Civil Engineering University of Zagreb - FCE_ZGB, other faculties of Civil Engineering in Croatia (Osijek, Rijeka, Split) - FCE_CRO, Ministry of Interior, Civil Protection Directorate – CPD, City Offices of the City of Zagreb – CoZ and Croatian Centre for Earthquake Engineering - CCEE

The following table and figure present the average values of the disaster resilience indicators evaluated by five different groups of experts.

Table 3.3 Disaster resilience index for the City of Zagreb

Group	FCE_ZGB	FCE_CRO	CPD	CoZ	CCEE	average
I1	2.20	3.00	3.00	2.20	3.00	**2.68**
I2	2.20	2.00	3.00	2.20	3.67	**2.61**
I3	2.20	2.67	2.33	2.60	3.00	**2.56**
I4	2.20	3.00	2.67	2.20	2.33	**2.48**
I5	2.00	2.50	3.00	2.50	2.67	**2.53**
I6	1.83	2.50	3.33	2.50	2.67	**2.57**
I7	2.40	3.00	4.33	2.50	3.33	**3.11**
I8	1.80	3.00	3.67	3.25	2.67	**2.88**
I9	2.50	3.00	3.33	3.20	2.67	**2.94**
I10	2.20	2.50	3.00	2.40	2.67	**2.55**

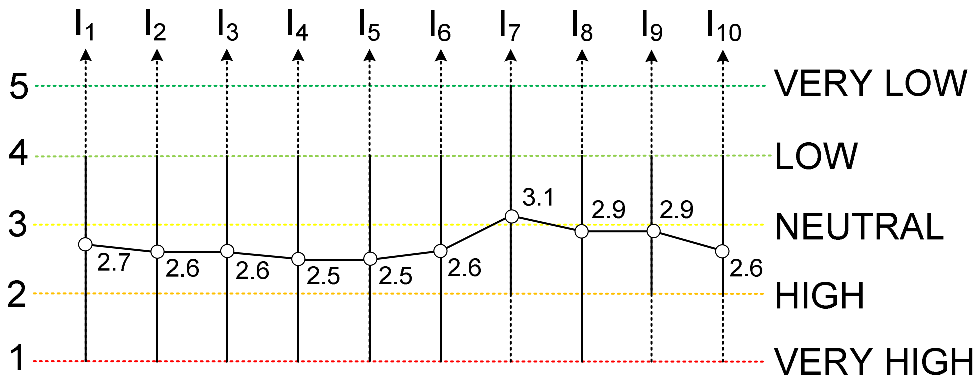


Figure 3.5 Schematic representation of the disaster resilience indicators

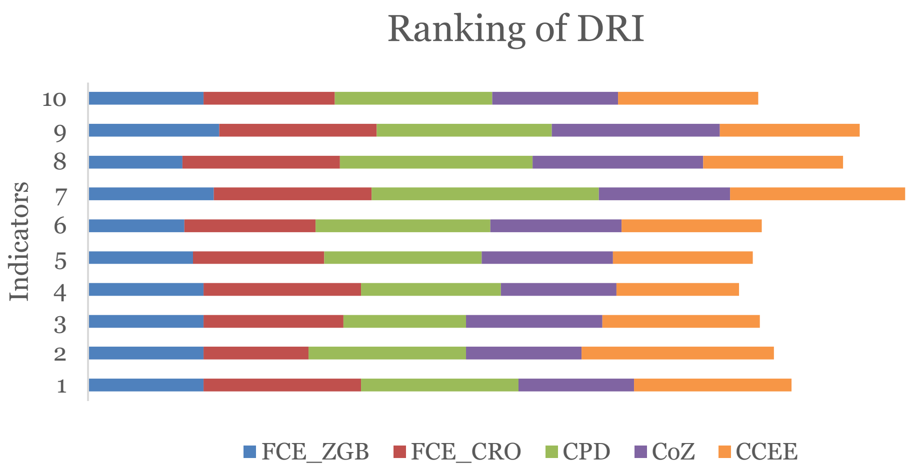


Figure 3.6 Ranking of the disaster resilience indicators by institutions

It may be observed from Fig. 3.5 that almost all disaster resilience indicators are below the average and that the strategy aimed at development and strengthening of institutions, polices and capacities, and systematic integration of risk reduction approaches into critical services and infrastructure, and emergency preparedness, response, and recovery need to be adopted as soon as possible.

4 CONCLUSIONS

In analyzing the results and building a picture of the system in Zagreb, there are several important elements to consider. Awareness of the earthquake risk was extremely low, which was reflected in a number of activities at the city/state level that completely ignored or paid no attention to the potential impact of the earthquake. The situation is perhaps best described by the fact that procedures for post-earthquake operations (particularly damage assessment) were not implemented in the systems at all, nor were there any official inspection forms. Considering this, it might be interesting to analyze the data in terms of confidence level, because the experts in the system had only a tangential contact with earthquakes, i.e. there was no institution / municipal body or person "professionally" in charge of earthquakes. It all came down to individual initiatives and the results of the survey should be looked at from the point of view of each individual being familiar with their specific part.

In addition, databases at the city (as well as the state) level were not developed or linked, and the statistics collected in the census are not fully applicable. After the earthquake, many things changed for the better as the crisis set in motion processes that skipped complicated administrative procedures, but unfortunately data quality did not reach a satisfactory level at this stage. The analyzes carried out and the reliability of the data used should be considered in this light.

During the inspection of the damage, the influence of Covid-19 did not significantly affect the operations, since protective measures were taken from the first day in the form of masks, gloves, prescribed procedures (room ventilation) and the like. Of course, there were isolated cases, but in the end, out of 150 engineers who were subsequently tested, only 3 showed "traces of Covid-19". This is very significant because it confirmed that the engineers did not cause further spread of the disease, which was also proven by independent analysis in health facilities. It should be taken into account that in practice, depending on the "panic level", one curve dominated over the other, but it is very difficult to draw the line or define the impact, because in the face of two crises, no attention was paid to statistics or analysis.

In conclusion, according to presented results, urban resilience in Zagreb is relatively low and further strategic actions need to be implemented as soon as possible.

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8 APPENDIX-A: SURVEY FORM FOR DISASTER RESILIENCE INDEX

Case study on City of Zagreb in prevention preparedness, and response to earthquakes form

Personal information

Name, surname and title *

Your answer

Education *

Your answer

Insitututtion/organisation/company name *

Your answer

Position in institution/organisation/company *

Your answer

three urban disaster risk and resilience indicator systems

A	Urban Disaster Risk Index (UDRi)
	A **risk communication tool** which provides a holistic view of disaster risk by capturing through indices, both the direct physical damages of buildings and infrastructure. It also considers social vulnerability and lack of resilience that can aggravate the physical effects.

B	Risk Management Index (RMI)
	A **risk management tool** which measures a city's risk management performance, reflecting organizational, development, capacity and institutional actions taken to reduce risk, to prepare for crisis and to recover efficiently from disasters.

C	Disaster Resilience Index (DRI)
	A **monitoring and evaluation tool** for benchmarking and measuring progress or lack thereof, along a city's key development policies and processes for mainstreaming risk reduction and increasing resilience.

CONFIDENCE LEVEL

- factor that takes into account the **confidence of the respondent when evaluating** the Valuation level
- factor that considers the fact that not every respondent can be **equally competent in each field**, therefore not every question can be answered with an **equal level of reliability**
- based on **five performance levels** corresponding to a range from 1 to 5, where 1 is the lowest level and 5 the highest

1. Confidence level 1: *Very low*
   My former and/or current work/research **has not any contact** with this issue. My answer is based **only on information from media and newspapers**. My overall opinion is **subjective without critical/scientific explanation**.
2. Confidence level 2: *Low*
   My former and/or current work/research **has little contact** with this issue. My answer is based **mostly on information from media and newspapers**. My overall opinion is **subjective,** but with **superficial critical/scientific explanation**.
3. Confidence level 3: *Moderate*
   My former and/or current work/research **has some** contact with this issue. My answer is based **partly on information from media and newspapers and partly from professional work**. My overall opinion **can be critically/scientifically explained**.
4. Confidence level 4: *High*
   My former and/or current work/research **has contact** with this issue. My answer is based on my **professional work**. My overall opinion is **objective with critical/scientific explanation.**
5. Confidence level 5: *Very high*
   My former and/or current work/research **is dealing with** this issue. My answer and opinion are **relevant in this field**.

B. Risk Management Index (RMI)

For RMI formulation, four components or public policies are considered:

B.1 Risk Identification (RI)
B.2 Risk Reduction (RR)
B.3 Disaster Management (DM)
B.4 Governance and Financial Protection (FP)

Each of which with six indicators.

Indicator valuation methodology

Each answer is **combination of two factors**: Valuation level and Confidence level.

VALUATION LEVEL

- **personal assessment** of the answer that the respondent considers to be the closest to the correct one
- based on **five performance levels** corresponding to a range from 1 to 5, where 1 is the lowest level and 5 the highest

CONFIDENCE LEVEL

- factor that takes into account the **confidence of the respondent when evaluating** the Valuation level
- factor that considers the fact that not every respondent can be **equally competent in each field**, therefore not every question can be answered with an **equal level of reliability**
- based on **five performance levels** corresponding to a range from 1 to 5, where 1 is the lowest level and 5 the highest

1. Confidence level 1: *Very low*
   My former and/or current work/research **has not any contact** with this issue. My answer is based **only on information from media and newspapers**. My overall opinion is **subjective without critical/scientific explanation**.
2. Confidence level 2: *Low*
   My former and/or current work/research **has little contact** with this issue. My answer is based **mostly on information from media and newspapers**. My overall opinion is **subjective**, but with **superficial critical/scientific explanation**.
3. Confidence level 3: *Moderate*
   My former and/or current work/research **has some** contact with this issue. My answer is based **partly on information from media and newspapers and partly from professional work**. My overall opinion **can be critically/scientifically explained**.
4. Confidence level 4: *High*
   My former and/or current work/research **has contact** with this issue. My answer is based on my **professional work**. My overall opinion is **objective with critical/scientific explanation**.
5. Confidence level 5: *Very high*
   My former and/or current work/research **is dealing with** this issue. My answer and opinion are **relevant in this field**.

INDICATOR RI1: Systematic disaster and loss inventory (In case of doubt, choose a lower-level answer) *

Level 1 VERY LOW	Level 2 LOW	Level 3 NEUTRAL	Level 4 HIGH	Level 5 VERY HIGH
Level 1	Some basic and superficial data on the history of events that have affected the city			
Level 2	Continual registering of current events, incomplete catalogues of the occurrence of some phenomena and limited information on losses and effects.			
Level 3	Some complete catalogues at the national and regional levels, systematization of actual events and their economic, social and environmental effects.			
Level 4	Complete inventory and multiple catalogues of events; registry and detailed systematization of effects and losses at the local level.			
Level 5	Detailed inventory of events and effects for all types of existing hazards and data bases at the sub-national and local levels.			

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

INDICATOR RI1: Confidence level *

1: Very low; 2: Low; 3: Moderate; 4: High; 5: Very high

Level 1 VERY LOW	Level 2 LOW	Level 3 MODERATE	Level 4 HIGH	Level 5 VERY HIGH

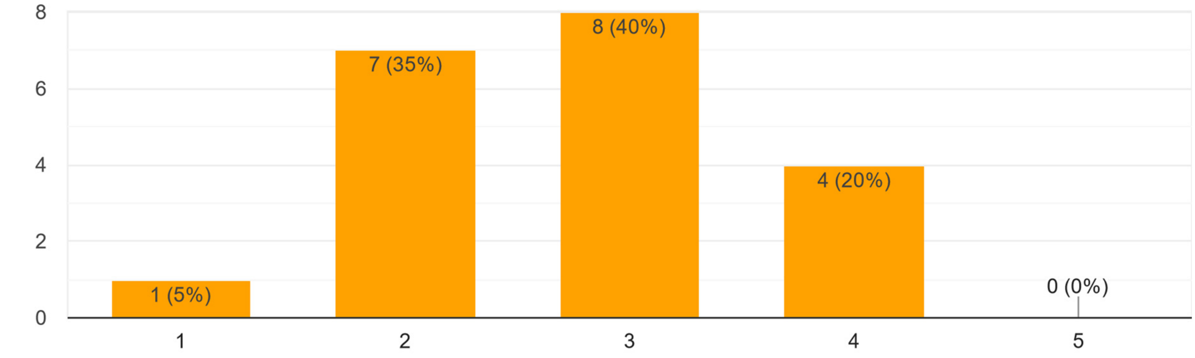
1 ○ 2 ○ 3 ○ 4 ○ 5 ○

The other questions in the survey form are not attached here, but they had the same form as the one shown above.

