ARTICLES

NEW POSSIBILITIES FOR ASSESSING THE DAMAGE CAUSED BY NATURAL DISASTERS IN SLOVENIA – THE CASE OF THE REAL ESTATE RECORD

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ABSTRACT
New possibilities for assessing the damage caused by natural disasters in Slovenia – The case of the Real Estate Record
This article presents the suitability of the Real Estate Record – a web application of the Surveying and Mapping Authority of the Republic of Slovenia – for assessing the damage caused by natural disasters. We performed an analysis for the village of Čezsoča, which was devastated by an earthquake in 1998 (M 5.6). We compared the data on earthquake damage with the data on the real-estate value. Such comparisons make it possible to establish the damage potential of future natural disasters.

KEY WORDS
geography, natural disasters, damage, prevention, Real Estate Record, Čezsoča, Slovenia

IZVLEČEK
Nove možnosti preučevanja škod ob naravnih nesrečah v Sloveniji – na primeru registra nepremičnin
Predstavljena je uporabnost registra nepremičnin – spletne aplikacije Geodetske uprave Republike Slovenije, ki vsebuje tudi vrednost nepremičnin – za preučevanje škod ob naravnih nesrečah. Za vas Čezsoča, ki jo je prizadel potres leta 1998 (M 5,6) je bila narejena analiza, v kateri smo primerjali podatke o škodi zaradi potresa in podatke o vrednosti nepremičnin. Tovrstne primerjave omogočajo ugotavljanje škodnega potenciala za prihodnje naravne nesreče.

KLJUČNE BESEDE
geografija, naravne nesreče, škoda, preventiva, register nepremičnin, Čezsoča, Slovenija

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1 Introduction

The term »natural disaster« denotes natural phenomena and processes in a landscape that affect society to the extent that they cause damage to it. Direct damage occurs during the disaster itself (e.g. damaged buildings and infrastructure, destroyed crops), whereas indirect damage is caused in other areas and can be considerably greater (e.g. lost income due to disrupted industrial production, agriculture, commerce, and power supply). Some authors (Guha-Sapir, Hargitt and Hoyois 2004) also refer to secondary damage, which is financial in nature and connected with lost budget funds, changed interest rates, and debt.

The damage caused by natural disasters is increasing around the globe (McBean 2004, 177; Löw and Wirtz 2010, 47), not only because of their potentially higher frequency, but also by the increased vulnerability of society. The greater vulnerability of society is connected with a rapid increase in population, the settlement of hazardous locations that were empty until only recently, more frequent increases in population density, and a larger share of urban population. Greater vulnerability is influenced by increasing property and real-estate prices, a more diverse and modern (expensive) infrastructure, and especially human alienation from the natural environment. There is also a resulting lack of knowledge of natural processes, leading to underestimating or even denying them (Zorn and Komac 2011, 12).

Damage to real estate and infrastructure is a substantial part of the damage caused by natural disasters. The greatest damage to real estate in Slovenia may be caused by earthquakes, followed by floods, thunderstorms, and some other rarely occurring natural disasters. The data on damage to public infrastructure are publicly available, whereas the data on the resources for renovation work on damaged real estate are only rarely publicly available (Orožen Adamič and Hrvatin 2001). The generalised market value of real estate in Slovenia is set at approximately € 140 billion (Mikoš 2012). The process of assessing damage is a complex one. In Slovenia, it is usually carried out after a natural disaster has occurred. If we want to evaluate damage from natural disasters or their economic impact, we have to know the economic value of the real estate that has been damaged. In Slovenia, data on the generalised market value of real estate have been available since 2011 (Internet 2). This enables an evaluation of the greatest possible damage to real estate in an area. Consequently, it is possible to produce models for damage assessment in case of different natural disasters or different scenarios on the grounds of the assessment of real estate value in combination with the data on damage from natural disasters. This paper presents such an analysis with the case of the village of Čezsoča near Bovec, Slovenia. We compared the data on damage from the 1998 earthquake and the data on real estate value from Real Estate Register.

2 Damage caused by natural disasters in Slovenia between 1994 and 2008

Slovenian literature most often states that the damage caused by natural disasters amounts from 0.6 to 3.0% of the annual GDP if there is no major disaster. With greater catastrophes, this share is higher; for example, in 1976 damage caused by the earthquakes in the Upper Soča Valley and a few other natural disasters was estimated at approximately 7% of GDP, and in the 1990 floods in the Savinja River Basin the damage amounted to more than 20% of GDP. These figures are fairly high and also include indirect damage caused by these disasters (Zorn and Komac 2011, 9). According to the Slovenian Statistical Office, the direct damage caused by natural disasters between 1994 and 2008 amounted to an annual average of 0.37% of GDP (Figure 1).

The last major disaster affecting Slovenia was the September 2010 floods (Komac and Zorn 2011). They affected 60% of Slovenian municipalities (137), and the total damage was estimated at more than € 240 million (including VAT), which exceeded the 0.3% of planned inflows in the 2010 national budget. For comparison, the damage caused by the 1990 floods mentioned above was estimated at more than € 500 million (Zorn and Komac 2011, 13).

Floods commonly appear in Slovenia. In the previous 15 years, floods (Komac, Natek and Zorn 2008) have caused an average of 15% of the total damage due to natural disasters in the country. The following years have stood out in this regard: 1994 (31.3%), 1995 (18.1%), 1998 (51.9%), 1999 (12.1%), 2004 (15.2%), and 2007 (64.8%). In the period discussed, **fires** caused substantial damage in 2002 (18.1%) and 2004 (24.5%). During the period discussed, **drought** caused substantial damage in 1997 (16.3%), 2000 (70.2%), 2001 (56.7%), 2003 (83.3%), 2006 (60.4%), and 2007 (13.4%). **Heavy wind** caused over 10% of all damage due to natural disasters in Slovenia in 1994 (26.1%), 1995 (37.5%), 1997 (26.6%), 2002 (15.6%), 2005 (31.4%), 2007 (12.7%), and 2008 (19.6%). During the period discussed, **hail** did not caused more than 10% of overall damage due to natural disasters in only four years (1998, 2000, 2003, 2007). In the other years the damage was 1994 (16.5%), 1995 (16.3%), 1996 (12.4%), 1997 (17.4%), 1999 (11.6%), 2001 (12%), 2002 (20.6%), 2004 (38.7%), 2005 (55.6%), 2006 (23%), and 2008 (75.2%). Among the natural disasters in Slovenia, **frost and freezing rain** cause the least damage; thus they only proved to be problematic (causing more than 10% of damage due to natural disasters) in 1996 (37.6%), 1997 (27%), and 2001 (23.6%). Unfortunately, the Slovenian Statistical Office collects data on **landslides and avalanches** as one type of disaster, although these are two completely different processes. Given that avalanches mostly only threaten local infrastructure, the majority of the damage listed includes damage caused by landslides. According to these data, landslides and avalanches caused more than 10% of overall damage due to natural disasters in 1994 (10.2%), 1995 (16%), 1996 (22.4%), 1998 (14.1%), 1999 (32.1%), and 2002 (17.8%). Two powerful **earthquakes** struck Slovenia during the period discussed and caused substantial damage: 18% (in 1998) and 13% (in 2004) of the total damage (Figure 2) caused by natural disasters in Slovenia as a whole (Figure 1; Zorn and Komac 2011).

