EU FLOODS RECOVERY PROGRAMME

This project is funded by the European Union

FLOODS AND LANDSLIDES RISK ASSESSMENT FOR THE HOUSING SECTOR IN BOSNIA AND HERZEGOVINA

$$\text{Risk} = \frac{\text{Hazard} \times \text{Vulnerability} \times \text{Exposure}}{\text{Capacity}}$$

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NOVEMBER, 2015

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LIST OF ACRONYMS

AHP	Analytical Hierarchy Process
BiH	Bosnia and Herzegovina
BAM	Bosnia and Herzegovina Convertible Mark
BD	Brčko District
CLC	CORINE Land Cover: Co-ordinated information on the environment land cover
DM	Digital Model
EUD	European Union Directive
EUFD	European Union Flood Directive
FBiH	Federation of Bosnia and Herzegovina
FOP	Federal Operational Plan
FEPP	Flood Emergency Preparedness Plan
FRAH	Flood Risk Assessment for the Housing sector
FRAM	Flood Risk Adaptive Measures
GIS	Geographic Information System
GOP	General Operational Plan
IGSD	Infrastructure of Geo-Spatial Data
IPPC	International Plant Protection Convention
INSPIRE	Innovation in Science Pursuit for Inspired Research
KOP	Cantonal Operational Plan
LRAH	Landslide Risk Assessment for the Housing sector
PFRA	Preliminary Flood Risk Assessment
RS	Republika Srpska
UNDP	United Nations Development Programme
USACE	US Army Corps of Engineers
USIS	Uniform Spatial Information System
WBIF	Western Balkan Investment Framework

EXECUTIVE SUMMARY

INTRODUCTION

The most severe flooding since the systematic recording of meteorological and hydrological processes began in Bosnia and Herzegovina (BiH), in 1892, struck BiH in May 2014. Intense rainfall caused several rivers and their tributaries to overflow, in particular the rivers Bosna and Sava as well as the Drina, Una and Sana. This resulted in sudden and extreme flooding with a number of locations in the Bosna River Basin recording a maximum outflow that exceeded the return period of 500 years. Considering that flood prevention systems in the country are by law designed for a return period of 100 years it is evident how extraordinary this devastating disaster was. In addition, this level of rainfall triggered numerous landslides in the affected areas, which highlighted the lack of attention that landslide risk management receives in BiH.

The total economic impact of the disaster is estimated to have reached 2.04 billion EUR or 15% of the country's GDP in 2014.[1]

Increased losses caused by disasters in BiH over the past decades and the effects of climate change, manifested through more frequent extreme weather events such as the floods of May 2014, warn us that sustainable development can only be secured through risk informed decisions.

The European Union launched the EU Flood Recovery Programme for Bosnia and Herzegovina, worth 43.52 million EUR, in order to support recovery efforts after the floods of May 2014. The EU contribution was 42.24 million EUR, while UNDP participated with 1.28 million EUR. The Programme consists of different components all aimed at assisting people in the flood affected areas and communities in the 24 most affected municipalities to normalise their lives. Furthermore, the Programme recognises the importance of investing in future risk informed decision making and thus initiated the development of a Flood and Landslide Risk Assessment for the Housing Sector in BiH (the Assessment). The overall objective of the Assessment is to contribute to strengthening disaster risk assessment and disaster risk management capacities in BiH. This required the production of a complete assessment of the risks posed to the housing sector associated with the occurrence of flooding and landslide events that integrate the impact of climate change and therefore increase the level of risk.

The Assessment therefore assesses the flood and landslide risk for the housing sector in Bosnia and Herzegovina, prioritises locations based on risk ranking and makes recommendations for risk reduction.

1 Post Disaster Needs Assessment, Bosnia and Herzegovina, June 2015; the World Bank, the United Nations, the European Union, government authorities.

2. METHODOLOGIES AND RESULTS

The adopted and by relevant stakeholders[2] validated methodologies enabled the objective identification and prioritisation of flood and landslide affected housing areas across BiH. This was based on the identified risk level for the housing sector and an assessment of the impact of climate change leading to increased levels of risk.

The Assessment first identified and conducted a flood risk assessment for the housing sector and a landslide risk assessment for the housing sector and then combined them into a multi-hazard assessment. Input data for exposure element for both flood and landslide risk assessments were spatial planning segment data and analysis. The floods risk assessment and the landslide risk assessment resulted in the identification of areas that are very significantly endangered by flooding and landslides. An additional tool in the selection of priority areas for the implementation of measures aimed at preventing or reducing the risk of floods and landslides was socioeconomic analysis. In the case of natural hazards, socioeconomic analysis had a purpose of analysing the degree of socioeconomic vulnerability of areas exposed to natural hazards.

a. Flood Risk Assessment for the Housing Sector [3]

Flood risk assessment input data for the hazards component of the disaster risk formula were either identified flood polygons (extent of the flooding) or, where available, flood hazard maps (hazard level showing the extent of the flooding) for a recurrence interval of 100 years.

Data for RS[4] was collected from the available spatial planning documents as well as from the hazard maps, which were published in the Preliminary Flood Risk Assessment (PFRA). Flood hazard maps for the FBiH[5] were collected from the preliminary flood risk assessments of the Agency for the Water Area of the River Sava and the Agency for the Water Area of the Adriatic Sea in the FBiH. The data for BD[6] was received from the Department for Agriculture, Forestry and Water Management, subdivision for forestry and water management, of the Government of BD.

Other data relevant for the identification of flood risks (exposure and vulnerabilities) for the housing sector were land usage data organised into layers. They included population, houses, public buildings and commercial facilities, roads, railways, communication infrastructure, electric power lines, water supply and sanitation facilities, water quality, cultural and historical heritage, and agriculture and forestry. The main data source for the layers related to housing was CORINE LC 2006[7]; where detailed data was available CORINE was further updated.[8]

A weighting factor was assigned to each layer, in line with the level of significance. The layers were then connected through a mathematical model developed in the Model Builder of the GIS[9] software. Overlapping all of the layers with the flood hazard maps produced a cumulative index to show whether or not areas were significantly endangered by flooding; the numeric value provided served as the basis for ranking housing areas according to their level of endangerment related to flooding.

In line with the proposed methodology, the specific results obtained are presented in the map below showing different areas at risk of flooding.

2 Hydrometeorological Institute of FBiH, the Hydrometeorological Institute of RS, the Agency for the Water Area of the River Sava, the Agency for the Water Area of the Adriatic Sea, the public institution 'Vode Srpske' Bijeljina, the Ministry of Agriculture, Water Management and Forestry of FBiH; the Institute for Geology of RS, the Institute for Geology of the FBiH, the Ministry of Agriculture, Forestry and Water Management of RS; the Ministry of Spatial Planning of FBiH, the Department for Spatial Planning and Property Relations of the Government of Brčko District; the Ministry of Environment and Tourism of FBiH, the Ministry of Spatial Planning, Civil Engineering and Ecology of RS; the Ministry of Foreign Trade and Economic Relations of BiH, the Department of Civilian Protection of FBiH and the Department of Civilian Protection of RS.

3 The methodology is defined in detail in II.1.b section of this Assessment.

4 Refer to acronyms

5 Refer to acronyms

6 Refer to acronyms

7 CORINE LC 2006 is a seamless European land cover vector database.

8 More detail on the exposure and vulnerability data can be found in the spatial planning segment in the data input and analysis chapters of the Assessment.

9 Refer to acronyms

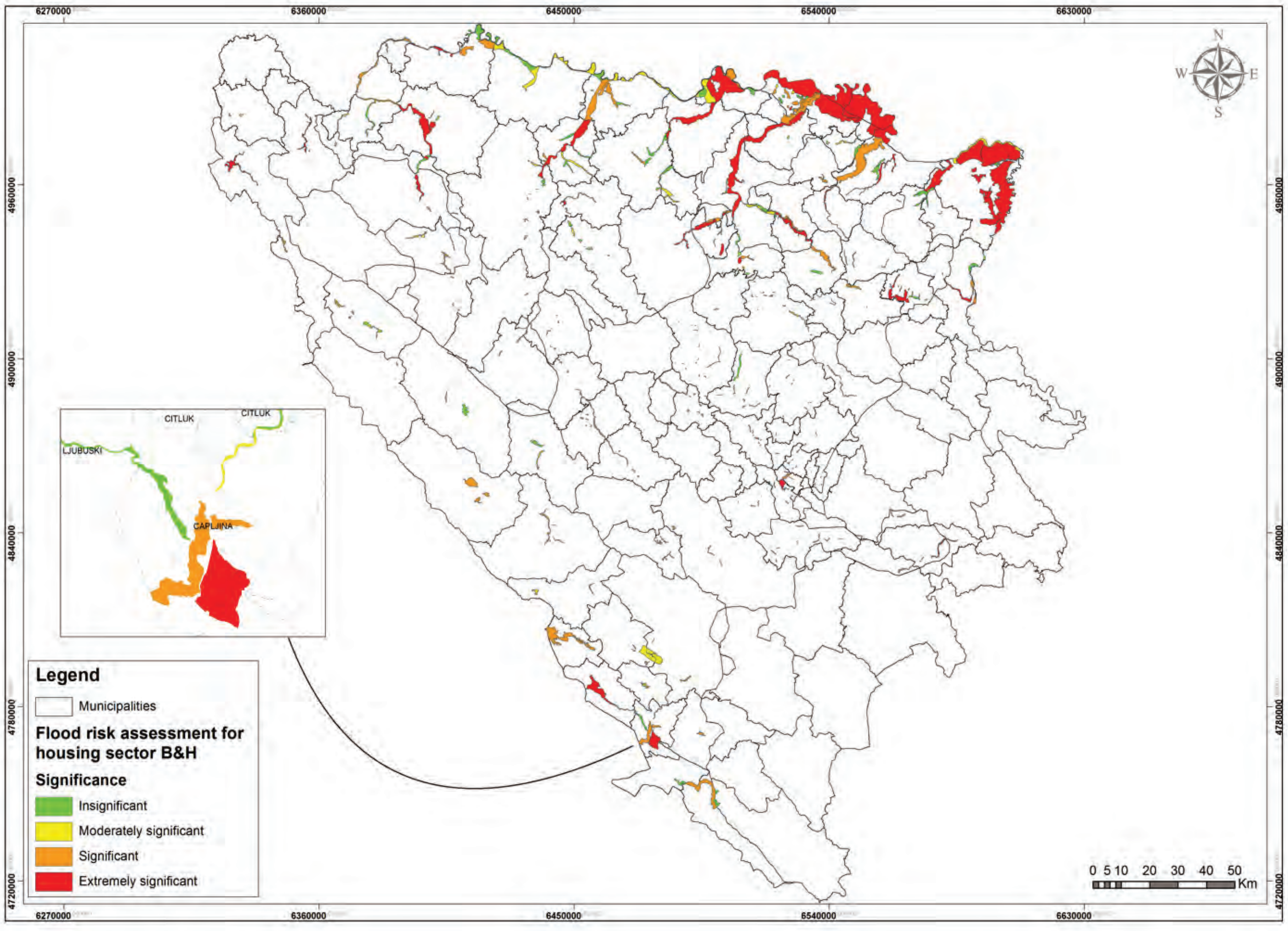


Figure 1: Preliminary flood risk assessment for the housing sector in BiH.

131 flood hazard maps (areas) were identified as being significantly endangered by flooding. These areas are located in 71 municipalities identified as being at high risk of flooding.

b. Landslide Risk Assessment for the Housing Sector

The methodological approach[10] adopted for the Landslide Risk Assessment for the Housing Sector (LRAH) was based on general AHP[11] principles[12], which were seen as the most suitable expert judgment system considering the scale of BiH. The first step of LRAH development was to provide a landslide susceptibility map of BiH. The landslide susceptibility map provides a proposed ranking of terrain units in terms of the spatial probability of the occurrence of landslides. A relative landslide risk map for the territory of BiH was prepared based on the landslide susceptibility map and vulnerability maps.

Notwithstanding the fact that landslides represent an important problem in Bosnia and Herzegovina, the landslide susceptibility map prepared as a part of LRAH is the first map to cover the entire territory of Bosnia and Herzegovina.

An appropriate AHP matrix was created using the four causative factors (lithology, slope, precipitation and land cover) and their relative importance, according to the methodology of landslide susceptibility assessment. Data on more than 4,500 landslide occurrences across the territory of BiH was collected during the LRAH analysis. This data and other relevant expert information were used to create and validate the Landslide Susceptibility Map of BiH.

10 The detailed methodology is defined in Chapter II.2.b section of this Assessment.
11 Refer to Acronyms
12 An Analytic Hierarchy Process is a structured technique for organising and analysing complex decisions, based on mathematics and psychology.

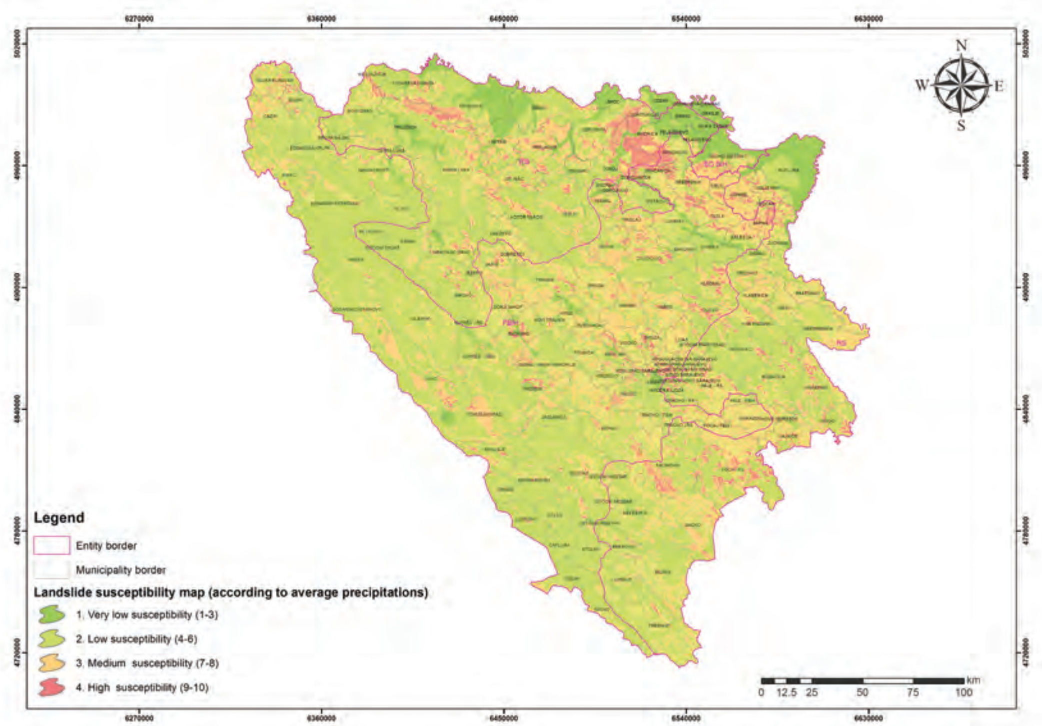


Figure 2: Landslide Susceptibility Map of BiH.

The relative landslide risk map for the housing sector was prepared based on the landslide susceptibility map and the level exposure of the elements at risk. The vulnerability map of BiH, developed for socioeconomic sector analysis, was overlapped with the landslide susceptibility map.

The results show that the main landslide prone areas are located in the northern part of the country, while the remaining landslide prone areas are in central Bosnia and the southern parts of BiH.

The 1:100,000 landslide risk map for the housing sector in BiH is presented below.

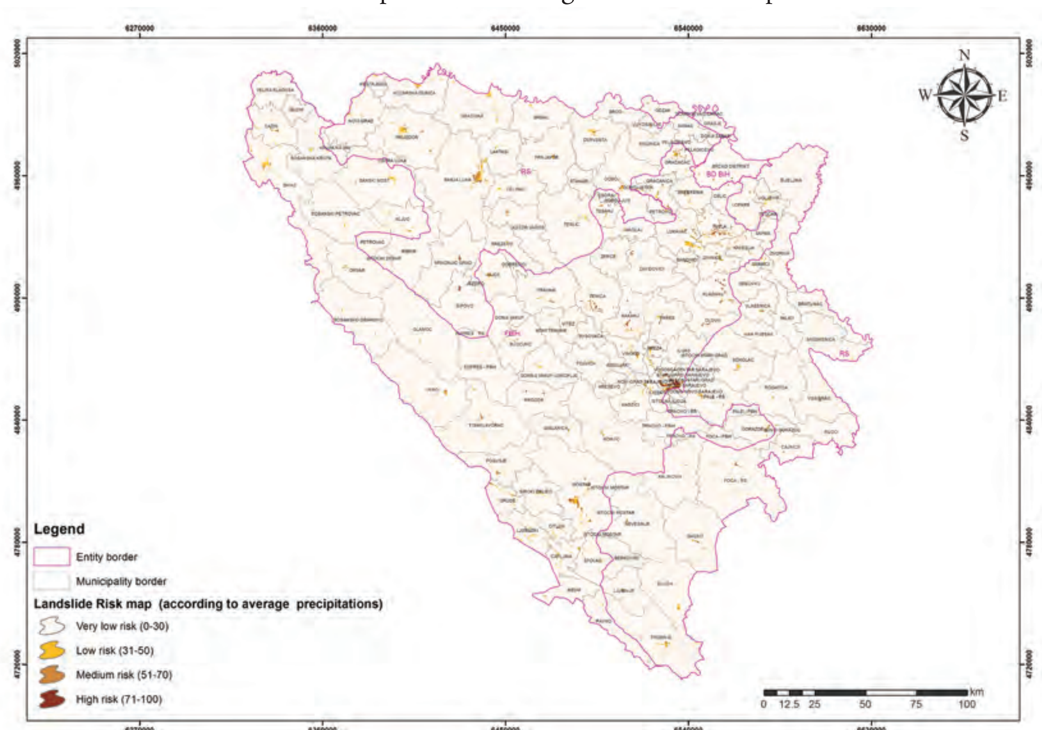


Figure 3: Landslide Risk Assessment Map for the Housing Sector in BiH.

c. Spatial Planning Segment Data Input and Analysis

In order to determine the flood and landslide risk for the housing sector in BiH it was necessary to provide an adequate database on urban areas for the whole country, as an exposure component of the risk formulas for the flood and landslide risk assessments. This was done through the spatial planning segment data input and analysis described below.

The housing sector in BiH comprises of 1,617,308 housing units, according to the preliminary results of the 2013 census: population, households and housing. The housing sector is concentrated in built-up settlement areas that, so far, include 6,118 registered settlements. The largest number of housing units is located in the areas of Sarajevo and Banja Luka (14.29% of the total number of dwellings in BiH).

The entire process of spatial planning analysis was done in two phases.[13]

In the first phase, identification and the characteristics of housing areas were assessed at the scale of 1:100,000. Urban areas were selected from CORINE 2006 as well as other appropriately modified spatial planning documents during this phase.

The total area covered by both the landslide and flood hazards was 210,425 ha (an area that corresponds to the entire cities of Banja Luka and Prijedor combined).

Because of the large area it was neither possible nor necessary to process all risk categories at a detailed scale, therefore, for the purposes of this Assessment, only areas of fourth category [14](those most affected or most vulnerable areas) were analysed at a scale of 1:5,000 in the second phase.

The total surface area of fourth category encompassed around 105,000 ha (an area that corresponds to the entire municipalities of Bratunac, Milići and Srebrenica combined). Detailed data on land usage (residential areas, commercial zones, public facilities, traffic and other public infrastructure) was collected and analysed together with data on monuments, protected areas and IPPC[15] plants (large pollutants). This created a synthesis map showing the distribution of urban area and crucial infrastructure in the previously defined zone of fourth category. This phase of assessment resulted in input data for the flood and landslide risk assessments.

13 The spatial planning methodology is described in detail in the Chapter III section 4 of this Assessment.

14 The methodologies for the flood and landslide risk assessments defined four risk categories ('not significant', 'moderately significant', 'significant' and 'very significant'). These same categories were used as input data for the housing sector in BiH.

15 Refer to acronyms

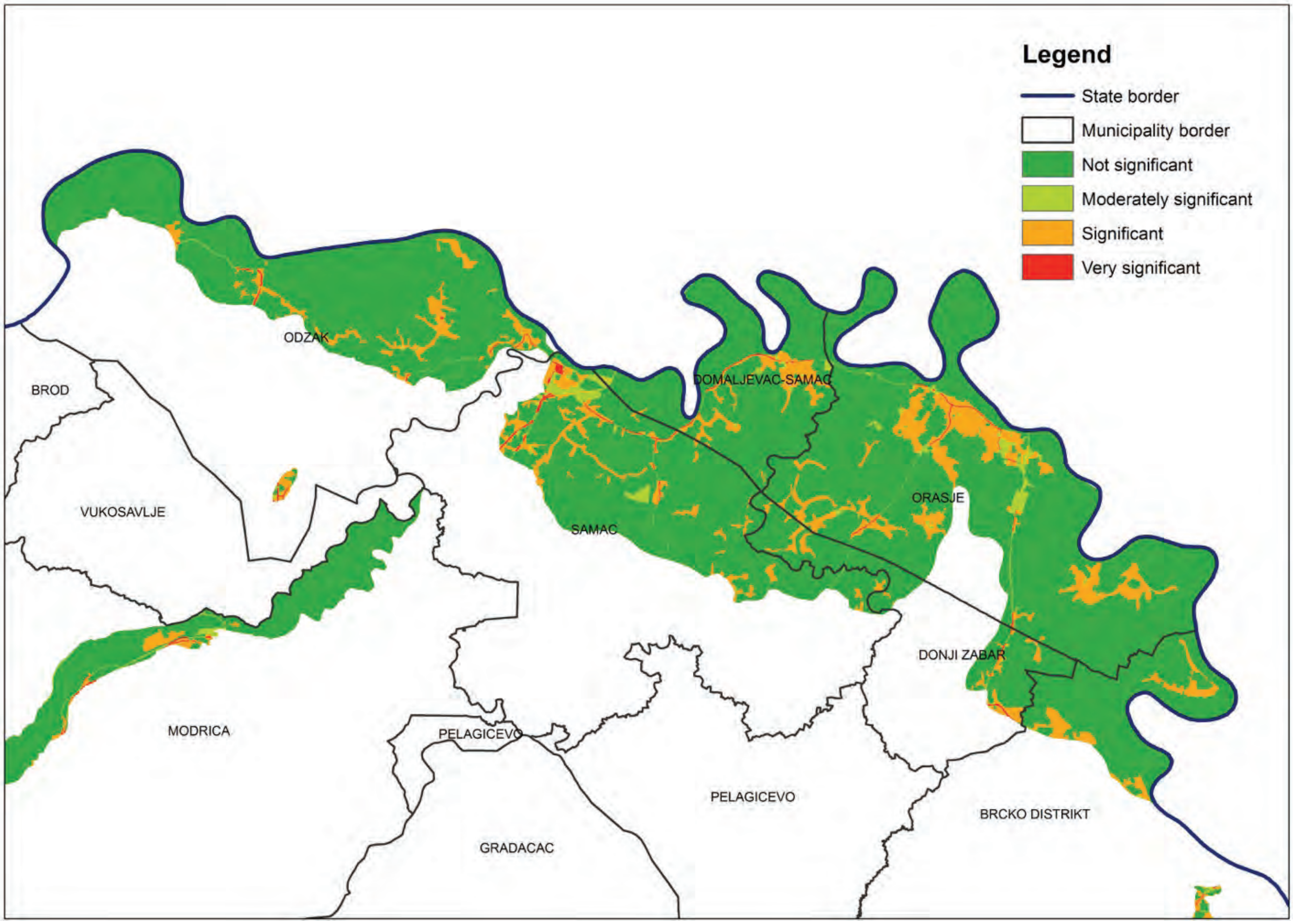


Figure 4: Example of detailed urban analysis for the flooded area in Posavina.

One of the results of the second phase of spatial planning analysis was data and criteria for the indicators, which were used in the socioeconomic vulnerability model. The defined parameters provided the basis for socioeconomic analysis of the actual risks and prioritisation in terms of recommendations for necessary actions to be carried out in order to prevent, reduce and minimise the risks posed to the housing sector in BiH.

Table 1: Structure of detailed analysis data for the municipalities affected by very significant risk of landslide.

No.	MUNICIPALITY	GROSS BUILT UP AREA OF THE HOUSING UNITS (m²)	No. OF INDIVIDUAL HOUSING UNITS	No. OF APPARTMENTS IN RESIDENTIAL BUILDINGS	HOUSEHOLD	POPULATION	IPPC PLANT
1	BANJA LUKA	312930	1905	1749	3654	11327	
2	BANOVICI	66320	554	156	710	2201	
3	BERKOVICI	200	2	0	2	6	
4	BIHAC	27000	270	0	270	837	
5	BOSANSKO GRAHOVO	3800	38	0	38	118	
6	BRATUNAC	2900	29	0	29	90	
7	BRCKO DISTRIKT	37300	373	0	373	1156	
8	BREZA	28000	280	0	280	868	
9	BUGOJNO	17400	174	0	174	539	
10	CAJNICE	9700	97	0	97	301	
11	CAPLJINA	17000	170	0	170	527	
12	CAZIN	35000	350	0	350	1085	
13	CELIC	46300	435	40	475	1473	
14	CENTAR SARAJEVO	1115240	4270	9832	14102	43716	1
15	CITLUK	6300	63	0	63	195	
16	DERVENTA	61670	476	201	677	2099	
17	DOBOJ	114820	1088	86	1174	3639	
18	DOBOJ-ISTOK	29600	296	0	296	918	
19	DOBRETICI	5300	53	0	53	164	
20	DONJI VAKUF	17700	177	0	177	549	
21	DRVAR	2000	20	0	20	62	
22	FOCA - FBiH	700	7	0	7	22	
23	FOCA - RS	167160	490	1688	2178	6752	
24	FOJNICA	1000	10	0	10	31	
25	GACKO	70810	517	273	790	2449	
26	GLAMOC	700	7	0	7	22	
27	GORAZDE	94400	944	0	944	2926	
28	GORNJI VAKUF-USKOPLJE	2100	21	0	21	65	
29	GRACANICA	109820	1087	16	1103	3419	
30	GRADACAC	76940	677	132	809	2508	
31	GRUDE	10800	108	0	108	335	
32	HADZICI	700	7	0	7	22	
33	HAN PIJESAK	21920	103	166	269	834	
34	ILIDZA	31100	311	0	311	964	
35	ILIJAS	65400	262	560	822	2548	
36	ISTOCNA ILIDZA	23500	235	0	235	729	
37	ISTOCNI STARI GRAD	2300	23	0	23	71	
38	ISTOCNO NOVO SARAJEVO	13500	135	0	135	419	
39	JAJCE	23300	233	0	233	722	
40	KAKANJ	189700	1491	580	2071	6420	1
41	KALESIJA	61800	618	0	618	1916	
42	KALINOVIK	600	6	0	6	19	
43	KLADANJ	132550	1301	35	1336	4142	
44	KLJUC	1700	17	0	17	53	
45	KNEZEVO	11500	115	0	115	357	
46	KONJIC	31040	29	402	431	1336	
47	KOSTAJNICA	6800	68	0	68	211	
48	KOTOR VAROS	12300	123	0	123	381	
49	KOZARSKA DUBICA	1400	14	0	14	43	
50	LIVNO	29600	296	0	296	918	
51	LJUBINJE	26460	161	148	309	958	
52	LJUBUSKI	56740	279	412	691	2142	
53	LOPARE	26400	264	0	264	818	
54	LUKAVAC	98540	732	362	1094	3391	
55	MAGLAJ	8200	82	0	82	254	
56	MILICI	3300	33	0	33	102	
57	MODRICA	18500	185	0	185	574	
58	MOSTAR	239330	1974	599	2573	7976	
59	MRKONJIC GRAD	206410	949	1593	2542	7880	
60	NEVESINJE	6400	64	0	64	198	
61	NOVI GRAD	12200	122	0	122	378	
62	NOVI GRAD SARAJEVO	523400	4037	1710	5747	17816	1
63	NOVI TRAVNIK	9300	93	0	93	288	
64	NOVO GORAZDE	14700	119	40	159	493	
65	NOVO SARAJEVO	392060	1185	3908	5093	15788	
66	OLOVO	58700	384	290	674	2089	
67	OSMACI	3100	31	0	31	96	
68	PALE - FBiH	6900	69	0	69	214	
69	PALE - RS	38400	272	160	432	1339	
70	POSUSJE	27640	268	12	280	868	
71	PRIJEDOR	15600	156	0	156	484	
72	PRNJAVOR	3400	34	0	34	105	
73	PROZOR	50700	507	0	507	1572	
74	RIBNIK	900	9	0	9	28	
75	ROGATICA	700	7	0	7	22	
76	RUDO	20400	99	150	249	772	
77	SANSKI MOST	2100	21	0	21	65	
78	SAPNA	10640	77	42	119	369	
79	SEKOVICI	21200	212	0	212	657	
80	SIPOVO	135490	986	527	1513	4690	
81	SIROKI BRIJEG	3800	38	0	38	118	
82	SOKOLAC	7100	71	0	71	220	
83	SREBRENICA	2900	29	0	29	90	
85	SREBRENIK	80800	808	0	808	2505	
86	STARI GRAD SARAJEVO	408060	3263	1168	4431	13736	
87	STOLAC	3300	33	0	33	102	
88	TEOCAK	12200	122	0	122	378	
89	TESANJ	10200	102	0	102	316	
90	TOMISLAVGRAD	3100	31	0	31	96	
91	TRAVNIK	27800	278	0	278	862	
92	TREBINJE	10100	101	0	101	313	
93	TRNOVO - FBiH	2200	22	0	22	68	
94	TRNOVO - RS	58520	147	626	773	2396	
95	TUZLA	556400	4745	1170	5915	18337	
96	UGLJEVIK	8700	87	0	87	270	
97	VARES	165100	405	1780	2185	6774	
98	VISEGRAD	71260	504	298	802	2486	
99	VISOKO	91460	797	168	965	2992	
100	VLASENICA	24500	245	0	245	760	
101	VOGOSCA	234690	1810	767	2577	7989	
102	VUKOSAVLJE	1500	15	0	15	47	
103	ZAVIDOVICI	139440	644	1072	1716	5320	
104	ZENICA	233560	1959	538	2497	7741	
105	ZEPCE	5800	58	0	58	180	
106	ZIVINICE	19600	196	0	196	608	
107	ZVORNIK	35500	355	0	355	1100	
	TOTAL	7407020	50651	33456	84107	260731	3

Table 2: Structure of detailed analysis data for the municipalities affected by very significant risk of flooding.

No.	MUNICIPALITY	GROSS BUILT UP AREA OF THE HOUSING UNITS (m^2)	AREA OF URBAN BLOCKS (ha)	No. OF INDIVIDUAL HOUSING UNITS	No. OF APPARTMENTS IN RESIDENTIAL BUILDINGS	HOUSEHOLD	POPULATION	IPPC PLANT
1	BANJA LUKA	124010	156.73	1119	173	1292	4005	
2	BIHAC	67400	76.34	674	0	674	2089	0
3	BIJELJINA	2285750	2712.06	16589	8955	25544	79186	
4	BOSANSKA KRUPA	76670	84.75	724	61	785	2434	
5	BRCKO DISTRIKT	203700	541.47	2037	0	2037	6315	0
6	BROD	607370	1257.23	4904	1671	6575	20383	
7	CAPLJINA	51200	64.37	512	0	512	1587	
8	CELINAC	55800	59.90	327	330	657	2037	
9	DERVENTA	212430	326.62	1768	509	2277	7059	
10	DOBOJ	880090	334.79	1369	10617	11986	37157	1
11	DOMALJEVAC-SAMAC	124500	355.45	1245	0	1245	3860	
12	DONJI ZABAR	53200	192.90	532	0	532	1649	
13	GORAZDE	197750	64.01	357	2315	2672	8283	
14	ILIDZA	106100	90.27	697	520	1217	3773	
15	KALESIJA	56700	134.99	567	0	567	1758	
16	KOZARSKA DUBICA	93350	106.95	713	315	1028	3187	1
17	LAKTASI	177080	432.96	1726	64	1790	5549	
18	LJUBUSKI	75650	122.99	746	15	761	2359	0
19	LUKAVAC	3600	9.48	36	0	36	112	
20	MAGLAJ	245450	81.41	708	2495	3203	9929	0
21	MODRICA	79900	166.83	799	0	799	2477	1
22	ODZAK	218540	548.93	2135	72	2207	6842	
23	ORASJE	748740	1296.34	7031	652	7683	23817	
24	PETROVO	84810	231.48	811	53	864	2678	
25	PRIJEDOR	450430	580.23	2566	2769	5335	16539	
26	SAMAC	353350	630.64	2536	1425	3961	12279	
27	SANSKI MOST	250450	141.18	1437	1525	2962	9182	
28	SREBRENIK	29200	61.15	292	0	292	905	
29	TESANJ	62400	254.77	624	0	624	1934	
30	TESLIC	40600	73.09	406	0	406	1259	
31	VISOKO	36800	19.92	32	480	512	1587	
32	ZVORNIK	50600	120.43	506	0	506	1569	1
	TOTAL	8103620	11331	56525	35016	91541	283777	4

d. Socioeconomic Segment Data Input and Analysis

Socioeconomic analysis is a tool used to analyse vulnerability in terms of the social and economic impact of a disaster, such as loss of life, destruction of houses and infrastructure, disruption of traffic and supply chains.[16] Measuring or quantifying socioeconomic vulnerability is a vulnerability component of disaster risk formula that allows for a comparison of the socioeconomic vulnerability of different areas.