SURVEY RESULTS

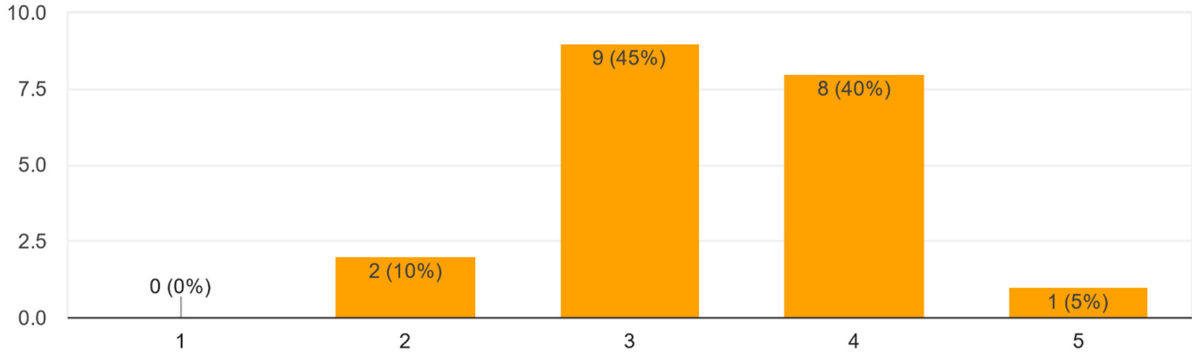
INDICATOR RI1: Systematic disaster and loss inventory (In case of doubt, choose a lower-level answer)

20 responses



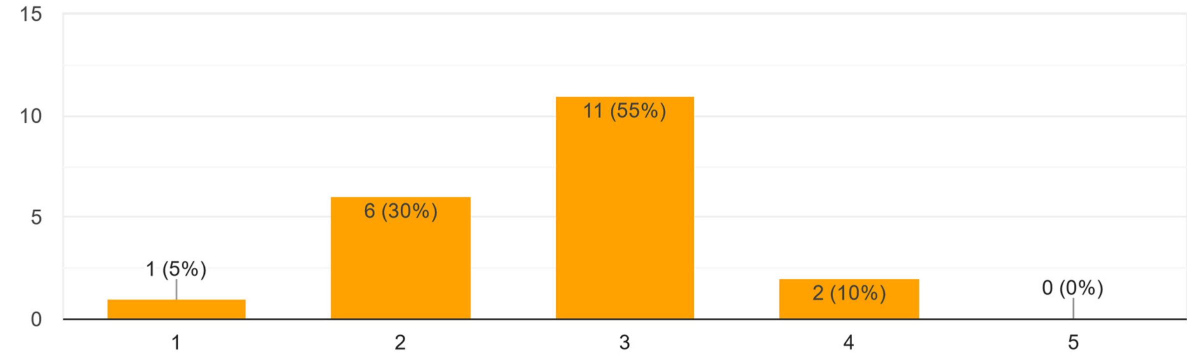
INDICATOR RI1: Confidence level

20 responses



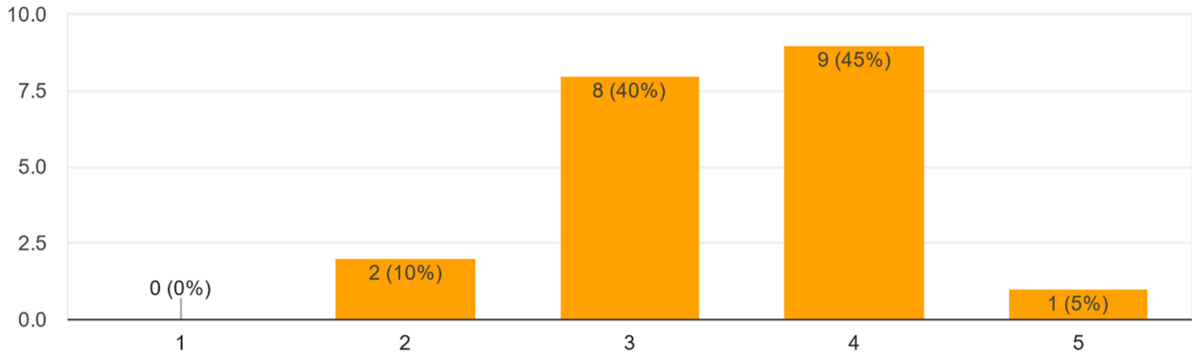
INDICATOR RI2: Hazard monitoring and forecasting (In case of doubt, choose a lower-level answer)

20 responses



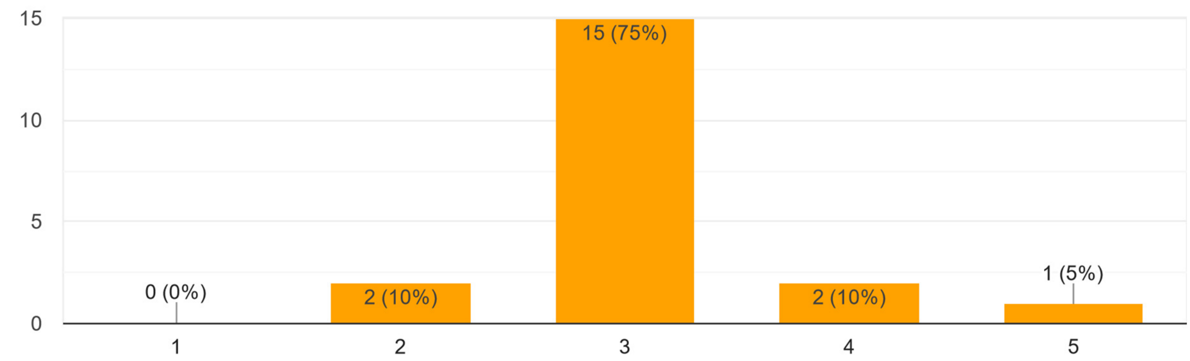
INDICATOR RI2: Confidence level

20 responses



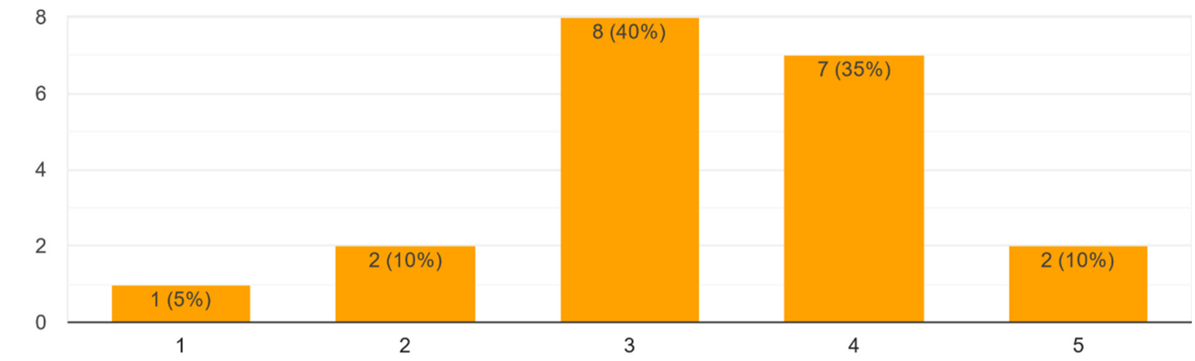
INDICATOR RI3: Hazard evaluation and mapping (In case of doubt, choose a lower-level answer)

20 responses



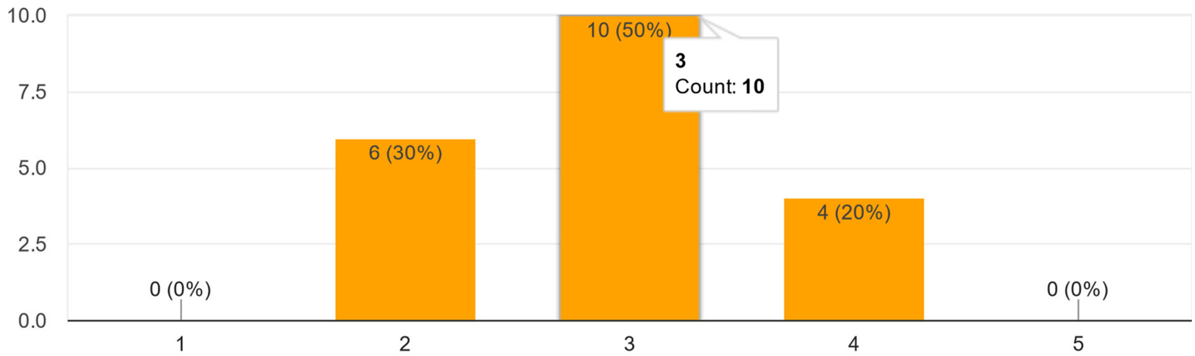
INDICATOR RI3: Confidence level

20 responses



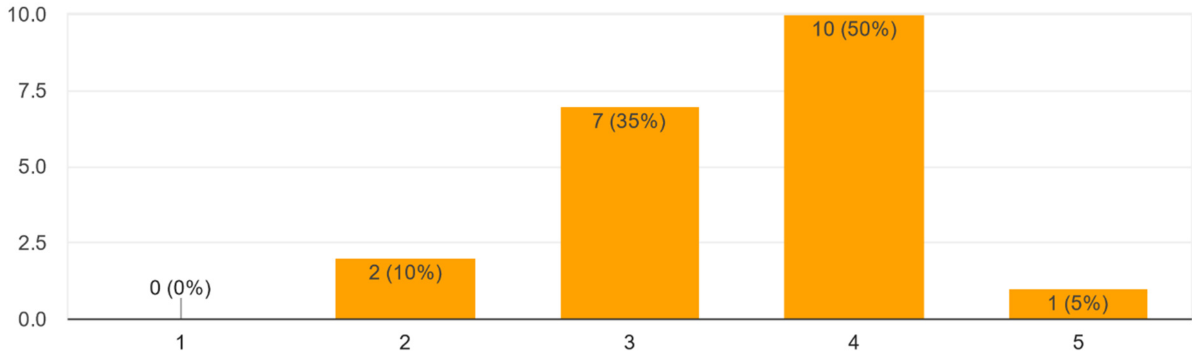
INDICATOR RI4: Vulnerability and risk assessment (In case of doubt, choose a lower-level answer)

20 responses

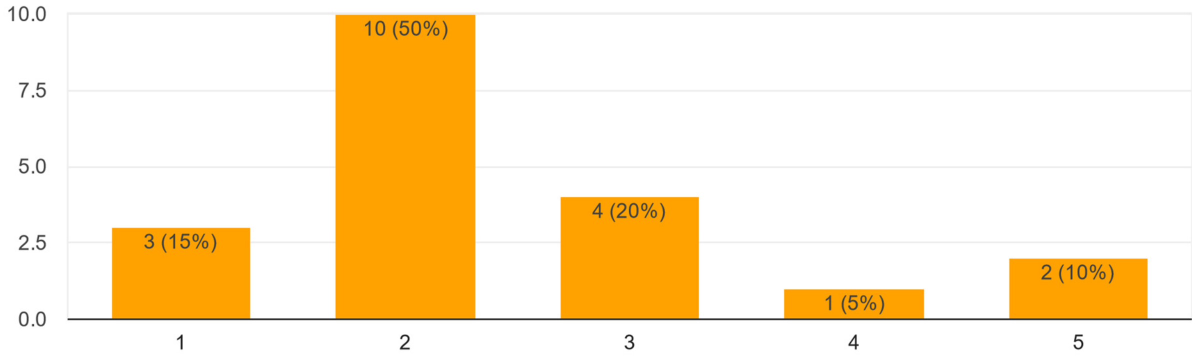


INDICATOR RI4: Confidence level

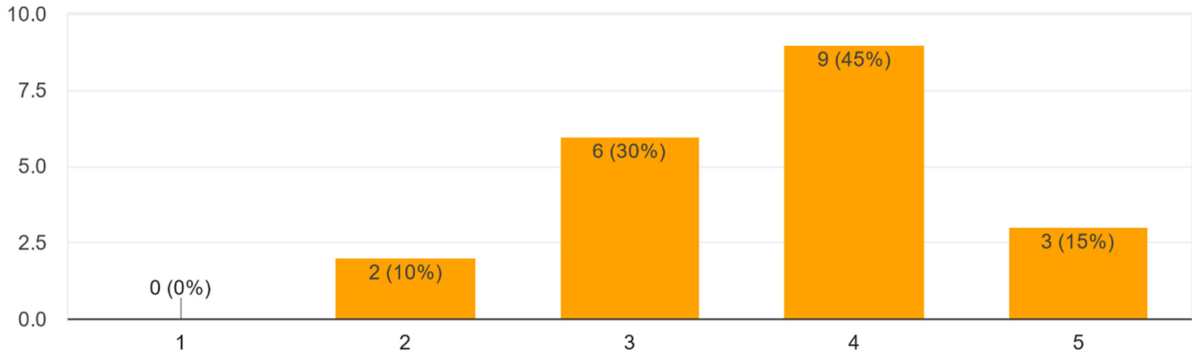
20 responses



INDICATOR RI5: Public information and community participation (In case of doubt, choose a lower-level answer)
20 responses