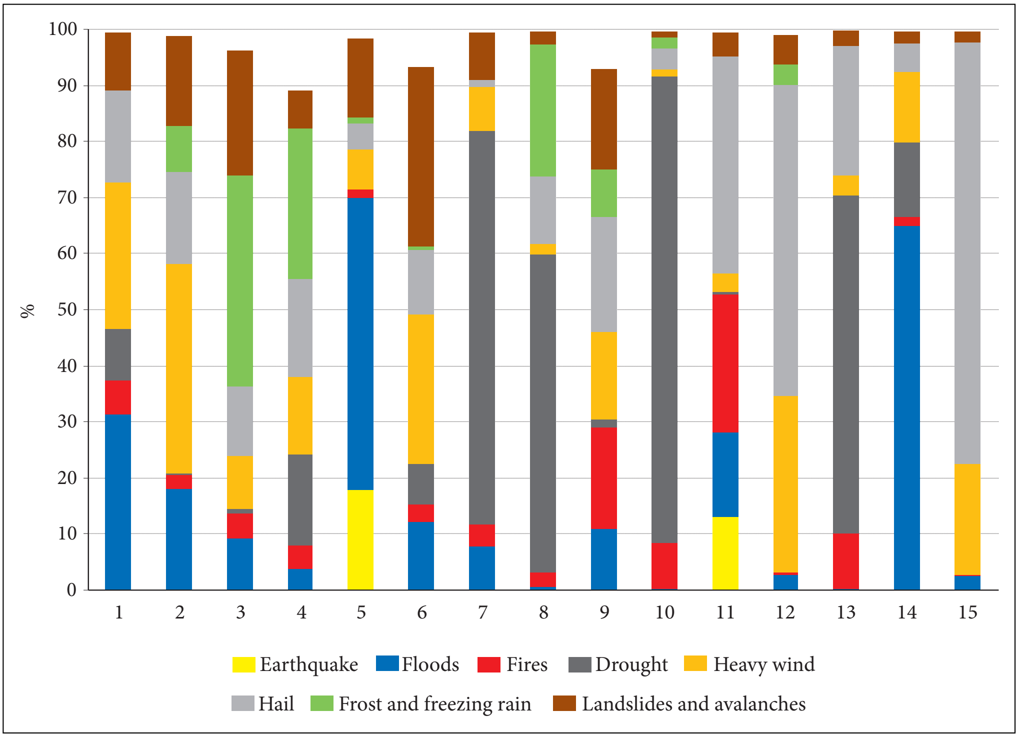


Figure 1: Direct damage caused by natural disasters in Slovenia from 1994 to 2008 by shares of annual GDP (Ocenjena … 2010).

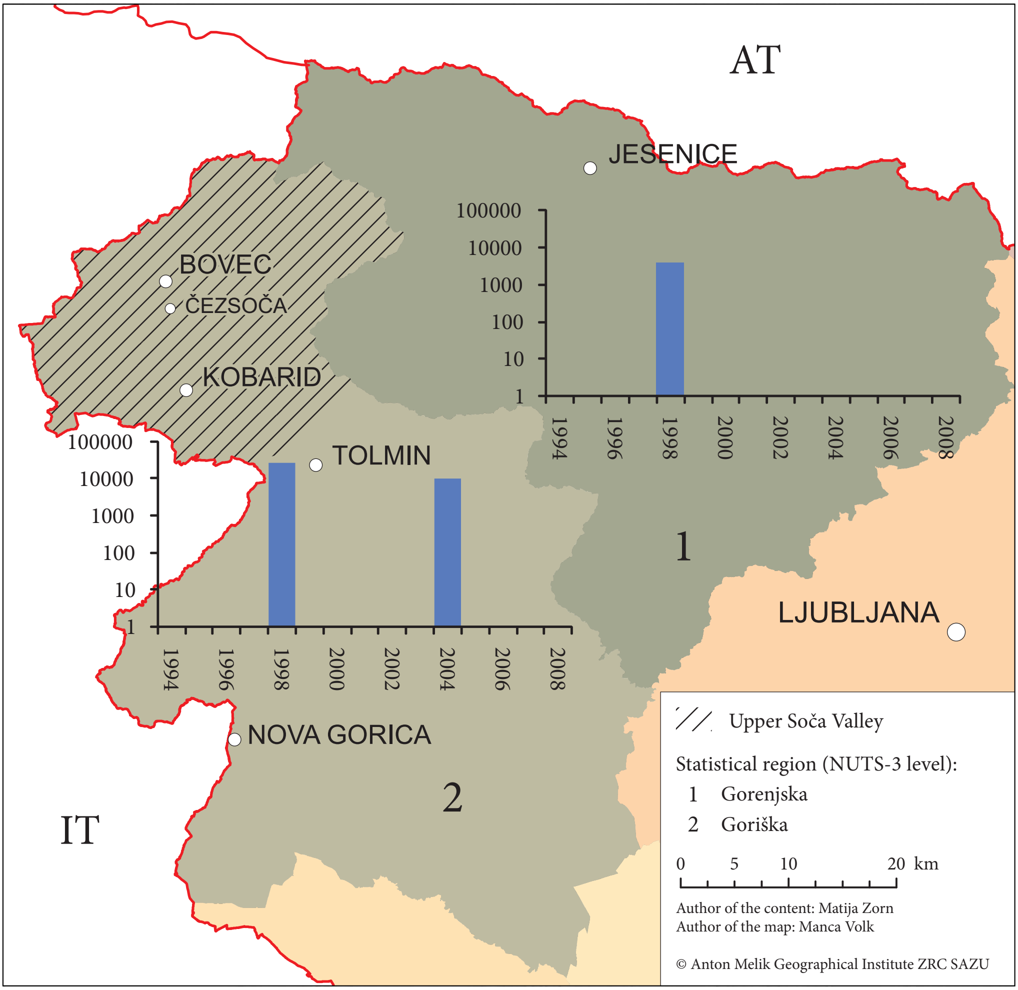


Figure 2: Damage (€ 000) due to earthquakes in Slovenia by statistical regions from 1994 to 2008 (Zorn and Komac 2011, 16).