A socioeconomic vulnerability model consists of a set of indicators grouped into three categories: spatial, social and economic. The model is based on a weighing system where the total score for each indicator is weighed according to specific ranking rules. The reason for using a socioeconomic model based on a weighing system is that it offers the possibility to combine various indicators expressed in different units (number, surface area, length, monetary units, etc.) and bring them to a comparable value.

For the purposes of this Assessment, the municipal level was selected for socioeconomic analysis. The final result of the socioeconomic analysis was a vulnerability score value for each municipality at very significant risk of flooding and landslide.

A socioeconomic vulnerability analysis was conducted for those municipalities where areas are at very significant risk of flooding or landslide (category 4 hazard maps). The total number of such municipalities amounted to 122[17]. Of these, category 4 flood hazard maps were created for 31 municipalities and category 4 landslide hazard maps for 110 municipalities. Category 4 landslide and flood hazard maps were created for 19 municipalities, but these hazard maps only overlapped each other in very few cases.

16 The detailed methodology is described in Chapter V of the Assessment.

17 Detailed lists of municipalities are provided in the section Results of the Socioeconomic Vulnerability Analysis

The total surface of BiH exposed to very significant risk of flooding (category 4 hazard maps) is 97,391 ha.

According to the category 4 hazard maps, the highest percentage of municipal territory threatened is found in the City of Bijeljina at 29%, followed by Orašje at 11%. If both category 3 and 4 hazard maps are taken into account then Domaljevac-Šamac has the largest municipal area covered by these hazard maps, accounting for 98.6%, then Orašje 92%, Odžak 52%, Bijeljina 38%, and Donji Žabar and Šamac. All these municipalities are located along the River Sava.

The total surface of BiH exposed to very significant risk of landslides (category 4 hazard maps) is 7,571 ha, whereas the surface at significant and very significant risk of landslides (category 3 and 4 hazard maps) is 26,073 ha.

The overlapping of flood hazard maps and landslide polygons of category 4 occurs in 11 municipalities on a total surface area of 11.85 ha.

The largest overlapping area of 3.94 ha is located in the Municipality of Maglaj. Since the area of overlap was very small this indicator was not included in the analysis.

The total population living in the areas exposed to very significant risk of flooding (category 4 hazard maps) is 283,777, while the total population living in areas at very significant risk of landslides (category 4 hazard maps) is 260,731. The housing area at very significant risk of flooding totals 8,103,620 m^2 and the housing area at very significant risk of landslides totals 7,407,020 m^2.

The total area covered by public infrastructure (schools, hospitals etc.) exposed to very significant risk of flooding is 533 ha, while the total area covered by public infrastructure (schools, hospitals etc.) exposed to very significant risk from landslides is 280 ha. The length of railroads, highways, trunk roads and regional roads in the areas at very significant risk of flooding is 327 meters, whereas the length of railroads, highways, trunk roads and regional roads in areas at very significant risk of landslides is 114 meters.

Category	Affected population	Total housing area (m^2)	Public infrastructure (schools, hospitals, etc.) (ha)	Length of railroads, highways, trunk roads and regional roads (meters)
Very significant flood risk (category 4)	283,777	8,103,620 m^2	533	327
Very significant landslide risk (category 4)	260,731	7,407,020 m^2	280	114

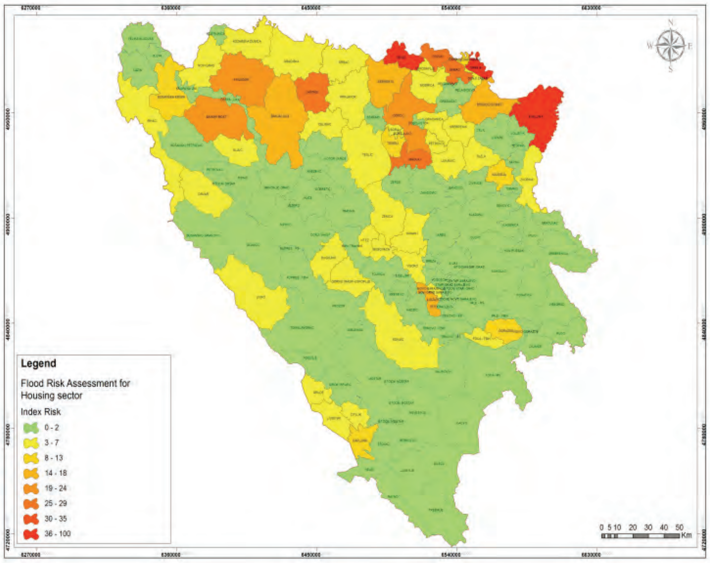
The total possible damage suffered by the housing sector in those areas at very significant risk of flooding is estimated at 3,500,763,840 BAM, of which the hardest hit is Bijeljina (987,444,000 BAM) followed by Doboj (380,198,880 BAM), Orašje (323,455,680 BAM) and Brod (262,383,840 BAM).

The total possible damage suffered by the housing sector in the areas at a very significant risk of landslide is estimated at 4,266,443,520 BAM, of which the hardest hit is Centar Sarajevo (642,378,240 BAM) followed by Tuzla (320,486,400 BAM), Novi Grad Sarajevo (301,478,400 BAM), Stari Grad Sarajevo (235,042,560 BAM) and Novo Sarajevo (225,826,560 BAM).

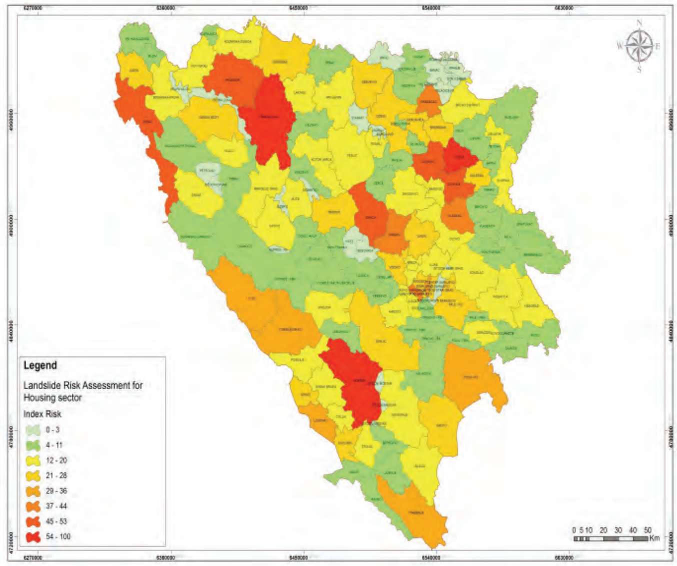
e. Multi-Hazard (Flood and Landslide) Risk Assessment

A multi-hazard risk assessment was done by integrating the flood and landslide risk assessments for the housing sector into a single database that produced combined risk maps. As a consequence, housing areas under significant risk were identified as well as a set of technical and socioeconomic criteria determined for the prioritisation of flood and landslide prone areas.

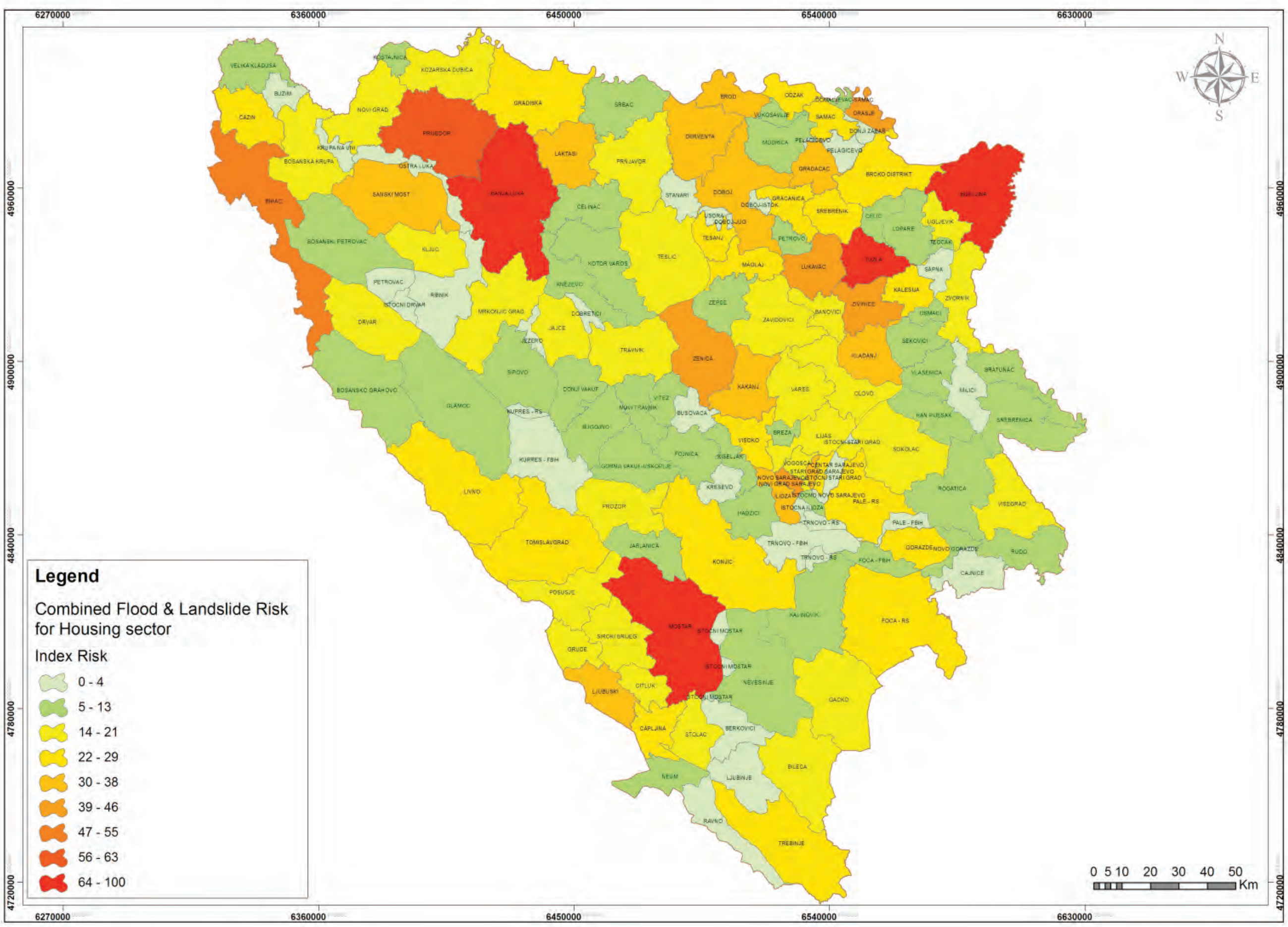
The following figures represent the multi-hazard risk for the housing sector in BiH, per municipality, as well as the relative flood/ landslide risk assessment for the housing sector in BiH. Because of a lack of data for RS a considerable area in the flood risk map remains relatively 'green'. Where the polygons were not available the computation yielded 'no risk'. The map can easily be updated once the data becomes available.



Relative flood risk assessment for the housing sector per municipality



Relative landslide risk assessment for the housing sector per municipality



Relative combined multi-hazard risk per municipality

Table 3: The municipalities most affected by flooding or landslides and their index risk.

	Municipalities affected by Floods or Landslides	Index risk
Flood risk assessment	Bijeljina	100
	Orašje	50
	Brod	34
	Šamac	27
	Laktaši	22
	Maglaj	22
	Doboj	20
	Sanski Most	19
	Prijedor	18
	Derventa	17
	Odžak	16
	Banja Luka	15
	Brčko district	12
	Goražde	10
	Bosanska krupa	9
Landslide risk assessment	Tuzla	100
	Centar Sarajevo	78
	Novi Grad Sarajevo	56
	Kladanj	56
	Mostar	55
	Stari Grad Sarajevo	43
	Zenica	37
	Vogošća	35
	Kakanj	34
	Šipovo	26
	Banja Luka	25
	Novo Sarajevo	23

Table 4: The municipalities most affected by floods and landslides and their index risk

	Municipalities affected by Floods and Landslides	Total Index risk
Combined Flood and Landslide risk for the housing sector in BiH	Doboj	100
	Center Sarajevo	96
	Bijeljina	94
	Tuzla	81
	Orašje	81
	Prijedor	80
	Šamac	80
	Stari Grad Sarajevo	77
	Brod	76
	Novi Grad Sarajevo	75
	Goražde	71
	Kalesja	70
	Derventa	69
	Novo Sarajevo	69
	Vogošća	68
	Maglaj	68
	Kladanj	67
	Srebrenik	67
	Sanski Most	67
	Banja Luka	63
	Vares	63
	Kakanj	62
	Odzak	62
	Mostar	60
	Šipovo	59
	Ljubuški	59
	Domaljevac-Šamac	59
	Mrkonjić Grad	58

f. Information System

It is important to mention that all of the institutions recognised as stakeholders for this Assessment have developed or are in process of developing information systems, to a larger or a lesser extent. However, data on human activity within this space should be stored in one place in order to obtain multi-hazard risk assessments such as this one. This is why the results of this Assessment are available through a web portal (http://eufloodsrecoveryhra.com/) that serves as a platform to host all types of GIS data related to this Assessment. It provides several options and tools for searching and presenting the data. In order to facilitate the use of required data, it allows switching between different maps and data allowing analysis of different layers. There is also the option to download the maps in PDF format and to custom the colours, scheme and layout. This web portal is an important step in providing the general public with information and data on the flood and landslide risks obtained through this Assessment.

The information system created for the purposes of this Assessment was prepared using the ArcGIS tool in the form of a geodatabase and all identified stakeholders will receive the database.

3. RECOMMENDATIONS/MEASURES FOR REDUCING THE RISK OF DISASTER[18]

a. Recommendations/Measures for Reducing the Flood Risk to the Housing Sector

The recommendations and measures for flood risk reduction take into account all ongoing or planned initiatives in this area and rely on Action Plan for Flood Protection and River Management in BiH 2014-2017 (Action Plan) as a prerequisite for the start of implementation that was adopted by the Council of Ministers of BiH. This Action Plan covers the main problems and deficiencies (structural and non-structural measures) related to flood risk management in BiH and sets the strategic framework for coordinated work in this area.

There are many ongoing activities being carried out by different actors, both at the state and regional level in this respect and are taken into account in this Assessment when proposing recommendations and measures for risk reduction.

Structural measures (construction of flood defences such as riverbed regulation and the rehabilitation or construction of dikes) were the most prevalent measures in BiH in the previous period.

Structural measures range from heavily engineered interventions, such as floodways and reservoirs, to more natural approaches like wetlands and greening measures. Heavily engineered structural measures can be highly effective when used appropriately, yet they share one characteristic: they tend to transfer flood risk from one location and as a consequence increase it at another. In some circumstances this is acceptable and appropriate, while in others this may not be the case.

Structural measures identified as "non-regret" in the Action Plan will be implemented through the EU Instrument for pre-accession assistance 2014-2020 (IPA 2) and World Bank (WB) programmes. Out of 39 areas identified as "under high flood risk", implementation of the above mentioned programmes is planned for 15 (within 12 municipalities). Non-structural measures are proposed for the remaining 24 areas in 19 municipalities.

Table 5: List of municipalities where structural or non-structural measures are proposed

	IPA 2	WB	UNDP Vrbas
Municipalities where structural measures are proposed	Bijeljina – Brčko District – Ilidža – Odžak – Orašje – Šamac – Srebrenik – Zvornik	Bijeljina Goražde	Banja Luka Čelinac Laktaši
Municipalities for which non-structural measures are proposed	Bihać – Bijeljina – Bosanska Krupa – Brod – Čaplina – Derventa – Domaljevac Šamac - Donji Žabar – Doboj - Kalesija – Kosarska Dubica – Ljubuški – Maglaj – Modrica – Petrovo – Prijedor – Sanski Most – Tešanj – Teslic – Visoko		

18 Detailed recommendations and measures for risk reduction can be found in section 7. Proposed Measures of the Assessment

Details are presented in Table 22: Description of the measures considered for the flooded areas

Non-Structural Measures encompass activities that can be categorised as non-physical (planning and designing structural measures, preparedness measures, environmental measures, government and legislative measures, financial measures) or physical (emergency response measures).

Additional measures, including legislative ones, are described in more detail in chapter "Physical Planning and Development Measures".

The proposed non-structural measures are applicable to certain municipalities, as presented in the table below.

Table 6: Presentation of flooded areas for which non-structural measures are proposed.

No.	Municipality	Flood area name	Watercourse	Catchment	Return period	Households	Endangered population
2	Bihać	Bihać area	Una	Una	100	674	2,089
5	Bijeljina	SAV.MOK.P01	Majevica perimeter canal	Sava catchment area	100		
6	Bijeljina	SAV.SAV.P01	Sava	Sava catchment area	100		
7	Bijeljina	SAV.SAV.P02	Sava	Sava catchment area	100		
8	Bosanska Krupa	Krupa and Otoka	Una	Una	100	785	2,434
11	Brod	SAV.SAV.P04	Sava	Sava catchment area	100	6,575	20,383
12	Čapljina	Čapljina and Hutovo Blato area	Krupa	Neretva	100	512	1,587
14	Derventa	UKR.UKR.P02	Ukrina	Ukrina	100	2,277	7,059
15	Domaljevac-Šamac	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	1,245	3,860
16	Donji Žabar	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	532	1,649
19	Kalesija	Rainći Gornji	Spreča	Bosna	20	567	1,758
20	Kozarska Dubica	UNA.UNA.P02	Una	Una	100	1,028	3,187
22	Ljubuški	Hrasljani-Veljaci	Trebižat, Vrioštica, Mlade	Neretva	100	761	2,359
23	Maglaj	Maglaj	Bosna	Bosna	20	3,203	9,929
24	Modrica	Modriča area	Bosna	Bosna	100	799	2,477
25	Doboj	BOS.BOS.P03	Bosna	Bosna	100	11,986	37,157
29	Petrovo	Spreča area	Spreča, Jala	Bosna	100	864	2,678
30	Prijedor	UNA.SAN.P01	Sana	Una	100	5,335	16,539
31	Prijedor	UNA.GOM.P01	Gomjenica	Una	100		
33	Sanski Most	Sana area	Sana	Una	100	2,962	9,182
35	Tešanj	Tešanj	Trebačka river	Bosna	20	293	909
36	Tešanj	area	Usora	Bosna	100	331	1,025
37	Teslic	BOS.USR.P01	Usora	Bosna	100	406	1,259
38	Visoko	Ozrakovići	Bosna	Bosna	20	512	1,587

The first step towards the proper planning of measures includes preparation of floodplain mapping (flood hazard and flood risk maps) based on hydraulic modelling that uses detailed Digital Model obtained through river and floodplain surveying along the stretch of river that covers but also exceeds the limits of the flood hazard map. The estimated cost per area is 100,000 to 200,000 BAM.

Following an analysis of the results for each flood risk map, the next step will include the development of a feasibility study to ascertain whether structural and/or non-structural measures are justified. The study should be carried out in order to identify the most suitable measures and to estimate the cost.

Other non-physical measures include early warning systems, flood emergency preparedness plans, evacuation plans, risk communication, land use regulation, zoning of floodplains/floodplaning mapping, zoning, flood insurance.

Physical measures include elevation, relocation, buyout, dry flood roofing, wet flood proofing, floodwalls.

b. Landslide Risk Assessment for the Housing Sector

Non-Structural Measures

Non-structural measures include several preventive activities prior to and after landslide occurrences. These measures include sets of legislative documents that should be reflected and emphasised in the laws on spatial planning and construction and in the laws on geological surveys in the FBiH, RS and BD. This means that it is necessary to harmonise all relevant legislation in BiH concerning geological research.

According to the Landslide Susceptibility Map for BiH, non-structural measures should be implemented in 15 municipalities identified as priority high landslide susceptibility areas.

At the municipal level there are a number of suggestions including the preparation of local landslide zoning maps on a scale of 1:5,000, 1:5,000 to 1:10,000 or, depending on the municipal area/population density, 1:25,000; preparation of landslide inventory, susceptibility, hazard and risk maps and the preparation of emergency response maps for civil protection units (based on 'scenario' models). It is also suggested that an Early Warning System and on-site EWS are established at specific locations and that capacity building and education guidelines for safer housing practices and emergency response exercises (Civil protection units) be implemented.

No	Name	Entity	Area (km2)	**Medium landslide susceptibility (km²)**	**High landslide susceptibility (km²)**
1	Doboj	RS	656.33	166.01	147.78
2	Foca - RS	RS	1118.4	384.74	116.94
3	Modrica	RS	326.73	90.33	107.29
4	Kalinovik	RS	679.5	206.77	60.15
5	Prijedor	RS	834.07	148.73	53.69
6	Gradacac	FBiH	215.25	59.85	43.15
7	Gracanica	FBiH	215.33	87.39	39.55
8	Prnjavor	RS	629.99	289.02	39.45
9	Derventa	RS	516.6	157.03	35.94
10	Banja Luka	RS	1238.89	323.43	35.91
11	Višegrad	RS	449.06	121.90	34.82
12	Lopare	RS	297.86	195.03	34.79
13	Gradiška	RS	761.62	94.21	31.28
14	Zavidovici	FBiH	555.69	193.41	30.71
15	Olovo	FBiH	409.32	75.90	30.57

Structural Measures

Due to the scale of the LRAH it was very hard (or not technically possible) to suggest functional structural measures for the housing sector in the whole territory of BiH. Structural measures generally focus on reducing the consequences of landslide occurrences and are strongly dependant on the landslide mechanism and material involved, causative and trigger factors, the mechanical properties of the landslide material and bedrock, stage of activity, etc. According to the Landslide Risk Assessment Map for the Housing sector in BiH, non-structural measures as the first stage and the structural measures that following should be implemented in 15 municipalities (see the table below) identified as priorities for the housing sector in BiH with high landslide risk areas.

No	Name	Area (km2)	Entity	High landslide risk (km²)
1	TUZLA	295.86	FBiH	7.18
2	CENTAR SARAJEVO	32.92	FBiH	5.57
3	KLADANJ	335.64	FBiH	3.98
4	NOVI GRAD SARAJEVO	47.31	FBiH	3.93
5	MOSTAR	1,164.95	FBiH	3.91
6	STARI GRAD SARAJEVO	49.46	FBiH	3.04
7	ZENICA	550.41	FBiH	2.64
8	VOGOSCA	71.69	FBiH	2.50
9	KAKANJ	376.98	FBiH	2.46
10	SIPOVO	549.97	RS	1.88
11	BANJA LUKA	1238.89	RS	1.80
12	NOVO SARAJEVO	9.2	FBiH	1.62
13	SREBRENIK	247.93	FBiH	1.27
14	GORAZDE	253.6	FBiH	1.19
15	GRADACAC	215.25	FBiH	1.18

c. Physical Planning and Development Measures

Measures in the field of spatial planning are by nature non-structural and preventative. Through the creation of different types of spatial and urban planning documents (strategic and detailed plans) and their implementation the negative effects of floods and landslides in the housing sector can be greatly decreased in BiH.

The existing legal framework in the field of spatial planning in Bosnia and Herzegovina (at the entity, cantonal and Brčko District level) provides a good basis for reducing the risk of floods and landslides in relation to the housing fund. Through consistent implementation of the legislation and preparation and implementation of compulsory spatial planning documents (required by law), which amongst other things define the use of space, the risk to the housing sector in Bosnia and Herzegovina posed by floods and landslides would certainly be reduced.

This risk would be further reduced by changing the legislation in the field of spatial planning regarding the methodological framework (regulations on the content of spatial planning documents), introduction of financial instruments (cost-benefit analysis for the legalisation of residential buildings in risk areas), strengthening the control mechanisms (more frequent inspections at the local government level) and tightening penalty policies.

Planned development creates favourable conditions for life, work, human health and the long-term management of natural resources. Spatial planning should be based on an integrated approach that combines all important factors of development and changes to and the resolution of conflicts related to the space. The issues of vulnerable areas (flood plains and landslide) and climate change constitute an integral part of an integrated approach to planning.

Housing development is generally prohibited outside the zones defined by the spatial planning documents (urban areas, building land/zones, residential zones, residential - commercial zones, etc). The spatial plans of local government units are the most important type of spatial plans in terms of the regulation of housing construction within the territory of BiH. The table below shows the coverage in the territory of BiH according to the spatial plans of local government units (municipalities and cities).

Table 7: Coverage in the territory of BiH according to the adopted spatial plans of local government units (LGU) for the period 1996-2015.

Entity/District	Number of local governments with adopted spatial plans (LGU)	Number of local governments	%
Federation of BiH	30	80	37.50
Republika Srpska	19	64	29.69
Brčko District	1	1	100.00
TOTAL	50	145	34.48

The legislative framework that regulates the preparation of spatial planning documents and their implementation is of great importance in this respect.

The problem of the lack of implementation and violations (non-compliance) of spatial planning documents should be emphasised in particular. This illegal practise results in the absence of the necessary protective infrastructure facilities and illegal housing construction in restricted areas (flood and landslide areas).

In this respect, the Law in RS emphasises that, "for the subsequent buildings that are constructed or reconstructed or upgraded without a building permit the building permit cannot be granted if the structures were built on land unsuitable for construction, such as landslide, swampy land, land exposed to floods and other disasters, etc".

According to the BiH water laws, it is explicitly forbidden to build any structure in areas that are prone to flooding (1/100), the only exception is facilities that serve to protect people and goods from flooding. Yet although a significant number of structures have been identified it is impossible to identify illegal buildings, because even local government bodies do not have statistical data on illegal building.

It should be noted that building permits were obtained for a certain number of structures in these zones under the condition that the structures were built in line with detailed plans (regulations and allotment plans) that envisaged the construction of different flood protection engineering structures in the vicinity of the structures. However, this was not how the plans were executed in reality.

The risk of flooding and landslide to the housing sector would be further reduced if changes were made to the legislation in the field of spatial planning. These changes should encompass the methodological framework (regulations on the content of spatial planning documents), the introduction of financial instruments (cost-benefit analysis for the legalisation of residential buildings in risk areas), strengthening control mechanisms (more frequent inspections at the local government level) and tightening penalty policy (illegal housing construction as a criminal offense). The key recommendations (measures) in this respect are described below:

- The mandatory obligation to prepare risk maps for areas/zones exposed to the risk of flooding and/or landslide in the Rulebook on the Method of Drafting, Content and Development of Spatial Planning Documents in RS and the Federal Decree on Single Methodology in the FBiH. These regulations define the content of spatial planning documents in RS and the FBiH. The future rulebook of BD should also define the obligation to prepare these maps.
- The tightening of sanctions and the introduction of additional mechanisms (the dissolution of local authorities or making plans at the expense of local budgets) as a response to the failure to adopt mandatory strategic spatial planning documents at the local level (local government land use plans and urban plans).
- Increase the frequency of inspections and supervision of implementation (at least once a year) of regulation plans in areas at risk of flooding and landslide (this would result in the prevention of housing construction prior to construction of the necessary planned protective infrastructure).
- Introduce cost-benefit analysis for the legalisation of illegally constructed residential buildings in areas at risk of flooding and landslides (this would result in the removal of the population or instigation of protection measures in the risk area).
- Introduce mandatory geomechanical soil testing for all planned residential buildings in areas at risk of landslide, regardless of their gross construction area.
- Introduce/tighten sanctions against illegal construction of residential buildings in areas at risk of flooding and landslide (imprisonment of 2 to 3 years together with a fine).

The timeframe for the proposed changes to the above legislation would apply as in the case of recommendation No. 2 (one year) and the other recommendations (three years).

There are a number of non-structural measures in the field of spatial planning that would not necessarily require changes to the existing legislation and which could be applied as of now:

- During the preparation of strategic spatial planning documents, create or take from other sources risk maps of areas/zones exposed to the risk of flooding and/or landslide.
- Use an integrated approach when preparing spatial planning documents in areas at risk of flooding and/or landslide, especially for the preparation of regulation plans.
- Carry out inspection control of the implementation of detailed spatial planning documents.
- Implement the existing prohibitions pertaining to the construction of residential buildings in the zones of one-century water (1/100).
- Prohibit the legalisation of illegally constructed residential buildings located in areas at risk from flooding and/or landslide.
- Prohibit the connection of illegally constructed residential buildings located in areas at risk of flooding and landslide to public utility networks.
- Implement sanctions against illegal housing construction in areas at risk of flooding and/or landslide in accordance with the most severe penalties defined under the existing laws.

Most of these measures should be implemented at the local government level (municipal) as residential construction is primarily under the jurisdiction of local government.

4. CONCLUSIONS

The main cause of the massive landslides that occurred in the northern part of BiH during May 2014 was extreme heavy precipitation events; however, all landslide occurrences were also very closely connected to landslide prone areas and associated with detrimental human activity. There was no direct relationship between the flood events and activation of landslides, except in areas around river embankments, during the events of May 2014. The flood events that took place from 14-15 May and the landslides occurrences of 14-18 May 2014 were triggered simultaneously by extreme precipitation caused by cyclone Tamara; however, additional massive landslides were caused by cumulative precipitation from April to May 2014.

In regard to the scale of the Assessment, there were limitations to defining the functional non-structural and structural measures for the housing sector throughout the territory of BiH. Thus, it is necessary to perform more detailed analysis of the areas in the high landslide susceptibility index; this is because the landslide susceptibility/hazard risk assessment methodology provides much better results. It is important to note that some of the structural measures that pertain to landslides were site specific and controlled by local causative (geological, morphological, etc.) and very site specific (geotechnical) factors.

Two municipalities in BiH will be selected based on the aforementioned multi-hazard and socio economic analyses in order to serve as pilot projects. These municipalities will showcase the methodology for further analysis of all built-up areas exposed to the risks and aid in the design of tailor-made structural and non-structural measures. These pilot projects may subsequently serve as comprehensive examples for which approach to take for all other municipalities or areas at risk of either flooding or landslide or both.

Detailed analysis of the quality of the constructed buildings will be carried out under these pilot projects along with an analysis of all spatial, demographic and socioeconomic parameters so that detailed engineering measures can be provided for the reconstruction and protection of all areas at risk. In addition, urban planning measures for future development will be recommended; these may include the displacement of certain residential areas and a comprehensive set of rules for the construction of new ones.

FLOODS AND LANDSLIDES RISK ASSESSMENT FOR THE HOUSING SECTOR IN BOSNIA AND HERZEGOVINA

DETAILED METHODOLOGIES AND RESULTS

1. PRELIMINARY FLOOD RISK ASSESSMENT FOR THE HOUSING SECTOR IN BIH

a. Introduction and Methodology

This phase of the study was based on determining the extent of the flood risks related to the housing sector and an assessment of how climate change has increased the level of danger or risk.

The flood risk assessment for the housing sector is based on the Preliminary flood risk assessment (PFRA) methodology for the FBiH, which follows Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks, but adjusted to better suit the housing risk assessment. Chapter II of the Directive covers preliminary flood risk assessments and Articles 4 and 5 require the preparation of a preliminary flood risk assessment for each river basin district and preliminary estimate content.

Main adjustments of the methodology relate to weighing factors that were adjusted and applied to the whole country. One example for this is a highway that crosses a flood hazard map. There were no elevations in the model and therefore it assumed that the highway was flooded; however, as it was known that the highway was designed to sit above the 100-year flood level, even if it fell within the boundaries of a floodplain it was unlikely that it would be flooded. There was, however, the very slight possibility that a short stretch might not have been constructed in line with the design and could therefore be susceptible to flooding. In this case the 'significance' was reduced. In this way the 'importance' of the structure was combined with the likelihood of it actually being flooded if it was within the boundaries of a hazard map. Furthermore, the 'base' flood level in the flood risk assessment for the housing sector was adopted as 1/100 (100-year return period) whereas the 'base' for the PFRA was 1/20.

The major limitations of the methodology for the flood risk assessment for the housing sector in BiH are as follows:

- There was a scarcity of available flood hazard maps, especially for RS, so the risk in these areas is underestimated.
- The population was estimated in two different ways depending on the available data: (1) calculation of the population density for the specific flood hazard maps where the dwellings were missing and (2) calculation of the population through the attribution of the specific number of persons for each type of dwelling present in the flooded area.
- There was an absence of a hydro-dynamic model and this lead us to use a hydrological method instead.

In spite of all these limitations, the results at this stage of the Assessment are important and sufficient. The adopted methodology was the basis for an objective classification and prioritisation of housing areas affected by the flooding in BiH (FBiH, RS and BD[19]).

In order to implement the proposed methodology, the data included but was not limited to:

- Flood hazard maps; and
- All risk categories and the impact that might represent a risk for human housing/life (organised into layers such as population, houses, public buildings and commercial units, roads, railways, communication infrastructure, electric power lines, water supply and sanitation, water quality, cultural and historical heritage, and agriculture and forestry).

The identified flood hazard maps were used at this stage as input data for mapping the flood risk for the housing sector in BiH.

The basis for determining the potential risks was flood hazard maps for a return period 1/100. In cases where only historical flood data was available the level of detail for all flood hazard maps was not equal. All of the collected data was stored in

19 Refer to Acronyms

the database for modelling results and based on a common denominator for all flood areas, presented in order to adjust and unify the collected data. The reduction to a 'common denominator' (see **Equation 1**) was based on an analysis of the areas for which feasibility studies had been developed (for instance the River Drina).