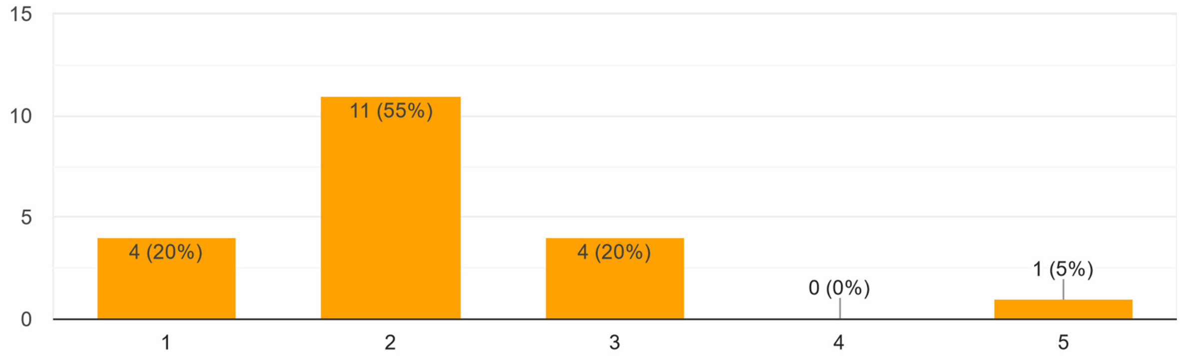


INDICATOR RI5: Confidence level
20 responses



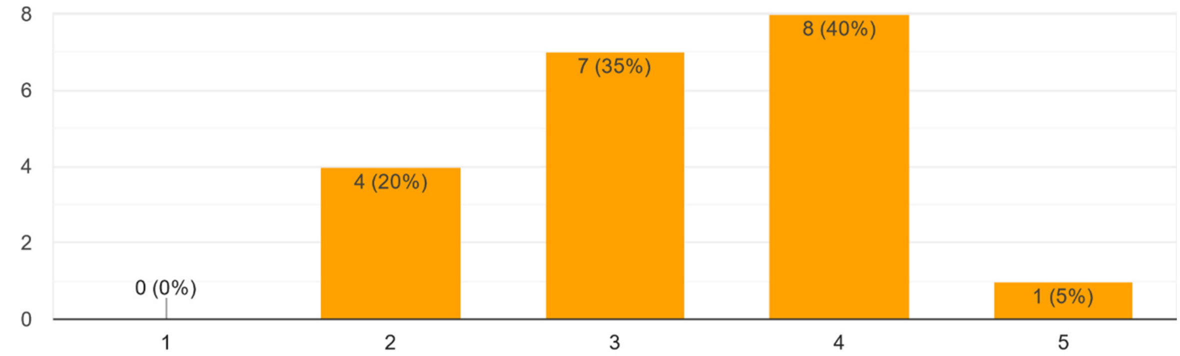
INDICATOR RI6: Training and education in risk management (In case of doubt, choose a lower-level answer)

20 responses

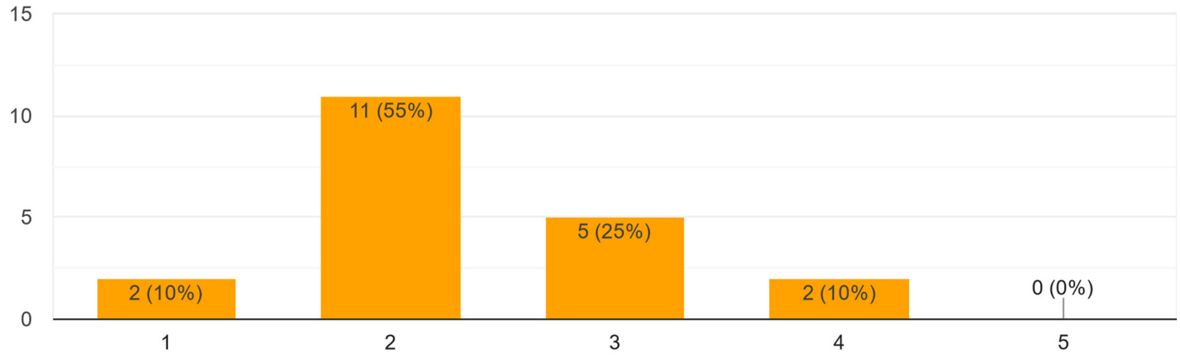


INDICATOR RI6: Confidence level

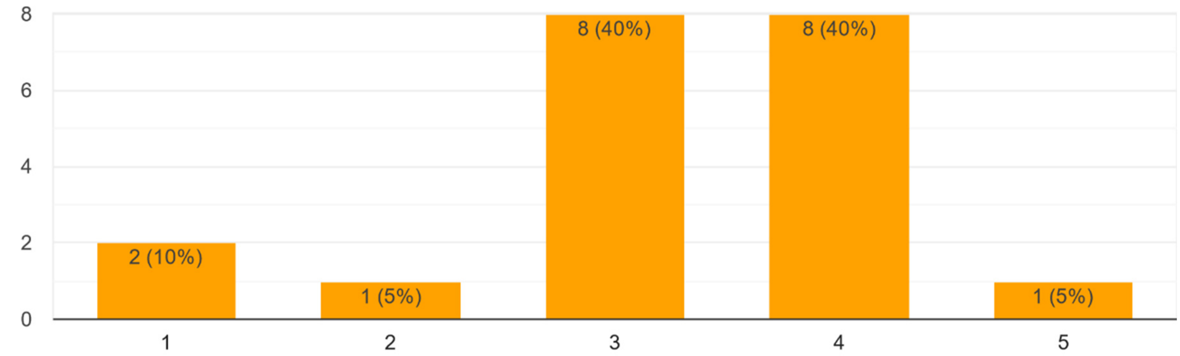
20 responses



INDICATOR RR1: Risk consideration in land-use and urban planning (In case of doubt, choose a lower-level answer)
20 responses

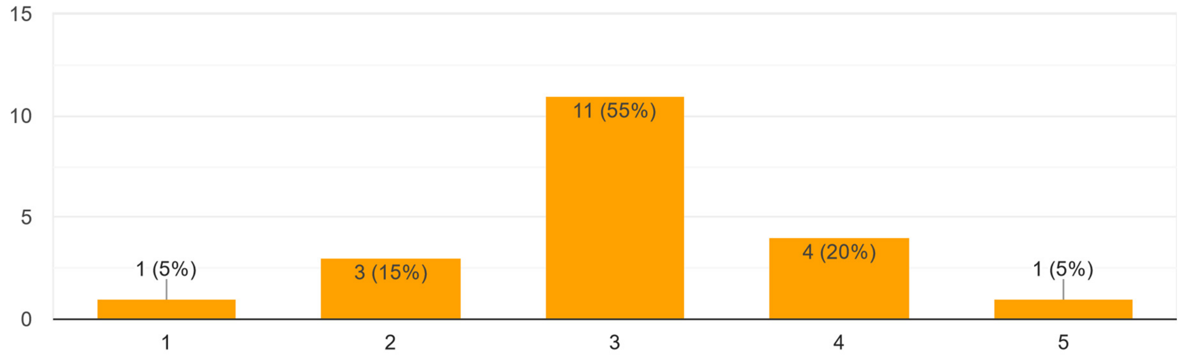


INDICATOR RR1: Confidence level
20 responses



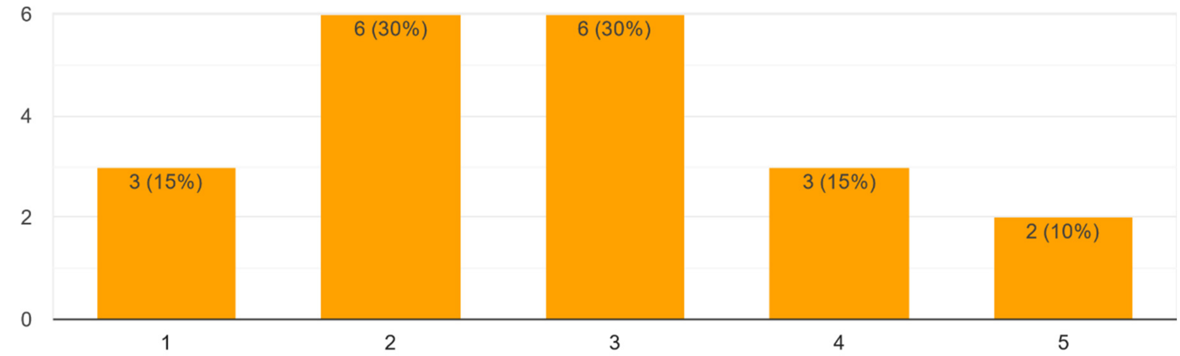
INDICATOR RR2: Hydrographic basin intervention and environmental protection (In case of doubt, choose a lower-level answer)

20 responses



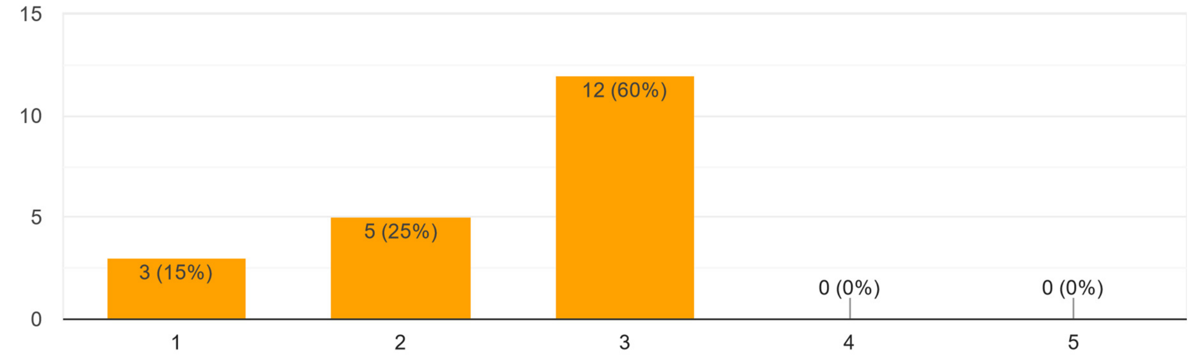
INDICATOR RR2: Confidence level

20 responses



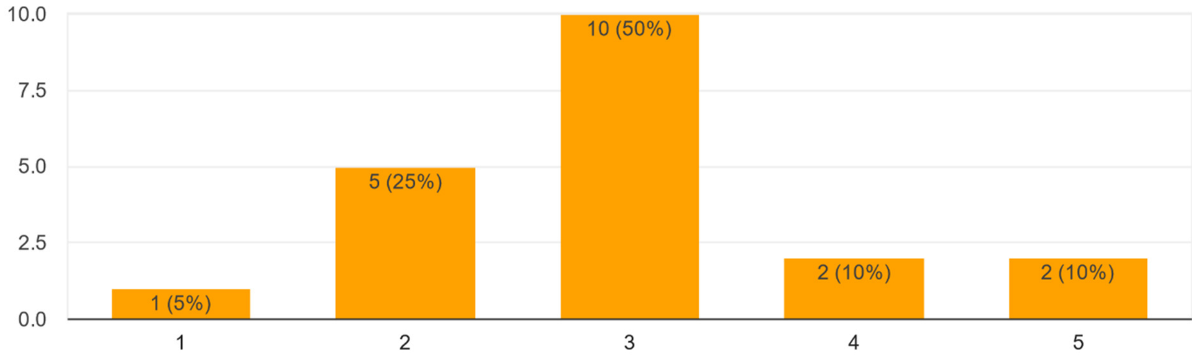
INDICATOR RR3: Implementation of hazard-event control and protection techniques (In case of doubt, choose a lower-level answer)

20 responses

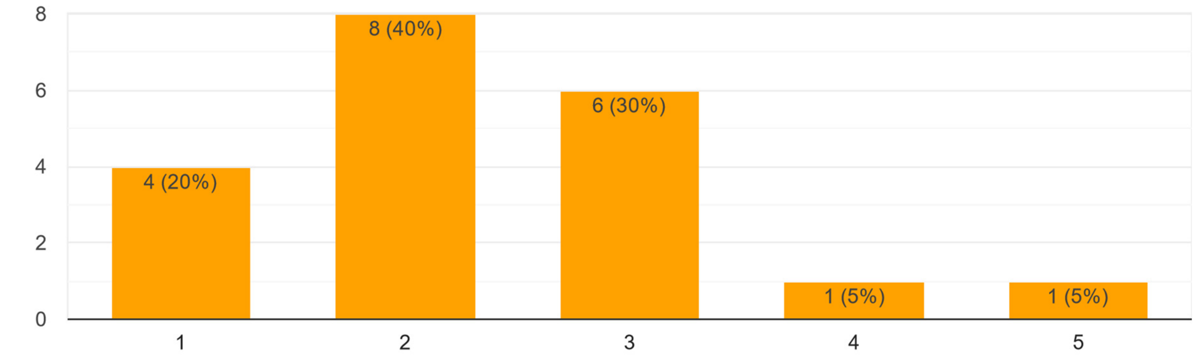


INDICATOR RR3: Confidence level

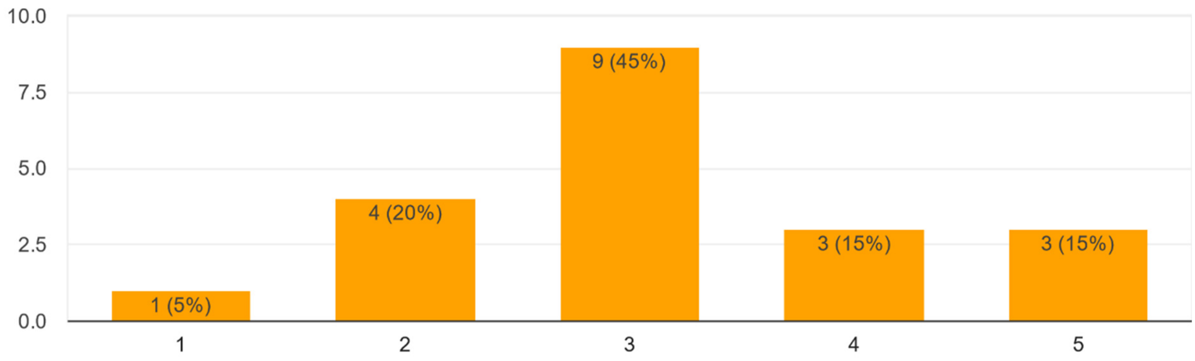
20 responses



INDICATOR RR4: Housing improvement and human settlement relocation from prone-areas (In case of doubt, choose a lower-level answer)
20 responses