3 Damage caused by the 1998 earthquakes in the Upper Soča Valley

The Upper Soča Valley is a region in western Slovenia. It is an Alpine region characterized by high mountain karst relief (up to 2800 m a.s.l.), big altitude differences (more than 2000 m) high precipitation (about 4000 mm annually) and torrential waters.

The **earthquake** that struck the Upper Soča Valley on April 12, 1998 (M 5.6) was the first strong earthquake to hit the region since the Furlanese earthquake in 1976 (M 6.5). Its epicentre was in the karst region south east of Bovec. Its magnitude reached its highest levels in the villages of Magozd, Drežniške Ravne, Lepena, and Tolminske Ravne. The area where the earthquake reached or exceeded a magnitude of 7 on the EMS scale had a diameter of about 22 kilometres (Geipel 1982; Vidrih 2008; Vidrih, Ribičič and Suhadolc 2001).

This earthquake also caused considerable **changes in nature**. A few hundred rockfalls and a few landslides were triggered during the earthquake. The largest rockfalls were recorded below Mount Lemež in the Lepena Valley, on the south-western slope of Mount Krn, in Polog above Tolmin, and at the source of the Tolminka River (Zorn 2002). The earthquake greatly accelerated normal geomorphic proceses. Average annual sediment production in the discussed area amounts to about 1400 m^3/km^2. However, earthquake-induced rockfalls and rainfall-induced landslides may release sediment in excess of about 125,000 m^3/km^2 annually (Mikoš, Fazarinc and Ribičič 2006), which is about twelve times higher than an average sediment production.

In the area, 2,543 houses were **affected** by the earthquake. The majority of them were in Bovec (473), Čezsoča (108), Kobarid (107), Jesenice (103), Soča (96), Tolmin (80), Drežnica (63), Kal-Koritnica (56), Trenta (53), Drežniške Ravne (51), and Poljubinj (51) (Orožen Adamič and Hrvatin 2001).

The earthquake caused considerable **damage** to residential, industrial, and commercial premises and to the infrastructure and cultural heritage sites from WWI in the Soča, Tolminka and Sava Bohinjka valleys. The settlements that were hit by the earthquake stand on Quarternary glacial and fluvial sediments, or on flysch and rubble slopes. The danger of soil-structure resonance is considerable in the area. The damage to houses in some parts of the Bovec basin was enhanced by site amplification and soil-structure resonance (Gosar et al. 2001; Gosar 2007). The damage was recorded in the sixteen of Slovenia's then 192 municipalities, which cover 15% of Slovenia, and in 224 of the 516 settlements in the Upper Soča Valley. In 39 settlements of the Upper Soča Valley, 20% to 40% of the houses were damaged. In Drežniške Ravne and Jezerca, all the houses were damaged (100%), followed by Magozd (96%), Krn (93%), Koseč (91%), Lepena (90%), and Bovec (81%). In eighteen settlements, damage was only evident to the infrastructure network or elsewhere. The damage was the greatest in the Bovec municipality where it reached € 3,230 per individual inhabitant. The damage calculated per inhabitant exceeded € 15,000 in the settlements of Zabrdo, Bavšica, Krn, Magozd and Ukanc and reached € 9,713 in Čezsoča and € 6,005 in Bovec.

During **reconstruction** special attention was devoted to increasing the earthquake safety of old buildings. The highest reconstruction costs by far were assessed in the town of Bovec (€ 10,021,338). In the neighbouring village Čezsoča, which ranked second according to damage, the reconstruction costs was less than one third of this amount (€ 3,205,247) (Orožen Adamič and Hrvatin 2001). The problem of reconstruction is well illustrated by the fact that 43% of the demolished buildings had been rebuilt following the 1976 Furlanese earthquake in the period between 1976 and 1980 (Ribičič, Vidrih and Godec 2000). Similar problems were encountered during the 2004 earthquake (M 4.9) when many buildings were damaged because of faulty reconstruction after the 1998 earthquake (Pipan 2011, 28).

4 Damage assessments according to real estate valuation on the example of Čezsoča village

The Čezsoča village is situated in the Bovec basin south of the town of Bovec. It is situated on the Pleistocene plain and the terraces of the Soča River. According to the data of the Statistical Survey of Slovenia (SI-Stat … 2012) 343 people live in 150 households. As noted above, the village was seriously hit by the 1998 earthquake.

The data on the damage caused by the earthquake were collected and analysed based on previous work of the Department of Natural Hazards of the Anton Melik Geographical Institute ZRC SAZU (Orožen Adamič and Hrvatin 2001). The data on the damage caused by the earthquake were compared to the generalised market value of real estate. In order to make the comparison possible, the data on damage caused by the 1998 earthquake were first translated from the then Slovenian national currency (Tolar, SIT) to Euros (€) and then revalorized according to the data of the Statistical Survey of Slovenia (SI-Stat … 2012). Only then could they be compared to the data on the generalised market values of the properties that were obtained from the web application of the the Surveying and Mapping Authority

Figure 3: Real Estate Register provides generalised market property value of real estates in Slovenia (Internet 1).

of the Republic of Slovenia (Si: *register nepremičnin*) (Internet 1). The evaluation of real estate was made for all the territory of the Republic of Slovenia for the purposes of the taxation; the results of the evaluation are public (Figure 3). In order to obtain correct assessments, different models of real estate valuation according to the type of property were used to calculate their values (Prostor … 2012). If we compare these data with the data on actual damage, it is possible to produce assessments on the potential damage of future disasters (Mikoš 2012; see also Kumelj and Geršak 2011; Bründl et al. 2010).

We analysed the data on earthquake damage and generalised market value for 94 houses, i.e. app. 60% of houses in the settlement. Only properties with available data on damage as well as value could be assessed.

The damage on all houses in the village amounted to almost one third of the overall generalised market value (28%). The damage was about € 1,654,000, while the generalised market value of the properties was € 5,882,000.

The average property market value was € 62,582 and average damage caused by the 1998 earthquake was € 17,406. The minimum property market value was € 11,978 and the maximum € 265,477. The minimum damage caused by the 1998 earthquake was € 514 and the maximum as high as € 139,060. Average generalised property value is about € 380/m^2, while average damage was about € 100/m^2. The amount of damage per area unit depends on the number of floors in a building; in four-floor buildings it is almost a third greater than in single-floor buildings (Figure 5).

It should be noted that property value is positively correlated to the age of buildings ($r = 0.72$, $p = 0.0005$) and to the type (stone, brick, concrete) of building material ($r = 0.29$, $p = 0.0025$), while the correlation with the type of the building (individual, duplex, apartment block) is low and negative ($r = -0.12$, $p = 0.04$). Damage is positively correlated to age of buildings ($r = 0.29$, $p = 0.0025$) and with the type of building material ($r = 0.23$, $p = 0.0025$), but correlations were low. The older the building is, the higher is the expected damage potential. The damage was the highest in prefabricated buildings and the lowest in the buildings built of bricks (Figure 4).