For FBiH, all of the data from the preliminary flood risk assessment in the FBiH was provided in GIS format by the water agencies. Unfortunately, it proved impossible to obtain PFRA for RS. Only the hazard maps, which are publically available and cover approximately 60% of the territory of RS, were used. A PFRA was not prepared for BD; however, the District did provide official 100-year hazard maps.[20]

The Flood Risk Assessment for the Housing Sector in BiH was carried out with regard to following risk categories:

- direct risk: population, housing (dwellings); and
- indirect risks: economy/business (social facilities, commercial buildings, residential buildings, roads, railways and land); protected areas; cultural and historical monuments; IPPC installations; the number of flooded buildings, displaced and injured population, and data on flooded roads and communications infrastructure, etc.

Input data for exposure element for both flood and landslide risk assessments were spatial planning segment data and analysis.[21] The basic data source for the layers related to housing was CORINE 2006. Where detailed data was available CORINE was updated.

A weighting factor was assigned to each layer based on the respective significance of risk according to expert criteria previously discussed and adopted by the stakeholders. The overlapping of each layer with flood hazard maps resulted in an appropriate individual index, i.e. for a certain category or subcategory. The layers were then connected through a mathematical model developed in the 'Model Builder' of the GIS software. The index was the result of summing up all of the individual indices for the subcategories. The subcategory data was in the form of numbers (for instance, inhabitants or houses, in the event that data was available in that format), hazard maps/surface area or lengths.

Overlapping all of the layers with flood hazard maps produced a cumulative index that showed whether the areas were significantly endangered by flooding or not; a numeric value was provided to serve as the basis for ranking the housing areas endangered by flooding.

Each sub-category was assigned a number identified through the weighting factor, which represented an index 100 for identification of significant flood risk. As an illustration of subcategories, index 100 was obtained if 100 houses were flooded or 300 people directly endangered. Each actual individual index was calculated by linear proportion (i.e. for 50 houses the index was 50). However, all of the individual indices were added-up to present the summary index. If the summary index exceeded 100 then the flood risk was identified as significant.

Flood risks classifications

Index	Significance
0-50	Not significant
50-100	Moderately significant
100-500	**Significant**
> 500	**Very significant**

From a hydrological point of view and with regard to flood reduction, the protection of urban and/or other inhabited areas was based on the maximum discharge occurrence (Q1/100). A certain number of flood hazard maps for Q1/100 maximum flows were available, but the flood hazard maps for certain areas correspond to the flows registered on the specific date (i.e. these flows were not reference Q1/100).

Therefore, the procedure below was proposed:

- For the registered flood date at the closest gauging station the registered water level is identified and, based on the analysis, an adequate probability of return period assumed to be representative for the above mentioned hazard map.
- The risk index calculated for these hazard maps is corrected by a correction factor that reduces the risk from the relevant flood to the 'water level occurrence 1/100'.

Basically, the housing risk is the potential damage that could be caused by the flood. Several feasibility studies demonstrated that there was a logarithmic correlation between the potential damage (risk) and probability of high water occurrence.

In addition to the flood area, the risk was defined by the depth of the flooding, flow velocity and flood duration. In the preliminary assessment the only known variable was the flood area and thus the correlation could not be used in its original form. However, it indicated the possibility to simplify the

20 This Assessment was developed using the below listed references:
- Preliminary Flood Risk Assessment for Water Courses and the Categories in the FBiH (see tables 17 and 18)
- Methodology for the Development of Preliminary Flood Risk Assessment for the Sava River Basin District in the FBiH for Water Courses and Categories – catchment areas (see chapters 4-9)
- Preliminary Flood Risk Assessment for Watercourses and the Categories in the FBiH (see Chapter 2)
- Federal Operative Flood Protection Plan
- Cantonal Operative Flood Protection Plan for Sarajevo Canton
- Cantonal Flood Protection Action Plan for Zenica-Doboj Canton (see Chapter 2)
- The following link <http://goo.gl/YZLU9q> provides a detailed description of previous significant floods in the region for PFRA in the Sava River Basin, which is also described in Chapter 4.

21 Described in detail in Detailed Spatial Planning Phase Methodology section of the Assessment

procedure for reducing floods with different return periods to a common one: 1/100. The ratios between the coverage of the flood hazard maps for 1/20, 1/100 and 1/500 floods were also analysed, based on hydraulic calculations from the available design file. These relations could be used to calculate correlations for any return period.

Therefore, the correction factor used to reduce a flood index to $Index_{100}$ was calculated based on the average ratio between the flood areas for 1/20 and 1/500 floods in relation to 1/100. The use of such average values with standard deviation = 0. 1 for the sample (n = 15) was adopted. It was believed that this approach was characterised by satisfactory accuracy in particular frameworks (in the case of editing and the particularly short deadline set for the preparation). Thus, the correction factor to bring Index T to Index 100 was 1/y, i.e. the index calculated for a hazard map formed by an arbitrary flood with occurrence 1/T flood would be equalised with the 1/100 index when multiplied by C=1/y.

Equation 1

$$\frac{1}{C} = y = 0{,}123\ln(T) + 0{,}4431$$

Where C is a correction coefficient and T is a return period.

b. Results for the Flood Risk Assessment for the Housing Sector in BiH

The main input for the mathematic model, suggested by the methodology described above, were the flooded areas, as presented in the previous reports, accompanied by the registration dates of the flood events and their return period. In addition, CORINE 2006 was used in the description of the hazard maps and especially the codes attributed to each surface; this was important for computing the index and also as a reference for the use of density.

Moreover, in compliance with the proposed methodology, the specific results were obtained by progressively adding a set of collected data linked to the preliminary flood risk map.

The data below was included, but without limitation:

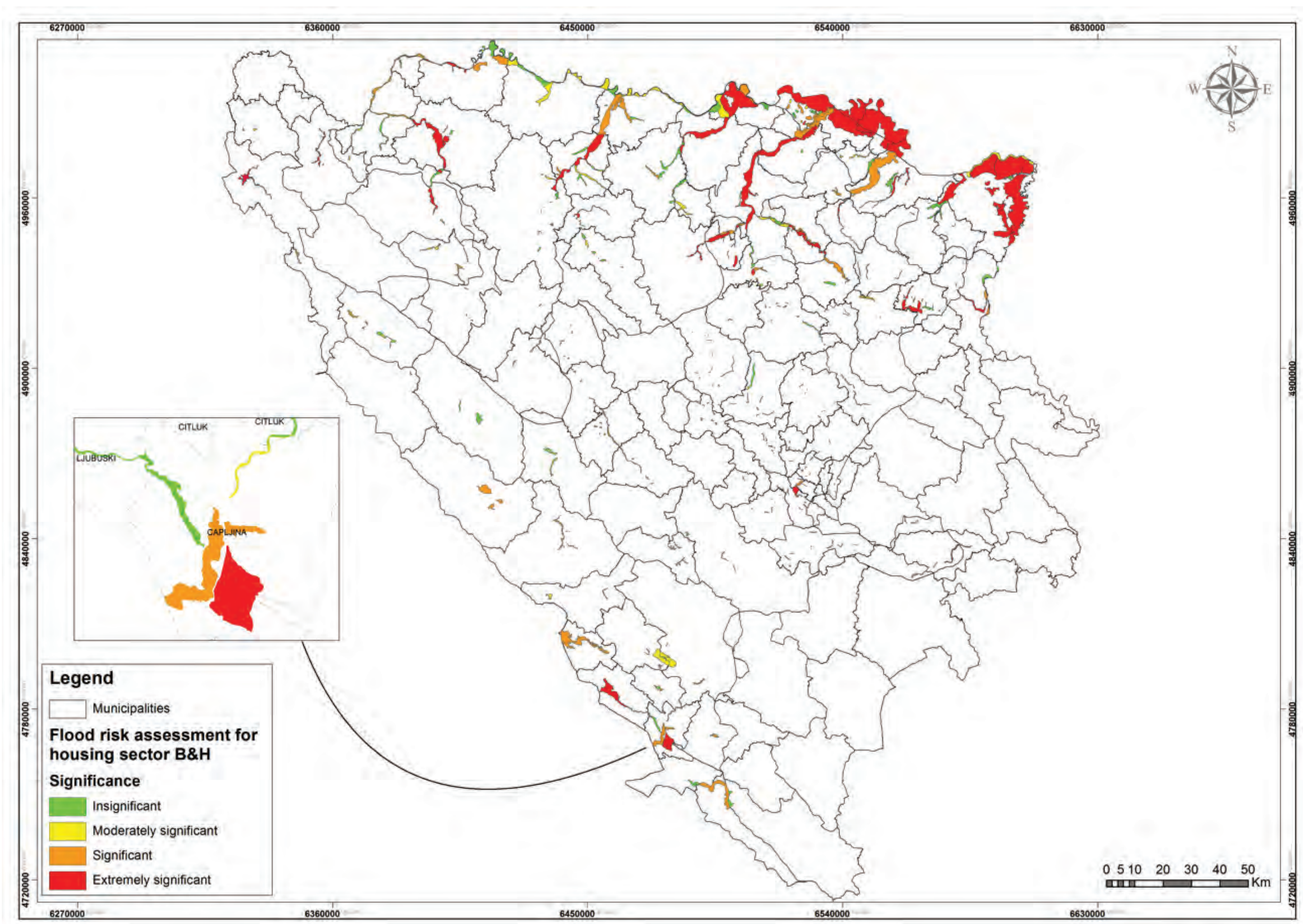
- population, in terms of density;
- social facilities, commercial buildings, residential buildings (defined manually using orthophoto and GIS);
- roads and railways;
- land;
- protected areas;
- cultural and historical monuments; and
- IPPC installations.

The inputs used relied on various tools (intersect calculator, density and others). This allowed for the processing of a large amount of data and the selection of exactly what was needed for the purpose of the required results.

Once the model was built the map of flood risk (presented in Annex 1) was finalised by adjusting the set of symbols for the different categories using the ArcMap tool. The categories were defined by municipality at the first level. The intersection of the data used for this purpose provided several hazard maps specific to a single area with an individual index assigned. These indices were then summed up and presented at the end as a summary index per municipality. The final index provided the significance of the risk in a given zone.

71 municipalities were identified as being at high risk of flooding and showed 131 flood hazard maps (areas) significantly endangered by flooding.

Figure 5: Flood Risk Assessment Map for the Housing Sector in BiH.



2. LANDSLIDE RISK ASSESSMENT FOR THE HOUSING SECTOR IN BIH

a. Introduction and Methodology

A significant number of landslide occurrences have occurred in BiH during recent decades. A large number of roads, households and other facilities have suffered partial or complete destruction caused directly or indirectly by different types of landslide. The main types of landslide were debris slides, earth slides and earth flows. The majority of landslides were shallow or superficial landslides (up to 5m), while deep seated landslides accounted for less than 5% of the total number of landslides. The main areas prone to landslides are located in the northern part of BiH, made of clastic tertiary soft rock with a thick crust of surface decomposition formed by weathering. The remaining landslides occurred in areas in central Bosnia (Bosnia Schist Mountains) and in the southern parts of BiH (made of flysch sediment).

Notwithstanding the fact that landslides represent an important problem in Bosnia and Herzegovina, the landslide susceptibility map prepared as a part LRAH is the first map to cover the entire territory of Bosnia and Herzegovina.

The main cause of the massive landslides that occurred in the northern part of BiH during May 2014 was extremely heavy precipitation (more than 50 mm/day); however, all landslide occurrences were also very closely connected to landslide prone areas and associated with detrimental human activity. The 1992-1995 war in the country caused a massive migration of people, which is linked to the illegal construction of houses on hillsides or alongside riverbanks. Furthermore, a lack of spatial planning documentation based on geological analysis has led to unsustainable territorial development and infrastructure investments that in the long-term create landslide hazards. Human activities related to the expansion on unstable locations, unscientific mining, the construction of roads and dams and lack of consideration of natural features have also contributed to increased intensity of landslides.

No direct relationship was established between the flood events and activation of landslides during the events of May 2014, except in areas along the river embankments. The flood events of 14-15 May 2014 and the landslides occurrences of 14-18 May 2014 were caused simultaneously by extreme precipitation resulting from cyclone Tamara; however, massive landslides were generally triggered by cumulative precipitation that accumulated from April to May 2014.

The first step during the LRAH procedure was to create a landslide susceptibility map. A landslide susceptibility map provides a proposed ranking of terrain units in terms of the spatial probability of the occurrence of landslides. An AHP approach was used for landslide susceptibility and relative landslide risk assessments.

AHP is a suitable procedure for raster based modelling in a multi-criteria hierarchical configuration and was therefore applied equally to both the landslide assessment and each spatial modelling framework. It is important to mention that AHP implementation in spatial analysis is usually restricted to the first level AHP, since true AHP implies a k-fold structure where levels from the 1st through to the k–1th include criteria analyses, while the last kth level includes the selection of alternatives. Herein, the procedure will be explained in detail and illustrated in such a context.

Prior to obtaining the true weights of the corresponding landslide factors (such as lithology, slope, land use and rainfall data) the procedure included a gross estimation of each factor's importance score, which was established by expert judgment through a personal consultation with scientists and engineers or formally through questionnaires. If 'n' is the number of conditioning factors then the total number of comparisons that an expert needs to establish is n(n-1)/2, which makes this procedure adequate for no more than a dozen of factors.

The original technique (Saaty 1980) implies a nine level scoring scale, but a different (arbitrary) range is also viable. The nine level scoring system is then applied to a two dimensional n×n reciprocal matrix, also called the comparison matrix (see Tab. 6), which is generated by pair-wising all of the factors across each other. Note that the scores are transposed over the main diagonal of the matrix so that the corresponding scores (1 through 9) turn reciprocal (1 through 1/9) symmetrically over the main diagonal.

To obtain the priority vector as a weights vector (see Tab. 7, shaded column) the procedure further requires the normalisation of the comparison matrix and averaging of the scores from the comparison matrix (Tab. 6) according to their row sums. The priority vector will represent the ultimate distribution of the weights $\mathbf{w}_i$ once the matrix turns consistent, i.e. when there is none or little contradiction within the scoring. Since the vector is normalised the weights sum is supposed to be 1 (100%). The procedure for shifting from an inconsistent to a near-consistent matrix is featured by versatile solutions.

However, their results have been proven to vary just a fraction from the simplified technique. Thus, it is understandable to control the matrix consistency according to the simplest basis, i.e. by Saaty's consistency parameters CI, RI and CR (Consistency Index, Random Index and Consistency Ratio, respectively) using the criterion $CR=(CI/RI)<0.1$. In this way the initial subjectivity of the score distribution is to a certain level unbiased, leaving the refined scores depicting the final distribution of weights in the priority vector (see Tab. 8, shaded columns). Finally, the priority vector or, more appropriately, the normalised linear distribution of the weights can be defined as illustrated below.

$$\sum_{i=1}^{n} \mathbf{w_i F_i} = M_{AHP}$$

Here F corresponds to the conditioning factor, respective to their order of appearance in Table 7 (F1 = lithology, F2 = slope.. F7 = aspect), and wi refers to the factor weight, which reflects its overall importance in the landslide susceptibility model. The model is then calculated directly by multiplying and adding the appropriate variables in a GIS environment. The weights in the model are simply the multipliers of the thematic GIS layers. This is because they multiply each pixel (its Digital Number – DN value) of each raster layer and then sum all (multiplied) layers together to yield a final raster model: the raw model of landslide susceptibility. It depicts the spatial distribution of the susceptible zones (revealing low susceptibility by low and high susceptibility by high overalls) in a custom scale. As the custom scale is inadequate the normalisation procedure is used to arrange the scale in a more common fashion, e.g. in a 0–1 span or 0–100%. It is also possible to choose more appropriate cut-offs and qualify intervals arbitrarily, e.g. low, moderate and high susceptibility.

Table 8: An example of the AHP comparison matrix.

FI	*F1*	*F2*	*.*	*Fn*
F1	*a11*	*a12*	*.*	*a1n*
F2	*a21*	*a22*	*.*	*a2n*
.	*.*	*.*	*.*	*.*
Fn	*an1*	*an2*	*.*	*ann*
Σ	*Σa1n*	*Σa2n*	*.*	*Σann*

Table 9: An example of the AHP weights derivation.

FI	*F1*	*F2*	*.*	*Fn*	*WI*	*%*
F1	*a’11 (=a11/Σa1n)*	*a’12*	*.*	*a’1n*	*W1 (=Σa’n1ln)*	*100*W1*
F2	*a’21*	*a’22*	*.*	*a’2n*	*W2*	*100*W2*
.	*.*	*.*	*.*	*.*	*.*	*.*
Fn	*a’n1*	*a’n2*	*.*	*a’nn*	*Wn*	*100*Wn*
Λmax=_____; CI=_____; RI=_____; CR=_____(CR<0.1);					*Σ=1*	*Σ=100*

The matrix with the following input raster sets was used to obtain the landslide risk to the housing sector in BiH (see the Table below).

Table 10: An example of the AHP for the susceptibility map.

F_i	Lithology	Slope	Rainfall	Land Cover	Weighting Factor
Lithology					
Slope					
Rainfall					
Land Cover					
Landslides					
Σ					**Σ=100**

The landslide layer is used as the basis for the identification of the weighting factors in terms of lithology. Thus, the majority of landslide inventory data pertaining to the territory of BiH was provided by the stakeholders. This data was also taken into account for the landslide susceptibility map model validation.

Landslide risk assessment is a process that uses the available information to calculate the risk posed to individuals, the population, property and the environment. The risk analyses generally comprise the following steps: scope definition, hazard identification, vulnerability evaluation and risk estimation. The process of risk estimation integrates the behaviour of the hazard (hazard analysis) with the elements at risk and their vulnerability (consequence analysis) in order to allow for the risk calculation, usually in the form of a generic hazard risk equation:

[**Risk = hazard × vulnerability × elements at risk**]

This is a simple yet very powerful equation that identifies the major factors contributing to the risk separately. These include the probability of an occurrence of a damaging landslide of a given magnitude (hazard), the valued attributes at risk (elements at risk) and the amount of damage expected from the specified landslide magnitude. The latter is expressed as a ratio of the value of damage to the total value of the element (vulnerability).

Hazard is a condition with the potential to cause an undesirable consequence. The characterisation of a landslide hazard should include the location, volume or area, the classification and velocity of the potential landslide(s) and any resulting detached material, and the probability of their occurrence within a given time period.

Vulnerability is a degree of loss for a given element or set of elements exposed to the occurrence of a landslide of a given magnitude/intensity. Exposure is an attribute of people, property and systems or other elements present in areas that could potentially be affected by a landslide. It is calculated as the temporal and spatial probability that an element at risk is within the path of a landslide, which also needs to be incorporated into the risk equation. The calculation of exposure depends mainly on the scale of the analysis and the type of potentially exposed element. Whether an element is exposed or not is determined by its location with respect to the path of the landslide, which varies according to the landslide mechanism. There is an important distinction between static elements (buildings, roads, other infrastructure, etc.) and moving elements (vehicles, persons, etc.) in regard to exposure.

b. Results for the Landslide Risk Assessment for the Housing Sector in BiH

The Landslide Susceptibility Map of BiH was produced at a scale 1:100,000, based on the above described methodology. The first step was to determine the causative factors and their relative importance, considering the scale of the LRAH and based on the principles of the AHP. Four main factors (lithology, slope, precipitation and land cover) were identified and map parameters (layers) developed in a GIS environment. Each parameter class was evaluated and their relationships weighted. A corresponding landslide susceptibility AHP matrix was developed as well as the final equation. The importance ratio between factors was according to the Eq.1.

$$H = 0.45xL + 0.30xS + 0.15xP + 0.10xC \quad (1)$$

Where

- H - Hazard (Susceptibility)
- L - Lithological data
- S - Slope angle data
- P - Precipitation data
- C - CORINE land cover data.

The correlation of causative factors is not related to any type of landslide (shallow or deep seated, rotational or translational), but is strictly related to sliding as a mechanism of movement. Regarding the scale of the Assessment, it is impossible to additionally adopt differences between sliding mechanisms (shallow versus deep seated) in an AHP matrix. Further analysis may be possible but with uniform inventory data from all entities and/or the smallest areas (and medium/detail scale of analysis). Additional correction may be possible in BiH after deep validation of landslide inventory data according to the Cruden and Varnes (1996) and Cruden (2013) classifications.

The existing geological maps (OGK 1:100,000) were collected in the initial phase of the Assessment and cover the entire territory of BiH. All maps are geo referenced and the main lithological units identified and prepared in digital form as hazard maps in a GIS environment. All lithological data is classified and weighted according to its relative impact (as the main causative factor) on landslides. Regarding the lithological data (and other causative factor data) expert opinion was used to determine the weighting classes. A simple test area was prepared for an area in the Municipality of Zvornik after basic parameter statistics. All categories were assigned and weighted. A similar procedure was applied to the rest of the causative factors.

Table 11: Lithological units and assigned weighting factors.

LITHOLOGICAL UNIT		WEIGHTING FACTOR
Limestone	Marly	4
	Massive	2
	With dolomites	3
	Miocene	5
Dolomites		3-4
Serpentinites		3-4
Flysch	Eocene	8-9
	Carbonate	5
	Jurassic - Cretaceous	6
Sandstone	Triassic	8
	Neogene	7
	Carbon	6
Phyllites		6-7
Tuffs		3
Breccia		4
Amphibolites		2
Amphibolites shale		4
Cherts		3
DRF		8
Igneous rocks		2-3
Marls		8
Alluvium		1
Morena		4
Delluvium		8
Proluvium		7
Conglomerates		6
Swamp sediments		3
Talus		7
Clay		9-10
Quartz sand		5
Coal		4
Sand, gravel, Pl,Q		6
Salt		5

Legend: 0 = most favourable and 10 = least favourable.

Figure 6: Lithological units with their corresponding weighting class.

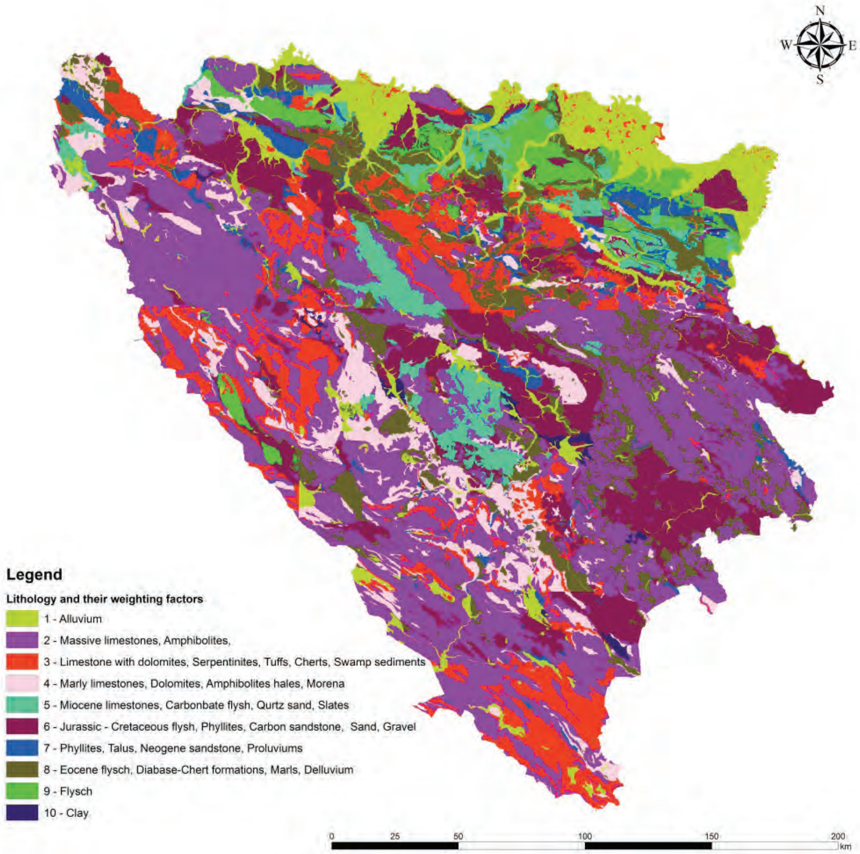


Table 12: Slope units with their corresponding weighting class.

No	Slope inclination (°)	Weighting factor - WF
1	0-5	3
2	5-15	10
3	15-25	9
4	25-35	6
5	35-45	4
6	> 45	3

Legend: 0 = most favourable and 10 = least favourable.

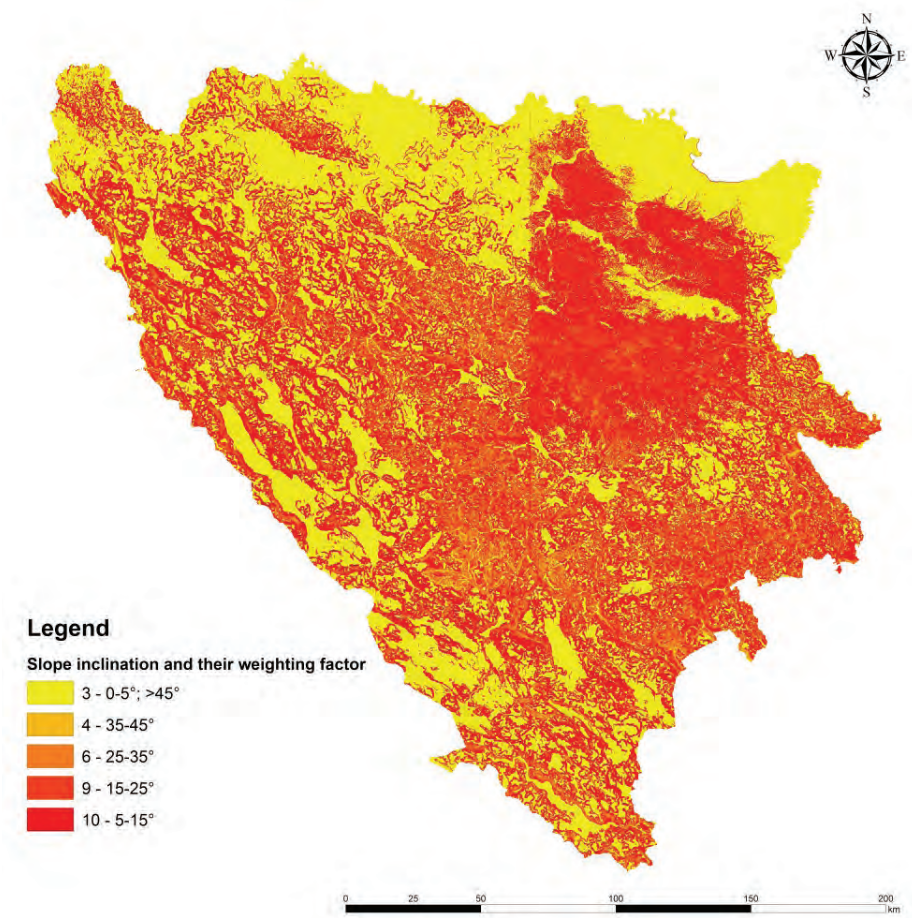


Figure 7: Slope angle units with their corresponding weighting class.

Table 13: Precipitation units with their corresponding weighting factors.

No	Precipitation (mm)	Weighting factor - WF
1	700-800	4
2	800-900	5
3	900-1100	7
4	1,100-1300	8
5	1,300-1500	9
6	>1,500	10

Legend: 0 = most favourable and 10 = least favourable.

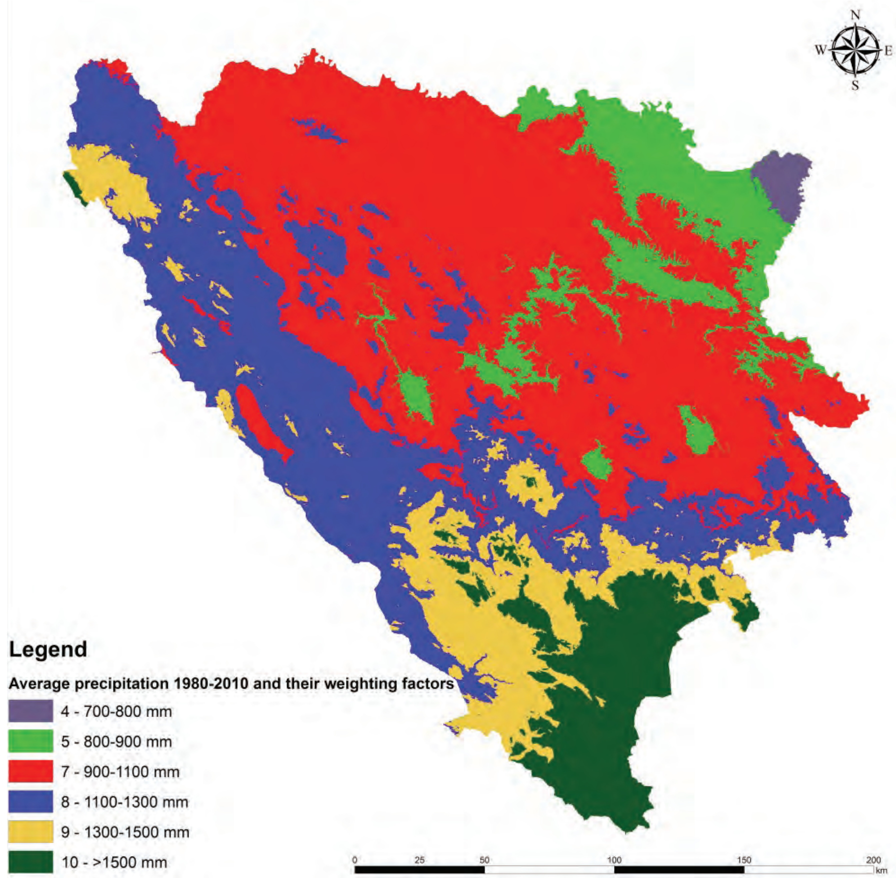


Figure 8: Precipitation data units with their corresponding weighting class.

Table 14: Land use units and their corresponding weighting factors.

TYPES OF LAND USE IN BOSNIA AND HERZEGOVINA ACCORDING TO CORINE 2006			
Description	Detail description	CORINE CODE_2006	Weighting factor - WF
Urban fabric	Continuous urban fabric	111	8
Urban fabric	Discontinuous urban fabric	112	
Industrial, commercial and transport units	Industrial or commercial units	121	5
Industrial, commercial and transport units	Road and rail networks	122	
Industrial, commercial and transport units	Airports	124	
Mine, dump and construction sites	Mineral extraction sites	131	5
Mine, dump and construction sites	Dump sites	132	
Mine, dump and construction sites	Construction sites	133	
Artificial, non-agricultural vegetated areas	Sport and leisure facilities	142	4
Agricultural areas	Non irrigated arable land	211	5
Agricultural areas	Permanently irrigated land	212	
Agricultural areas	Vineyards	221	
Agricultural areas	Fruit trees and berry plantations	222	
Agricultural areas	Pasture	231	
Agricultural areas	Complex cultivation patterns	242	
Agricultural areas	Land principally occupied by agriculture	243	
Forest and semi natural areas	Broad leaved deciduous forest	311	2
Forest and semi natural areas	Coniferous forest	312	
Forest and semi natural areas	Mixed forest	313	
Surb and/or herbaceous vegetation associations	Natural grassland	321	5
Surb and/or herbaceous vegetation associations	Moors and heath land	322	6
Surb and/or herbaceous vegetation associations	Sclerophyllous vegetation	323	5
Surb and/or herbaceous vegetation associations	Transitional woodland shrub	324	4
Open spaces with little or no vegetation	Beaches, dunes and sand plains	331	6
Open spaces with little or no vegetation	Barren rock	332	6
Open spaces with little or no vegetation	Sparsely vegetated areas	333	6
Open spaces with little or no vegetation	Burnt areas	334	10
Inland wetlands	Inland marshes	411	4
Coastal wetlands	Water courses	511	1
Coastal wetlands	Water bodies	512	1
Water bodies	Sea	523	No WF

Legend: 0 = most favourable and 10 = least favourable.