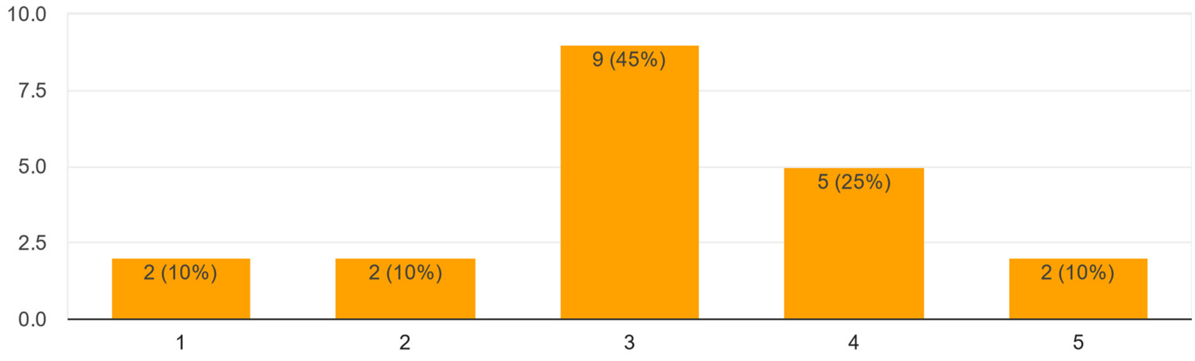


INDICATOR RR4: Confidence level
20 responses



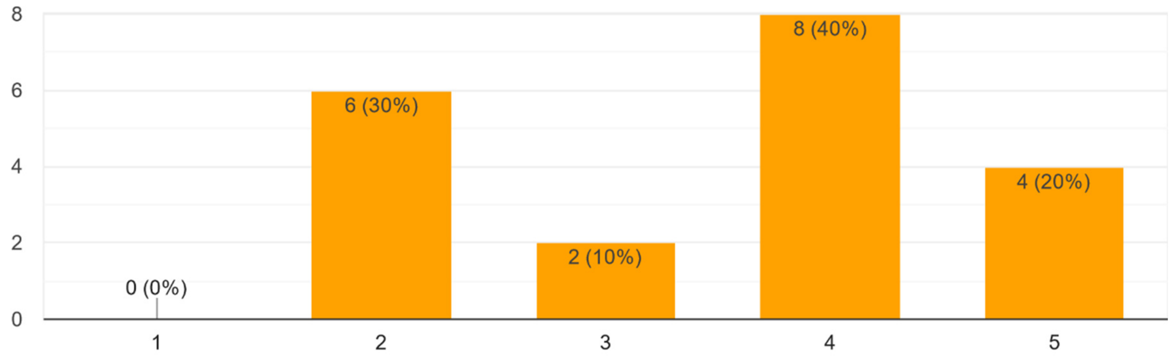
INDICATOR RR5: Updating and enforcement of safety standards and construction codes (In case of doubt, choose a lower-level answer)

20 responses



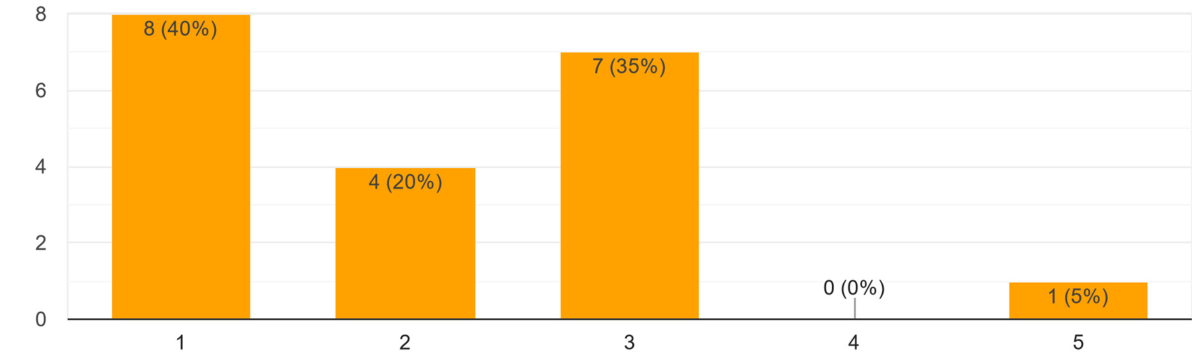
INDICATOR RR5: Confidence level

20 responses



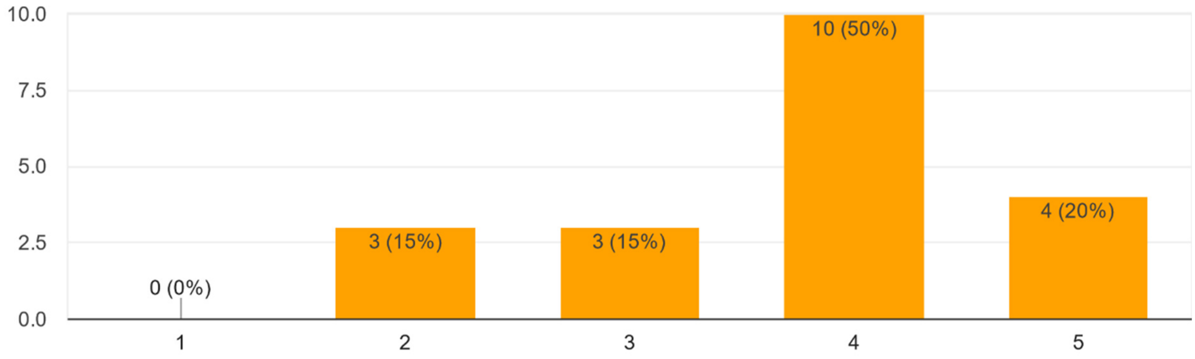
INDICATOR RR6: Reinforcement and retrofitting of public and private assets (In case of doubt, choose a lower-level answer)

20 responses



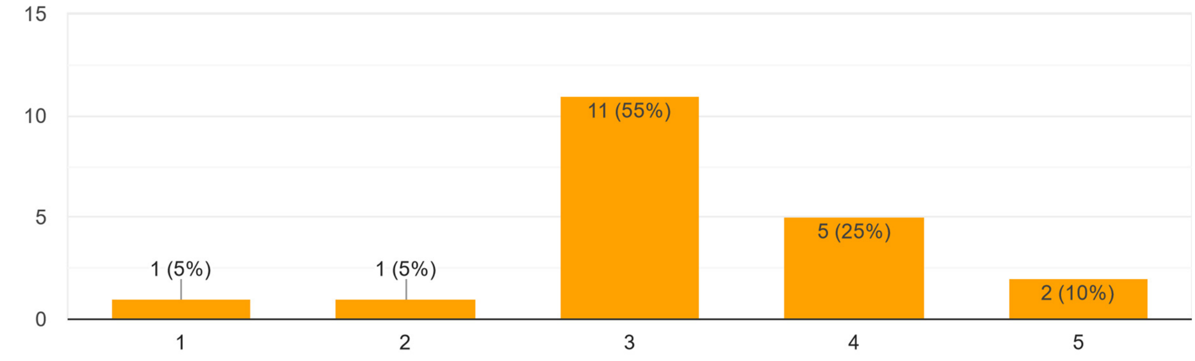
INDICATOR RR6: Confidence level

20 responses



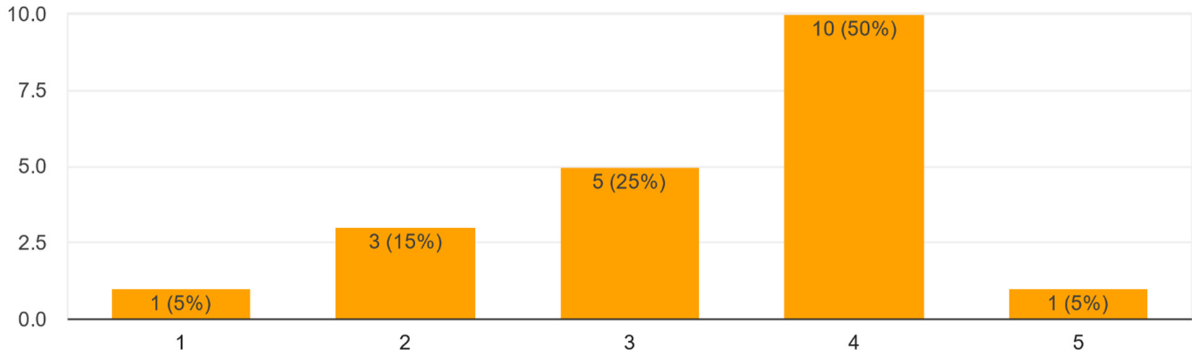
INDICATOR DM1: Organization and coordination of emergency operations (In case of doubt, choose a lower-level answer)

20 responses



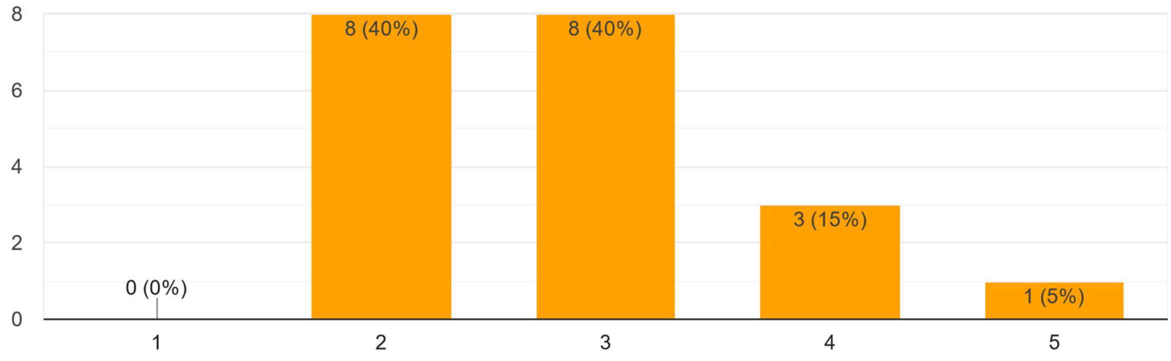
INDICATOR DM1: Confidence level

20 responses



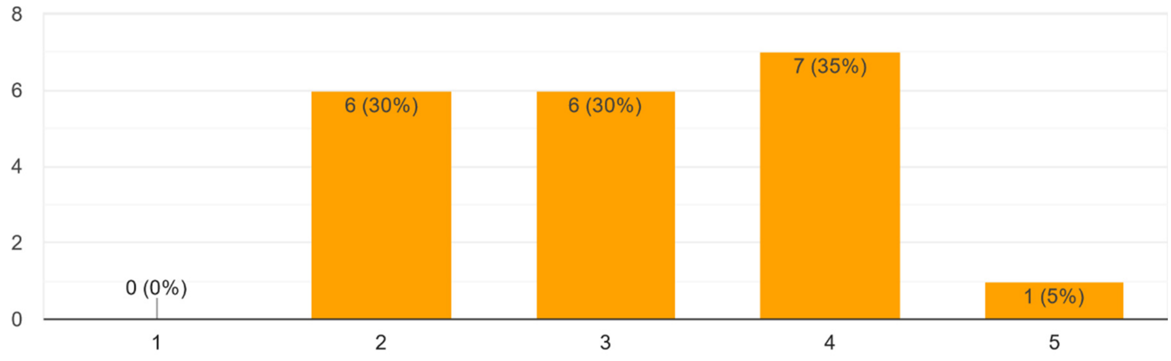
INDICATOR DM2: Emergency response planning and implementation of warning systems (In case of doubt, choose a lower-level answer)

20 responses



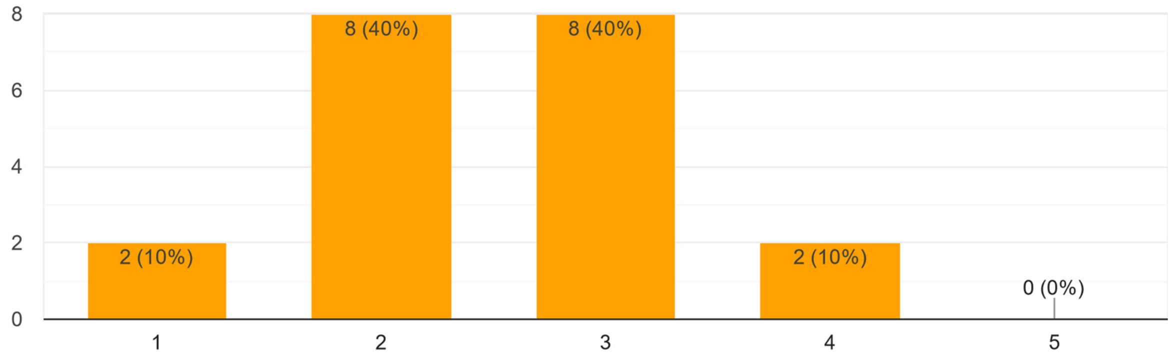
INDICATOR DM2: Confidence level

20 responses



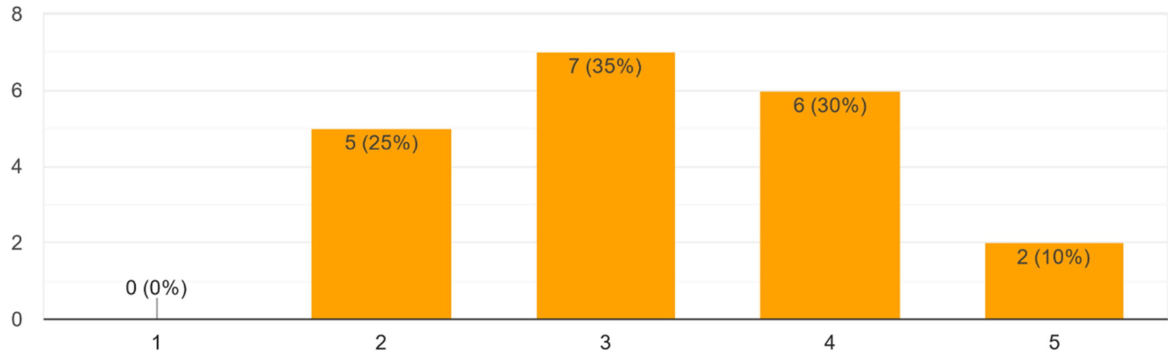
INDICATOR DM3: Endowment of equipment's, tools and infrastructure (In case of doubt, choose a lower-level answer)