Half of the buildings that were damaged by the earthquake were built before 1940, especially in the decades after WWI (1920–1930) and during and after WWII (1940–1950) (Figure 6). The damage caused by earthquake is generally higher for younger buildings (exceeding € 150/m^2) and lower for older buildings (in the range between 50 and € 100/m^2) (Figure 7).

*Table 1: The data used in the study (Legend: * Building material: (1) brick, (2) concrete, (3) stone, (4) other materials, (5) combination of different materials, (6) prefabricated materials; ** Type of the building: (1) individual building, (2) duplex, (3) semi-detached building, (4) edge semi-detached building.*

Value of the property (€; 2012)	Damage (SIT; 1998)	Damage (€; 1998)	Damage (€, revalo-rised; 2012)	Area of the property (m^2)	Generalised market value per m^2	Damage per m^2	Damage / Generalised market value	Number of floors	Age of the building	Building material*	Type of the building**
11,978	1,045,700.31	4,364	7,881	94.8	126	83	65.8	2	87	3	1
13,079	1,608,543.24	6,712	12,122	125.1	105	97	92.7	2	112	3	1
18,550	666,734.05	2,782	5,025	60	309	84	27.1	2	92	3	1
19,647	1,623,132.90	6,773	12,232	108.6	181	113	62.3	2	92	3	4
21,067	979,888.55	4,089	7,385	104.8	201	70	35.1	2	91	3	4
22,331	2,528,300.82	10,550	19,054	202.7	110	94	85.3	2	71	8	1
23,925	2,113,916.18	8,821	15,931	91.4	262	174	66.6	2	92	3	3
24,379	2,156,990.06	9,001	16,256	122.3	199	133	66.7	3	122	3	1
25,171	2,016,721.39	8,416	15,199	119.4	211	127	60.4	2	85	3	1
25,716	2,280,241.49	9,515	17,185	96.9	265	177	66.8	2	91	3	2
26,360	236,600.40	987	1,783	77.9	338	23	6.8	2	112	3	3
26,815	5,218,939.40	21,778	39,332	239.5	112	164	146.7	3	64	8	1
28,124	400,387.69	1,671	3,017	90.5	311	33	10.7	2	112	3	1
29,702	991,638.39	4,138	7,473	149.6	199	50	25.2	2	181	3	3
30,770	1,109,090.01	4,628	8,358	132.4	232	63	27.2	2	90	3	1
31,528	994,669.98	4,151	7,496	99.7	316	75	23.8	2	65	3	4
32,159	2,943,039.00	12,281	22,180	189.3	170	117	69.0	2	132	3	1
32,161	2,071,418.07	8,644	15,611	96.1	335	162	48.5	2	112	3	3
33,117	299,570.81	1,250	2,258	73.4	451	31	6.8	3	94	5	1
33,654	609,819.21	2,545	4,596	208.5	161	22	13.7	2	90	3	1
33,837	1,630,877.23	6,806	12,291	124	273	99	36.3	2	142	8	1
35,092	361,626.65	1,509	2,725	130	270	21	7.8	2	112	3	1
36,374	2,523,420.08	10,530	19,017	89.9	405	212	52.3	2	92	3	1
36,604	1,260,755.64	5,261	9,501	122.6	299	77	26.0	2	89	3	1
36,975	2,333,418.70	9,737	17,585	77.5	477	227	47.6	2	2	7	3
37,864	2,238,165.91	9,340	16,868	102.2	370	165	44.5	2	112	3	1

38,828	299,438.44	1,250	2,257	114.1	340	20	5.8	2	77	3	2
38,932	1,104,702.01	4,610	8,325	103.2	377	81	21.4	2	71	8	1
39,097	3,486,596.00	14,549	26,276	164.2	238	160	67.2	2	92	3	1
39,743	1,568,730.33	6,546	11,822	122.2	325	97	29.7	2	81	3	1
40,007	1,727,772.00	7,210	13,021	121.2	330	107	32.5	3	100	3	1
40,045	1,006,136.21	4,199	7,583	112.8	355	67	18.9	2	71	8	1
40,406	497,485.54	2,076	3,749	177.2	228	21	9.3	2	91	3	1
40,466	2,373,462.00	9,904	17,887	130	311	138	44.2	1	90	3	1
41,724	1,476,308.33	6,161	11,126	112	373	99	26.7	2	92	3	1
41,906	916,217.06	3,823	6,905	112.7	372	61	16.5	2	71	8	1
42,053	436,306.89	1,821	3,288	148.4	283	22	7.8	2	87	8	2
42,554	1,363,558.39	5,690	10,276	152.2	280	68	24.1	2	90	3	1
43,424	405,867.00	1,694	3,059	104	418	29	7.0	2	72	3	1
43,873	85,236.36	356	642	135	325	5	1.5	2	84	3	3
45,943	2,281,065.23	9,519	17,191	200.1	230	86	37.4	2	92	3	1
46,724	682,714.63	2,849	5,145	148.2	315	35	11.0	2	71	5	1
47,486	4,074,350.48	17,002	30,706	133	357	231	64.7	3	71	8	1
48,063	858,575.88	3,583	6,470	231	208	28	13.5	2	142	3	1
48,107	2,459,160.25	10,262	18,533	181.6	265	102	38.5	2	72	2	1
48,520	402,080.99	1,678	3,030	180.5	269	17	6.2	3	65	3	4
49,455	1,416,330.00	5,910	10,674	154.8	319	69	21.6	2	71	8	1
49,641	1,933,878.49	8,070	14,574	140.4	354	104	29.4	2	90	3	1
50,366	1,785,658.90	7,451	13,457	157.6	320	85	26.7	2	71	3	1
51,160	1,475,163.78	6,156	11,117	201.1	254	55	21.7	2	38	1	1
51,357	711,573.03	2,970	5,363	147.6	348	36	10.4	2	71	8	1
51,366	1,698,383.00	7,087	12,800	102.8	500	125	24.9	2	90	3	1
52,789	2,773,491.57	11,574	20,902	145.1	364	144	39.6	0	17	8	1
54,107	1,853,291.36	7,734	13,967	198.5	273	70	25.8	2	143	3	1
54,150	2,787,939.06	11,634	21,011	260.8	208	81	38.8	2	64	3	1
55,699	1,104,886.49	4,611	8,327	137.3	406	61	14.9	3	71	5	4
59,562	2,500,744.71	10,435	18,846	170.7	349	110	31.6	2	84	3	3
59,941	2,279,344.19	9,512	17,178	194.5	308	88	28.7	2	92	3	1
61,715	1,291,331.26	5,389	9,732	108.8	567	89	15.8	2	5	7	1
62,701	2,397,382.00	10,004	18,067	158	397	114	28.8	2	71	3	3