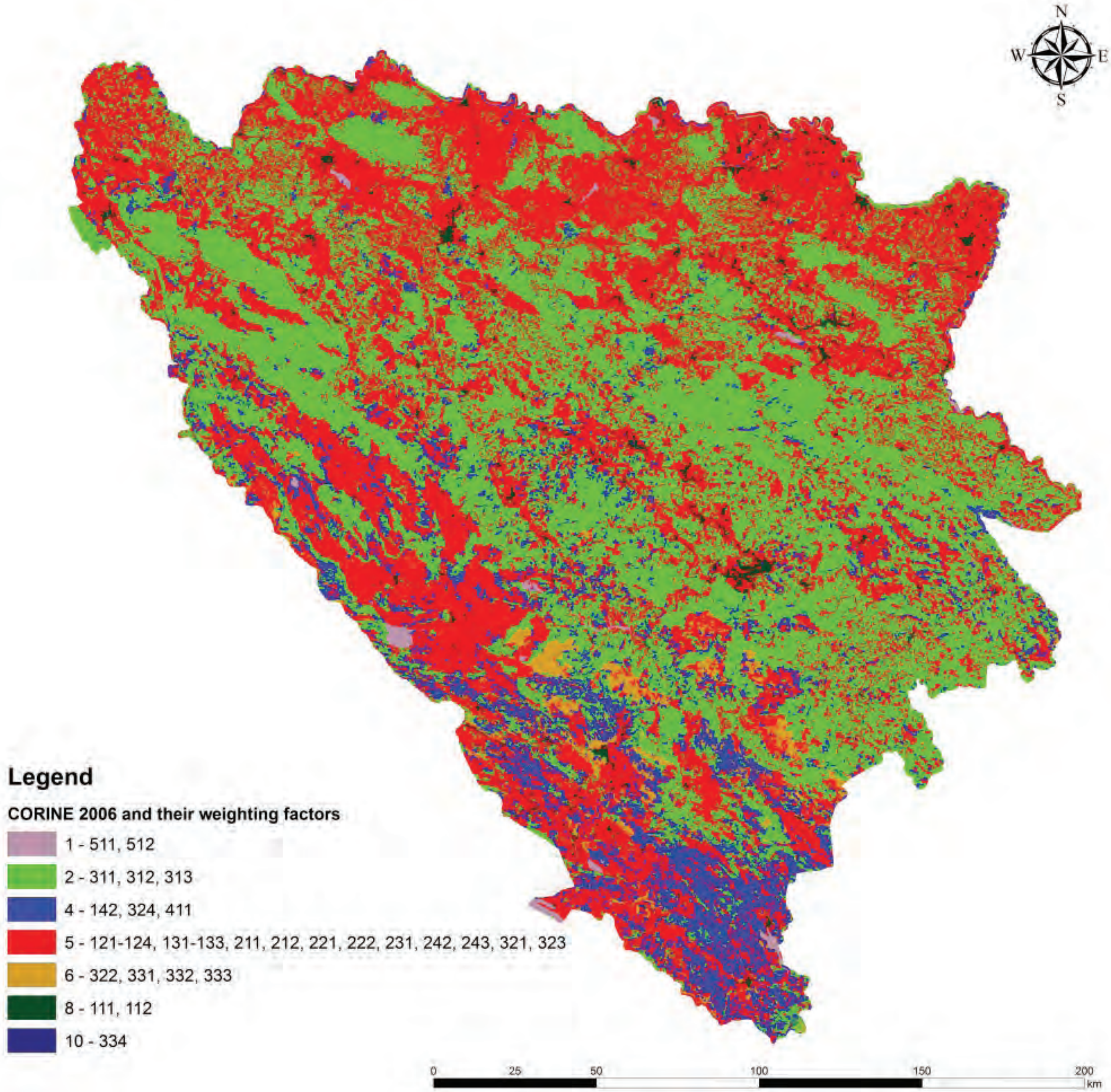


Figure 9: Land use units with their corresponding weight class.

AHP	Lithology	Slope	Precipitation	CORINE
Lithology	1	**1.18**	**4.2**	**5**
Slope	0.847457627	1	**1.75**	**2.5**
Precipitation	0.238095238	0.571428571	1	**1.5**
CORINE	0.2	0.4	0.666666667	1
sum	2.285552865	3.151428571	7.616666667	10

AHP	Lithology	Slope	Precipitation	CORINE	Average
Lithology	0.438	0.374	0.551	0.500	0.466
Slope	0.371	0.317	0.230	0.250	0.292
Precipitation	0.104	0.181	0.131	0.150	0.142
CORINE	0.088	0.127	0.088	0.100	0.100
sum	1	1	1	1	1

λmax =	4.068988026
CI =	0.022996009
CR =	3%

FINAL LANDSLIDE SUSCEPTIBILITY EQUATION

R = 0.45*L + 0.30*S + 0.15*P + 0.10*C

CR=CI/RI

CI - index of consistency

RI - random index

CI=(λmax-n)/(n-1) Saaty table for RI										
n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

If CR <0.1 (10%) then the model is consistent. Tolerance to 0.3 (30%); if the CR>0.3 (30%) it is necessary to correct the model.

λmax - Principal Eigen Value

n - number of layers

Figure 10: Final AHP matrix.

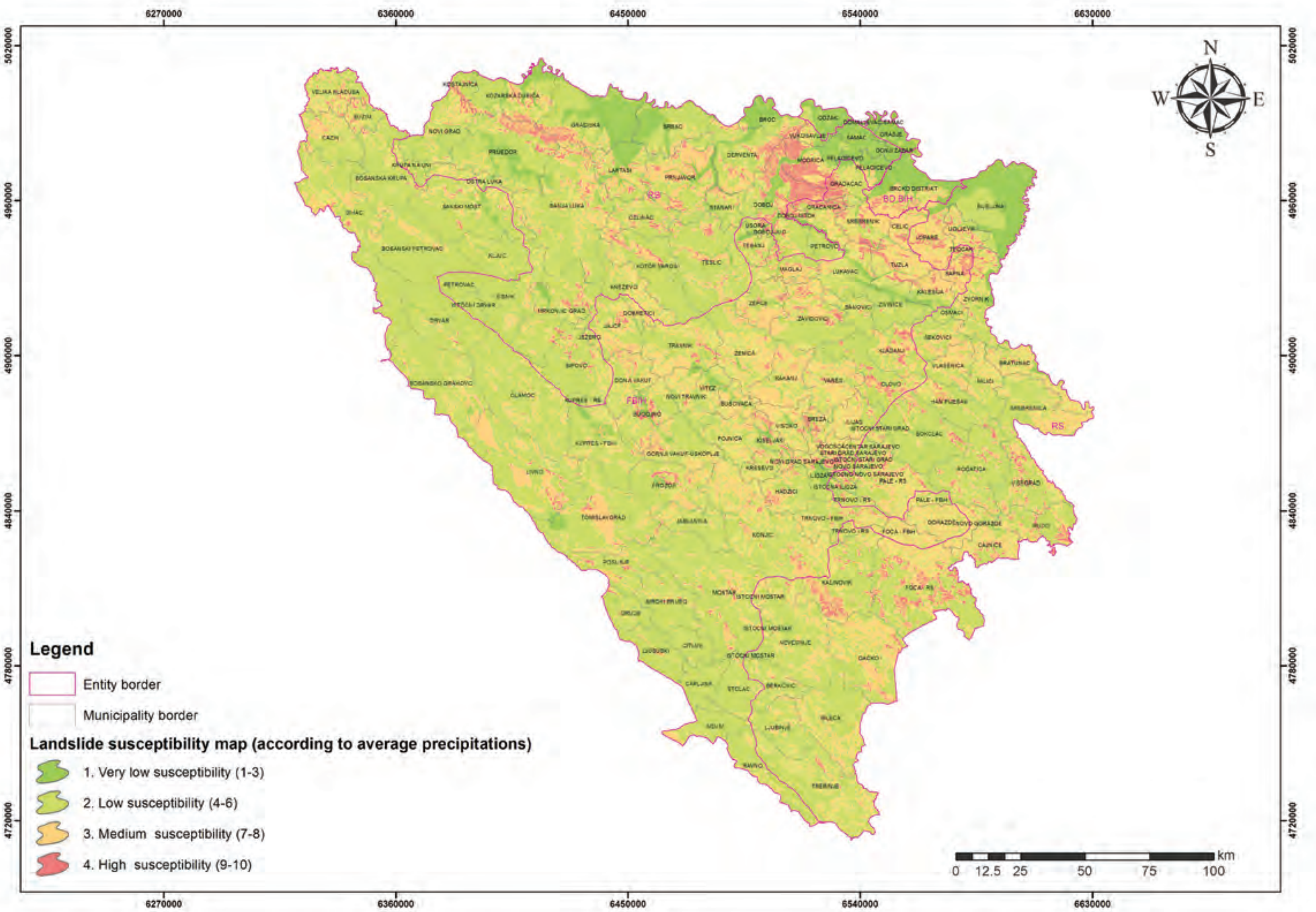


Figure 10: Landslide Susceptibility Map of BiH 1: 100,000.

The AHP matrix was also used to validate the model consistency (see Fig. 11). The landslide susceptibility map was validated after overlap with the landslide inventory data (collected during the project activity). The result indicated a solid percentage of overlap between the theoretical model and the existing landslide data. After the calculation the result showed a high level of model consistency (3% in comparison with the 10% allowed under Saaty).

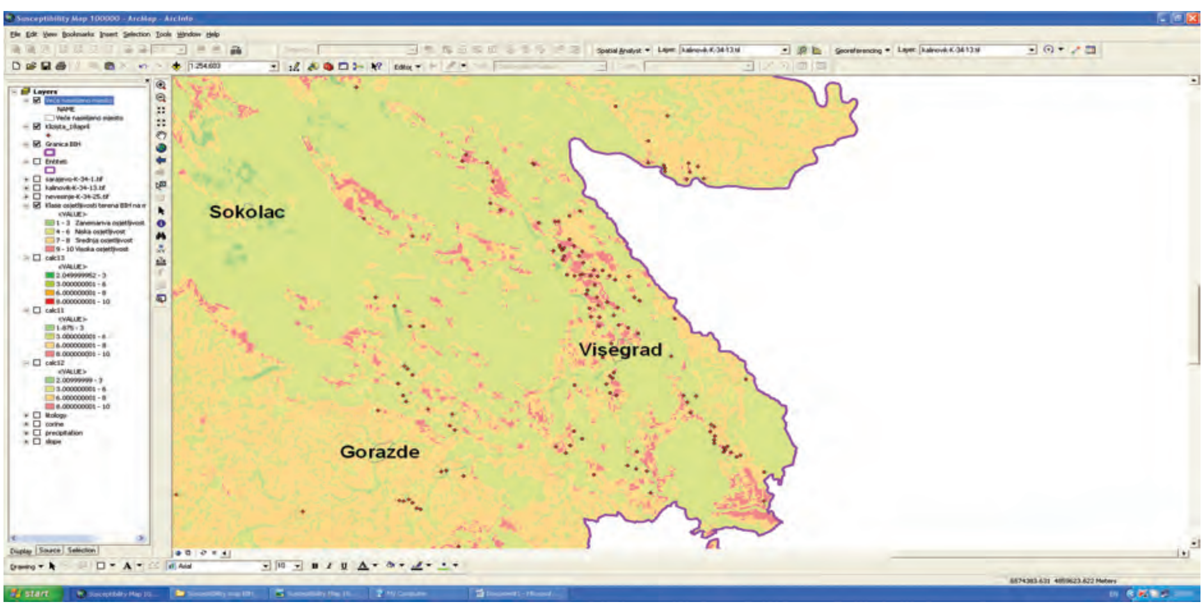


Figure 11: Validation of the Landslide Susceptibility Map by overlapping LSM data with the landslide inventory data.

Based on the landslide susceptibility map and exposure of elements at risk, it was possible to generate the relative landslide risk map for the housing sector in BiH. The housing sector is considered the most vulnerable sector in BiH. The Vulnerability Map of BiH, developed for socioeconomic analysis, was overlapped with the Landslide Susceptibility Map. According to the proposed international methodology,[22] the Vulnerability Map of BiH is a map of the exposure of the elements at risk (housing sector). To complete the QLRA procedure it was necessary to create a landslide hazard map; however, this was impossible because of the non-temporal data in the landslide inventory data and the scale of the assessment. The landslide risk map for the housing sector is presented in figures 13 and 14.

The definition of risk by Varnes (1974) and UNESCO was used: R=H*V, (2)

Where
R represents the risk

H represents the hazard (Susceptibility)

V represents the element at risk

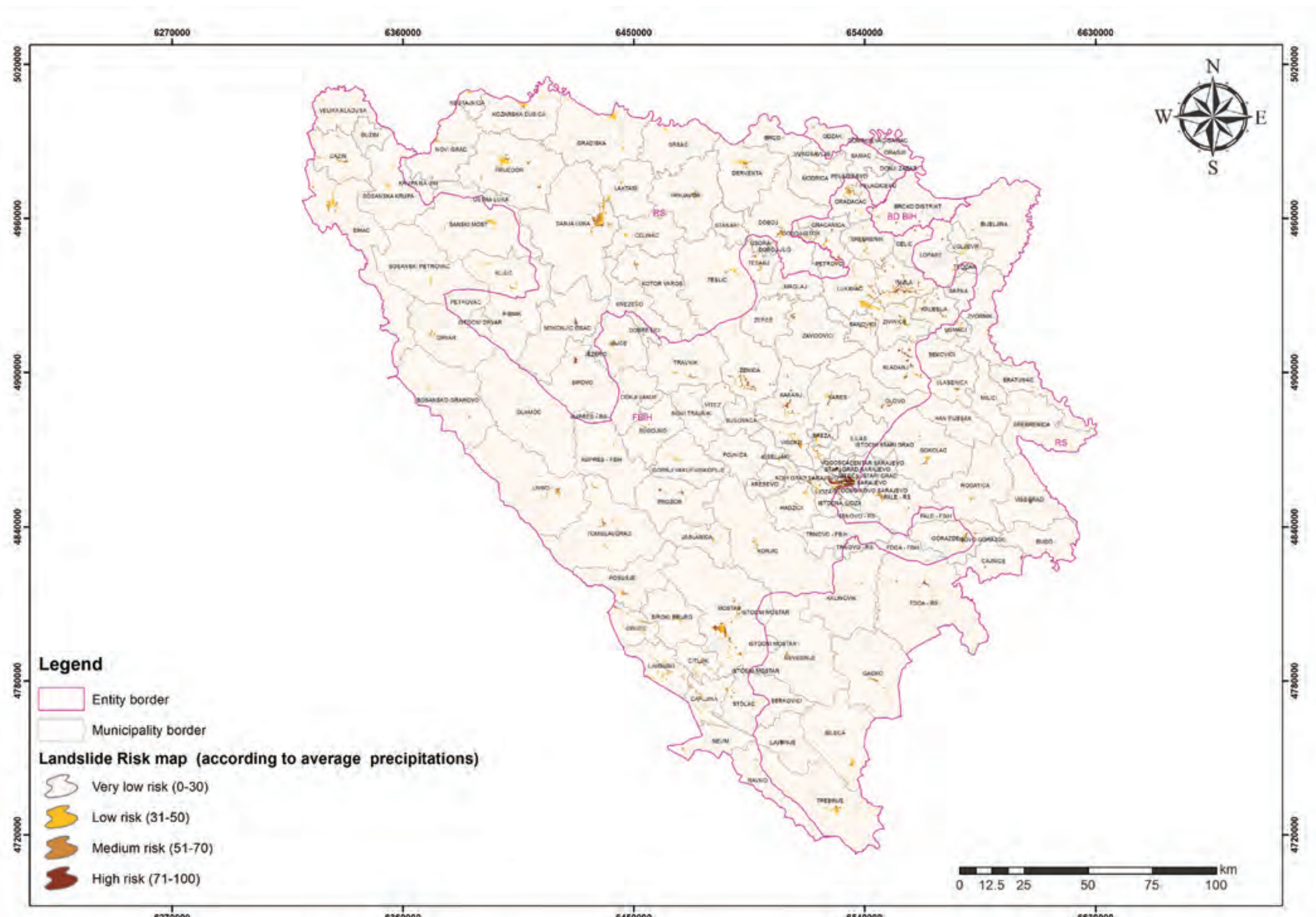


Figure 12: 1:100,000 landslide risk assessment map (LRAH) for the housing sector in BiH (according to average precipitation).

22 See Fell et al. 2008-JTC-2008, Corominas et al. 2014

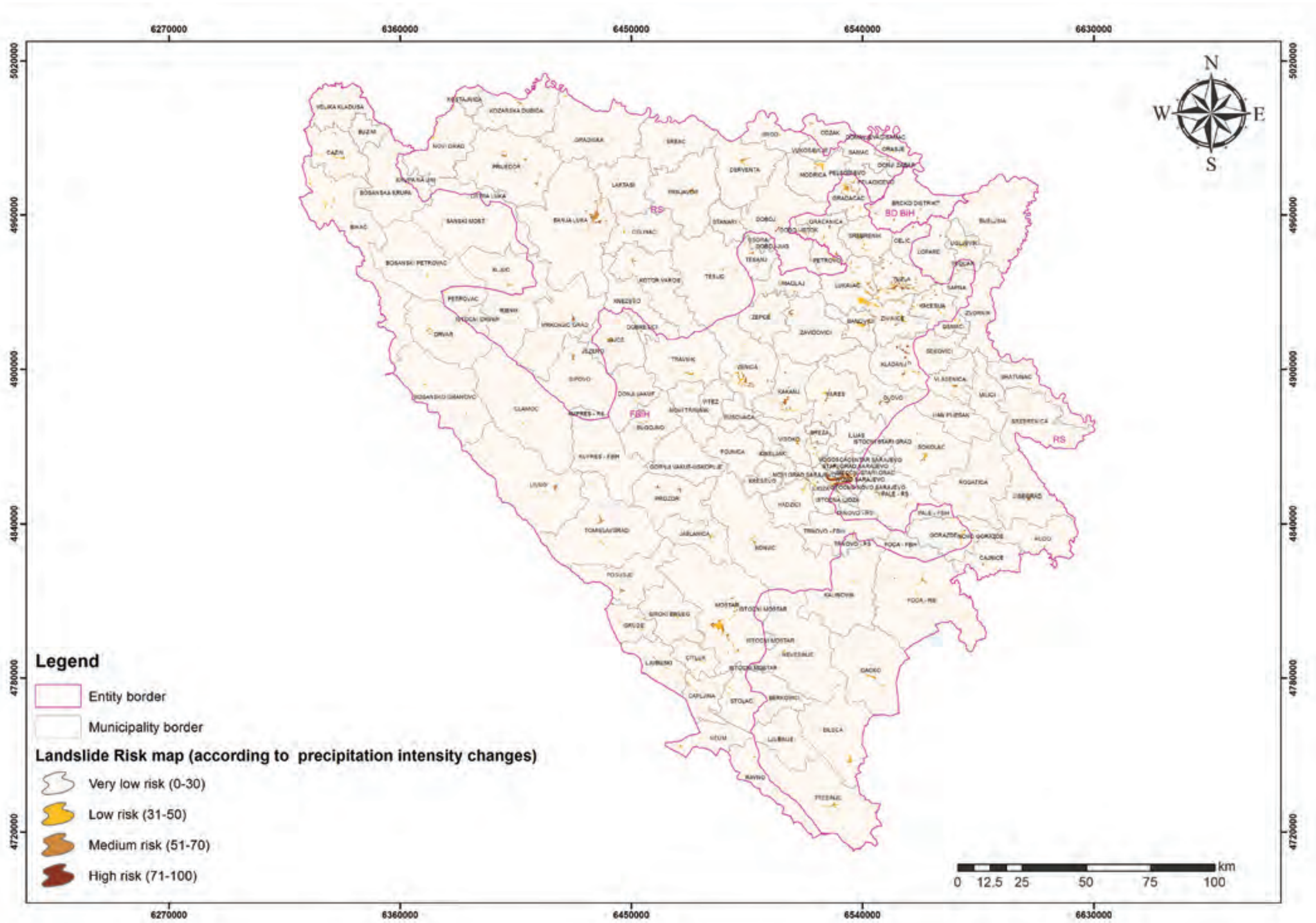


Figure 13: 1:100,000 landslide risk assessment map (LRAH) for the housing sector in BiH (according to changes in the intensity of precipitation).

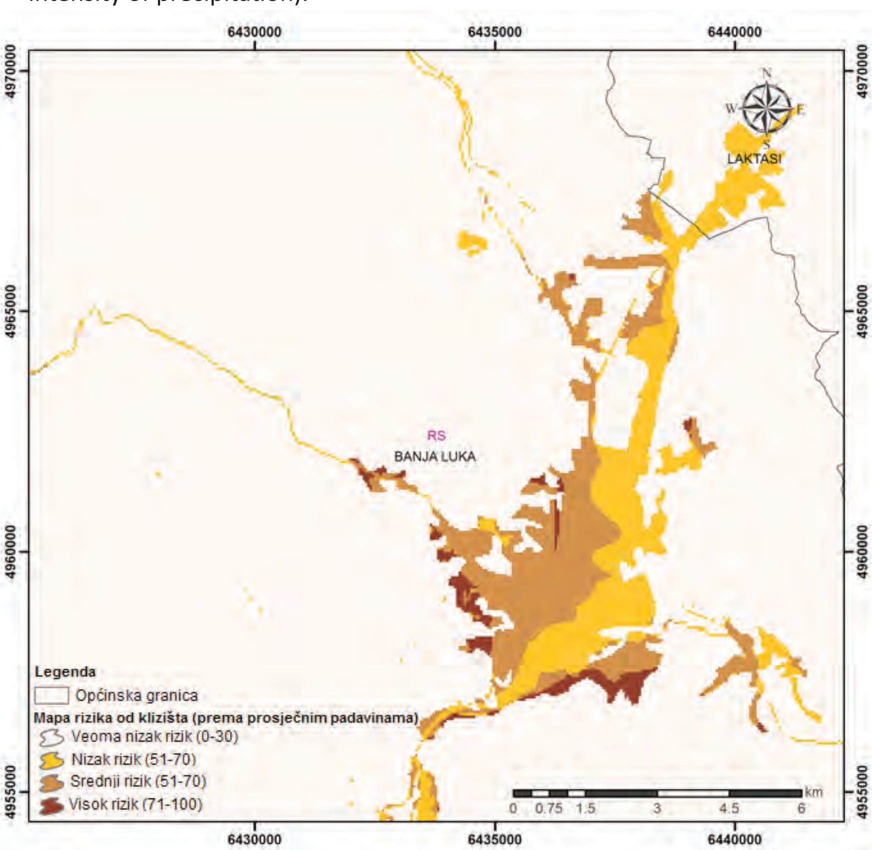


Figure 14: 1:100,000 detail from the landslide risk assessment map for the housing sector in the Municipality of Banja Luka.

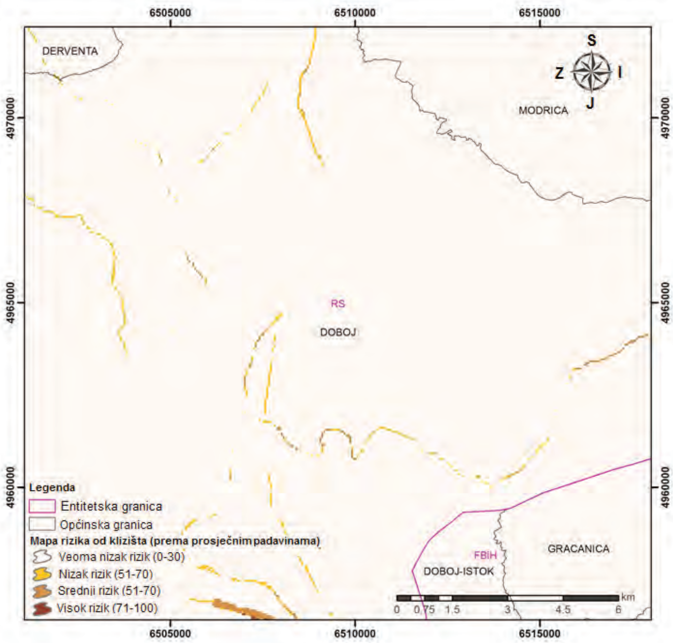


Figure 15: 1:100 000 details from the landslide risk assessment map for the housing sector in the Municipality of Doboj.

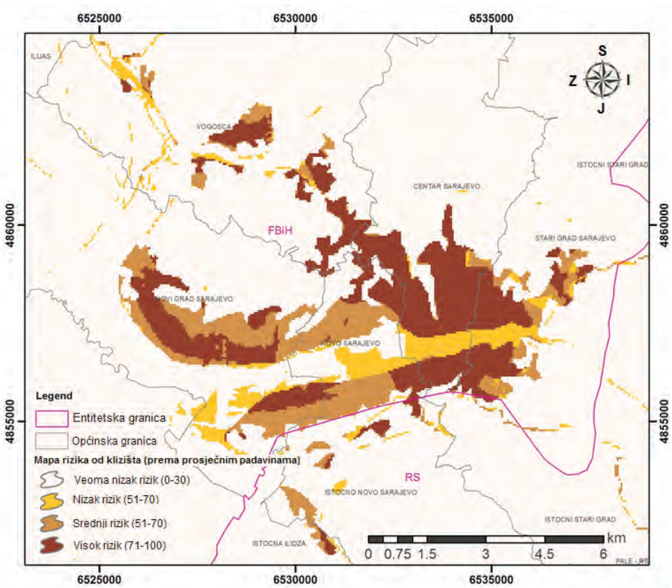


Figure 16: Detail from the landslide risk assessment map for the housing sector in the area of the Municipality of Sarajevo.

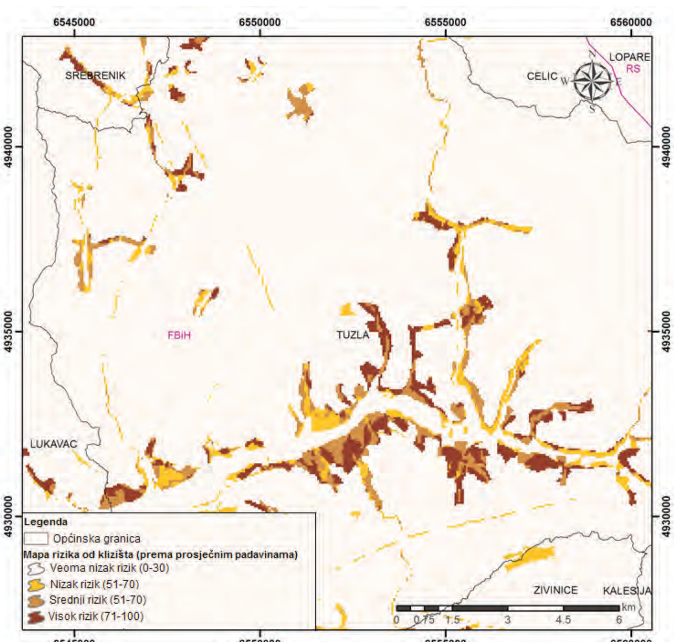


Figure 17: 1:100,000 detail of the landslide risk assessment map for the housing sector in the area in the Municipality of Tuzla.

The results obtained by these analyses are acceptable considering the scale at which the analysis was carried out. For example, as the area of Mostar does not have a problem with landslides the methodological approach was an AHP method on a scale of 1:100 000 that included the evaluation of four causative factors: lithology, slope, rainfall and land use. Since the side of the Mostar valley is built of Neogene sediment (lake sediments) the weighting factor relating to the lithological composition contributed to 'raising' the susceptibility to sliding. The most active landslide processes occurred in all other areas of BiH in areas of Neogene sediment, with the same high weighting factor. That is why the area of Mostar 'entered' partially into the high and medium landslide susceptibility class. A similar situation occurred in municipalities such as Sipovo, which obtained a high rating for landslide susceptibility due to its lithological composition.

Neogene sediments have the same weighting factors throughout the whole area of BiH. Therefore, some parts were classified in a higher category of landslide risk (for example Mostar and Trebinje). Yet in spite of this, the evaluation method is acceptable. Any additional or partial changes to the AHP rules or weighting system would have produced unreal results and a complete analysis would have been unacceptable. Therefore, we accepted these exceptions in terms of the scale of analysis and the level of the preliminary estimation. It was because of this that the validation model was performed in those municipalities with more uniform data.

Elements of risk defined as populated areas in BiH were singled out through CORINE Land Cover 2006 at a scale of 1: 100,000 (aspect scale defined by the terms of reference). Population density had a direct impact on the distribution of landslide risk and therefore a similar instance of disagreement could be seen in the difference in the extent of susceptibility to landslides in the municipalities of Ugljevik, Lopare, Sapna, Teočak and Zvornik. A high landslide susceptibility class does not imply a high landslide risk class towards the individual elements of risk. A more detailed analysis in the appropriate scale should be performed for these specific cases. It should be emphasised that the distribution and quality of available landslide data was very uneven and unbalanced, i.e. the majority of landslide data was just points rather than hazard maps and this further hampered the validation process.

3. MULTI-HAZARD (FLOOD AND LANDSLIDE) RISK FOR THE HOUSING SECTOR

a. Introduction and Methodology

A multi-hazard risk assessment for the housing sector in BiH was carried out by integrating the flood and landslide risk assessments for the housing sector into a single database, which resulted in a combined risk map. In this way the housing areas at significant risk were identified. A set of technical and socioeconomic criteria for the prioritisation of flood and landslide prone areas was also determined.

The flood risk assessment for the housing sector provided the flood risk indices for various flood hazard maps (522 available), ranging from 0 to approximately 8,000 (≥100 being 'significant' and ≥500 being 'very significant').

The landslide risk assessment for the housing sector used a somewhat different approach after receiving the index values. It resulted in more than 44,400 small hazard maps classified into a range between 'low risk' and 'high risk'. These were grouped into classes (2-30, 30-50, 50-70 and 70-100) where the meaning of '100' was not the same as when used for floods, where it indicated that a certain number of households (or other housing risk related structures) were flooded or, in other words, threatened by flooding.

The hazards were a predominant factor (proneness to sliding in a certain area as a result of the lithology, slope, precipitation etc.) in this landslide risk assessment for the housing sector. In order to combine both it was proposed to use the relative indices, summarised over the administrative unit (municipality), as this was the best way to establish a link with the socioeconomic aspects.

The risk assessment for the housing sector was carried out as a natural phenomenon under natural conditions. Anthropogenic impacts that were not taken into account were mining activities in the mine area, the uncontrolled depositing of material on the slope and large cuts into the terrain.

When carrying out a landslide risk assessment on a higher scale it is necessary to take into account the human impact.

The relative indices were obtained separately for the flood and landslide assessments.

- Floods: The maximum index for the flood hazard maps (or their parts) within a certain municipality was "brought down" to 100 and then the indices for all of the other municipalities were adjusted accordingly so that they obtained from 0-100.
- Landslides: All landslide hazard maps within a municipality were added up by multiplying the total area of high risk by the average class category (Area HR x 0.85 + Area MR x 0. 6…etc). This provided summary indices per municipality. In the same fashion, they were brought to present 0-100.

Then both indices were added up and again related from 0-100. The resulting map provides a good representation of the municipalities most affected by the combined risks.

Maps with actual hazards and separate indices indicated precisely where the problems related to floods or landslides were, as presented in the table below. Yet this map (as described above) showed which municipalities were most affected and also provided a relative ranking. Obviously, municipalities with larger areas (given all the other similar conditions) tended to have a higher index, but this was expected to partially even up once the socioeconomic aspects were included.

This presentation provides the relevant information on ranking for the most hazard prone administrative units.

Table 15: The municipalities most affected by floods or landslides with their index risk.

	Municipalities affected by Floods or Landslides	Index risk
Flood risk assessment	Bijeljina	100
	Orašje	50
	Brod	34
	Šamac	27
	Laktaši	22
	Maglaj	22
	Doboj	20
	Sanski Most	19
	Prijedor	18
	Derventa	17
	Odžak	16
	Banja Luka	15
	Brčko district	12
	Goražde	10
	Bosanska krupa	9
Landslide risk assessment	Tuzla	100
	Centar Sarajevo	78
	Novi Grad Sarajevo	56
	Kladanj	56
	Mostar	55
	Stari Grad Sarajevo	43
	Zenica	37
	Vogošća	35
	Kakanj	34
	Šipovo	26
	Banja Luka	25
	Novo Sarajevo	23

Table 16: The municipalities most affected by floods and landslides with their index risk.

	Municipalities affected by Floods and Landslides	Total Index risk
Combined flood and landslide risk for the housing sector in BiH	Doboj	100
	Centar Sarajevo	96
	Bijeljina	94
	Tuzla	81
	Orašje	81
	Prijedor	80
	Šamac	80
	Stari Grad Sarajevo	77
	Brod	76
	Novi Grad Sarajevo	75
	Goražde	71
	Kalesja	70
	Derventa	69
	Novo Sarajevo	69
	Vogošća	68
	Maglaj	68
	Kladanj	67
	Srebrenik	67
	Sanski Most	67
	Banja Luka	63
	Vares	63
	Kakanj	62
	Odzak	62
	Mostar	60
	Šipovo	59
	Ljubuški	59
	Domaljevac-Šamac	59
	Mrkonjić Grad	58

b. Results for Multi-Hazard (Flood and Landslide) Risks for the Housing Sector

The following figures represent, per municipality, the risk posed to the housing sector by floods and landslides as well as the combined risk. The fact that uneven classes were selected by ArcGIS, using the statistical approach portion of standard deviation, should be taken into account when viewing these figures.

Because of the lack of data for RS a considerable area of the flood risk map remains relatively 'green'. Where hazard maps were not available the computation yielded 'no risk'. However, the map can easily be updated once the data becomes available.

Based on the flood risk assessment methodology for the housing sector described in detail in the corresponding section, the areas (municipalities) exposed to the most significant housing related risks were selected for further analysis (urban and socioeconomic). This methodology served to select the areas/municipalities to be covered by further analysis. Once selected, more detailed analyses were carried out taking into account the estimated cost of damage and other socioeconomic parameters (such as GDP and municipal budgets).

In Figure 16, certain municipalities highly vulnerable to the landslide events are classified as 'low risk' areas because of their small population. However, any type of construction activity poses a hazard to these areas and this should be taken into account in future lower scale analysis. These primarily belong to the territories of the municipalities of Zvornik, Lopare, Bratunac, Vlasenica, Zenica, Zavidovići and Goražde.

Figures 16 to 18 in this section are illustrations, whereas the detailed maps comprising readable information are included in annex.