20 responses



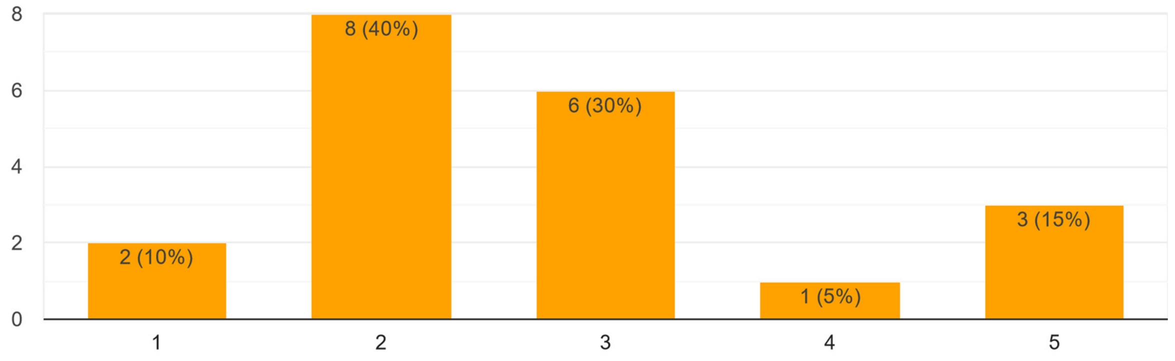
INDICATOR DM3: Confidence level

20 responses



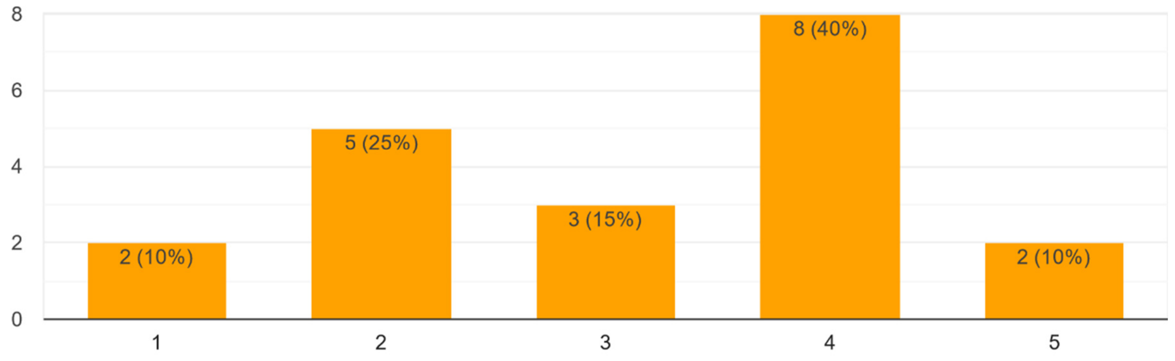
INDICATOR DM4: Simulation, updating, and test of inter institutional responses (In case of doubt, choose a lower-level answer)

20 responses



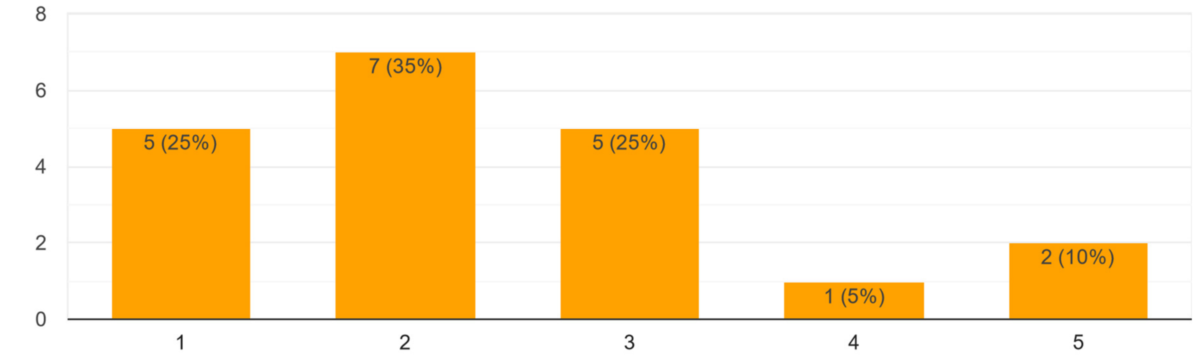
INDICATOR DM4: Confidence level

20 responses



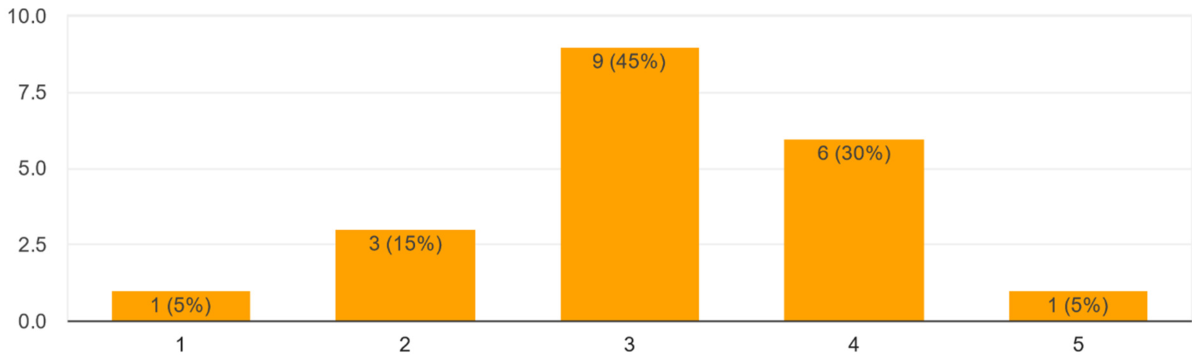
INDICATOR DM5: Community preparedness and training (In case of doubt, choose a lower-level answer)

20 responses



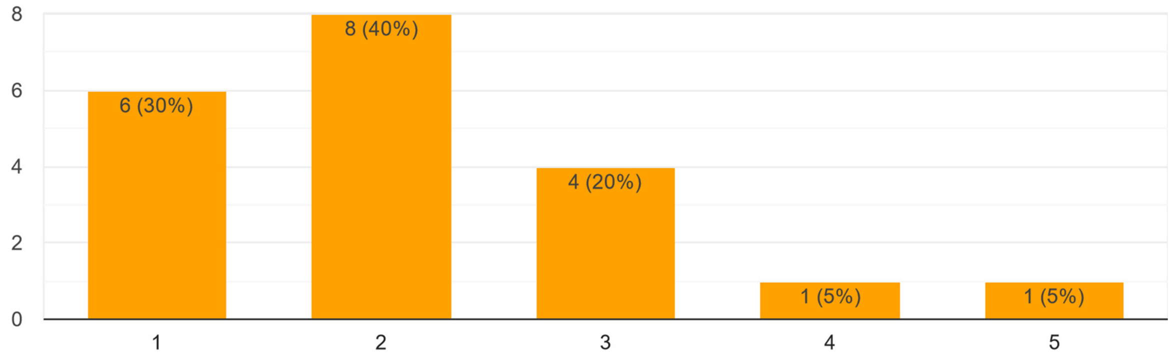
INDICATOR DM5: Confidence level

20 responses



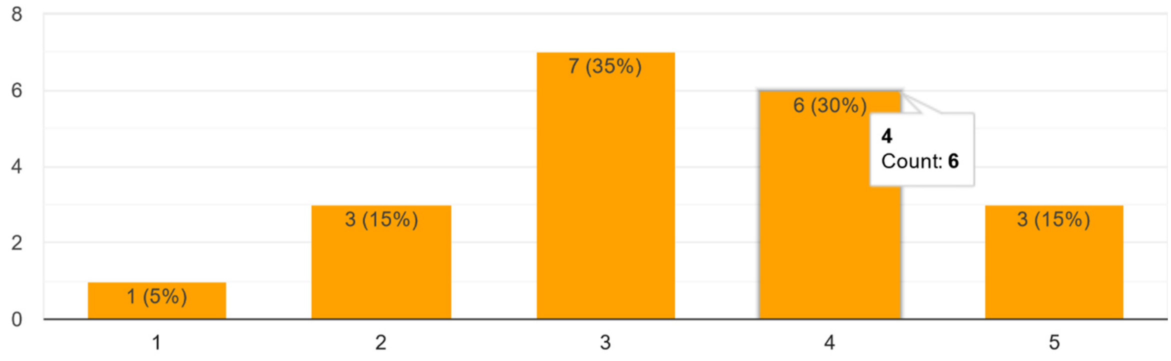
INDICATOR DM6: Rehabilitation and reconstruction planning (In case of doubt, choose a lower-level answer)

20 responses



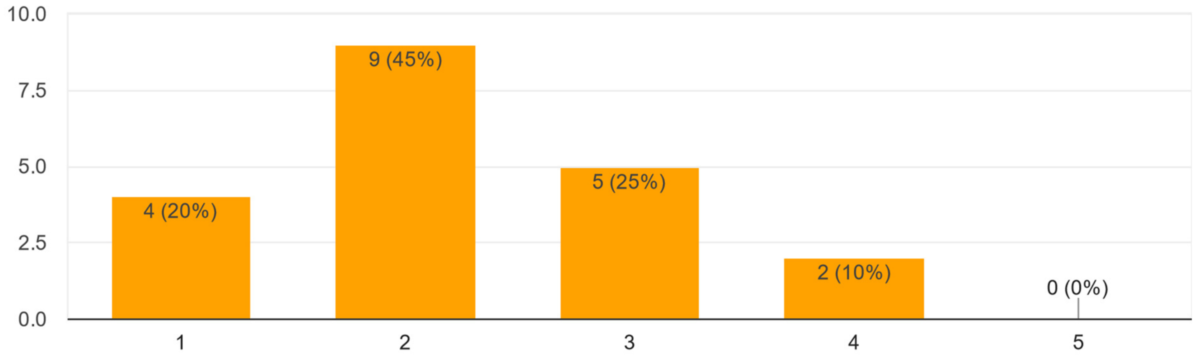
INDICATOR DM6: Confidence level

20 responses



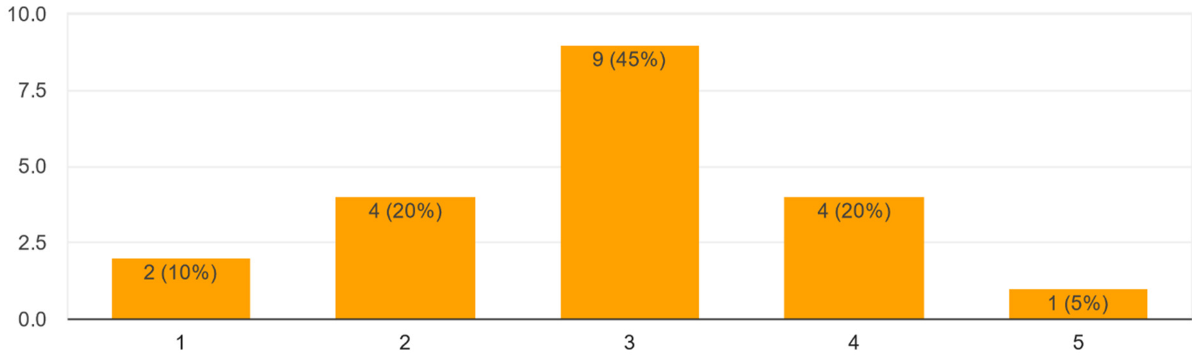
INDICATOR FP1: Interinstitutional, multisectoral and decentralizing organization (In case of doubt, choose a lower-level answer)

20 responses



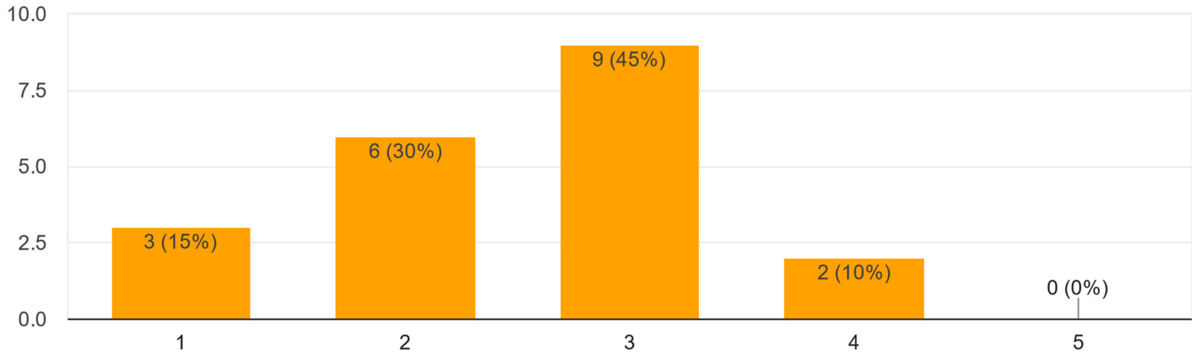
INDICATOR FP1: Confidence level

20 responses



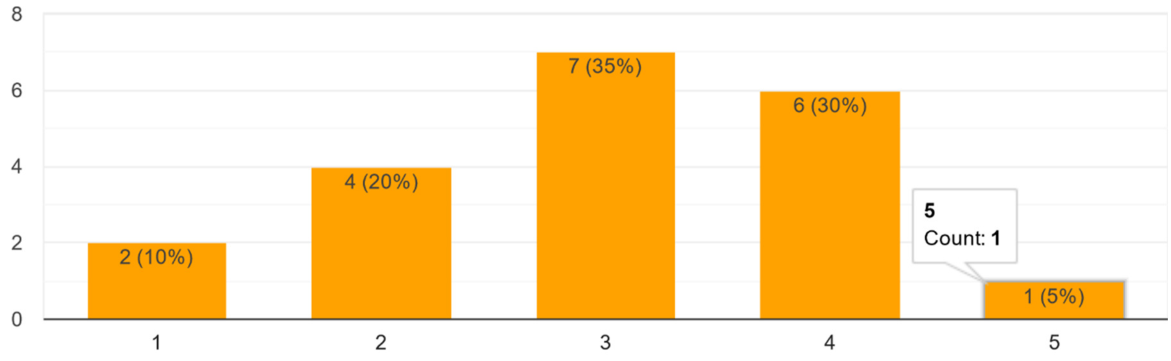
INDICATOR FP2: Reserve funds for institutional strengthening (In case of doubt, choose a lower-level answer)