62,875	2,315,758.41	9,663	17,452	192.7	326	91	27.8	2	74	3	1
63,637	275,074.81	1,148	2,073	219.9	289	9	3.3	3	62	1	4
65,143	6,084,309.53	25,389	45,853	173.2	376	265	70.4	3	44	1	1
65,561	1,684,650.90	7,030	12,696	74.8	876	170	19.4	2	5	1	1
67,009	934,210.88	3,898	7,040	316	212	22	10.5	3	116	3	1
67,586	337,831.42	1,410	2,546	83.1	813	31	3.8	2	6	7	3
69,640	906,040.46	3,780	6,828	216.8	321	31	9.8	2	82	8	1
69,980	1,217,998.84	5,083	9,179	108.4	646	85	13.1	2	5	7	1
71,969	3,619,028.00	15,102	27,274	164.7	437	166	37.9	2	7	5	1
72,597	104,950.35	438	791	160.5	452	5	1.1	2	49	3	1
77,733	5,315,923.00	22,183	40,062	166.3	467	241	51.5	2	9	8	1
78,219	883,490.33	3,687	6,658	89.9	870	74	8.5	2	6	7	1
79,660	1,839,497.05	7,676	13,863	100	797	139	17.4	2	8	7	1
82,296	2,314,209.69	9,658	17,441	200	411	87	21.2	3	100	5	1
84,390	369,448.00	1,542	2,784	271.4	311	10	3.3	4	92	3	1
84,907	150,349.11	627	1,133	170.8	497	7	1.3	2	32	1	1
87,780	4,480,682.00	18,698	33,768	128.3	684	263	38.5	2	33	8	1
88,445	1,823,106.77	7,608	13,739	119	743	115	15.5	2	5	7	1
89,948	2,436,625.80	10,168	18,363	113.6	792	162	20.4	2	3	7	1
94,283	7,593,163.00	31,686	57,224	127	742	451	60.7	2	7	7	1
99,186	4,035,074.00	16,838	30,410	144.1	688	211	30.7	2	6	1	1
103,393	11,434,380.04	47,715	86,173	309	335	279	83.3	3	92	5	1
105,829	2,939,042.96	12,264	22,150	151.7	698	146	20.9	3	5	7	1
106,102	1,664,509.79	6,946	12,544	174.4	608	72	11.8	3	6	2	1
107,868	7,878,468.00	32,877	59,375	232.1	465	256	55.0	4	61	5	3
108,848	68,255.02	285	514	402.7	270	1	0.5	3	71	3	3
109,251	2,985,842.46	12,460	22,502	179.4	609	125	20.6	3	6	5	1
116,113	13,035,357.00	54,396	98,238	327.6	354	300	84.6	3	12	8	1
119,909	207,282.61	865	1,562	239.1	502	7	1.3	3	27	1	1
120,427	1,587,691.48	6,626	11,965	253	476	47	9.9	2	66	3	1
192,446	5,895,649.95	24,602	44,431	478.1	403	93	23.1	2	152	3	1
203,090	3,132,530.67	13,072	23,608	700	290	34	11.6	3	22	8	1
252,267	18,451,968.00	76,999	139,060	1250.1	202	111	55.1	3	71	1	1
265,477	3,348,765.00	13,974	25,237	330.7	803	76	9.5	2	6	7	1

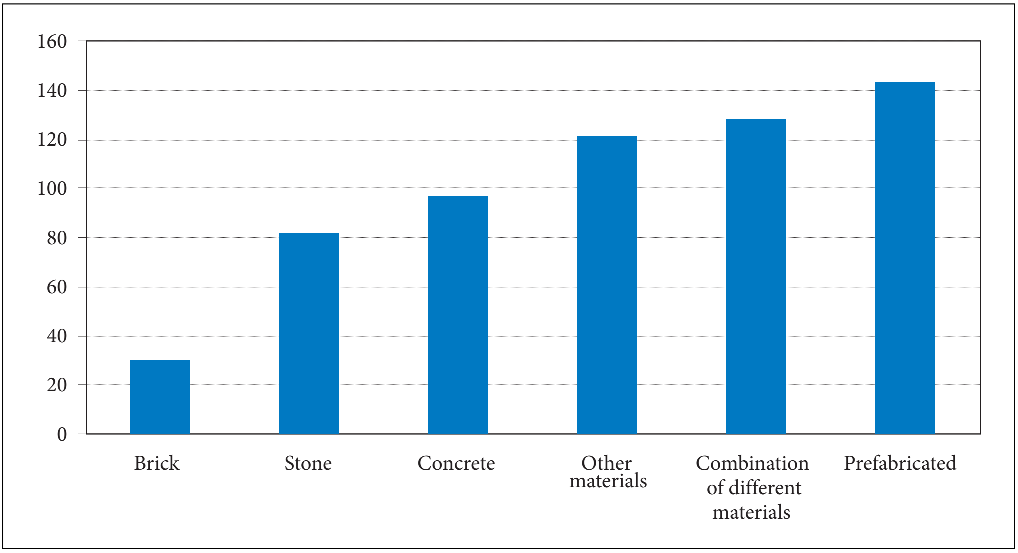


Figure 4: Damage to buildings (€/m^2) according to type of building material.