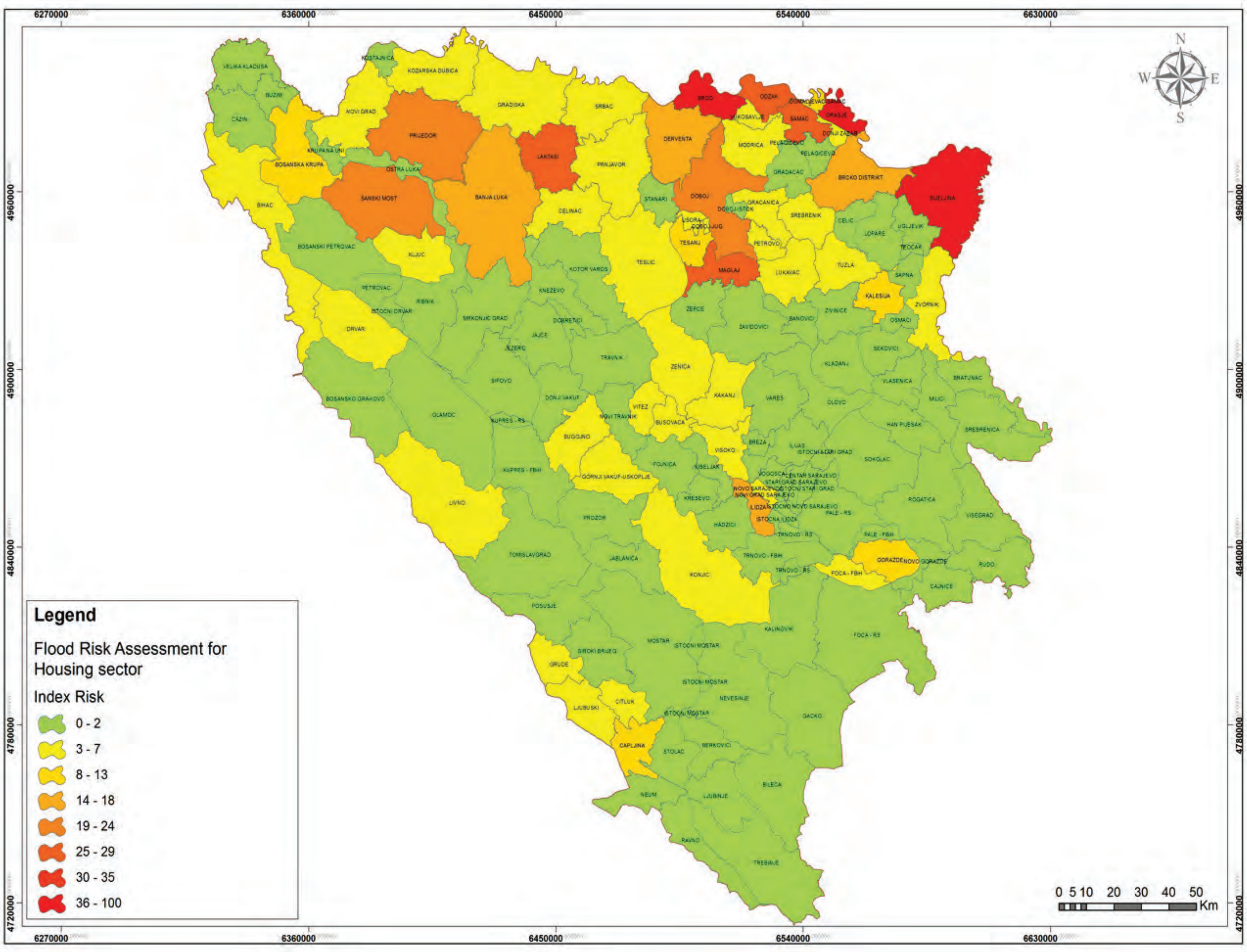


Figure 18: Relative flood risk assessment for the housing sector per municipality.

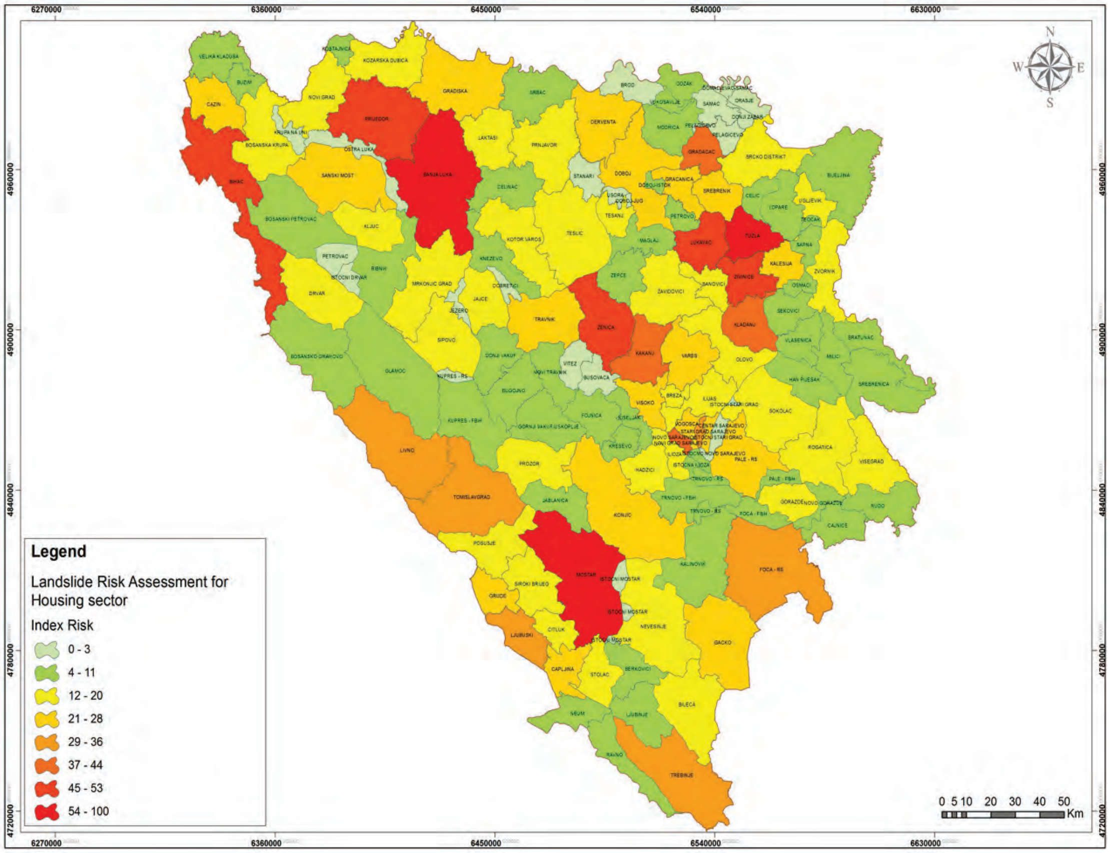


Figure 19: Relative landslide risk assessment for the housing sector per municipality.

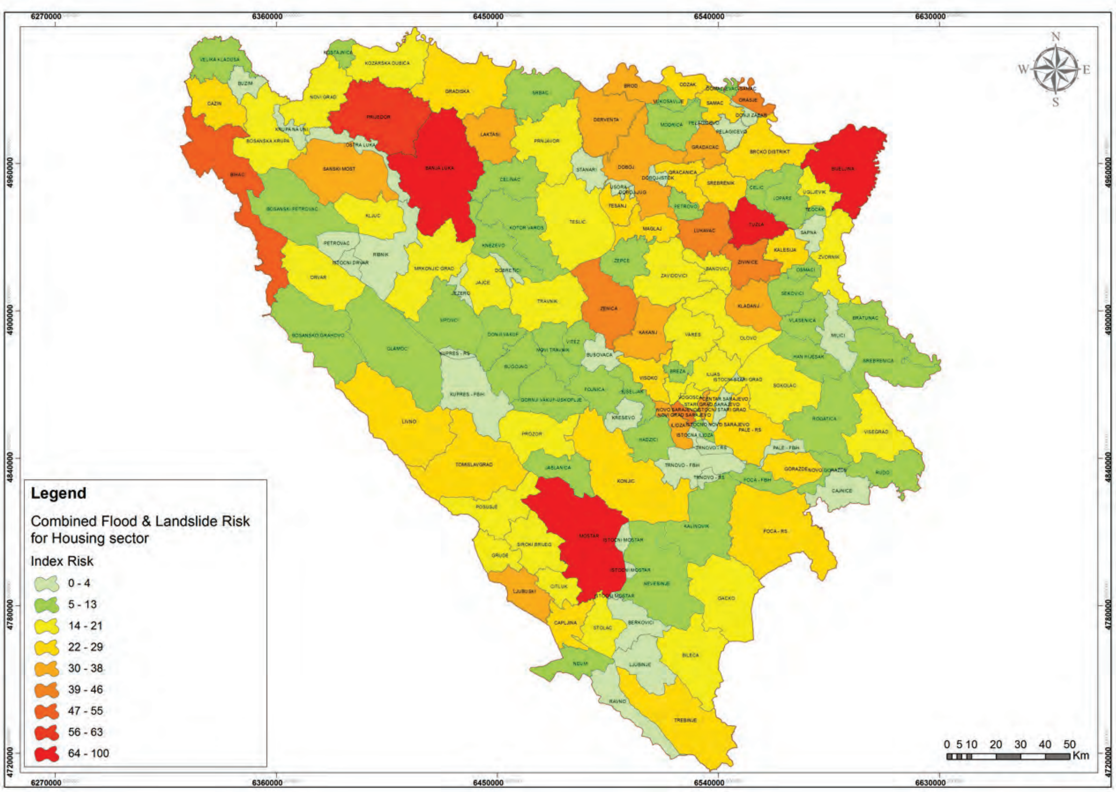


Figure 20: Relative combined multi-hazard risk per municipality.

4. DETAILED SPATIAL PLANNING PHASE METHODOLOGY

a. Introduction, Methodology and Results

The housing sector in BiH has 1,617,308 housing units, according to the preliminary results of the 2013 census of population, households and housing. This represents an increase of approximately 25% compared to 1991. Therefore, this sector has fully recovered from the effects of the 1992–1995 war. Currently, the FBiH accounts for 61.3%, RS 36.37% and BD 2.33% of the total number of the housing units (dwellings) in BiH. This sector is concentrated in the built-up areas (where construction activities are allowed) with 6,118 registered settlements. In a certain number of settlements residential buildings could either not be found or the number of existing residential units was below four. The largest number of housing units is located in the areas of Sarajevo and Banja Luka[14] (29% of the total number of dwellings in BiH).

Phase One [scale 1: 100,000]: Identification and Characteristics of Housing Areas

The only adequate data source for the identification of housing areas at a scale of 1: 100,000 was CORINE Land Cover - LC (2006 CORINE project - Coordination of Information on the Environment). The urban areas were selected from that project and linked to data on the name, rank of urban areas in the system of settlements (centres) of BiH, range of population density and average population density of urban areas. In this way it was estimated that approximately sixty to seventy per cent of the total housing sector of BiH exists within these urban areas. Adjustments were made for urban areas in specific parts of BiH, primarily by using various spatial planning documents, in order to achieve a higher level of accuracy.

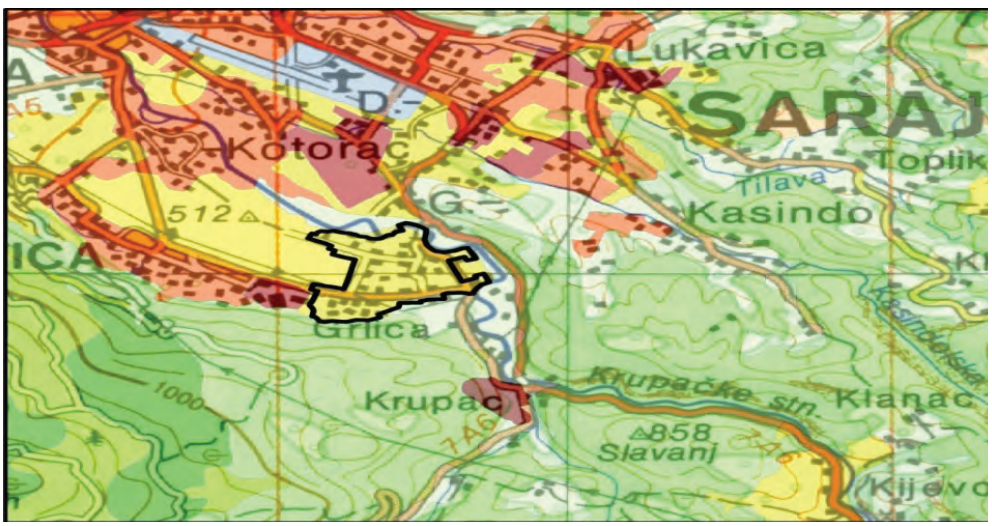


Figure 21: Example of the modification of CORINE Land Cover 2006 for the territory of BiH.

The GIS database of urban areas in BiH includes attributes including the name and rank of the urban areas in the system of settlements (centres) in BiH. The six ranks of this system are defined as:

- entity centres (Sarajevo and Banja Luka);
- macro-regional centres (Mostar, Tuzla and Zenica);
- macro-regional centres (Bihać, Bijeljina, Brčko, Doboj, Prijedor, Travnik and Trebinje);
- sub-regional centres (Bugojno, Cazin, Foča, Goražde, Gradiška, Livno, Orašje, Pale, Sanski Most, Široki Brijeg and Zvornik);
- primary local centres (90 seats of local government and the settlement of Janja); secondary local centres (other settlements).

The criteria for ranking the settlements within the system of centres were as follows:

- population,
- administrative importance,
- technical and social infrastructure in the settlement, and
- defined rank of the settlement in spatial planning documentation.

Each urban area has a certain level of population density, which depends on the individual rank of the given area in the system of centres. In general, the framework densities in certain categories ranged as follows:

- entity centres with 70 - 90 inhabitants/ha,
- macro-regional centres with 50 - 70 inhabitants/ha,
- macro- regional centres with 40 - 60 inhabitants/ha,
- sub-regional centres with 35 - 50 inhabitants/ha,
- primary local centres with 25 - 35 inhabitants/ha, and
- secondary local centres with 10 - 25 inhabitants/ha.

The identified urban areas were then included as one of the key parameters in the methodology for the flood and landslide risk to the housing sector.

Phase Two [scale 1: 5,000]: Detailed Urban - Residential Zone Analysis in Areas with Very Significant Risk (Category 4), Defined by Multi-Hazard (Flood and Landslide) Risk Assessment

The urban areas and residential zones, defined as the urban blocks, are characterised by the presence of a very significant flood and/or landslide risk to the housing sector (category 4). These were analysed in greater detail at the level of urban and detailed planning using a variety of maps and databases at a scale of 1:5,000.

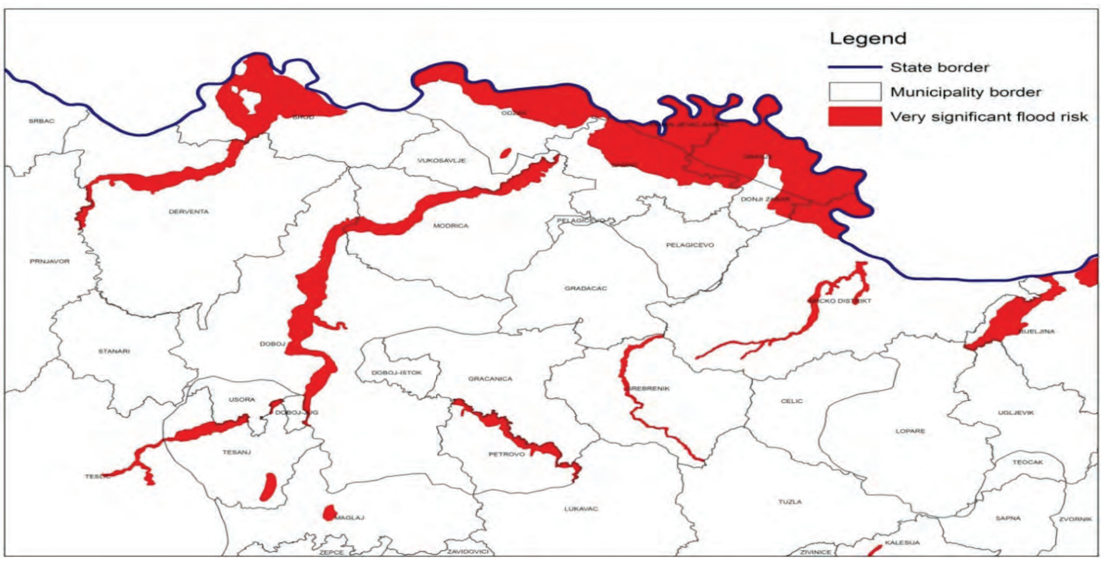


Figure 22: Example of the spatial distribution of areas with very significant flood risk for the housing sector in the north of the country that were the subject of detailed urban analysis.

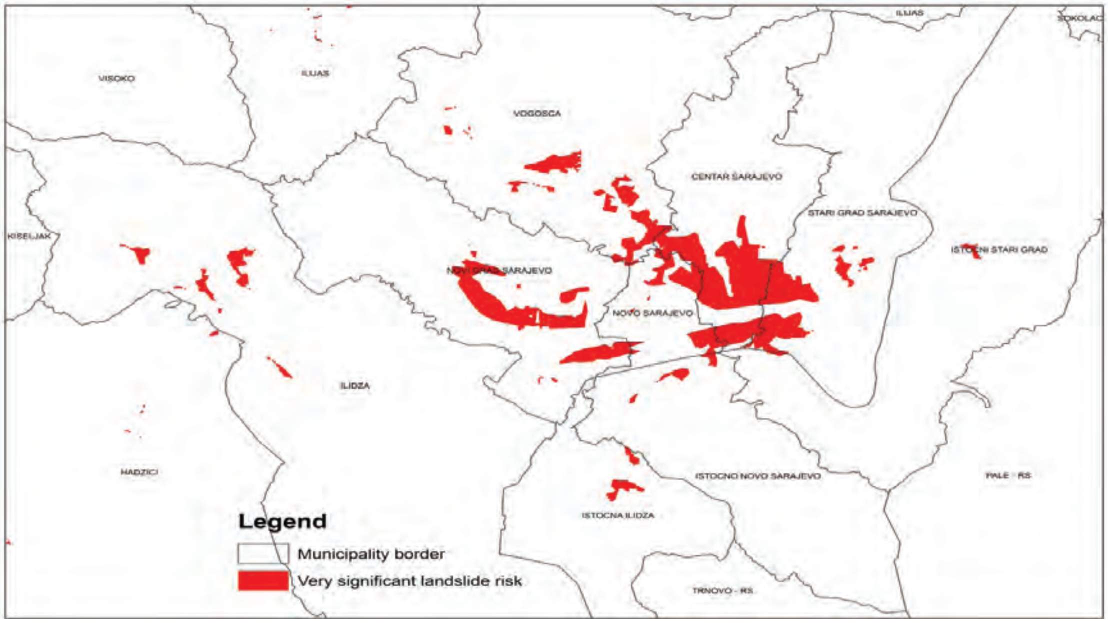


Figure 23: Example of the spatial distribution of areas with very significant landslide risk for the housing sector in the central part of the country that were the subject of detailed urban analysis.

These areas were further analysed in terms of the prevailing types of housing typologies and relevant planning parameters:

- density of the built-up area,
- number of houses,
- estimated gross building area,
- population density, and
- population number.

Analysis of the urban matrix was provided in terms of land use with defined areas:

- several relevant types of residential areas;
- commercial central zone;
- zone of public facilities;
- industrial complexes;
- infrastructure complexes;
- protected cultural and natural heritage; and
- heavy polluters, according to the IPPC Directive.

In this phase traffic infrastructure and other types of infrastructure were also analysed in terms of the spatial disposition (visible) of their parts and according to data collected from existing planning documents that were available and relevant to the defined areas.

The spatial disposition of functions, their categories and subcategories, type of geometric data in GIS analysis and their weighting factor are provided in the table below.

A new countrywide database on protected cultural and natural heritage, and heavy pollutants, according to IPPC (Integrated Pollution Prevention and Control) Directive, with spatial distribution was created. The type of geometric data in the GIS analysis included the hazard maps or dots, according to the available data input combination for these parameters defined evaluation system for the analysed areas with regard to their vulnerability to risk, both in terms of affected population and financial damage.

The defined parameters served as the basis for socioeconomic analysis of the actual risks and prioritisation in terms of recommendations for necessary actions to be carried out in order to prevent, reduce and minimise the risks to the housing sector in BiH.

Table 17: Weighting factors for the detailed analysis of urban planning parameters for socioeconomic analyses at the level of urban planning (scale 1:5,000) for identified areas with the most significant risk (category 4).

Category	Sub-category	GIS geometry	Weight factor	Weight factor for the summary map
Social standard functions	Bus stations	Polygon	40	20%
	Hospitals	Polygon	100	
	Nursing homes for the elderly	Polygon	95	
	Children social care	Polygon	100	
	Cultural centres	Polygon	20	
	Health centres	Polygon	80	
	Sports halls	Polygon	30	
	Schools	Polygon	80	
	Post offices	Polygon	60	
	Sports terrain, parks	Polygon	20	
	Shopping centres	Polygon	50	
	Religious facilities	Polygon	30	
	Military facilities	Polygon	60	
	Kindergartens	Polygon	80	
	Railway stations	Polygon	45	
	State institutions, border crossings	Polygon	50	
Communal infrastructure, industrial and business complexes	Gas stations	Polygon	50	20%
	Electrical power plants	Polygon	80	
	Transformer substations of 110 kV and higher voltage	Polygon	70	
	Mobile telephony base stations	Polygon	50	
	Factories	Polygon	60	
	Utility companies, dumps	Polygon	50	
	Cemeteries	Polygon	45	
	Water distribution pumping stations	Polygon	80	
	Wastewater treatment plants	Polygon	50	
	Hotels/Motels of larger capacity	Polygon	45	
	Farm holdings	Polygon	30	
	Business and warehouse centres	Polygon	30	
	Mines	Polygon	40	
Housing	Family housing of density up to 60 inhabitants per 1 ha	Polygon	70	40%
	Family housing of density from 60 to 120 inhabitants per 1 ha	Polygon	75	
	Mixed family housing and apartment buildings of density from 100 to 300 inhabitants per 1 ha	Polygon	80	
	Apartment buildings of density from 150 to 300 inhabitants per 1 ha	Polygon	90	
	Apartment buildings of density over 300 inhabitants per 1 ha	Polygon	95	
Traffic	Highways (60m)	Line	75	20%
	Regional roads (25m)	Line	40	
	Trunk roads (40m)	Line	50	
	Railways (40m)	Line	80	

According to the BiH water laws, with the exception of facilities that serve to protect people and goods from floods, it is explicitly forbidden to build any structure in an area prone to flooding (1/100). However, a significant number of structures were identified in these areas. It was impossible to identify illegal buildings, because even the local government bodies had no statistical data on illegal building. It should be noted that building permits were issued for a certain number of structures in these zones based on these structures being built in line with detailed plans (regulations and parcelling plans). The plans envisaged the construction of different flood protection engineering structures in the vicinity of the houses; however, this was not how the plans were executed in reality.

The result of this assessment was a flood risk map of urban and housing areas. This map (below) was created using the weighted overlay GIS tool, which combined four input data sets:

- residential zones,
- public buildings zones,
- commercial central zones and infrastructural complexes, and
- traffic.

Each data set was assigned a percentage of flood or landslide risk importance for the housing sector; higher values generally indicate that a dataset was more important. The data sets included a detailed classification (provided in the table above). Each subcategory was weighted by a 'weighting factor' from 20 to 100, where higher values are attributed to categories considered more vulnerable.

The measurement scale and weights were used to overlay the input data sets, in accordance with the given importance.

This analysis is presented below.

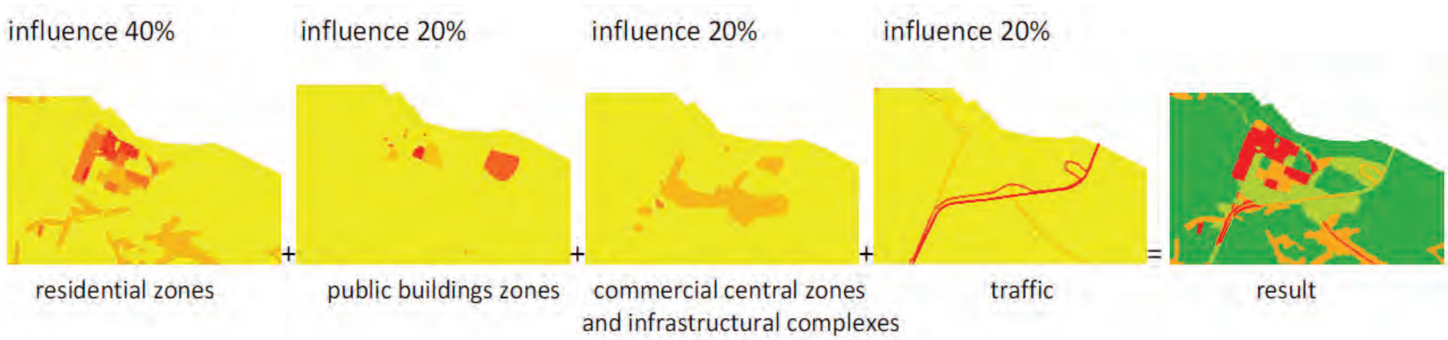


Figure 24: Overlay analysis of urban and residential zones.

The output data set were reclassified to a scale from (1) to (4) where (1) identifies non-significant areas, (2) moderately significant areas, (3) significant areas and (4) areas with a very significant flood risk for the housing sector.

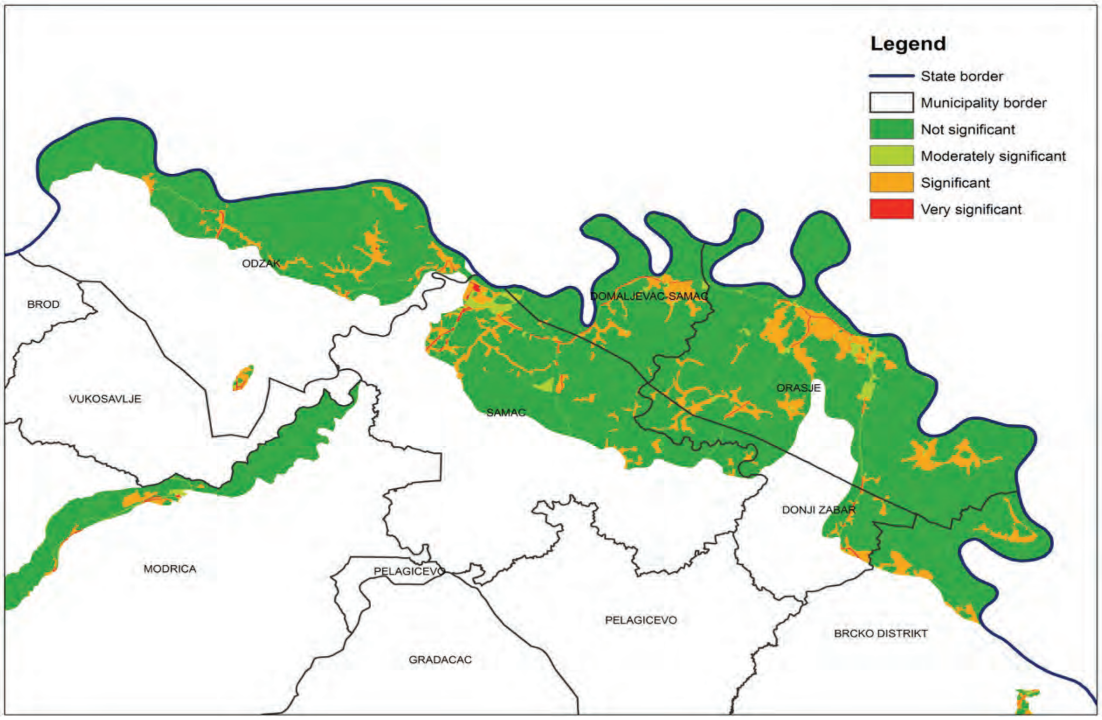


Figure 25: Example of detailed urban analysis of the flooded areas with very significant risk (category 4) in Posavina.

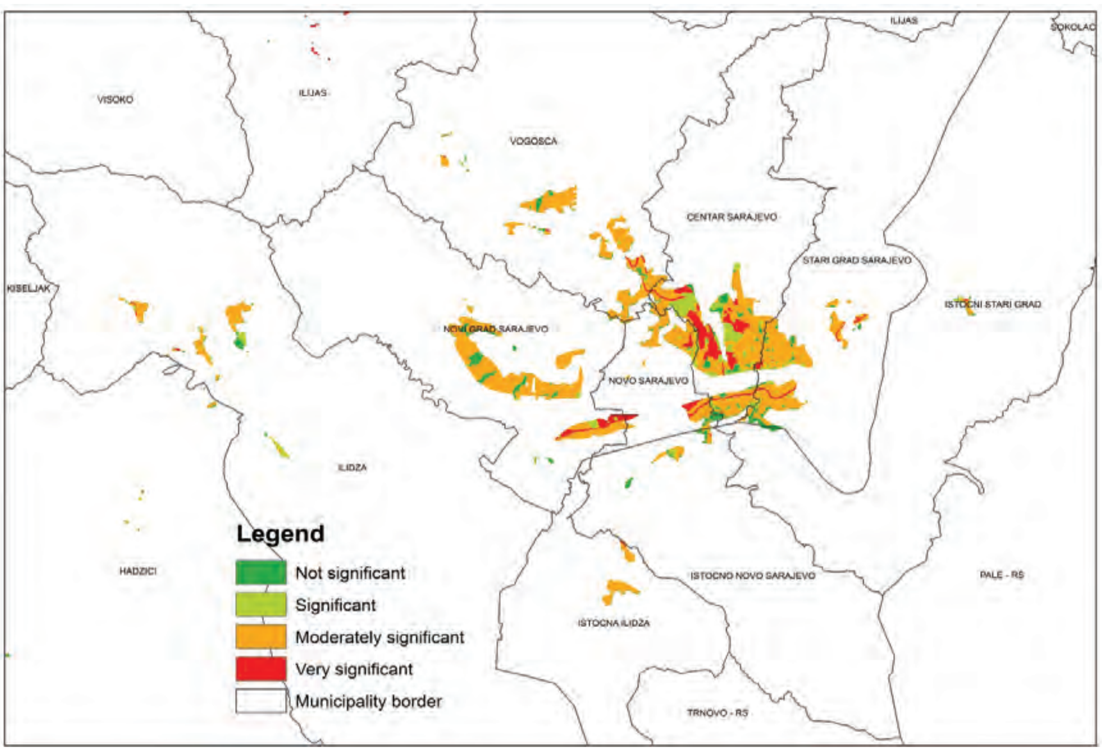


Figure 26: Example of detailed analysis of landslide areas with very significant risk (category 4) in Sarajevo and the surrounding municipalities.

The final assessment maps for flood and landslide risk were created by overlaying the previous results and a number of data sets:

- monuments of BiH,
- protected natural areas of BiH, and
- IPPC plants in BiH.

Similarly, the final maps were created using the weighted overlay GIS tool. The monuments and protected natural areas were assigned a weighted factor of 60 and IPPC plants 100. The weighted factors in the previous map of urban and housing areas with significant flood risk ranged from 1 to 53.

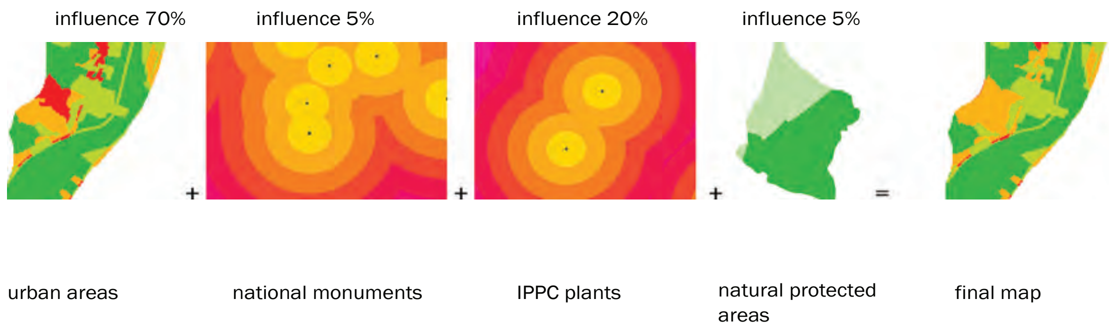


Figure 27: Creation of the final assessment map for flood risk for the housing sector for areas with very significant risk (category 4).