20 responses



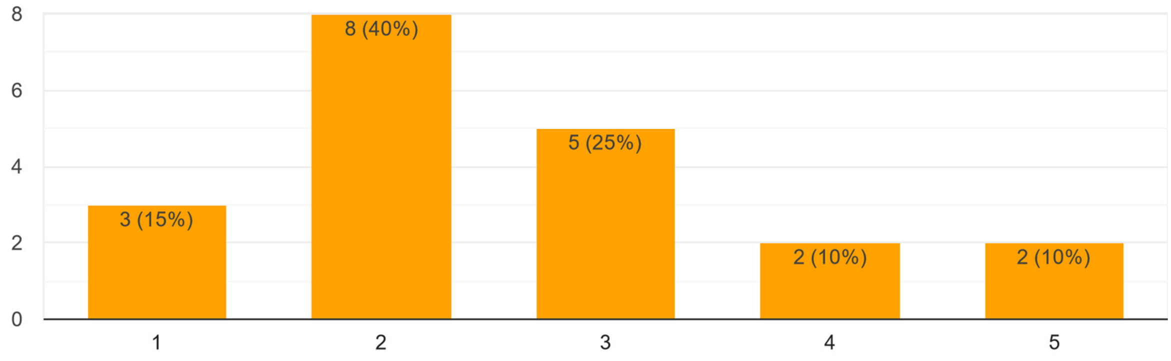
INDICATOR FP2: Confidence level

20 responses



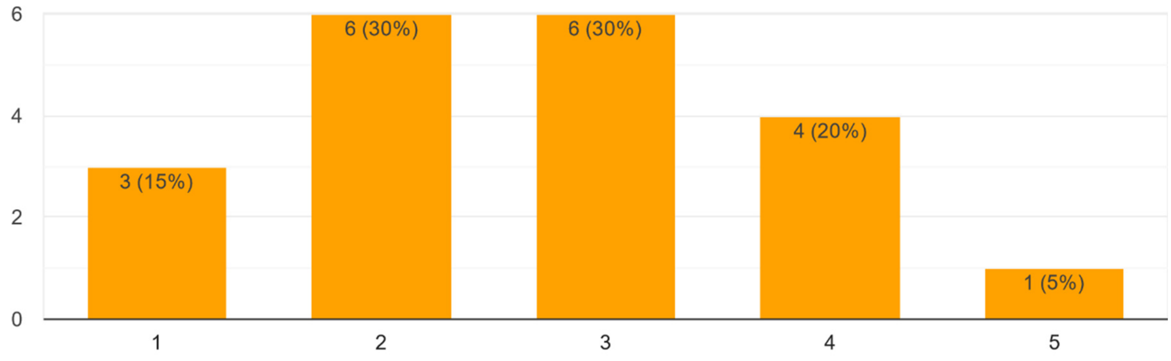
INDICATOR FP3: Budget allocation and mobilization (In case of doubt, choose a lower-level answer)

20 responses



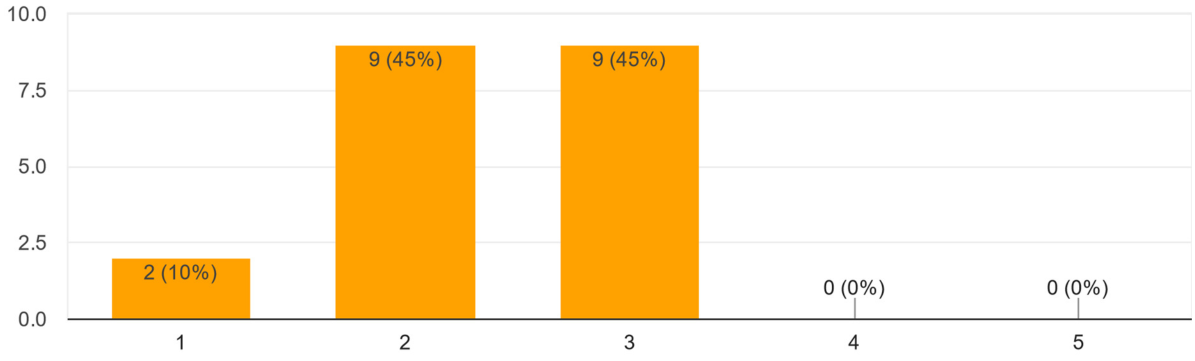
INDICATOR FP3: Confidence level

20 responses



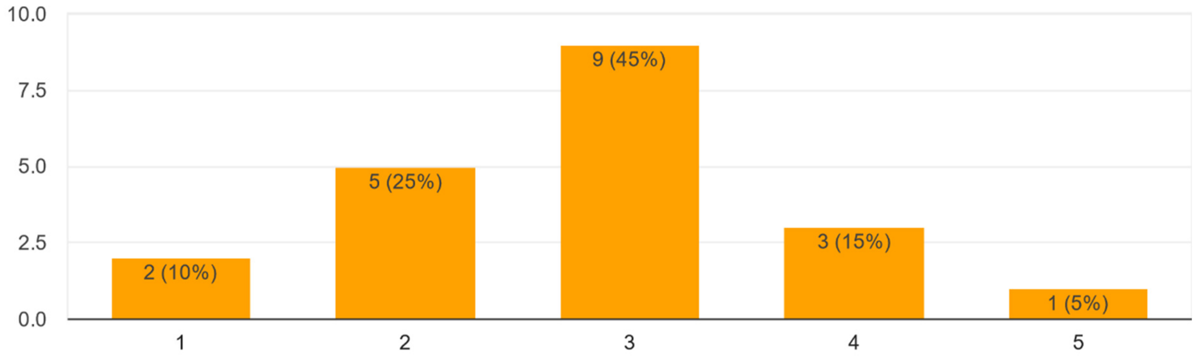
INDICATOR FP4: Implementation of social safety nets and funds responses (In case of doubt, choose a lower-level answer)

20 responses



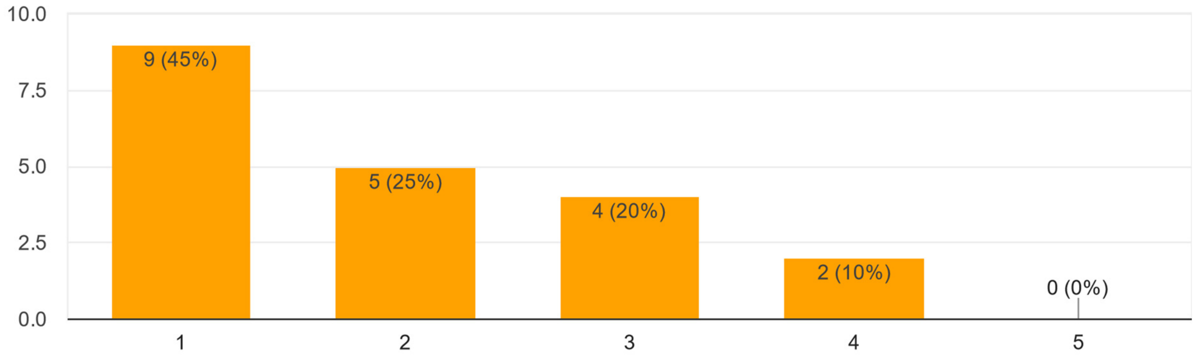
INDICATOR FP4: Confidence level

20 responses



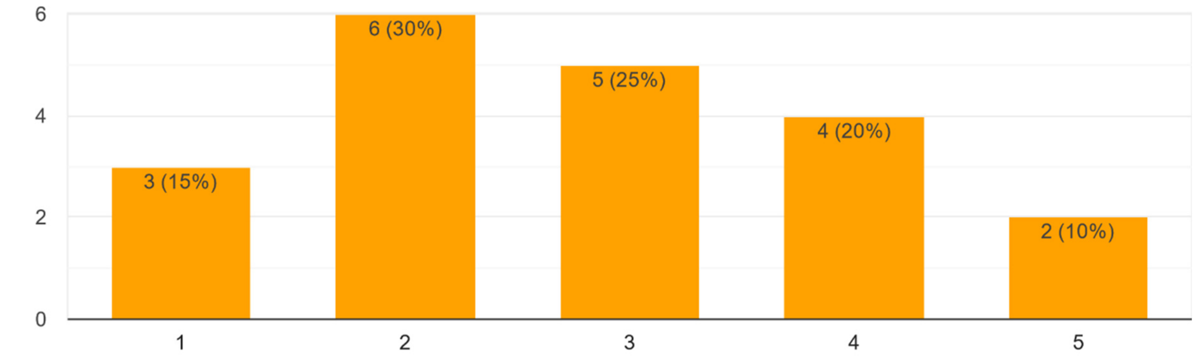
INDICATOR FP5: Insurance coverage and loss transfer strategies of public assets (In case of doubt, choose a lower-level answer)

20 responses



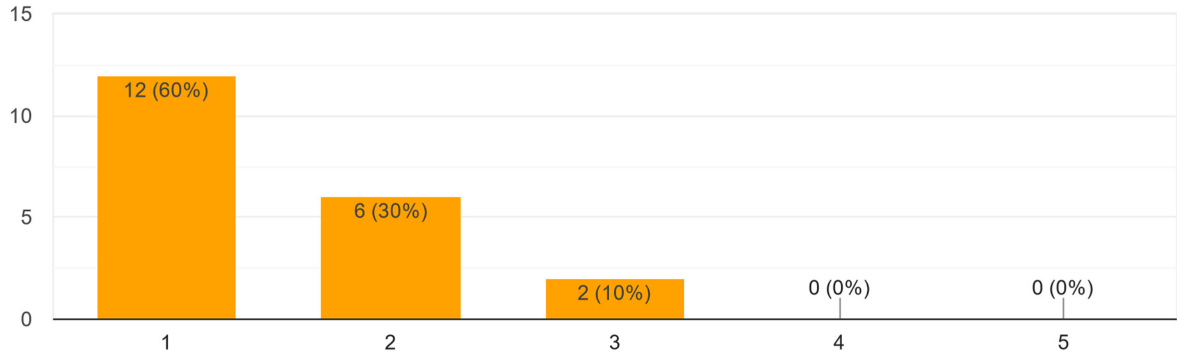
INDICATOR FP5: Confidence level

20 responses



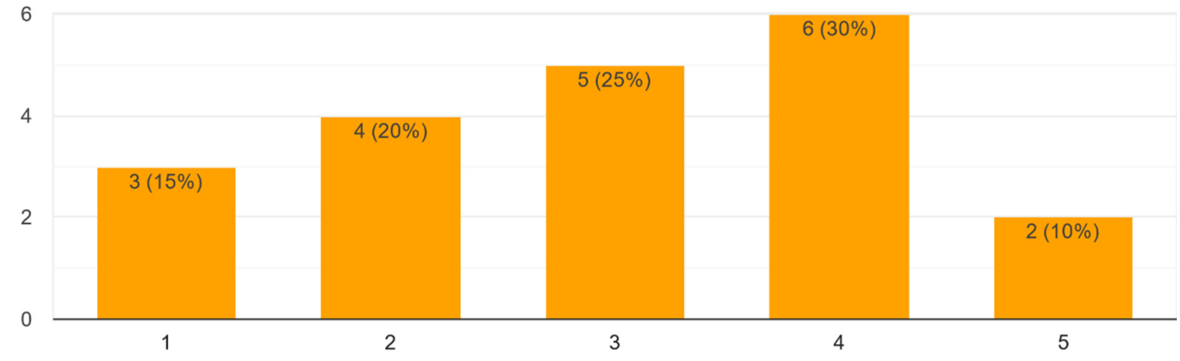
INDICATOR FP6: Housing and private sector insurance and reinsurance coverage (In case of doubt, choose a lower-level answer)