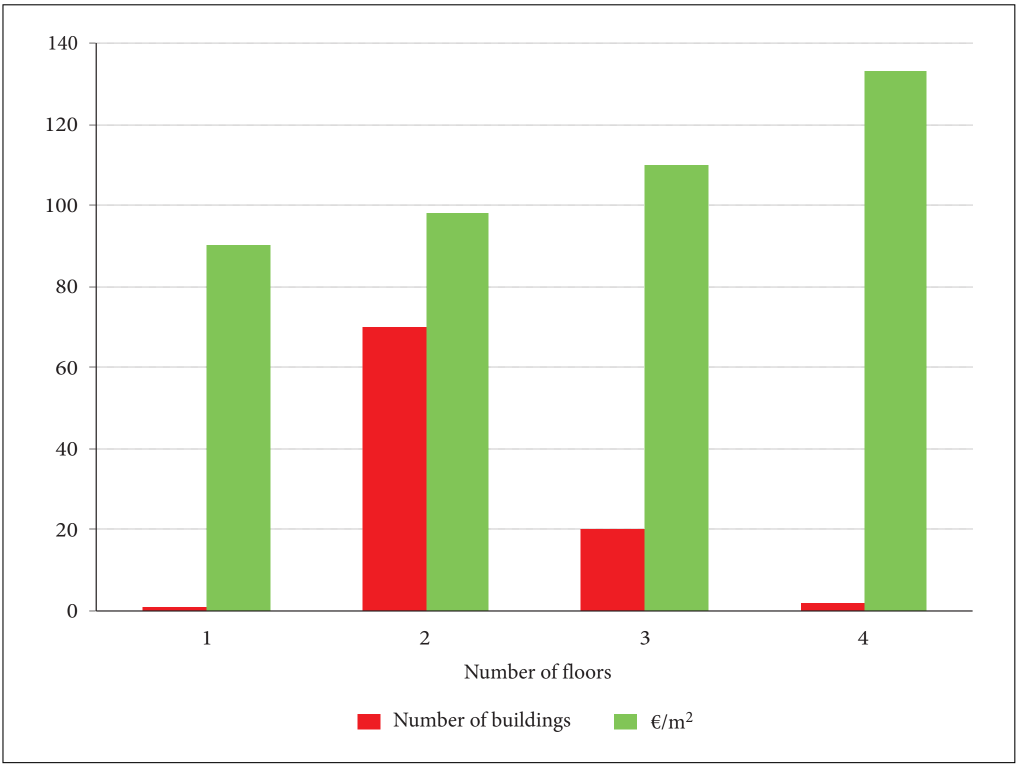


Figure 5: Number of buildings according to damage per number of floors in the building.

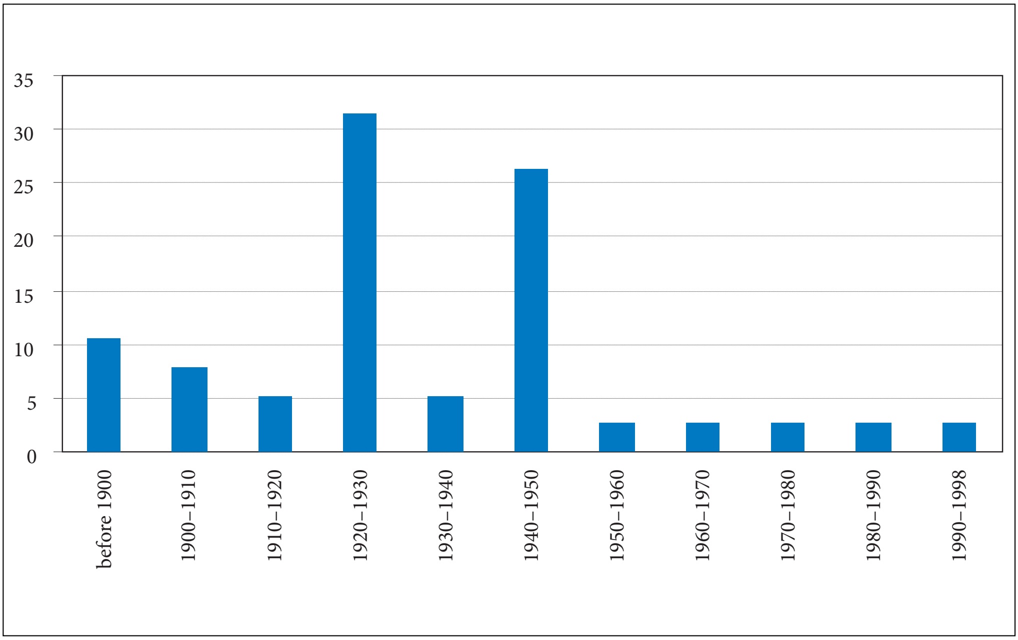


Figure 6: Share (%) of buildings, damaged by the 1998 earthquake, according to their age.

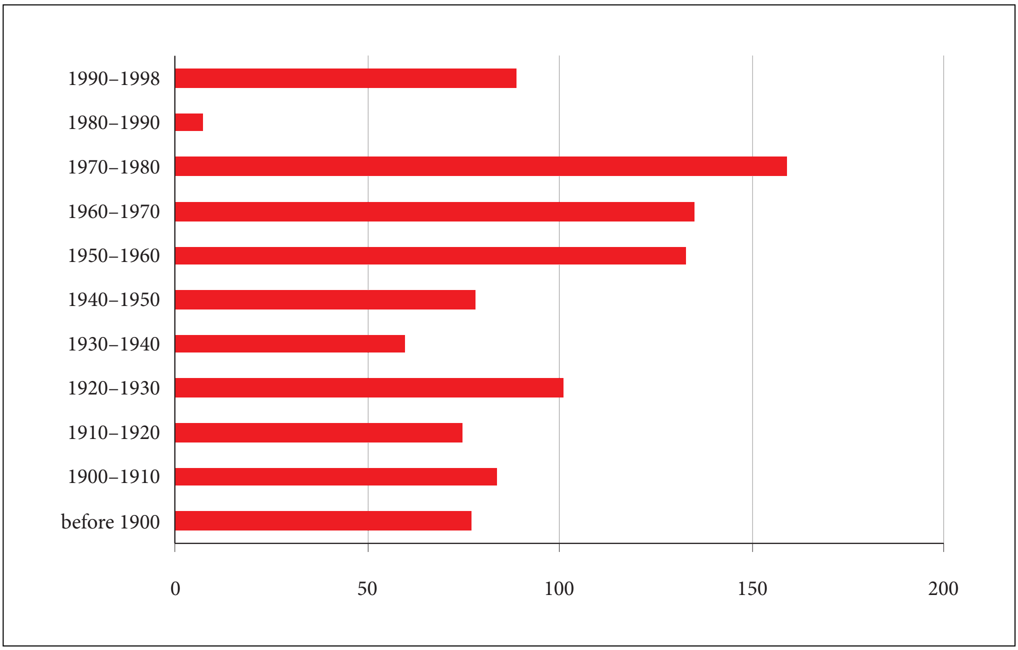


Figure 7: Damage per square metre (€/m^2) according to age of the buildings, damaged by the 1998 earthquake.

MATIJA ZORN

Figure 8: Typical damage on buildings caused by the 1998 earthquake in the town of Bovec.