Attributes of 8_demogr_pokazatelji_poplave

Name	Naziv_1	Povrs_km2	Entitet	Povrs_ha	_BGP	_pov_st_bl	br_ind_obj	_br_stan_v	br_domac_1	_br_stanov	br_zagadj
VISOKO	Visoko	233.62	FBiH	23361.63	36800	19.917892	32	480	512	1587	0
SREBRENIK	Srebrenik	247.93	FBiH	24793.16	29200	61.145855	292	0	292	905	0
CELINAC	Celinac	361.8	RS	36179.83	55800	59.903343	327	330	657	2037	0
GORAZDE	Goražde	253.6	FBiH	25359.83	197750	64.008044	357	2315	2672	8283	0
TESLIC	Teslic	846.49	RS	84649.23	40600	73.087728	406	0	406	1259	0
ZVORNIK	Zvornik	374.39	RS	37439.18	50600	120.426514	506	0	506	1569	1
CAPLJINA	Capljina	253.74	FBiH	25374.17	51200	64.3682	512	0	512	1587	0
DONJI ZABAR	Donji Žabar	46.8	RS	4679.61	53200	192.901169	532	0	532	1649	0
KALESIJA	Kalesija	197.81	FBiH	19781.5	56700	134.993601	567	0	567	1758	0
TESANJ	Tešanj	160.8	FBiH	16080.41	62400	254.767284	624	0	624	1934	0
BIHAC	Bihac	945.44	FBiH	94544.06	67400	76.34357	674	0	674	2089	0
ILIDZA	Ilidža	136.46	FBiH	13646.26	106100	90.26525	697	520	1217	3773	0
MAGLAJ	Maglaj	238.72	FBiH	23872.1	245450	81.413284	708	2495	3203	9929	0
KOZARSKA DUBICA	Kozarska Dubica	499.35	RS	49935.14	93350	106.946926	713	315	1028	3187	1
BOSANSKA KRUPA	Bosanska Krupa	566.58	FBiH	56657.93	76670	84.751202	724	61	785	2434	0
LJUBUSKI	Ljubuški	292.73	FBiH	29272.77	75650	122.989354	746	15	761	2359	0
MODRICA	Modrica	326.73	RS	32672.93	79900	166.83255	799	0	799	2477	1
PETROVO	Petrovo	109.53	RS	10953.04	84810	231.479604	811	53	864	2678	0
BANJA LUKA	Banja Luka	1238.89	RS	123889.4	124010	156.733404	1119	173	1292	4005	0
DOMALJEVAC-SAMAC	Domaljevac-Šamac	36.83	FBiH	3683.1	124500	355.454092	1245	0	1245	3860	0
DOBOJ	Doboj	656.33	RS	65633.1	880090	334.793613	1369	10617	11986	37157	1
SANSKI MOST	Sanski Most	767.26	FBiH	76725.78	250450	141.181105	1437	1525	2962	9182	0

Record: 0 Show: All Selected Records (0 out of 143 Selected) Options

Table 18: The structure of the produced data in GIS.

5. DETAILED METHODOLOGY FOR CLIMATE CHANGE

a. Introduction and Methodology

Regional Climate Models (RCM) were the most commonly used tools for regionalisation results (dynamical downscaling) and global climate models (General Circulation Model - GCM) for the assessment of future changes in regional climate conditions, depending on different scenarios for potential increases in the concentration of greenhouse gases.[23]

The methodology for regionalisation allows for relevant information on future climate change to be provided according to an appropriate spatial and temporal scale. This information is necessary for the implementation of studies on impact and vulnerability, especially when focused on regional and sub-regional areas. This Assessment used the results of several regional climate models, according to the SRES scenarios on future climate change A1B and A2, Nakićenović and Swart, 2000; the Fourth Report of the Intergovernmental Panel on Climate Change (IPCC - AR4) and the RCP8.5 Scenario on Future Climate Change, Moss et al., 2008 and the Fifth Report of the Intergovernmental Panel on Climate Change (IPCC - AR5).

The results of Đurđević and Rajković's 2010 regional climate model EBU-POM for the territory of BiH and for the period from 2001 to 2100, under scenarios A1B and A2, will serve as the basis for future analysis into changes in extreme precipitation regimes. The latter resulting in a possible increase in the risk of landslides, floods and other disasters. The results of this model were the basis for the analysis of the impact of climate change and the vulnerability of socioeconomic sectors to climate change[24] in the Second National Communication of BiH under the UNFCCC.

The horizontal resolution of these results was 25 km and the time resolution 6 hours. The use of high temporal resolution results of 6 hours will provide a better insight into possible changes in short-term intense rainfall, which is the most common cause of the the above mentioned disasters. Additional data to be used are the results from the Janjić and Gall 2012 regional NNMB model. This model has a high horizontal resolution of 8 km and temporal resolution of 6 hours for the period 2011–2100. The RCP8.5 regional scenario was used.

Regional models, such as high resolution, allow for better representation of intense convective systems; these are the most common cause of extreme accumulations of rainfall over short periods of a few hours, especially during the warmer part of the year.[25]

The uncertainty level results and EBU-POM model for the A1B scenario will be evaluated based on the results of other regional climate models available through the public database project ENSEMBLES.[26] The horizontal resolution of the model is 25 km and the results available for the base have a time resolution of one day. The uncertainty level results and NMMB model for the RCP8.5 scenario will be evaluated based on the results of regional climate models having a horizontal resolution of 8 km.

Evaluation of uncertainty in the results of the two models will enable identification of the most probable range of possible future changes in the state of future climate and, to some extent, extreme climatic conditions. The period 1970-2000 was selected as the reference period, while the integration of future climate covers the period 2011-2100. The boundary conditions from the global climate model CMCC-CM[27] were used for the RCP8.5 integrated scenarios, while the boundary conditions for A1B and A2 scenarios were used for the global climate model ECHAM5.[28]

Table 19: Summary of regional climate models and climate scenarios.

Regional model	Horizon resolution	Scenario	Reference period	Future period	Global model
NMMB	8 km	RCP8.5	1971-2000	2011-2100	CMCC-CM
EBU-POM	25 km	A1B	1971-2000	2011-2100	ECHAM5
EBU-POM	25 km	A2	1971-2000	2011-2100	ECHAM5

According to the selected scenarios, the value of CO_2 concentration at the end of the twenty-first century will be about 690 ppm for the A1B scenario and 850 ppm for the A2 scenario. With regard to the concentration of greenhouse gases, A1B was characterised as jacket 'medium' and A2 as 'high' scenario. According to the RCP8.5 scenario, at the end of the twenty-first century CO_2 concentrations will slightly exceed 900 ppm; therefore this scenario can be viewed as pessimistic compared to the A2 scenario.

23 Giorgi et al., 2001.
24 See Trbić et al., 2015
25 See Đurđević and Krzić, 2013
26 See Van der Linden and Mitchell, 2009
27 See Scoccimarro et al. 2011
28 See Roeckner et al. 2003

Climatic Indices of Extreme Rainfall

In addition to the analysis of changes to the total accumulated annual precipitation, changes in the seasons - December-January-February (DJF), March-April-May (MAM), June-July-August (JJA) and September- October-November (SON) - changes to the selected indices of extreme daily rainfall accumulation, which indicate the frequency and intensity of extreme individual events, will be analysed and compared to the reference period. Index definitions and units together with the corresponding index mark are given in Table 5.

The selected indices for daily accumulation can be classified into two groups with regard to the threshold, which is an extreme event. The first three indices are defined in relation to the threshold of 20mm daily accumulation in Table 2. The RR20 precipitation index is characterised by the occurrence of certain events whereas indices RR20t and RR20dt are characterised by the intensity of rainfall in the days when the daily accumulation exceeds the adequate threshold index. Similar indices of daily accumulation were calculated in the RCP8.5 scenario analysis. Analogue indices are related to 5-day accumulation, the accumulation threshold used to record extreme events when five-day rainfall is 60 mm.

Table 20: Definitions of indices used in the analysis (changes in distribution and the incidence of daily extreme precipitation are possible depending on the various scenarios of future climate).

Index	Definition	Unit
RR20	The number of days with daily accumulated rainfall exceeding 20 mm.	day
RR20t	Total accumulated rainfall for days with daily accumulated rainfall exceeding 20 mm.	mm
RR20dt	Daily average rainfall for the days with accumulated rainfall of more than 20 mm.	mm/day
R5D60	Episodes from the five-day accumulated rainfall exceeding 60 mm.	Number episodes
R5D60t	Total accumulated precipitation during the episode with the five-day accumulated rainfall exceeding 60 mm.	mm
R5D60dt	Mean five-day accumulated precipitation during the episode with the five-day accumulated rainfall exceeding 60 mm.	mm/episodes

Examples of the results

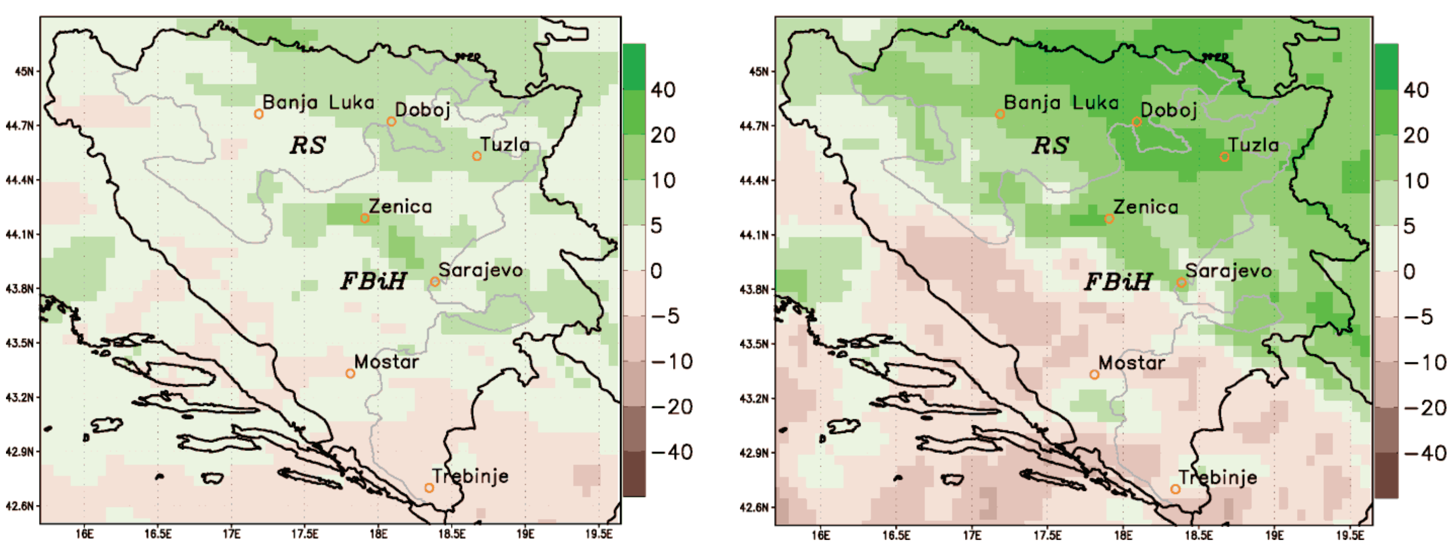


Figure 28: Right, RCP8.5 scenario 2011-2040 (Year); left, RCP8.5 scenario 2011-2040 springs (MAM)

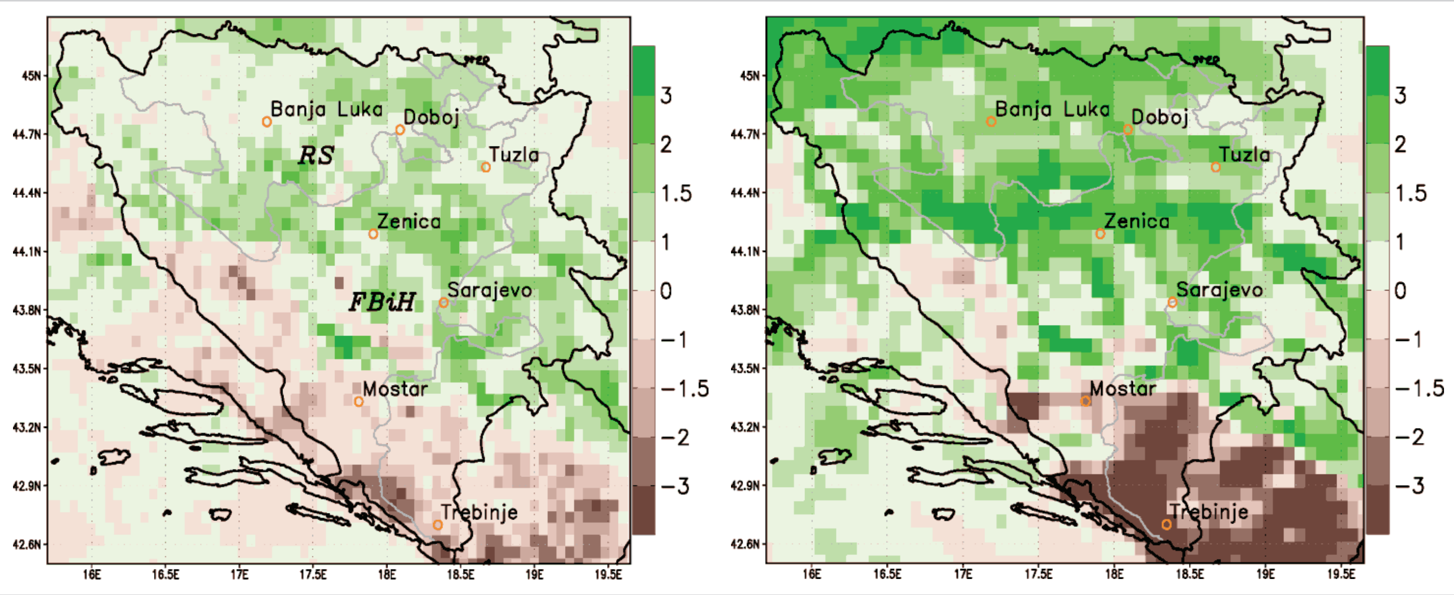


Figure 29: Right, RCP8.5 scenario 2011-2040 (Year) RR20 compared to the period 1971-2000, according to the RCP8.5 scenario on the Left, Change in annual (ANN) vault is the index R60-5du episodes / year, for the period 2011-2040, compared to the period 1971-2000, (right)

6. SOCIOECONOMIC ANALYSIS

a. Introduction and Methodology

The floods risk assessment and the landslide risk assessment resulted in the identification of areas that are very significantly endangered by flooding and landslides. An additional tool in the selection of priority areas for the implementation of measures aimed at preventing or reducing the risk of floods and landslides was socioeconomic analysis.

In the case of natural hazards, socioeconomic analysis had a purpose of analysing the degree of socioeconomic vulnerability of areas exposed to natural hazards. This involves an analysis of the social and economic characteristics of the areas likely to be harmed by a natural hazard and a community's resilience to the hazard (capacity to respond to and recover from the losses caused by the natural hazard). These characteristics can include, amongst others, spatial exposure to a hazard, the population size, housing and poverty factors, the human development index, land degradation, the expected level of financial losses, state of emergency planning and response, community preparedness and the community budget.

The analysis was aimed at determining the initial vulnerability condition: the vulnerability index of the area/community. This was intended to serve as the basis for identifying interventions/measures for improvement aimed at exposure reduction, susceptibility reduction and resilience improvement.

Measuring or quantifying the socioeconomic vulnerability of areas at risk of flooding or landslides was carried out by means of a socioeconomic model, which allowed for a comparison between socioeconomic vulnerability in different areas.

The socioeconomic vulnerability model consisted of a set of indicators aimed at gaining a practical understanding of the socioeconomic reality. The structure and content of the model, in terms of opting for an appropriate set of indicators, depends on the spatial scale or the organisational level of the analysis. Data scarcity proved to be a limiting factor for the socioeconomic vulnerability analysis and often determined which type of vulnerability indicators could be included in the model.

In view of the purposes of this Assessment, the municipal level was chosen for the socioeconomic analysis, based on the fact that certain data was only available at the municipal level. The selection of indicators for the proposed model was made following an in-depth analysis of the areas exposed to a very significant flood/landslide hazard as well as analysis of the available data. The selected indicators for the model were chosen in such a way that required input data to be collected from statistics, maps or other easily accessible data. The proposed model included indicators that presented the magnitude of the social and economic consequences of floods/landslides in the exposed areas as well as the extent of the community's ability to cope with and recover from damage associated with floods/landslides.

The model is based on a weighting and scoring system where the weight and score for each indicator is assessed according to predetermined rules. There are no standard procedures for the weighting and scoring of indicators. Namely, each indicator is assigned a weight factor depending on the relevance of the specific indicator in the overall vulnerability analysis. In this case, the weighting of indicators was based on the judgment of urban experts and flood experts. Weight factors were determined to be in the range of 1 to 3, where weight 1 represented low relevance of the indicator to the overall vulnerability and 3 represented high relevance of the indicator. Furthermore, each indicator was scored using a scale from 1 to 5, where score 1 corresponded to a very low vulnerability and score 5 to very high vulnerability. The final vulnerability index was an aggregation of the vulnerability indicator score values.

The socioeconomic model based on a scoring system was used because it allowed for the combination of various social and economic indicators expressed in different units (number, surface area, length, monetary units, etc.), which it brought to a comparable value.

The methodology proposed for the assessment of socioeconomic vulnerability of areas to natural hazards was based on methodologies previously developed and validated through other projects. Examples of the developed methodologies and case studies of application of social and economic vulnerability analysis can be found in the literature listed below:

- 'Methods for the Improvement of Vulnerability Assessment in Europe' Project - seventh Framework Programme of the European Commission Manual 'Assessing Vulnerability to Natural Hazards in Europe: From Principles to Practice', 2011.
- 'Methods for the Improvement of Vulnerability Assessment in Europe' Project - seventh Framework Programme of the European Commission, 'Handbook of Vulnerability Assessment in Europe', 2011.
- 'Living with Landslide Risk in Europe: Assessment, Effects of Global Change and Risk Management Strategies' Project - seventh Framework Programme of the European Commission, 'Methodology for the Evaluation of the Socioeconomic Impact of Landslides (socioeconomic vulnerability)', 2012.

The table below describes the socioeconomic vulnerability model with the suggested indicators, their corresponding weights, sources of data collection and indicator scoring criteria.

INDICATORS		WEIGHTS AND MEANS OF DATA COLLECTION	INDICATOR SCORING CRITERIA (1 = Low vulnerability, 5 = very high vulnerability)
SPATIAL INDICATORS			
1.	The percentage of the area of the municipality exposed to a significant and/or very significant risk of flooding.	1 Maps	1. from 0 - 10% 2: from 10 - 30% 3: from 30 - 50% 4: from 50 - 90% 5: over 90%
2.	The percentage of the area of the municipality at significant and/or very significant risk of landslides.	1 Maps	1. from 0 - 2% 2: from 2 - 5% 3: from 5 - 10% 4: from 10 - 20% 5: over 20%
3.	Ratio of the area of the municipality at very significant risk of flooding along with the total area covered by this category of flood risk across country.	1 Maps	1. from 0 - 1% 2: from 1 - 5% 3: from 5 - 8% 4: from 8-20% 5: over 20%
4.	Ratio of the area of the municipality at very significant risk of landslide along with the total area covered by this category of landslide risk across the country.	1 Maps	1. from 0 - 1% 2: from 1 - 3% 3: from 3 - 5% 4: from 5 - 7% 5: over 7%
SOCIAL AND PHYSICAL INDICATORS			
5.	Number of residents in areas at very significant risk of flooding.	3 Maps and census	1. from 3 - 5,000 2: from 5,001 - 15,000 3: from 15,001 - 25,000 4: from 25,001 - 40,000 5: over 40,000
6.	Number of people in areas at very significant risk of landslides.	3 Maps and census	1. from 6 - 1,500 2: from 1,501 - 5,000 3: from 5,001 -12,000 4: from 12,001 - 20,000 5: over 20,000
7.	Number of large pollutants located in areas at very significant risk of flooding.	2 Maps	1. 1 pollutant 2: 2 pollutants 3: 3 pollutants 4: 4 pollutants 5: 5 pollutants

INDICATORS		WEIGHTS AND MEANS OF DATA COLLECTION	INDICATOR SCORING CRITERIA (1 = Low vulnerability, 5 = very high vulnerability)
8.	Number of large pollutants located in areas at very significant risk of landslides.	2 Maps	1. 1 pollutant
			2: 2 pollutants
			3: 3 pollutants
			4: 4 pollutants
			5: 5 pollutants
9.	Gross area of housing facilities at very significant risk of flooding.	2 Maps	1. from 100 - 150,000 m^2
			2: from 150,001 - 250,000 m^2
			3: from 250,001 - 500,000 m^2
			4: from 500,001 - 1,000,000 m^2
			5: over 1,000,000 m^2
10.	Gross area of housing facilities at very significant risk of landslides.	2 Maps	1. from 200 - 50,000
			2: from 50,001 - 150,000
			3: from 150,001 - 350,000
			4: from 350,001 - 600,000
			5: over 600,000
11.	Area covered by public infrastructure (schools, hospitals etc.) at very significant risk of flooding.	2 Maps	1. from 0 - 5 ha
			2: from 5 - 20 ha
			3: from 20 - 30 ha
			4: from 30 - 60 ha
			5: over 60 ha
12.	Area covered by public infrastructure (schools, hospitals etc.) at very significant risk of landslides.	2 Maps	1. from 0 - 2 ha
			2: from 2 - 5 ha
			3: from 5 - 10 ha
			4: from 10 - 20 ha
			5: over 20 ha
13.	Length of railroads, highways, trunk roads and regional roads in areas at very significant risk of flooding, with a damage estimate of 50%.	2 Maps	1. from 0 - 5 km
			2: from 5 -10 km
			3: from 10 - 20 km
			4: from 20 - 40 km
			5: over 40 km
14.	Length of railroads, highways, trunk roads and regional roads in areas at very significant risk of landslides, with a damage estimate of 80%.	2 Maps	1. from 0 - 1 km
			2: from 1 - 3 km
			3: from 3 - 4 km
			4: from 4 - 5 km
			5: over 5 km

INDICATORS		WEIGHTS AND MEANS OF DATA COLLECTION	INDICATOR SCORING CRITERIA (1 = Low vulnerability, 5 = very high vulnerability)
ECONOMIC INDICATORS			
15.	Cost of the damage to the net surface living area at very significant risk of flooding, damage estimate 60%; cost of the damage to the net surface of the living area at very significant risk of landslides, damage estimate 80%.	3 Maps and trade data	1. < 30 mil BAM
			2. 30-50 mil BAM
			3. 50-100 mil BAM
			4. 100-200 mil BAM
			5. > 200 mil BAM
16.	Personal income (GDP per capita).	3 Statistical data	1: > 6 thousand BAM
			2: 5 - 6 thousand BAM
			3: 4 - 5 thousand BAM
			4: 3 - 4 thousand BAM
			5: < 3 thousand BAM
17.	Municipality budget/costs of the damage	3 Municipalities	1: 0 -1
			2: 1- 4
			3: 4 - 10
			4: 10 - 20
			5: > 20

Percentage of the area of the municipality at significant and very significant risk

- The indicator value was obtained by adding areas/hazard maps at significant and very significant risk of flooding/landslide within a municipality and calculating the area at risk as a percentage of the total municipal territory.

Ratio of the area of the municipality at very significant risk with the total area covered by this category of risk across the country

- The indicator value was obtained by adding areas/hazard maps at very significant risk of flooding/landslide within a municipality and calculating the area under risk as a ratio of this area to the total territory of this type of risk throughout the country.

Number of people in areas at very significant risk

- The indicator value was obtained through a detailed analysis of the areas at very significant risk and by counting the houses in the defined areas. The parameters applied were 3.1 people per family/household with an average of 100 m^2 of gross built up area in the housing unit for a single family dwelling/house and an average of 70 m^2 of gross built up area for a housing unit in multi-family dwellings/apartments, taking into account the actual elevation (number of stories of the structure).

Number of large pollutants located in areas at very significant risk of flooding

- The indicator value was obtained through detailed analysis of the areas at very significant risk and by counting the large pollutants in the defined areas.

Gross area of housing facilities at very significant risk

- The indicator value was obtained through detailed analysis of the areas at very significant risk and by counting the houses in the defined areas. The parameters used were 3.1 people per family/household with an average of 100 m^2 of gross built up area in the housing unit for a single family dwelling/house and an average of 70 m2 of gross built up area for a housing unit in multi-family dwellings/apartments, taking into account the actual elevation (number of stories of the structure).

Area covered by public infrastructure (schools, hospitals etc.) at very significant risk

• The indicator takes into account critical care facilities: hospitals, schools, etc. The damage caused by flooding and/or landslides to hospitals would threaten the provision of medical services in disaster areas, not only during the event but also for a longer period afterwards. As schools provide the basic social service in the community they are highly valuated in the socioeconomic model. Damage to schools caused by flooding/landslides would disrupt implementation of the education process. The indicator value was obtained by adding areas/hazard maps covered by public infrastructure at very significant risk of flooding/landslides within a municipality.

Length of railroads, highways, trunk roads and regional roads in areas at very significant risk

• As roads serve as an evacuation route and provide major access to a community it is very important that they are properly evaluated in the socioeconomic model. The indicator value was obtained by adding linear information on the total length covered by the traffic infrastructure at very significant risk of flooding/landslides within a municipality. The expert estimate used was 60% damage caused by flooding (as a result of the elevation of traffic routes) and 80% damage to the affected routes caused by landslides.

Cost of the damage to the net surface of the living area at very significant risk

• The indicator value was obtained through detailed analysis of the areas at very significant risk and by counting the houses in the defined areas. The parameters used were an average of 100 m^2 of gross built up area for a housing unit in a single family dwelling/house and an average of 70 m^2 of gross built up area for a housing unit in multi-family dwellings/apartments, taking into account the actual elevation (number of stories of the structure). Parameter of net area is the usual engineering estimate of 80% of gross built up area. The average price for 1 m^2 of net area in housing taken into account was 900 BAM. The expert estimate of damage that the housing unit may suffer as a result of flooding was 60% of the net area, 80% of the net area for landslides and 100% damage for both flooding and landslides.

Personal wealth

• This indicator presents the wealth/funds of the community/municipality required to rebuild after a flood/landslide. Personal wealth was presented through GDP per capita at the municipal level. GDP takes into account personal and government consumption, investment and the ratio of export/import. As the institutes for statistics in both entities only calculate GDP at the entity level, for the purposes of this analysis GDP at the municipal level was calculated based on the formula below:

$$\frac{number\ of\ employees\ in\ municipality * average\ wages\ in\ municipality}{number\ of\ employees\ in\ entity * average\ wages\ in\ entity} * GDP\ in\ entity$$

In order to estimate the GDP per capita municipal GDP was divided by the number of inhabitants in the municipality.

Municipal budget/cost of the damage

• This indicator shows the financial ability of the municipality to promptly respond to the damage caused by a flood/landslide. The indicator is expressed as a ratio of the municipal budget and the total cost of the damage to the net surface of the living area at very significant risk of both flooding and landslides.

The indicators were ranked by their degree of influence.

- Most influential: (i) number of people who reside in areas at very significant risk of flooding/landslides, (ii) cost of the damage to the net surface of the living area at very significant risk of flooding/landslide, (ii) personal wealth and (iii) municipal budget/cost of the damage.
- Moderately influential: (i) the gross area of housing facilities at very significant risk of flooding/landslides, (ii) area covered by public infrastructure at very significant risk of flooding/landslides, (iii) length of railroads, highways, trunk roads and regional roads in areas at very significant risk of flooding/landslides, (iv) number of large pollutants located in areas at very significant risk of flooding/landslides.
- Least influential: (i) percentage of the area of the municipality covered by significant and very significant risk of flooding/landslides, (ii) ratio of the area of the municipality at very significant risk of flooding/landslides and the total area covered by this category of flood/landslide risk across the country.

Guidelines for using the proposed vulnerability model:

- assign a weight factor to each indicator (1-3),
- score each indicator (1-5) in accordance with the corresponding criteria in the model,
- multiply the indicator score value by its weight, and
- sum up all weighted vulnerability scores as a Σ weighted vulnerability score.

$$Total\ vulnerability\ index = \Sigma\ weighted\ vulnerability\ score$$

b. Results of the Socioeconomic Vulnerability Analysis

The socioeconomic vulnerability analysis was conducted for the municipalities that have areas/hazard maps at very significant risk of flooding/landslides (category 4 hazard maps). The total number of such municipalities is 122, of which 31 municipalities had category 4 flood hazard maps. The 31 municipalities were Banja Luka, Bihać, Bijeljina, Bosanska Krupa, Brčko District, Brod, Čapljina, Čelinac, Derventa, Doboj, Domaljevac-Šamac, Donji Žabar, Goražde, Ilidža, Kalesija, Kozarska Dubica, Laktaši, Ljubuški, Maglaj, Modriča, Odžak, Orašje, Petrovo, Prijedor, Šamac, Sanski Most, Srebrenik, Tešanj, Teslić, Visoko and Zvornik.

Category 4 landslide hazard maps existed for 110 municipalities: Banja Luka, Banovići, Berkovići, Bihać, Bosansko Grahovo, Bratunac, Brčko District, Breza, Bugojno, Čajniče, Čapljina, Cazin, Čelić, Centar Sarajevo, Čitluk, Derventa, Doboj, Doboj-Istok, Dobretići, Donji Vakuf, Drvar, Foča (FBiH), Foča (RS), Fojnica, Gacko, Glamoč, Goražde, Gornji Vakuf-Uskoplje, Gračanica, Gradačac, Grude, Hadžići, Han Pijesak, Ilidža, Ilijaš, Istočna Ilidža, Istočni Stari Grad, Istočno Novo Sarajevo, Jajce, Kakanj, Kalesija, Kalinovik, Kiseljak, Kladanj, Ključ, Kneževo, Konjic, Kostajnica, Kotor Varoš, Kozarska Dubica, Kupres (FBiH), Livno, Ljubinje, Ljubuški, Lopare, Lukavac, Maglaj, Milići, Modriča, Mostar, Mrkonjić Grad, Nevesinje, Novi Grad, Novi Grad Sarajevo, Novi Travnik, Novo Goražde, Novo Sarajevo, Olovo, Osmaci, Pale (FBiH), Pale (RS), Pelagićevo, Posušje, Prijedor, Prnjavor, Prozor, Ribnik, Rogatica, Rudo, Sanski Most, Sapna, Šekovići, Šipovo, Široki Brijeg, Sokolac, Srebrenica, Srebrenik, Stari Grad Sarajevo, Stolac, Teočak, Tešanj, Tomislavgrad, Travnik, Trebinje, Trnovo (FBiH), Trnovo (RS), Tuzla, Ugljevik, Vareš, Velika Kladuša, Višegrad, Visoko, Vlasenica, Vogošća, Vukosavlje, Zavidovići, Zenica, Žepče, Živinice and Zvornik.

Category 4 landslide and flood hazard maps were available for 19 municipalities: Banja Luka, Bihać, Brčko District, Čapljina, Derventa, Doboj, Goražde, Ilidža, Kalesija, Kozarska Dubica, Ljubuški, Maglaj, Modriča, Prijedor, Sanski Most, Srebrenik, Tešanj, Visoko and Zvornik. These hazard maps overlapped each other in only 11 municipalities: Banja Luka, Bihać, Brčko District, Doboj, Goražde, Kalesija, Ljubuški, Lukavac, Maglaj, Srebrenik and Visoko.

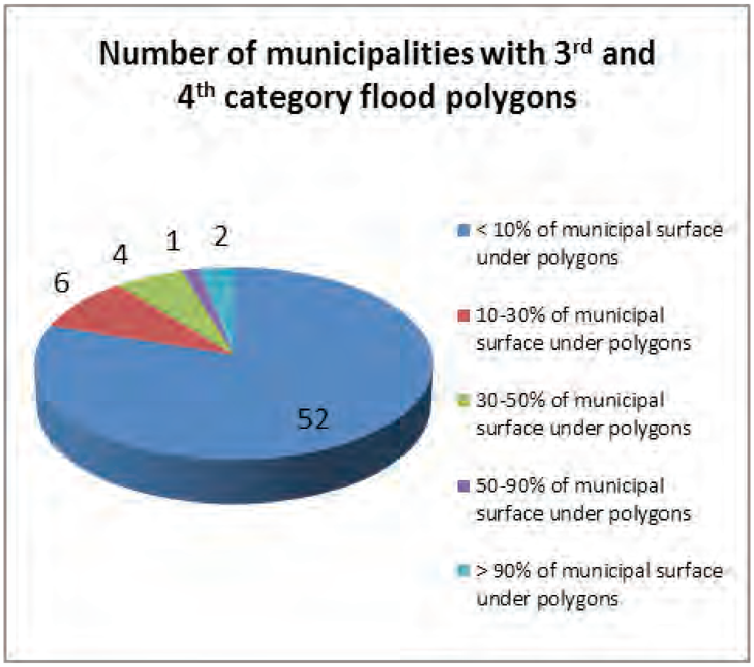
Spatial Indicators

The spatial indicators included (1) the percentage of the area of the municipality covered by significant or a very significant risk of flooding, (2) the percentage of the area of the municipality covered by a significant or very significant risk of landslides, (3) the ratio of the area of the municipality covered by a very significant risk of flooding to the total area covered by this category of flood risk in the entire country and (4) the ratio of the area of the municipality covered by very significant risk of landslides to the total area covered by this category of landslide risk for the entire country.

The total surface area of BiH exposed to a very significant risk of flooding (category 4 hazard maps) is 97,391 ha. According to the category 4 hazard maps, the highest percentage of municipal territory threatened is found in the City of Bijeljina at 29%, followed by Orašje at 11%. If both category 3 and 4 hazard maps are taken into account then the Municipality of Domaljevac-Šamac has the largest area covered by these hazard maps, accounting for 98.6%, followed by Orašje 92%, Odžak 52%, Bijeljina 38%, Donji Žabar 38% and Šamac 39% all of which are municipalities along the River Sava.

The diagram below on the left indicates the number of analysed municipalities with percentages of their territory at significant or very significant risk of flooding.

The diagram below on the right indicates the number of municipalities with their surface areas at very significant risk of flooding as a percentage of the total area covered by this category of flood risk in BiH.