20 responses



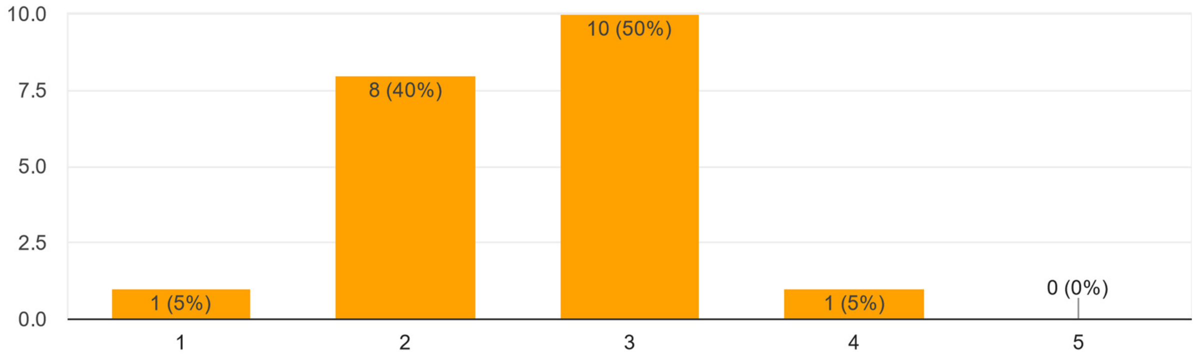
INDICATOR FP6: Confidence level

20 responses



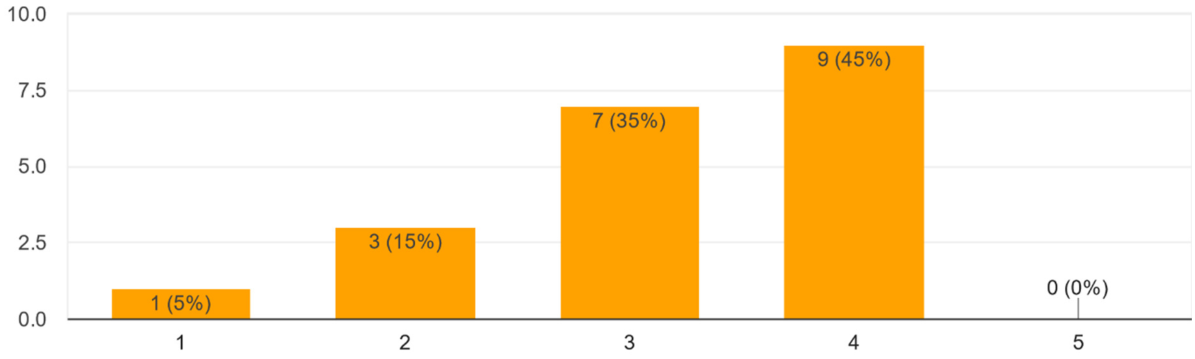
INDICATOR 1: Effectiveness of Legislative Framework (In case of doubt, choose a lower-level answer)

20 responses



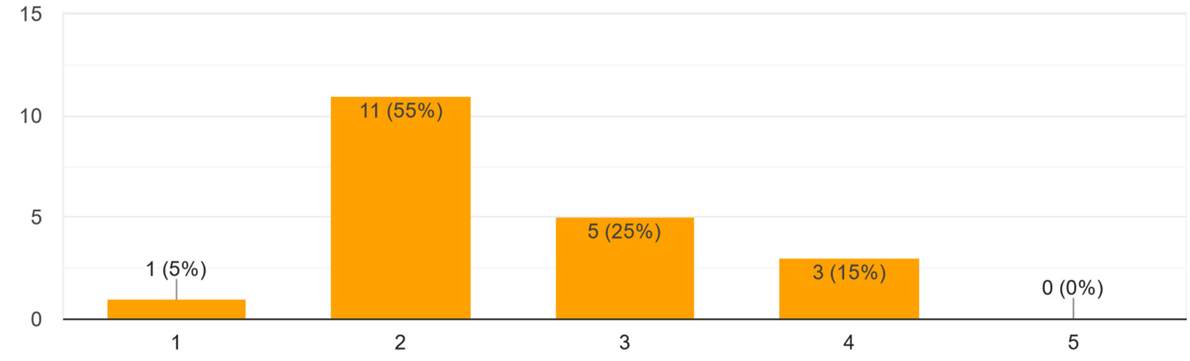
INDICATOR 1: Confidence level

20 responses



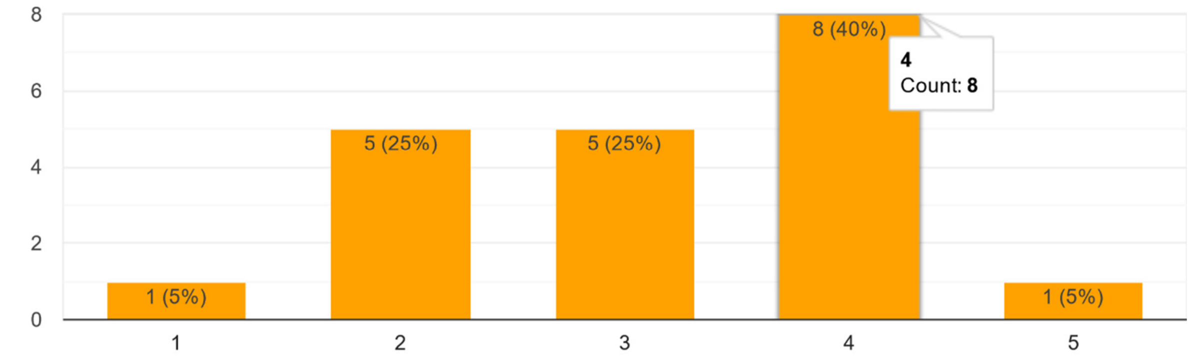
INDICATOR 2: Effectiveness of Institutional Arrangements (In case of doubt, choose a lower-level answer)

20 responses



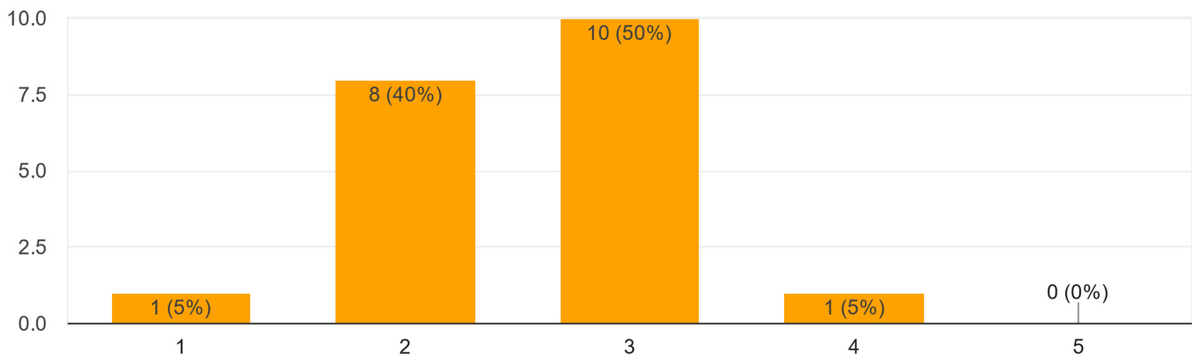
INDICATOR 2: Confidence level

20 responses



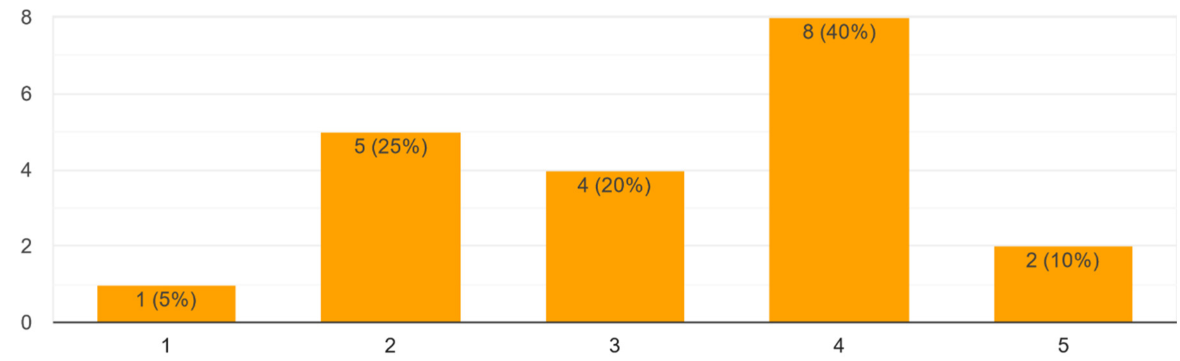
INDICATOR 3: Training and Capacity Building (In case of doubt, choose a lower-level answer)

20 responses



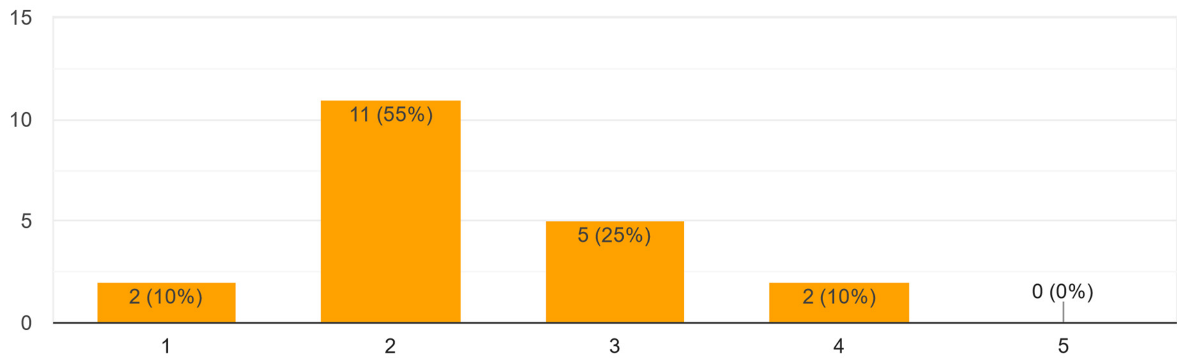
INDICATOR 3: Confidence level

20 responses



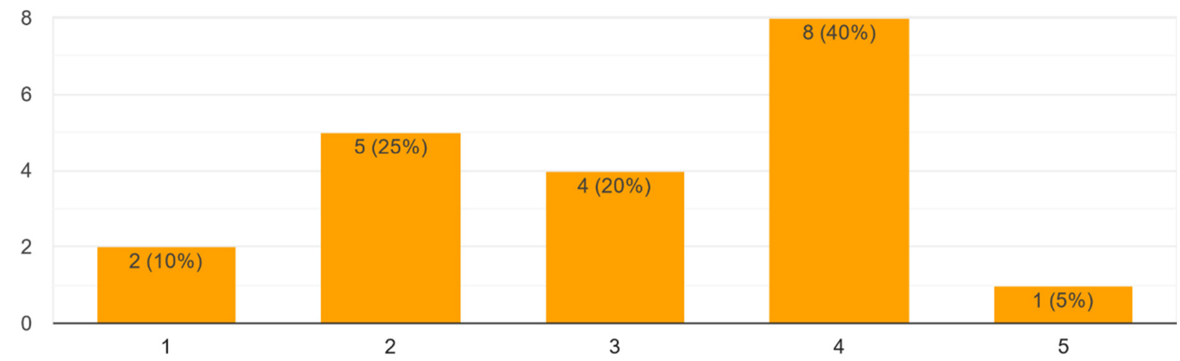
INDICATOR 4: Advocacy, Communication, Education and Public Awareness (In case of doubt, choose a lower-level answer)

20 responses



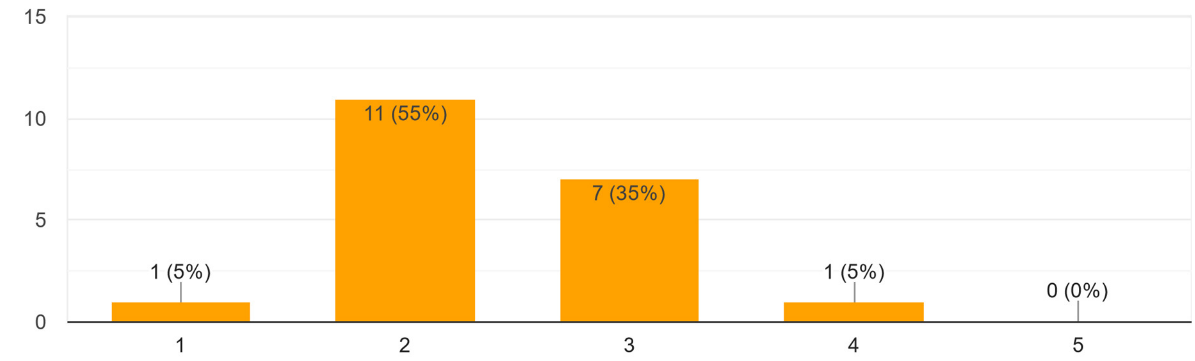
INDICATOR 4: Confidence level

20 responses



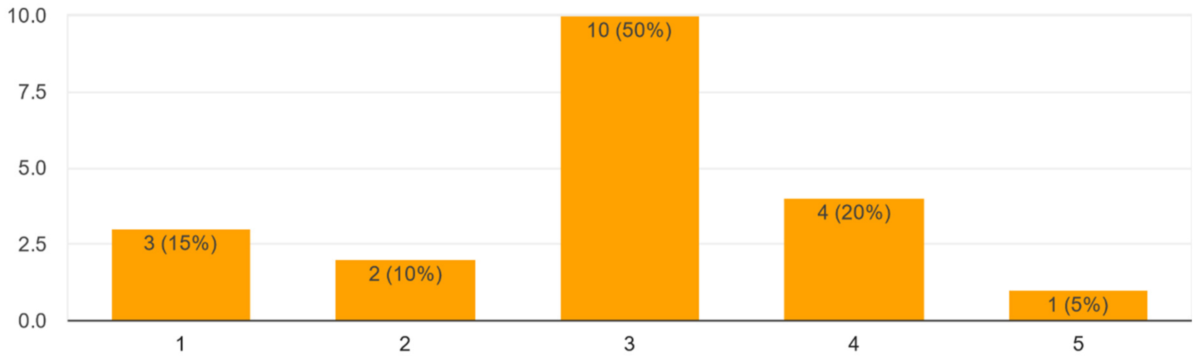
INDICATOR 5: Resilience of Critical Services (In case of doubt, choose a lower-level answer)