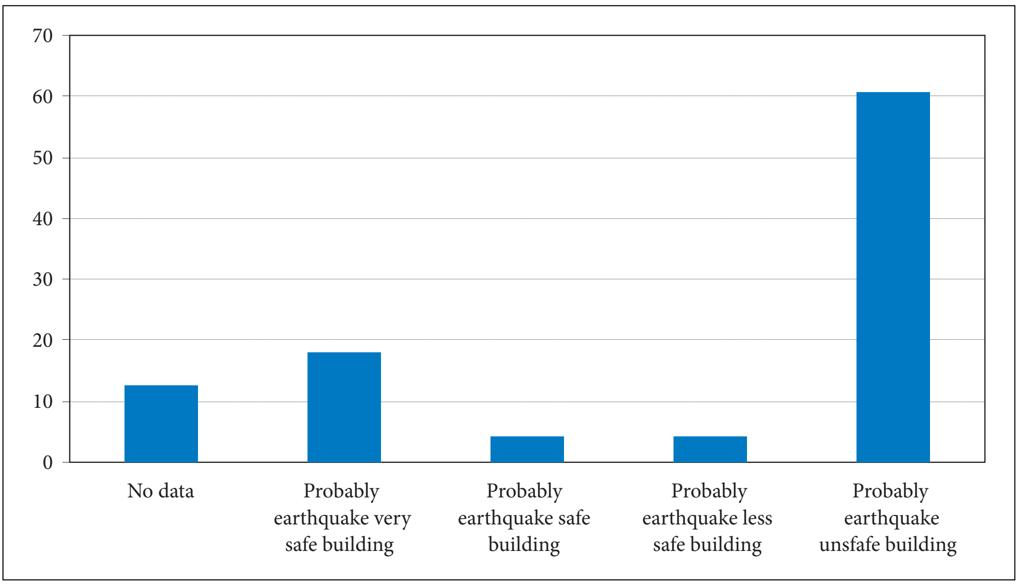
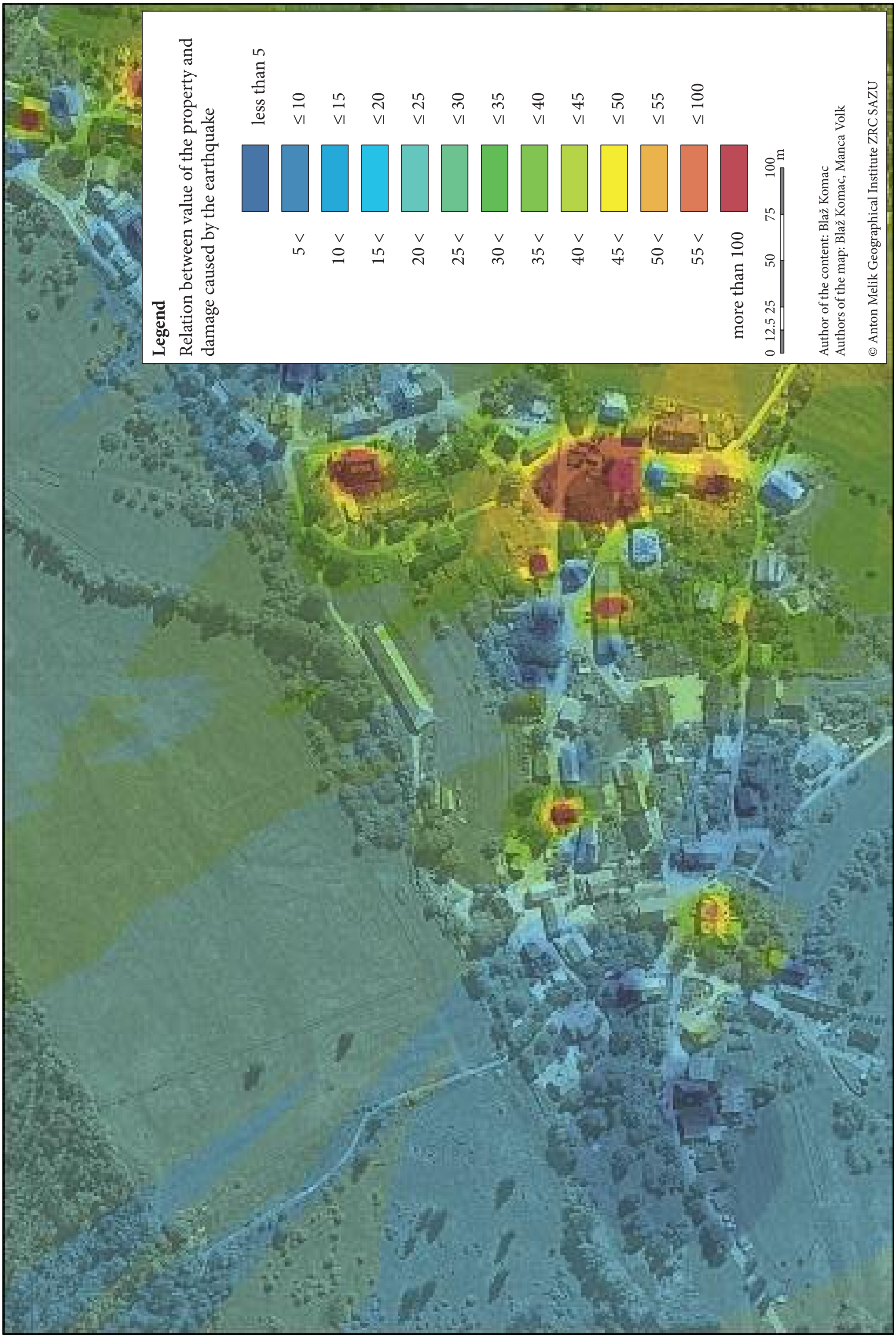


Figure 9: Assessment of buildings in the Čezsoča village according to their earthquake safety was done by the method proposed by Kilar and Kušar (2009).

Figure 10: The relation between value of the property and damage caused by the 1998 earthquake in the Čezsoča village. ➤


Legend
Relation between value of the property and damage caused by the earthquake
less than 5
5 < ≤ 10
10 < ≤ 15
15 < ≤ 20
20 < ≤ 25
25 < ≤ 30
30 < ≤ 35
35 < ≤ 40
40 < ≤ 45
45 < ≤ 50
50 < ≤ 55
55 < ≤ 100
more than 100
0 12.5 25 50 75 100 m
Author of the content: Blaž Komac
Authors of the map: Blaž Komac, Manca Volk
© Anton Melik Geographical Institute ZRC SAZU

5 Conclusion

In many regions natural disasters are a geographical constant (Komac 2009); therefore, they can be understood from both natural-geographical and social-geographical perspectives. Studying natural disasters may be considered one of the key-geographical topics. Globally, natural disasters have claimed an average of 75,000 lives a year over the past decade and caused approximately $100 billion of damage a year (Zorn and Komac 2011, 27). In Slovenia, damage due to natural disasters amounted to an average of 0.37% of annual GDP during this period. A large part of this figure is due to earthquakes.

Earthquakes are strong natural processes that may hit large areas and affect large number of people. In the territory of Slovenia, large earthquakes were recorded in 1348, 1511, 1895, 1917, 1956, 1963, 1974, 1976, 1977, 1982, 1995, 1998, 2004 and 2005. In the Upper Soča Valley, seven strong earthquakes (1918, 1942, 1944, 1968, 1976, 1998, 2004) were recorded in the 20th century alone (Vidrih 2008).

Even though earthquakes are not unexpected, people rarely prepare for them with the proper reconstruction of their buildings in advance. The dwellings are usually reconstructed after larger events. In Slovenia, this was supported by state financing in 1976, 1998, and 2004 (Pipan 2011).