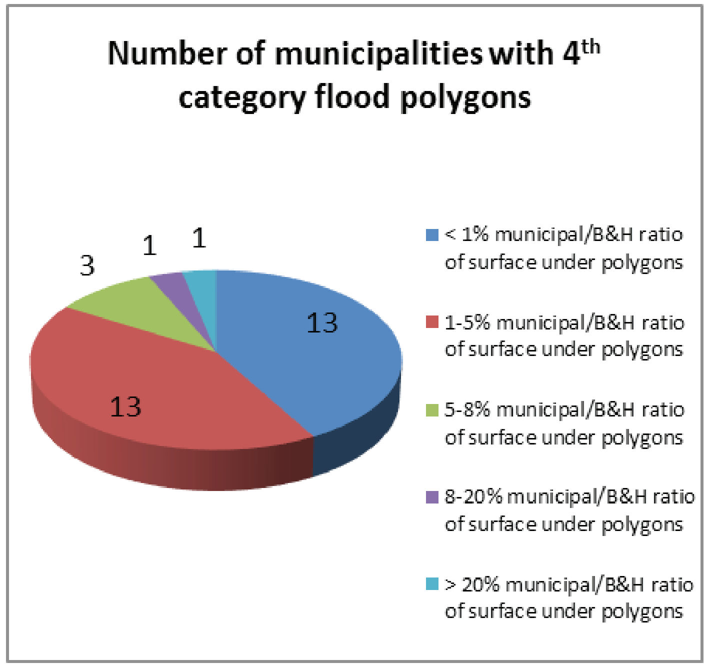
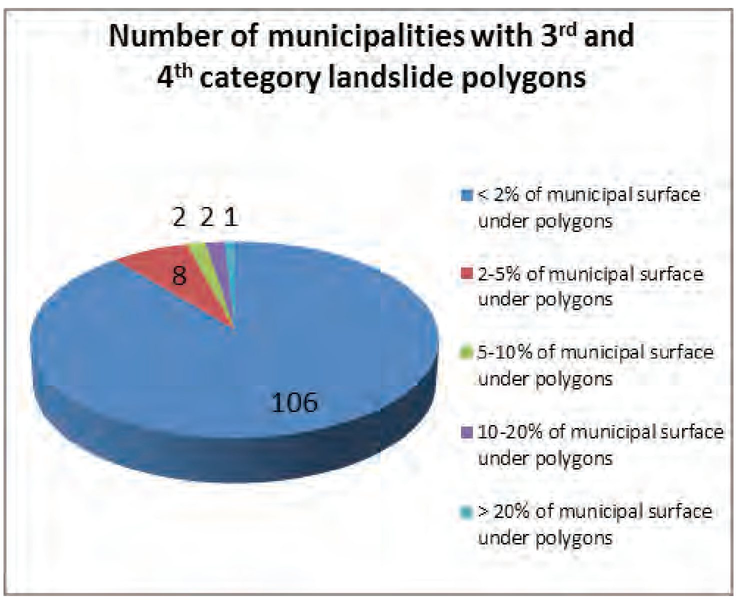


Figure 30: Coverage of municipal territory by hazard maps of significant and very significant risk of flooding.

The total surface of BiH exposed to a very significant risk of landslides (category 4 hazard maps) is 7,571 ha, whereas the surface at significant and very significant risk of landslides (category 3 and 4 hazard maps) is 26,073 ha.

The diagram on the left shows the number of analysed municipalities with a percentage of their territory at significant and very significant risk of landslides. The diagram on the right shows the number of municipalities with their surface area at very significant risk of landslides as a percentage of the total area covered by this category of landslide risk in BiH.



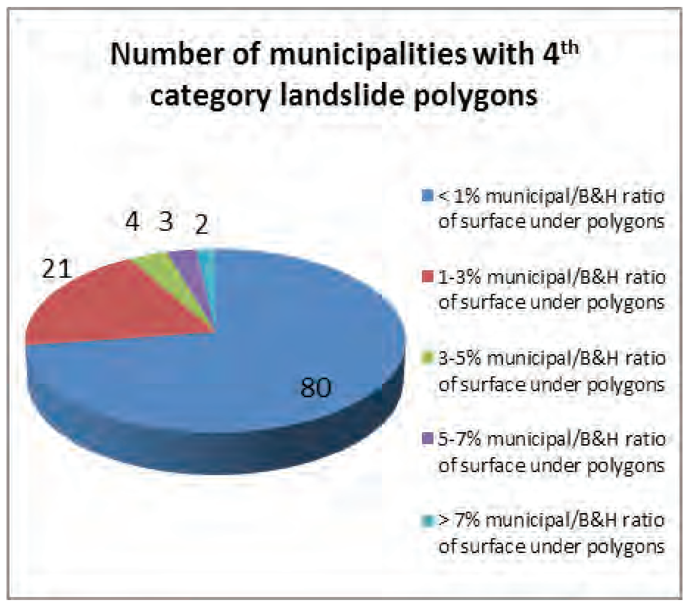


Figure 31: Coverage of municipal territory by hazard maps of significant and very significant risk from landslides.

The overlapping of flood hazard maps and landslide polygons of category 4 occurs in 11 municipalities on a total surface area of 11.85 ha. The largest overlapping area of 3.94 ha is located in the Municipality of Maglaj. Since the area of overlap was very small this indicator was not included in the analysis.

No	MUNICIPALITY NAME	FLOODED AREA (ha)	TOTAL AREA OF MUNICIPALITY (ha)	%
3	BIJELJINA	27919.78	73408.27	38.03%
49	ORAJSJE	10941.00	11885.76	92.05%
5	BRCKO DISTRIKT	9235.50	49329.11	18.72%
47	ODZAK	8573.76	16556.78	51.78%
6	BROD	7729.49	23005.55	33.60%
54	SAMAC	6682.24	17223.62	38.80%
14	DOBOJ	4689.27	65633.10	7.14%
57	SRBAC	4030.09	45263.86	8.90%
51	PRIJEDOR	3649.05	83407.17	4.37%
16	DOMALJEVAC-SAMAC	3632.99	3683.10	98.64%
42	MODRICA	3268.08	32672.93	10.00%
36	LAKTASI	3251.82	38833.51	8.37%
25	GRUDE	2900.74	21855.76	13.27%
13	DERVENTA	2716.85	51659.90	5.26%
9	CAPLJINA	2625.33	25374.17	10.35%
35	KOZARSKA DUBICA	2443.96	49935.14	4.89%
53	RAVNO	2108.42	32291.09	6.53%
38	LJUBUSKI	1972.04	29272.77	6.74%
18	DONJI ZABAR	1768.89	4679.61	37.80%
69	VUKOSAVLJE	1503.12	7374.77	20.38%

Legend

	%	Municipalities
(light grey)	more than 90% flooded area	Domaljevac, Orašje
(dark grey)	more than 50% flooded area	Odžak
(orange)	more than 30% flooded area	Šamac, Bijeljina, Brod, Donji Žabar
(yellow)	more than 20% flooded area	Vukosavlje

Figure 32: (Indicator 1) The percentage area of a municipality at significant and very significant risk of flooding.

No	MUNICIPALITY NAME	AREA UNDER LANDSLIDE RISK (ha)	TOTAL AREA OF MUNICIPALITY (ha)	%
83	NOVO SARAJEVO	479.71	920.43	52.118%
21	CENTAR SARAJEVO	582.76	3292.08	17.702%
80	NOVI GRAD SARAJEVO	824.22	4730.68	17.423%
111	STARI GRAD SARAJEVO	463.34	4945.61	9.369%
113	TEOCAK	170.38	3024.47	5.633%
121	TUZLA	1467.09	29586.10	4.959%
130	VOGOSCA	343.37	7168.60	4.790%
38	GRADACAC	647.80	21524.60	3.010%
47	ISTOCNO NOVO SARAJEVO	102.30	3791.99	2.698%
52	KALESIJA	452.78	19781.50	2.289%
11	BREZA	158.56	7288.75	2.175%
45	ISTOCNA ILIDZA	59.77	2927.21	2.042%
55	KLADANJ	684.14	33563.82	2.038%
2	BANOVICI	322.45	18327.39	1.759%
135	ZIVINICE	509.83	29066.21	1.754%
114	TESANJ	267.32	16080.41	1.662%
37	GRACANICA	353.84	21532.70	1.643%
25	DOBOJ-ISTOK	65.39	3989.80	1.639%
109	SREBRENIK	392.15	24793.16	1.582%
133	ZENICA	865.96	55040.82	1.573%
71	LUKAVAC	523.27	33831.19	1.547%

Legend		Municipalities
(light grey)	more than 50% area under landslide risk	Novo Sarajevo
(dark grey)	more than 17% area under landslide risk	Centar Sarajevo, Novi Grad Sarajevo
(orange)	more than 9% area under landslide risk	Stari Grad Sarajevo
(yellow)	more than 5% area under landslide risk	Teoèak

Figure 33: (Indicator 2)– The percentage area of a municipality covered by significant and very significant risk from landslides.

Social and Physical Indicators

These indicators included (1) the number of people located in areas at very significant risk of flooding and (2) the number of people located in areas at very significant risk of landslides; (3) the number of large pollutants located in areas at very significant risk of flooding and (4) the number of large pollutants located in areas at very significant risk from landslides; (5) the gross area of housing facilities at very significant risk of flooding and (6) the gross area of housing facilities at very significant risk from landslides; (7) the area covered by public infrastructure (schools, hospitals etc.) at very significant risk of flooding and (8) the area covered by public infrastructure (schools, hospitals etc.) at very significant risk from landslides; (9) the length of railroads, highways, trunk roads and regional roads in areas at very significant risk of flooding, with a damage estimate of 50%, and (10) the length of railroads, highways, trunk roads and regional roads in areas at very significant risk from landslides, with a damage estimate of 80%.

The total **population living in areas at very significant risk of flooding** (category 4 hazard maps) was 283,777, of which 79,186 (28%) lived in Bijeljina, 37,157 (13%) in Doboj, 23,817 (8.4%) in Orašje, 20,383 (7.2%) in Brod, 16,539 (5.8%) in Prijedor and 12,279 (4.3%) in Šamac. The other municipalities had less than 10,000 people living in these areas.

The total **population living in areas at very significant risk of landslides** (category 4 polygons) was 260,731, of which 43,716 (16.8%) lived in Centar Sarajevo, 18,337 (7%) in Tuzla, 17,816 (6.8%) in Novi Grad Sarajevo, 15,788 (6.1%) in Novo Sarajevo, 13,736 (5.3%) in Stari Grad Sarajevo and 11,327 (4.3%) in Banja Luka, the other municipalities had under 10,000 people living in these areas.

The gross area of housing facilities at very significant risk of flooding was 8,103,620 m^2, of which Bijeljina accounted for 28.2%, Doboj 10.9%, Orašje 9.2%, Brod 7.5% and Prijedor 5.6%. The other municipalities accounted for less than 5%.

The gross area of housing facilities at very significant risk of landslides amounted to 7,407,020 m^2, of which 15.1% was in Centar Sarajevo, 7.5% in Tuzla, 7.1% in Novi Grad Sarajevo, 5.5% in Stari Grad Sarajevo and 5.3% in Novo Sarajevo. The other municipalities accounted for less than 5%.

The total **area covered by public infrastructure (schools, hospitals etc.) at very significant risk of flooding** amounted to 533 ha, of which 26% was in Bijeljina, 11.1% in Doboj, 10.8% in Orašje, 7.8% in Šamac, 7.1% in Brod and 5.4% in Domaljevac-Šamac. The other municipalities accounted for less than 5%.

The total **area covered by public infrastructure (schools, hospitals etc.) at very significant risk from landslides** amounted to 280 ha, of which 24.5% was in Centar Sarajevo, 7% in Tuzla, 6.5% in Foča, 4.5% in Stari Grad Sarajevo, 4% in Kakanj, 3.7% in Novi Grad Sarajevo and in Šipovo, and 3.5% in Bihać. The other municipalities accounted for less than 3%.

The length of railroads, highways, trunk roads and regional roads in areas at very significant risk of **flooding** was 327 m, of which 20% was in Bijeljina, 11% in Doboj, 9.5% in Prijedor, 7.7% in Orašje, 7.5% in Šamac and 6.3% in Modriča. The other municipalities accounted for less than 5%.

The length of railroads, highways, trunk roads and regional roads in areas at very significant risk from **landslides** was 114 m, of which 7.4% was in Tuzla, 5.5% in Centar Sarajevo, 4.2% in Mostar and in Vareš, 3.9% in Stari Grad Sarajevo, 3.8% in Vogošća, 3.6% in Kladanj, 3.3% in Novo Sarajevo and 3.2% in Novi Grad. The other municipalities accounted for less than 3%.

Four large pollutants were located in areas at very significant risk of **flooding,** one in each of the municipalities of Doboj, Kozarska Dubica, Modriča and Zvornik.

In areas at very significant risk of **landslides there were 3 large pollutants**, one in each of the municipalities of Centar Sarajevo, Kakanj and Novi Grad Sarajevo.

Economic Indicators

The economic indicators included (1) the cost of damage to the net surface of the living area at very significant risk of flooding, with an estimate of 60% ruined and an estimate of 80% ruined for the cost of the damage to the net surface of the living area at very significant risk from landslides; (2) personal wealth (GDP per capita) and (3) the municipal budget/Cost of damage.

The cost of the damage was estimated based on a number of assumptions:

- average of 100 m^2 of gross built up area for a housing unit in a single family dwelling/house;
- average of 70 m^2 of gross built up area for a housing unit in multi-family dwellings/apartments, taking into account the actual elevation (number of stories of the structure);
- the usual engineering estimate for gross built up net areas was 80%;
- an average price of 900 BAM for 1 m^2 of net housing area was taken into account;
- the expert estimation of flood damage to a housing unit was 60% of the net area;
- the expert estimation of landslide damage to a housing unit was 80% of the net area; and
- the expert estimation of both flood and landslide damage to a housing unit was 100% damage.

The total potential damage suffered by the housing sector in the areas at a very significant risk of flooding was estimated to have reached 3,500,763,840 BAM, of which the hardest hit was Bijeljina (987,444,000 BAM), followed by Doboj (380,198,880 BAM), Orašje (323,455,680 BAM) and Brod (262,383,840 BAM).

The total potential damage suffered by the housing sector in the areas at a very significant risk of landslides was estimated at 4,266,443,520 BAM, of which the hardest hit was Centar Sarajevo (642,378,240 BAM), followed by Tuzla (320,486,400 BAM), Novi Grad Sarajevo (301,478,400 BAM), Stari Grad Sarajevo (235,042,560 BAM), and Novo Sarajevo (225,826,560 BAM).

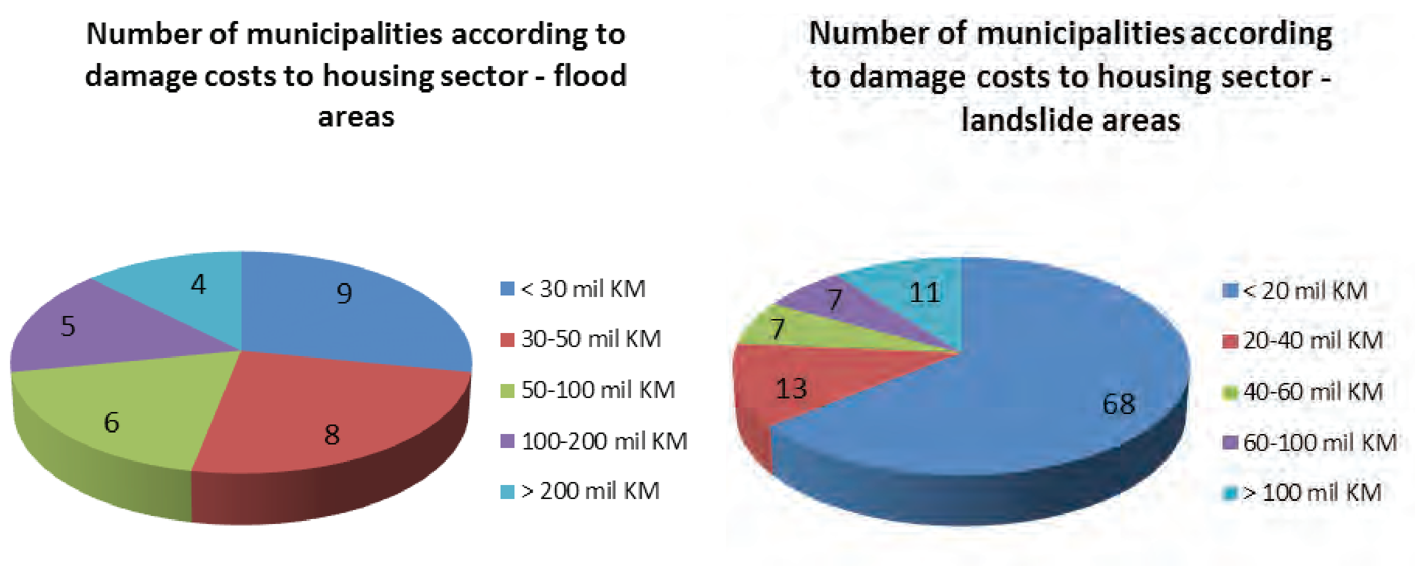


Figure 34: (Indicator 1) The percentage area of a municipality at significant and very significant risk of flooding

The number of municipalities classified according to GDP/capita is presented in the diagram below.

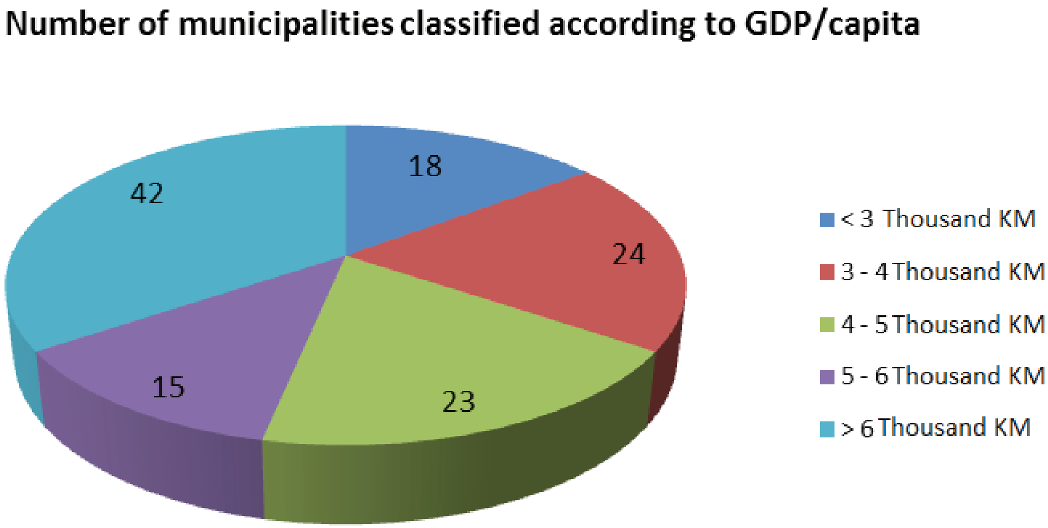


Figure 35: Municipalities according to GDP/capita

The ratio of the municipal budget to the total amount of damage (both flood and landslide) in each municipality constitutes an important indicator of the ability of the municipalities to cope with the consequences of a disaster.

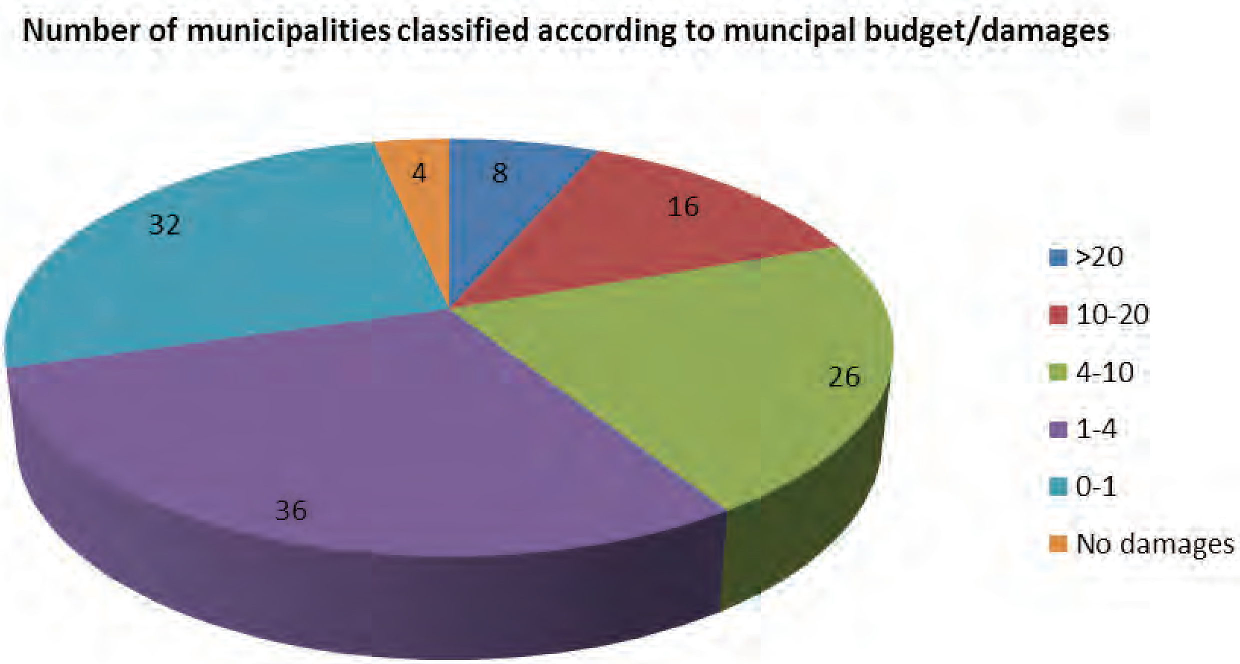


Figure 36: Municipalities according to the ratio municipal budget to damage cost.

The following map is one of the final results of the current study. It represents the flood and landslide risk assessment for the housing sector taking into account category 4 events per municipality, which was emphasised in the above mentioned socioeconomic study. The outcome is represented in Figure 36: the combined flood and landslide risk assessment with socioeconomic analysis.

Based on the methodologies adopted by this Assessment and described in detail in previous reports as well as in the first sections of this final report, the areas with different degrees of risk across BiH are represented in figures 11, 12 and 13. All of the collected and analysed data was incorporated into these maps and therefore they may be used in future projects or analysis in order to form an overview of the flood and landslide risk to the housing sector for the entire territory of BiH.

The following map, Figure 36, was prepared using several indicators from the abovementioned socioeconomic analysis. These included the spatial indicators, the social and physical indicators and the economic indicators. It is interesting to note that the results presented in these maps (11:13 and 36) mutually confirm each other. Since the comparison of the flood risk assessment maps, landslide and even the multi-hazard maps proves that the areas considered as high risk are the same it demonstrates that the flood risk related to the housing sector is predominant.

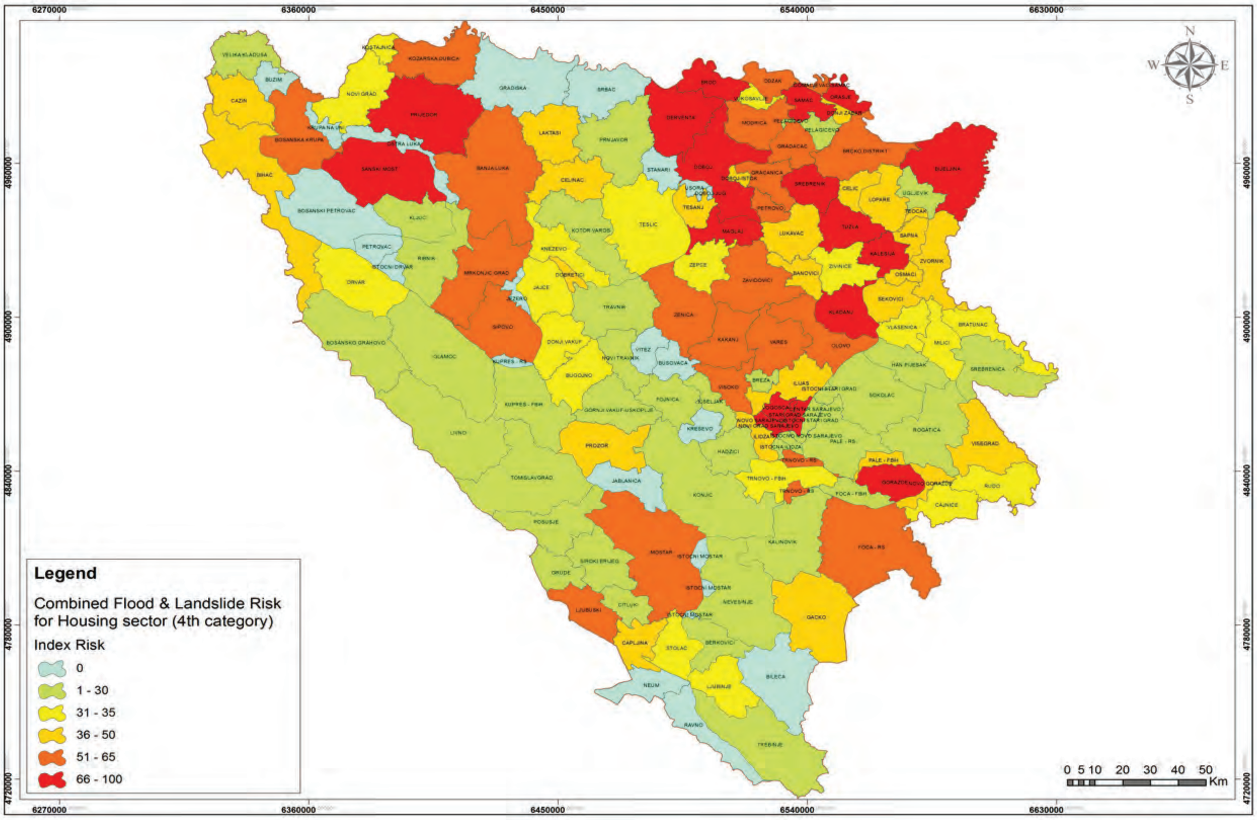


Figure 37: Relative combined multi-hazard (category 4) risk per municipality.

The table below represents the different indexes used for the socioeconomic analysis.

Table 21: Attribute table for socioeconomic vulnerability.

Socio-economic vulnerability ranking	Municipality name	Spatial indicators index	Social indicators index	Economic indicators index	Total socio-economic vulnerability index
1	Doboj	6	54	33	93
2	Centar Sarajevo	9	47	33	89
3	Bijeljina	9	45	33	87
4	Orašje	9	33	33	75
5	Tuzla	8	40	27	75
6	Prijedor	5	36	33	74
7	Šamac	7	28	39	74
8	Stari Grad Sarajevo	6	36	30	72
9	Brod	7	31	33	71
10	Novi Grad Sarajevo	9	34	27	70
11	Goražde	5	34	27	66
12	Kalesjia	7	25	33	65
13	Derventa	5	32	27	64
14	Novo Sarajevo	7	30	27	64
15	Maglaj	4	23	36	63
16	Vogošća	6	27	30	63
17	Kladanj	7	22	33	62
18	Sanski Most	4	25	33	62
19	Srebrenik	5	27	30	62
20	Banja Luka	5	30	24	59

7. PROPOSED MEASURES

1. FLOOD RISK REDUCTION RECOMMENDATIONS/MEASURES FOR THE HOUSING SECTOR

a. Introduction

The recommendations and measures for flood risk reduction take into account all ongoing or planned initiatives in this area and rely on Action Plan for Flood Protection and River Management in BiH 2014-2017 as a prerequisite for the start of implementation that was adopted by the Council of Ministers of BiH. This Action Plan covers the main problems and deficiencies (structural and non-structural measures) related to flood risk management in BiH and sets the strategic framework for coordinated work in this area.

In addition The European Commission concluded that the best way forward for regional coordination in flood risk management was two-stage coordination. The first stage includes the preparation of a detailed and clear mapping of all flood prevention and flood management activities in the region. The second stage, which will build on the mapping, includes a detailed gap analysis to identify concrete measures that may be agreed by the relevant stakeholders at the regional level. There are many ongoing activities being carried out by different actors, both at the state and regional level in this respect and are taken into account in this Assessment when proposing recommendations and measures for risk reduction.

Within this context, the project 'Gap Analysis/Needs Assessment in the Context of Implementing the EU Flood Directive in the Western Balkans' covers both investment and policy measures and leads to a tailored prioritisation of the needs per country.

This also led to a project pipeline, which should be incorporated into the project pipelines and serve as the basis for investment strategies and for EU and international funding mechanisms.

Thus, the gap analysis/needs assessment included, among others, the areas outlined below:

- Risk information required to determine the investment needed at the municipal, state and regional levels;
- Identification of 'no-regret' investments and measures that are high priority, address hot spot areas, communities and infrastructure that are particularly vulnerable, and that do not impact downstream or upstream; and
- Feasible a multi-annual investment prioritisation schedule to be tailored for each country and associated with likely financing (including domestic and international resources as well as private sector sources).

The project, 'Gap Analysis/Needs Assessment in the Context of Implementing EU Flood Directive in the Western Balkans', was published in late September 2015.

b. Structural Measures

Structural measures (construction of flood defences) were the prevailing type in BiH in the previous period.

With regard to identified areas, given the scale of the assessments (preliminary multi-hazard housing risk assessment), it was not technically feasible to propose concrete structural flood protection measures. Flooding is a phenomenon that spreads across a vast expanse of territory and 'local' interventions can adversely affect adjacent areas. This is especially true for downstream locations. One example is the protection of a specific area through the construction of levees to reduce the cross-section area of the river (cutting off protected floodplains from the waterway). This will result in more water being passed, without retention, further downstream, thus worsening the conditions in that area. It is impossible to do this without proper analysis of the effects and this requires more detailed analysis.

In terms of structural measures, it is impossible to list the most suitable since further and more detailed analysis needs to be carried out in order to be able to propose tailor-made structural measures. Such an analysis would comprise detailed geodetic surveying and hydraulic modelling of the identified flood areas. This in turn would result in detailed risk maps and subsequent proposals for actual structural measures that could be applied in order to achieve better flood control, but without adversely affecting the environment or adjacent areas (based, among other things, on repeated hydraulic model runs with the proposed measures incorporated into the model).

Structural measures that can be proposed in this Assessment are those already identified through the abovementioned Action Plan, whilst taking into account any ongoing or planned implementation of structural measures through other interventions.

The entity institutions responsible for water management have proposed structural measures to be implemented with regard to two IPA 2 programmes: (1) BiH Support to Flood Protection and Water Management, and (2) Regional Action for BiH and Serbia, Rehabilitation and Construction of Flood Prevention Infrastructure.

Out of 39 identified areas (municipalities) 15 are presented as 'no-regret'[29] structural measures that will be implemented through an IPA 2 or World Bank programmes. Three areas (municipalities) are planned to be assessed in detail within the frame of the UNDP project 'Technology Transfer for Climate Resilient Flood Management in the Vrbas River Basin', which started in April 2015. The planned completion date for the project is April 2021.

Non-structural measures proposed through this Assessment are for the remaining 24 areas. The first activity for each of them should be the preparation of hazard and risk maps based on hydraulic modelling.

29 Measures that are high priority address hot spot areas and communities and infrastructure that are particularly vulnerable and do not impact downstream or upstream.

Table 22: Description of the measures considered for the flooded areas.

No.	Hazard map number	Municipality	Flood area name	River	Catchment	Return period	Households
1	17	Banja Luka	VRB.VRB.P01	Vrbas	Vrbas	100	1,292
2	133	Bihać	Bihać area	Una	Una	100	674
3	58	Bijeljina	DRN.JANJ.P01	Janja	Drina	100	25,544
4	58	Bijeljina	DRN.DRN.P01	Drina	Drina	100	
5	58	Bijeljina	SAV.MOK.P01	Majevica perimeter canal	Sava catchment area	100	
6	58	Bijeljina	SAV.SAV.P01	Sava	Sava catchment area	100	
7	58	Bijeljina	SAV.SAV.P02	Sava	Sava catchment area	100	
8	137	Bosanska Krupa	Podr. Krupa & Otoka	Una	Una	100	785
9	64	Brčko District	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	445
10	64	Brčko District	Brka	Brka	Sava catchment area	100	1,592
11	25	Brod	SAV.SAV.P04	Sava	Sava catchment area	100	6,575
12	87	Čapljina	Čapljina and Hutovo Blato area	Krupa	Neretva	100	512
13	19	Čelinac	VRB.VBNJ.P01	Vrbanja	Vrbas	100	657
14	23	Derventa	UKR.UKR.P02	Ukrina	Ukrina	100	2,277
15	127	Domaljevac-Šamac	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	1,245
16	29	Donji Žabar	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	532
17	90	Goražde	Drina area	Drina	Drina	100	2,672
18	89	Ilidža	Podr. Plandište	Bosna	Bosna	100	1,217
19	78	Kalesija	Rainći Gornji	Spreča	Bosna	20	567
20	2	Kozarska Dubica	UNA.UNA.P02	Una	Una	100	1,028
21	18	Laktaši	VRB.VRB.P01	Vrbas	Vrbas	100	1,790
22	73	Ljubuški	Hrasljani-Veljaci	Trebižat, Vrioštica, Mlade	Neretva	100	761
23	98	Maglaj	Maglaj	Bosna	Bosna	20	3,203
24	27	Modriča	Modriča area	Bosna	Bosna	100	799
25	63	Doboj	BOS.BOS.P03	Bosna	Bosna	100	11,986
26	128	Odžak	Odžak	Bukovica	Bosna	20	959

Endan. popul.	Structural measures estimate	Estimated cost (BAM)	Total	Note
4,005				UNDP Vrbas
2,089				
79,185	River Janja rehabilitation, Janja-Bijeljina. Riverbed regulation. River Janja rehabilitation in Janja settlement, l=6.5 km	6,604,000	**32,199,000**	IPA II 2014 Low level maturity
	River bank protection along the River Drina, Bijeljina. Dike rehabilitation, dike construction. River bank protection of River Drina, L=33 km.	25,595,000		World Bank Low level maturity
2,434				
1,780	Reconstruction of the Sava dike. Reconstruction of the Sava dike on chainage km 0 + 000.00 to km 1 + 500.00 and chainage km approx. 2 + 900.00 to km 9 + 650.00 in Brčko District.	6,525,000		IPA II 2014 Medium level maturity (design in progress)
4,535	1. Regulation of River Brka and River Zovičica in urban Brčko area. Channel rehabilitation, channel construction, riverbed regulation. 2. Construction of right bank embankment at Brčko.[1]	10,508,000 122,000	**17,033,000**	IPA II 2014 Multi-Country Medium level maturity (design in progress)
20,383				
1,587				
2,037				UNDP Vrbas
7,059				
3,860	Reconstruction works on the embankment along the River Sava L = 5,734 km	420,000		UNDP 'Support to Recovery and Risk Mitigation in Bosnia and Herzegovina'
1,649				
8,283	Rehabilitation of existing dikes and construction of new ones in order to protect urban areas of Goražde, Prača-Pale and Foča-Ustikolina.	15,556,000	15,556,000	WB Drina flood protection project.
3,773	Regulation of the River Bosna in Sarajevsko Polje, i.e. construction, riverbed regulation, floodway rehabilitation /regulation.	10,366,000		Highly mature (preparation of the procurement documents is in progress)
1,758				
3,187				
5,549				
2,359				
9,929				
2,477				
37,157	Construction of protective concrete fence L = 1,450 m	355,000		UNDP project 'Support to Recovery and Risk Mitigation in Bosnia and Herzegovina'
1,850	Reconstruction of dikes on River Sava (right bank in FBiH) - Odžačka Posavina, flood area km 22+272 - 27+117. Dike rehabilitation, floodway rehabilitation / regulation.	4,800,000		IPA II 2014 Highly mature (preparation of the procurement documents in progress).