20 responses



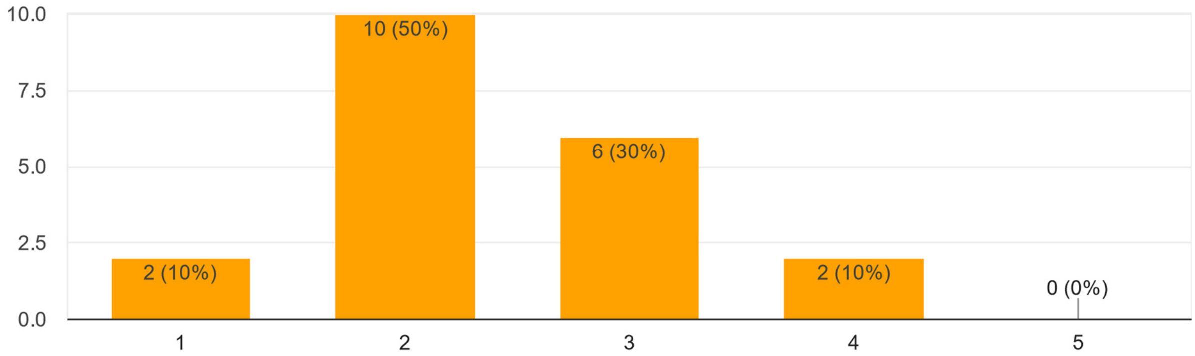
INDICATOR 5: Confidence level

20 responses

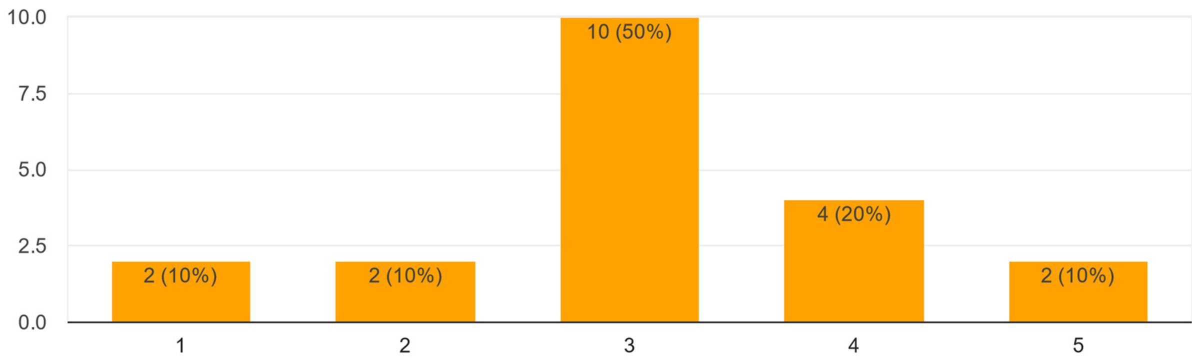


INDICATOR 6: Resiliency of Infrastructure (In case of doubt, choose a lower-level answer)

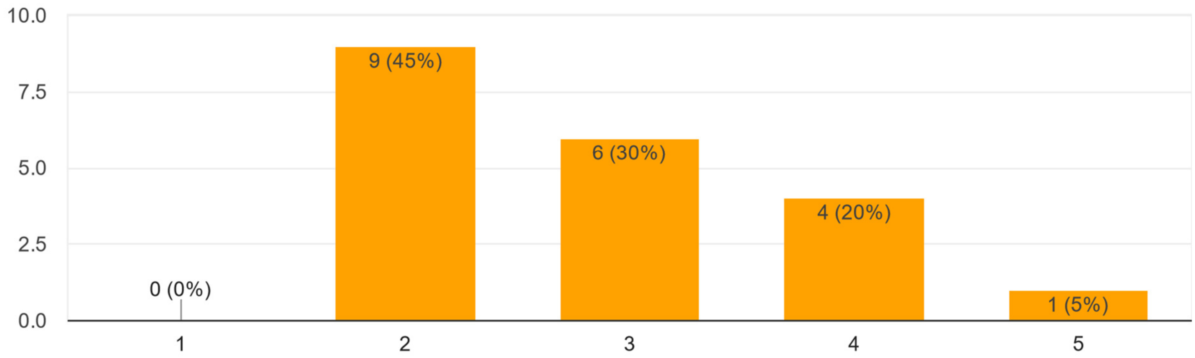
20 responses



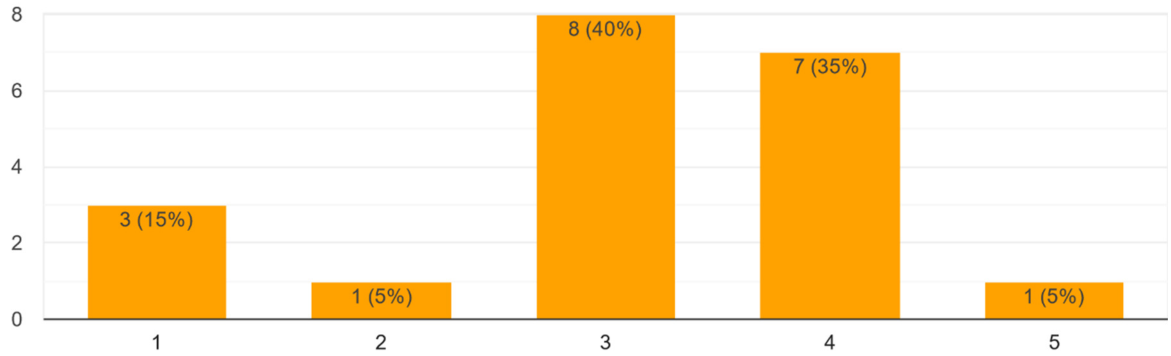
INDICATOR 6: Confidence level
20 responses



INDICATOR 7: Emergency Management (In case of doubt, choose a lower-level answer)
20 responses

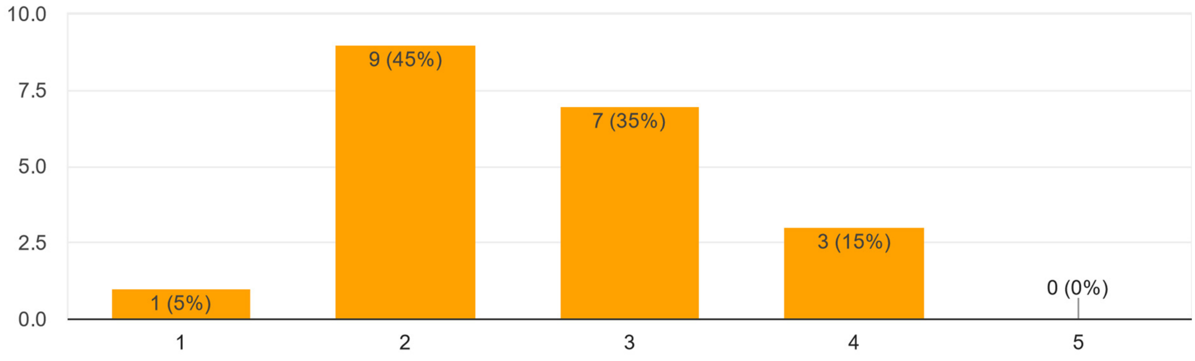


INDICATOR 7: Confidence level
20 responses



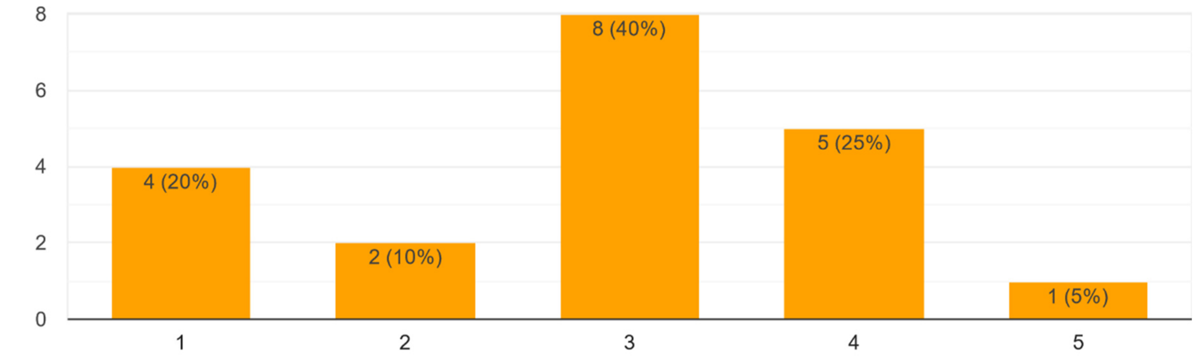
INDICATOR 8: Resource Management, Logistics and Contingency Planning (In case of doubt, choose a lower-level answer)

20 responses



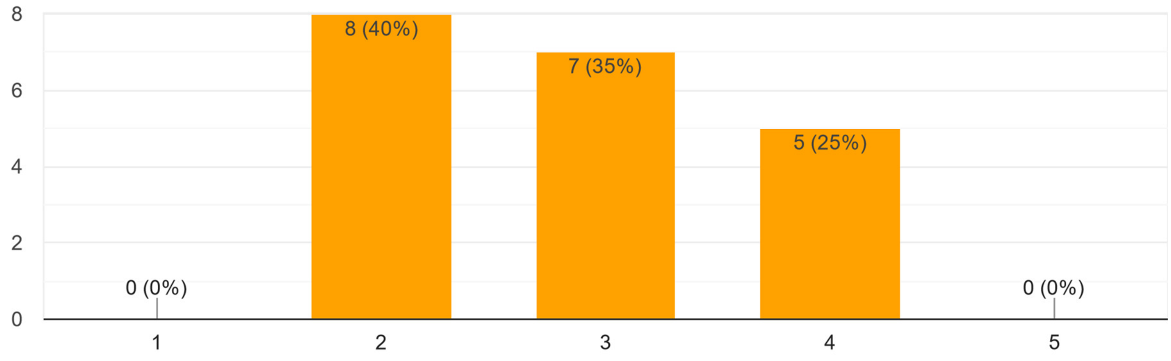
INDICATOR 8: Confidence level

20 responses



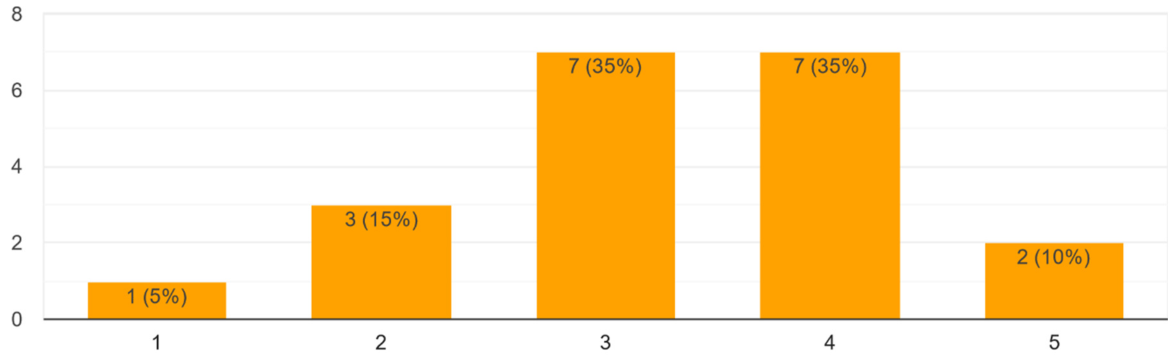
INDICATOR 9: Hazard, Vulnerability and Risk Assessment (In case of doubt, choose a lower-level answer)

20 responses



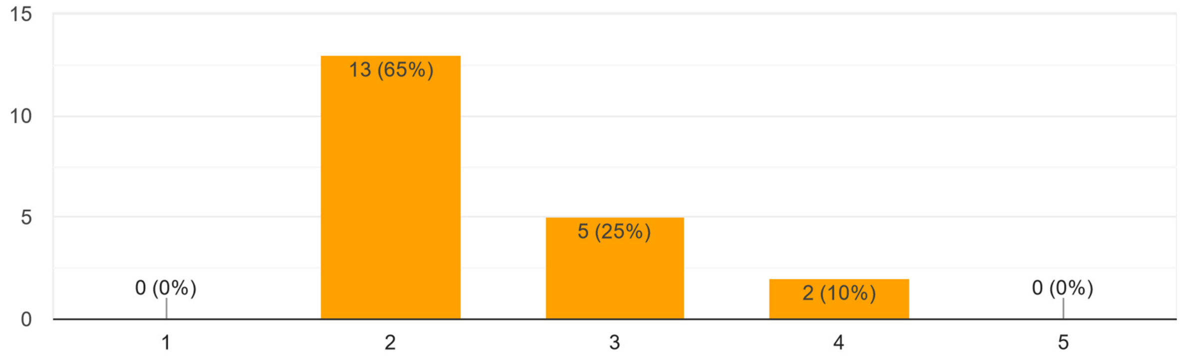
INDICATOR 9: Confidence level

20 responses



INDICATOR 10: Risk Sensitive Urban (and Rural) Development and Mitigation (In case of doubt, choose a lower-level answer)

20 responses



INDICATOR 10: Confidence level

20 responses