On the example of the 1998 earthquake we showed that it is possible to assess the damage on the basis of available data which was done by the method proposed by Kilar and Kušar (2009; Figure 9) and with the help of an open-access database (the Real Estate Register) of the the Surveying and Mapping Authority of the Republic of Slovenia. It is shown that damage depends most on the age of buildings. This information is partly due to the characteristics of the property value model and partly due to the relation between age of the building and the quality of building.

In the modern world, in which capital plays a key role, good knowledge of damage costs is crucial in advocating prevention. According to an estimate by the World Bank and the U.S. Geological Survey, the global economic damage caused by natural disasters during the 1990s could have been $280 billion lower if $40 billion (only 14%) had been invested in advance in natural disaster prevention and preparedness (Guha-Sapir, Hargitt and Hoyois 2004).

In Slovenia, only scant attention is paid to prevention in natural disaster management, despite the fact that the 2002 Water Act established the obligation to prepare hazard maps and establish damage potential for hydro-geomorphological natural disasters. Our aim is to put an increased emphasis on prevention with the aid of the Real Estate Register, which was established in 2011 and provides data on real estate value. The registry makes it possible to make new and more realistic calculations and models (Figure 10) of potential damages for future natural disasters on the national, regional or local scales.

6 References

Bründl, M., Dlof, F., Gutwein, P., Krummenacher, B., Winkler, C. 2010: EconoMe-Develop 1.0: Online-Berechnungsprogramm zur Bestimmung der Risiken sowie der Wirksamkeit und Wirtschaftlichkeit von Schutzmassnahmen gegen Naturgefahren gemäss Leitfaden Risikokonzept PLANAT. Bern. Internet: http://78.47.131.193/doc/Handbuch-EconoMe-Develop10_d.pdf (15. 1. 2012).

Geipel, R. 1982: Disaster and Reconstruction. London.

Gosar, A. 2007: Microtremor HVSR study for assessing site effects in the Bovec basin (NW Slovenia) related to 1998 Mw 5.6 and 2004 Mw 5.2 earthquakes. Engineering Geology 91, 2-4. Amsterdam. DOI: 10.1016/j.enggeo.2007.01.008

Gosar, A., Stopar, R., Car, M., Mucciarelli, M. 2001: The earthquake on 12 April 1998 in the Krn mountains (Slovenia): ground-motion amplification study using microtremors and modelling based on geophysical data. Journal of Applied Geophysics 47-2. Amsterdam. DOI: 10.1016/S0926-9851(01)00058-1

Guha-Sapir, D., Hargitt, D., Hoyois, P. 2004: Thirty years of natural disasters 1974–2003: The numbers. Brussels.

Internet 1: http://prostor3.gov.si/javni/ (27. 2. 2012).

Internet 2: http://www.rtvslo.si/slovenija/podatki-o-vrednosti-nepremicnin-na-spletu/273618 (27. 2. 2012).

Kilar, V., Kušar, D. 2009: Assessment of the earthquake vulnerability of multi-residential buildings in Slovenia. Acta geographica Slovenica 49-1. Ljubljana. DOI: 10.3986/AGS49103

Komac, B, Natek, K., Zorn, M. 2008: Geografski vidiki poplav v Sloveniji. Geografija Slovenije 20. Ljubljana.

Komac, B, Zorn, M. 2011: Geografija poplav v Sloveniji septembra 2010. Neodgovorna odgovornost, Naravne nesreče 2. Ljubljana.

Kumelj, Š., Geršak, V. 2011: Ocenjevanje ogroženosti zaradi naravnih nesreč z orodjem RiskPlan. Neodgovorna odgovornost, Naravne nesreče 2. Ljubljana.

Kušar, D. 2008: The impact of natural disasters on buildings' architectural styles. Acta geographica Slovenica 48-1. Ljubljana. DOI: 10.3986/AGS48104

Löw, P., Wirtz, A. 2010: The year in figures. TOPICS GEO – Natural catastrophes 2010: Analyses, assessments, positions. München. Internet: http://www.munichre.com/publications/302-06735_en.pdf (17. 8. 2011).

McBean, G. 2004: Climate change and extreme weather: A basis for action. Natural Hazards 31-1. Dordrecht. DOI: 10.1023/B:NHAZ.0000020259.58716.0d

Mikoš, M. 2012: Res ne potrebujemo registra nepremičnin?: pomisleki o javnosti registra. Delo 53-9 (12. 1. 2012). Ljubljana.

Mikoš, M., Fazarinc, R., Ribičič, M. 2006: Sediment production and delivery from recent large landslides and earthquake-induced rock falls in the Upper Soča River Valley, Slovenia. Engineering Geology 86, 2-3. Amsterdam. DOI: 10.1016/j.enggeo.2006.02.015

Ocenjena škoda, ki so jo povzročile elementarne nesreče. Statistični urad Republike Slovenije. Ljubljana, 2010. Internet: http://www.stat.si/pxweb/Database/Okolje/27_okolje/05_Nesrece/27089_ocenjena_skoda/27089_ocenjena_skoda.asp (17. 11. 2010).

Orožen Adamič, M., Hrvatin, M. 2001: Geographical characteristics of earthquakes in the Soča River Region. Geografski zbornik 41. Ljubljana.

Pipan, P. 2011: Sodelovanje javnosti v obnovi po naravnih nesrečah na primeru potresov v Furlaniji in Zgornjem Posočju v letih 1976, 1998 in 2004. Neodgovorna odgovornost, Naravne nesreče 2. Ljubljana.

Prostor – prostorski portal. Geodetska uprava Republike Slovenije. Ljubljana, 2012. Internet: http://e-prostor.gov.si (27. 2. 2012).

Ribičič, M., Vidrih, R., Godec, M. 2000: Seizmogeološki in geotehnični pogoji gradnje v zgornjem Posočju. Geologija 43-1. Ljubljana. DOI: 10.5474/geologija.2000.011

SI-Stat podatkovni portal. Statistični urad Republike Slovenije. Ljubljana, 2012. Internet: http://pxweb.stat.si/pxweb/dialog/statfile1.asp (27. 2. 2012).

Vidrih, R. 2008: Seismic activity of the Upper Soča valley. Ljubljana.

Vidrih, R., Ribičič, M., Suhadolc, P. 2001: Seismo-geological effects on rocks during the 12 April 1998 upper Soča Territory earthquake (NW Slovenia). Tectonophysics 330, 3-4. Amsterdam. DOI: 10.1016/S0040-1951(00)00219-5

Zakon o vodah. Uradni list Republike Slovenije 67/2002. Ljubljana.

Zorn, M. 2002: Rockfalls in Slovene Alps. Geografski zbornik 42. Ljubljana.

Zorn, M., Komac, B. 2011: Damage caused by natural disasters in Slovenia and globally between 1995 and 2010. Acta geographica Slovenica 51-1. Ljubljana. DOI: 10.3986/AGS51101