No.	Hazard map number	Municipality	Flood area name	River	Catchment	Return period	Households
27	128	Odžak	Odžačka Posavina area	Srnotaća	Sava catchment area	100	1,248
28	141	Orašje	Central Posavina area	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	7,683
29	24	Petrovo	Spreča area	Spreča, Jala	Bosna	100	864
30	4	Prijedor	UNA.SAN.P01	Sana	Una	100	5,335
31	4	Prijedor	UNA.GOM.P01	Gomjenica	Una	100	
32	30	Šamac	Central Posavina area	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	3,961
33	139	Sanski Most	Sana area	Sana	Una	100	2,962
34	115	Srebrenik	Tinja area	Tinja	Tinja	100	292
35	130	Tešanj	Tešanj	Trebačka river	Bosna	20	293
36	130	Tešanj	Usora area	Usora	Bosna	100	331
37	20	Teslic	BOS.USR.P01	Usora	Bosna	100	406
38	97	Visoko	Ozrakovici	Bosna	Bosna	20	512
39	56	Zvornik	DRN.SAP.P01	Sapna	Drina	100	506

Endan. popul.	Structural measures estimate	Estimated cost (BAM)	Total	Note
4,992	Reconstruction of dikes along the Svilaj - Potočani canal (left and right dike km 0+00-km1+600). Dike rehabilitation, floodway rehabilitation / regulation.	2,800,000	7,600,000	IPA II 2014 Highly mature (the preparation of the procurement documents in progress)
23,817	Reconstruction of dikes on Sava river - Orašje (km 26+856 to km 29+370). Dike rehabilitation, floodway rehabilitation / regulation.	2,500,000		IPA II 2014 Highly mature (the preparation of the procurement documents in progress)
	Reconstruction of dikes on River Sava - section Kopanice - Vidovice (km 9+650 to km 15+196). Dike rehabilitation, floodway rehabilitation / regulation.	5,600,000	8,100,000	IPA II 2014 Highly mature (the preparation of the procurement documents in progress)
2,678				
16,539				
12,279	Reconstruction of Sava embankment at Šamac to a total length of 1,350 m (at a distance of 850 m from the Port in Šamac, elevation necessary) and the rehabilitation of the right embankment of the River Bosna to a total length of 1.0 km. Dike rehabilitation, dike construction. 2. Reconstruction of the parapet wall on the River Sava embankment, length 622 m.[2]	4,890,000 370,000		IPA II 2014 Low level maturity
9,182				
905	Regulation of the River Tinja in the Municipality of Srebrenik (approx. 1300 m length). Dike construction, riverbed regulation, floodway rehabilitation / regulation.	1,600,000		
909				
1,025				
1,259				
1,587				
1,569	Flood protection of settlement Ekonomija from the Drina and Sapna rivers. Dike rehabilitation, channel rehabilitation, riverbed regulation. Flood protection of settlement Economical - right dike on the River Drina and River Sapna, L=3 km.	3,280,000		IPA 2014 Low level maturity

Some of the above areas have a 'blank' column "structural measures estimate". These are for areas that have various levels of structural measures in the early phase of planning, but the same were not available for the purposes of this Assessment.

The spatial positions of the areas in the table above are presented in the four figures below.

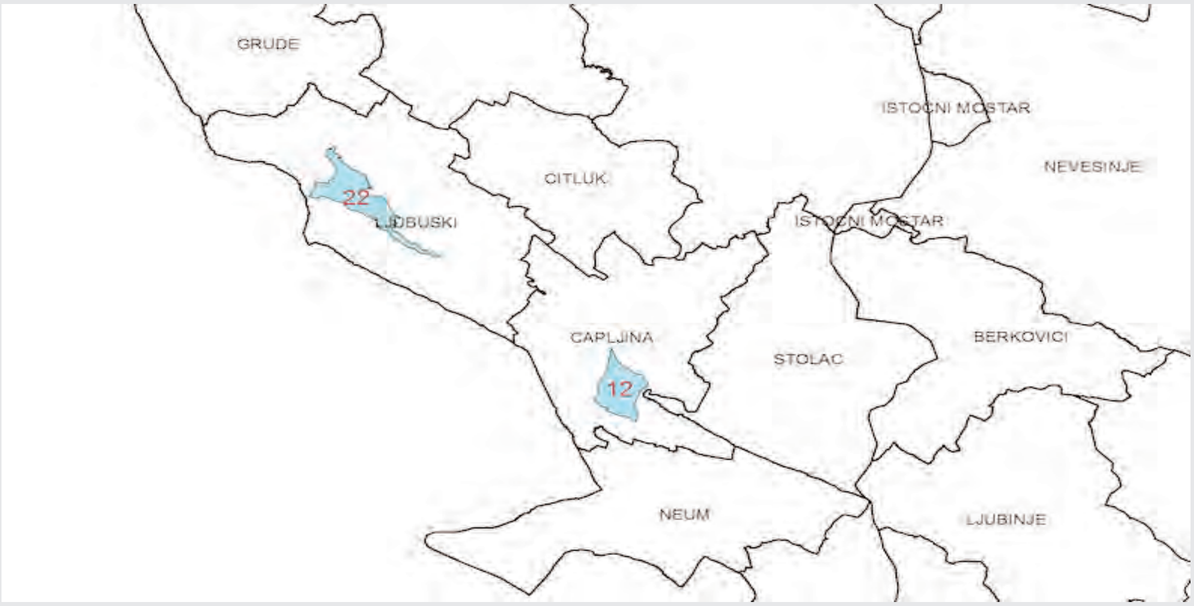


Figure 38: View of the southwest part of BiH.

Figure 39: View of the central part of BiH.

Figure 40: View of the northeast part of BiH.

Figure 41: View of the north western part of BiH.

c. Non-Structural Measures

Non-structural measures can be categorised as:

- non-physical
- physical

hysical measures include:

- planning and designing structural measures (hazard and risk maps, feasibility studies and design);
- preparedness measures;
- environmental measures;
- governmental and legislative measures; and
- financial measures.

Physical measures include:

- emergency response measures.

The flood prone areas for which non-structural measures are proposed for the time being are presented in the table below.

Table 23: Presentation of the flood prone areas for which non-structural measures are proposed.

No.	Municipality	Flood area name	Watercourse	Catchment	Return period	Households	Endangered population
2	Bihać	Bihać area	Una	Una	100	674	2,089
5	Bijeljina	SAV.MOK.P01	Majevica perimeter canal	Sava catchment area	100		
6	Bijeljina	SAV.SAV.P01	Sava	Sava catchment area	100		
7	Bijeljina	SAV.SAV.P02	Sava	Sava catchment area	100		
8	Bosanska Krupa	Krupa and Otoka	Una	Una	100	785	2,434
11	Brod	SAV.SAV.P04	Sava	Sava catchment area	100	6,575	20,383
12	Čapljina	Čapljina and Hutovo Blato area	Krupa	Neretva	100	512	1,587
14	Derventa	UKR.UKR.P02	Ukrina	Ukrina	100	2,277	7,059
15	Domaljevac-Šamac	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	1,245	3,860
16	Donji Žabar	Central Posavina	Tolisa, Leskovac, Smrdulja	Sava catchment area	100	532	1,649
19	Kalesija	Rainći Gornji	Spreča	Bosna	20	567	1,758
20	Kozarska Dubica	UNA.UNA.P02	Una	Una	100	1,028	3,187
22	Ljubuški	Hrasljani-Veljaci	Trebižat, Vrioštica, Mlade	Neretva	100	761	2,359
23	Maglaj	Maglaj	Bosna	Bosna	20	3,203	9,929
24	Modrica	Modriča area	Bosna	Bosna	100	799	2,477
25	Doboj	BOS.BOS.P03	Bosna	Bosna	100	11,986	37,157
29	Petrovo	Spreča area	Spreča, Jala	Bosna	100	864	2,678
30	Prijedor	UNA.SAN.P01	Sana	Una	100	5,335	16,539
31	Prijedor	UNA.GOM.P01	Gomjenica	Una	100		
33	Sanski Most	Sana area	Sana	Una	100	2,962	9,182
35	Tešanj	Tešanj	Trebačka river	Bosna	20	293	909
36	Tešanj	area	Usora	Bosna	100	331	1,025
37	Teslic	BOS.USR.P01	Usora	Bosna	100	406	1,259
38	Visoko	Ozrakovići	Bosna	Bosna	20	512	1,587

Planning and design of structural measures (hazard and risk maps, feasibility study and design)

These are non-physical measure that needs to be implemented as first priority in all of the above listed areas (municipalities). These measure should result in the concrete definition of adequate measures.

The first step towards proper planning of structural measures includes the preparation of floodplain mapping (flood hazard and flood risk maps), based on hydraulic modelling using a detailed DM[30] obtained through river and floodplain surveying along the stretch of river covering but also exceeding the limits of the flood hazard map (the estimated cost per area is 100,000 to 200,000 BAM).

If structural measures are to be proposed following an analysis of the results of each flood risk map then the next step will include development, design and a feasibility study. The feasibility study should prove whether or not structural measures are justified and should be carried out in order to identify the most suitable measures and to estimate the cost. The cost per area cannot be estimated at this stage but it will certainly range from millions to tens of millions of BAM per area, depending on its size, position and other conditions. The rough estimate for the remaining 24 areas, based on areas for which structural measures are already planned, is around 150 million BAM.

Preparedness Measures

Early Warning Systems (EWS) - EWS are a measure that requires full coordination and cooperation with the authorities and respective agencies at different administrative levels and units. It also requires a clear command hierarchy and delegation of responsibility. Operations (Action) Plans at different levels (BD and RS have GOP - Main Operations Plan, while the FBiH has FOP – Federal Operations Plan and 10 KOPs – cantonal operations plans) define who does what and when. Yet currently there is a considerable lack of coordination between the relevant institutions. It is essential to achieve more efficient coordination as quickly as possible since, as was clearly illustrated during the May 2014 flood event, floods do not recognise administrative borders. The existing operational plans at the local level require detailed evaluation and assessment. This can be done based on the experiences of the May 2014 flood event, where bottlenecks were identified and where room for improvement exists. A precondition for setting up EWS is the establishment of a monitoring network (meteorological and hydrological).

Flood Emergency Preparedness Plans – Local officials are encouraged to develop and maintain a flood emergency preparedness plan (FEPP) that identifies hazards and risks, based on the level of exposure and vulnerabilities, and encourages the development of local measures of mitigation. The FEPP should include the community's response to flooding, the location of evacuation centres, evacuation routes and flood recovery processes.

Evacuation Plans – These plans require detailed hydrologic analysis in order to determine the rate at which floodwaters will rise for various rainfall or snowmelt events. This measure can provide significant reduction in the loss of life and flood damage reduction benefits when used in conjunction with flood warning systems. Evacuation planning should consider vertical evacuation as well as the traditional horizontal evacuation. This measure should only be implemented when there is significant response and action time available for floodplain occupants to be evacuated. Rally points as well as evacuation routes should be thoughtfully planned and communicated to the public.

Risk Communication – This develops and uses educational tools such as presentations, workshops, hand-outs and pamphlets to communicate flood risk and flood risk reduction measures to government entities and floodplain occupants in an effort to reduce the consequences associated with flooding.

Governmental and Legislative Measures

Land Use Regulation – Such regulation is an effective tool for reducing flood risk and flood damage. The principles of this tool should be based on flood insurance programme, which requires the minimum standards for floodplain regulation. Significant numbers of structures have been identified in flood prone zones, despite entity **laws that forbid construction on floodplains with up to 1/100 year returns**. Floodplain mapping and consecutive land use zoning (planning) should discourage the construction of such structures in the future. In exceptional cases, if a certain structure has to be built on a floodplain then it should be raised above the 1/100 flood level or other proper protective measure applied.

Zoning of floodplains/floodplain mapping – This is a measure which identifies flood risk, whether in the form of a map that portrays the flood boundaries or as an inundation map illustrating the depth of flooding. This measure is a significant tool when addressing flood risk. It is probably the most urgent and the most useful measure for planning other measures (structural as well

30 Refer to acronyms

as non-structural) and is also mandatory under EU Floods Directive.

Zoning – Zoning is also beneficial in reducing flood risk. A community can determine that certain areas are too hazardous for human habitation and therefore restrict development in these locations. Other areas may be determined to be risk free. This is a long-term investment tool for alleviating flood risk.

Financial Measures

Flood insurance – This type of insurance is a worldwide recognised non-structural measure that has not yet been introduced in BiH. There are very few cases where, for example, agricultural land (crops) is insured against disasters when it is the sole decision of the owner. Flood insurance provides insurance to assist in recovery from a flood event.

According to data from the Insurance Agency of BiH,[31] property insurance (against fire, disasters and other damage to property) only accounts for about 3.5% of all insurance types. The largest portion goes on car accident insurance (44%) and life insurance (14%). Based on existing legal, institutional and policy practise in both entities and BD, the possibility to introduce such insurance should be assessed in the selected pilot areas. Based on such an assessment, recommendations on the possibilities, advantages and disadvantages should be prepared.

Physical Measures

Non-structural physical (flood proofing) measures should be proposed in order to minimise future damage in cases where structures already exist and their removal is not feasible (regardless of the reasons why).

These are permanent or contingent measures that can be applied to a structure and/or its contents in order to prevent or provide resistance to damage from flooding. Non-structural flood proofing measures focus on reducing the consequences on flooding as opposed to focusing on reducing the probability of flooding.

A more detailed list of non-structural measures can be found in the list of the US Army Corps of Engineers (USACE) and can be followed directly or with minor adjustment in BiH.

Non-structural flood proofing includes a number of physical measures.

- **Elevation** involves raising buildings in situ so that the structure experiences a reduction in the frequency and/or depth of flooding during high water events. Elevation can be done on fill, foundation walls, piers, piles, posts or columns. Selection of the appropriate elevation method depends on the flood characteristics, such as flood depth or velocity.
- **Relocation** involves moving a structure to another location away from the flood hazard. Relocation is the most dependable method of protection and provides the added benefit of use of the evacuated floodplain.
- **Buyout/Acquisition** involves the purchase and elimination of flood damageable structures, which allows the inhabitants to relocate to locations away from the flood hazard.
- **Dry flood proofing** involves sealing the walls of a building with waterproofing compounds, impermeable sheeting or other such material to prevent floodwaters from entering into damageable structures. Dry flood proofing is applicable in areas of shallow low velocity flooding.
- **Wet flood proofing** measures allow floodwater to enter a structure where vulnerable items, such as utility appliances and furnaces, are relocated or waterproofed at higher locations within the structure. By allowing floodwater to enter the structure the hydrostatic forces on the inside and outside of the structure can be equalised thus reducing the risk of structural damage.
- **Floodwalls** are freestanding structures located away from the building that prevent the encroachment of floodwater.

31 "http://www.azobih.gov.ba"

Identification of the Most Suitable Measure

With 30 years of experience of this systematic approach behind it, the US Army Corps of Engineers has developed a useful checklist of measures and means for their application in specific cases. The most suitable measure for a certain combination of factors may be found by consulting a simple checklist (see the table below).[32)]

A check list matrix, such as the one above, can be applied in the form of a questionnaire for detailed assessments in specific locations; this would result in tailor-made measures for each dwelling or group of dwellings that could be affected in a flood prone area. The following example, by USACE, illustrates the way the matrix can be used to identify the most appropriate measure.

Purpose and Intent

This quick reference guide is for use in an initial assessment of non-structural flood risk adaptive measures (FRAM). The matrix allows the user to identify potential FRAM measures for further evaluation and assessment, based on a series of responses associated with the characteristics of the flood conditions, site conditions, building conditions, potential economic conditions or recreational and/or environmental opportunities and challenges.

Directions for Use

The user should have a thorough knowledge and understanding of the aforementioned characteristics that the targeted structure could be exposed to during a flood event. The user will consider the characteristics and determine whether the targeted structure has those characteristics by responding with a 'Y' for yes or a 'N' for no. The objective is to work through as many of the specific characteristics as possible, responding to each one with either a 'Y' or 'N'. After having completed the responses, the user will then tally up all 'Y' responses for each FRAM measure. The measure with the most 'Y' responses should then be considered for additional evaluation.

Example

In this example the user has a developed knowledge of the structure and the conditions the structure would be exposed to during a flood event. The user has determined the 'Y' responses, presented in the table below, and after analysing the responses has determined that the FRAM measure - Elevation on Foundation Walls - received the most 'Y' responses and should therefore be considered for additional evaluation.

Matrix Characteristic	Assessment
Flood Depth - Shallow (less than 3 feet)	Y
Flood Velocity – Slow (less than 3 fps)	Y
Flash Flooding – Yes (less than 1 hour)	Y
Site Location – Riverine Floodplain	Y
Soil Type - Permeable	Y
Structure Foundation – Crawl Space	Y
Structure Construction – Wood	Y
Economics – Potential Flood Insurance Cost Reduction	Y
Recreational Potential	N
Social – Community Remains Intact	Y

32021.contentdm.oclc.org/cdm/ref/collection/p16021coll11/id/363>

February 2015		FLOOD DAMAGE REDUCTION MEASURES																		
		NONSTRUCTURAL MITIGATION MEASURES															STRUCTURAL MITIGATON MEASURES			
														NFIP						
FLOOD DAMAGE REDUCTION MATRIX		Elevation on Foundation Walls	Elevation on Piers	Elevation on Posts or Columns	Elevation on Piles	Elevation on Fill	Relocation	Buyout/ Acquisition	Floodwalls & Levees	Floodwalls & Levees w/ Closures	Dry Flood Proofing	Wet Flood Proofing	Flood Warning Preparedness	Flood Plain Regulation	Flood Insurance	Flood Mitigation 1	Channel	Levee/Wall	Dams	Diversions
Flooding Characteristics	**Flood Depth**																			
	Shallow (<3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Deep (greater than 6 ft)	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Flood Velocity																			
	Slow (less than 3 fps)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 5 fps)	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	Fast (greater than 5 fps)	N	N	N	Y	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	Flash Flooding																			
	Yes (less than 1 hour)	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Ice and Debris Flow																			
	Yes	N	N	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**																			
	Coastal Flood Plain																			
	Beach Front	N	N	N	Y	N	Y	Y	N	N	N	N	Y	Y	Y	Y	N	2	N	N
	Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N
	Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Soil Type																			
	Permeable	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Building Characteristics	**Structure Foundation**																			
	Slab on Grade	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Crawl Space	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Basement	Y	N	N	N	N	Y	Y	Y	Y	N	Y	Y	y	Y	Y	Y	Y	Y	Y
	Structure Construction																			
	Concrete or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Structure Condition																			
	Excellent to Good	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fair to Poor	N	N	N	N	N	N	Y	Y	Y	N	N	Y	Y	Y	3	Y	Y	Y	Y
NED/NER/Recreation/Social Characteristics	**Economic**																			
	Structure Protected	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	5	N	Y	Y	Y	Y	Y
	Cost to Implement	M	M	M	M	M	H	H	M	M	L	L	L	L	L	H/M	H	H	H	H
	Potential Flood Insurance Cost Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	-	Y	Y	Y	Y	Y
	Potential Flood Insurance Cost Reduction (Commercial)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	-	Y	Y	Y	Y	Y
	Potential Adverse Flooding Impact on Other Property	N	N	N	N	Y	N	N	Y	Y	N	N	N	Y	N	N	Y	Y	Y	Y
	Reduction in Admin Costs of NFIP	N	N	N	N	Y	Y	Y	N	N	N	N	N	6	-	3	7	7	7	7
	Reduction in Costs of Disaster Relief	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Reduction in Emergency Costs	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	3	Y	Y	Y	Y
	Reduction in Damage to Public Infrastructure	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	3	Y	Y	Y	Y
	Potential for Catastrophic Damages if Design Elevation Exceeded	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	Y	Y	N
	Promotes Flood Plain Development	N	N	N	N	N	N	N	N	N	N	N	N	N	8	N	Y	Y	Y	Y
	Environmental																			
	Ecosystem Restoration Possible	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
	Potential Adverse Environmental Impact	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y
	Recreation																			
	Recreation Potential	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	3	N	N	Y	N
	Social																			
	Community Remains Intact	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	4	Y	Y	Y	Y
	Population Protected	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	3	Y	Y	Y	Y
	Potential Structure Marketability Increase	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	5	N	Y	Y	Y	Y	Y

1 NFIP Flood Mitigation may vary but it is usually buyout/ acquisition or elevation
2 Not generally recommended
3 Buyout/acquisition only
4 Elevation only
5 Post FIRM construction only
6 Post FIRM structures elevation on fill
7 Yes, if project provides 100 year or greater protection
8 Yes, if in flood plains less frequent than the 100-year

Y-Yes
N-No
L-Low
M-Med
H-High

2. MEASURES FOR LANDSLIDE RISK ASSESSMENT FOR THE HOUSING SECTOR[33]

Many ongoing activities are still being carried out at different levels by various actors regarding landslide risk management in BiH. The project 'Landslide Disaster Risk Management in BiH' will strengthen the landslide management capacity of local government partners through tailored technical assistance, training and improvement of the cadastres. The project will also conduct a stabilisation of landslide areas in the target localities.

The project works directly with the responsible entity institutions within nine selected local The project is funded by the Government of Japan in partnership with the United Nations Development Programme (UNDP) in BiH.

In this context, it was concluded that the best way forward for coordination was to instigate a two-stage process. The first stage includes the preparation/updating of a landslide inventory (prior to and after the events of May 2014) and related landslide management activities. This should be carried out by state institutions and the Geological Survey of the FBiH and the Geological Survey of RS or with strong support from experienced experts from both surveys. In this respect, it is essential to produce large scale multitemporal landslide inventories and to use them for in-depth hazard analysis; this is the only way to actually learn from catastrophes and to better involve and prepare local community decision makers and civil protection offices for such occasions in the future. The second stage, which will be based on the inventory/mapping, will include a detailed analysis aimed at identifying priority areas/locations for structural measures to possibly be implemented based on a cost-benefit analysis and agreement by the relevant stakeholders at the regional/municipal level.

The measures proposed in this document relate to preventive non-structural measures and a summary of possible structural measures.

33 References

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a. Non-Structural Measures

Non-structural measures include several preventive activities to be implemented both prior to and after the occurrence of landslides as part of land use and urban planning, emergency response for civil protection, on-site Early Warning Systems at specific locations, capacity building, education, guidelines for safer housing practices and emergency exercises. This means that it is necessary to harmonise all legislation in BiH (FBiH, RS and BD) concerning geological research. Dislocation of houses, as one of the measures should be proposed after detail cost benefit analysis for landslide in question.

1. PREVENTATIVE ACTIVITIES

Landslide Zoning Maps

Landslide zoning can be performed by preparing different maps that, according to the type of zoning, can be classified into different categories:

- landslide inventory maps,
- landslide susceptibility zoning maps,
- landslide hazard zoning maps, and
- landslide risk zoning maps.

Within the framework of landslide risk management, landslide zoning maps can be intended for different purposes:[34] information, advisory, statutory or design. Considering the number of stakeholders involved in landslide risk management (owners, occupiers, affected public, regulatory authorities, geotechnical professionals and risk analysts) and the different extent of the areas to be zoned, landslide zoning maps must be prepared at an appropriate scale. The current practice in Europe[35] shows that the scale of landslide zoning maps required by state or local authorities varies significantly from country to country. This depends on the coverage, input data and methods that are used as well as the information provided (qualitative or quantitative). The scale of work constrains the type of map.

As a consequence, the approach to susceptibility, hazards and risk management as non-structural measure in BiH is based on a number of assumptions.

1) **Landslide zoning maps** at a state scale (informative level) are created to provide a general overview of problem areas for the entire country. The result of the project 'Development of Flood and Landslide Risk Assessment for the Housing Sector in BiH' provides such a general overview through the Landslide Susceptibility Map and Landslide Risk Assessment Map for the whole of BiH at a scale of 1:100 000. This can be used to inform policy makers and the general public as well as to specify and plan early warning systems controlled by the central authorities (Council of Ministers of BiH). It should be supported by the State Action Plan for Disaster Reduction in BiH, in accordance with the Sendai 2015 framework for Priority Action.

2) **Landslide zoning maps** at a regional scale (advisory level) are typically suited to the activities of planners during the early phases of regional development projects or for engineers evaluating possible constraints that may arise in the development of large engineering projects or regional development plans as a result of instability. Such work may also be used to specify and plan warning systems and urban emergency plans at a regional level. Regional and entity/District (FBiH, RS and BD) scale work can be performed in the next phase of the landslide risk management procedure. Regional entity/District scale of work should be done at a scale of 1: 25 000 and can be prepared and improved using more detailed analysis according to data received from the geological surveys and civil protection units at the entity/District level. This should be supported by improvement and amendment to the Law on Spatial Planning and Construction in RS (Official Gazette of RS, 40/13), the Law on Spatial Planning and Land Use in the FBiH (Official Gazette of FBiH, 02/06, 72/07, 32/08, 4/10, 13/10 and 45/10) along with the cantonal laws on urban planning in the FBiH and the Law on Spatial Planning and Construction in BD (Official Gazette of BD of BiH, 29/08).

3) **The municipal level (statutory)** typically uses local scale for statutory purposes (zoning maps can be legally binding for public administrations and land users) and it is the reference scale used when planning and implementing urban development, warning systems and emergency plans at the local level. Moreover, this scale is required to rank areas most at risk and to prioritise those requiring mitigation works aimed at reducing the risk to property. Local scale maps should be made at a scale of 1:5000 and have sufficient resolution to support Quantitative Landslide Risk Analysis (QLRA); however, they are very sensitive to the quality of the input data.

34 R. Fell, et al., JTC-1, *Guidelines for Landslide Susceptibility, Hazard and Risk Zoning for Land use Planning, Engineering Geology* 102, 2008, pp. 85-111.
35 See Corominas et al. 2010

The project 'Landslide Disaster Risk Management in BiH' selected nine municipalities for updating the landslide inventories: Doboj (RS), Goražde (FBiH), Maglaj (FBiH), Srebrenik (FBiH), Tuzla (FBiH), Vogošća (FBiH), Zenica (FBiH), Zvornik (RS) and Žepče (FBiH). This represents the first step in implementation of the Landslide Risk Assessment and Management procedure at the municipal level. These municipalities are ranked as High Landslide Susceptibility areas as a result of landslide susceptibility analysis for BiH. The next step should be a revision of the Land Use Plans for these municipalities and strong constraints for design and work activities in areas of High Landslide Risk. Additionally, housing sector and infrastructure data should be more detailed as should population data (dasymetirc data). The same procedure should be prioritised in the remaining municipalities shown in the table below, as a result of the landslide susceptibility analysis and simple analysis of the number of landslides per municipality done for the PRLA for BiH.

Table 24: 15 municipalities in BiH according to the high landslide susceptibility risk.

No	Name	Entity	Area (km²)	Very low landslide susceptibility (km²)	Low landslide susceptibility (km²)	Medium landslide susceptibility (km²)	High landslide susceptibility (km²)
1	Doboj	RS	656.33	85.63	256.88	166.01	147.78
2	Foca - RS	RS	1118.4	0.53	613.18	384.74	116.94
3	Modrica	RS	326.73	93.00	36.08	90.33	107.29
4	Kalinovik	RS	679.5	0.40	412.16	206.77	60.15
5	Prijedor	RS	834.07	137.50	494.13	148.73	53.69
6	Gradacac	FBiH	215.25	25.26	86.97	59.85	43.15
7	Gracanica	FBiH	215.33	16.89	71.48	87.39	39.55
8	Prnjavor	RS	629.99	75.73	225.77	289.02	39.45
9	Derventa	RS	516.6	63.39	260.07	157.03	35.94
10	Banja Luka	RS	1238.89	35.00	844.53	323.43	35.91
11	Višegrad	RS	449.06	3.09	288.29	121.90	34.82
12	Lopare	RS	297.86	24.20	43.81	195.03	34.79
13	Gradiška	RS	761.62	351.89	283.05	94.21	31.28
14	Zavidovici	FBiH	555.69	4.20	327.36	193.41	30.71
15	Olovo	FBiH	409.32	0.28	302.54	75.90	30.57

As result of the Landslide Risk Assessment for the Housing Sector in BiH prioritisation for the next municipalities should be as shown in the table below.

Table 25: 15 municipalities in BiH according the high landslide risk.

No	Name	Area (km²)	Entity	High landslide risk (km²)	Medium landslide risk (km²)	Low landslide risk (km²)	Very low landslide risk (km²)
1	TUZLA	295.86	FBiH	7.18	7.64	8.78	272.24
2	CENTAR SARAJEVO	32.92	FBiH	5.57	0.24	1.02	26.07
3	KLADANJ	335.64	FBiH	3.98	2.92	1.78	326.94
4	NOVI GRAD SARAJEVO	47.31	FBiH	3.93	4.29	1.52	37.54
5	MOSTAR	1,164.95	FBiH	3.91	8.83	15570009.81	1136.63
6	STARI GRAD SARAJEVO	49.46	FBiH	3.04	1.60	1.17	43.63
7	ZENICA	550.41	FBiH	2.64	6.07	4.61	537.07
8	VOGOSCA	71.69	FBiH	2.50	0.96	1.47	66.74
9	KAKANJ	376.98	FBiH	2.46	2.48	5.39	366.63
10	SIPOVO	549.97	RS	1.88	0.13	0.86	547.07
11	BANJA LUKA	1,238.89	RS	1.80	12.90	15.30	0
12	NOVO SARAJEVO	9.2	FBiH	1.62	3.15	1.09	3.31
13	SREBRENIK	247.93	FBiH	1.27	2.71	3.54	240.39
14	GORAZDE	253.6	FBiH	1.19	1.81	2.33	248.25
15	GRADACAC	215.25	FBiH	1.18	5.34	4.77	203.93

All activities should be supported by improvement or amendment to the Law on Spatial Planning and Construction in RS (Official Gazette of RS, 40/13), the Law on Spatial Planning and Land Use in the FBiH (Official Gazette of FBiH, 02/06, 72/07, 32/08, 4/10, 13/10 and 45/10) along with the cantonal laws on urban planning and the Law on Spatial Planning and Construction in BD (Official Gazette of BD of BiH, 29/08).

It is necessary to introduce the legal mandatory obligation for local authorities/municipalities to develop and adopt regulation plans using an integrated approach to planning for all mapped areas prone to landslides or according to the landslide susceptibility/hazard/risk maps.

4) **The site specific zoning map** (design level) typically uses a scale from 1:200 to 1: 1000 depending on the level of design (feasibility, preliminary design etc.) and can be used for statutory purposes. It is the only one that can be adopted at the level of site investigation prior to the design phase of stabilisation works. They are an obligatory part of the design phase for remedial measures. As a part of the geotechnical documentation they must be the result of geotechnical site investigation and followed by laboratory geomechanical testing.

Early Warning Systems

The concept of Early Warning Systems (EWS) is a part of geotechnical monitoring of slope instability methods and should be performed after a detail site specific geotechnical investigation. It is a tailor-made system of several monitoring methods for active landslides (including all types of landslide, rock fall and debris flow). Active real time monitoring techniques and systems are usually very expensive and should be designed, performed and maintained by very experienced practitioners. It is expected that the concept of EWS is well connected to the municipal civil protection unit for the housing sector. If an EWS were designed for regional infrastructure facilities (such as roads, railways, pipelines etc.) then it should be strongly supported at the entity/District (FBiH, RS and BD) or cantonal level (FBiH). Unfortunately, it is not possible to provide any recommendations for EWS for the housing sector in BiH at this moment.

Education and Capacity Building

Education and capacity building for municipal authorities and local communities regarding landslides and other instability issues are crucial for the application of the Law. It should be organised by the Chamber of Engineers in the entities, the geological surveys and universities as well as civil protection units. It is important to improve overall community knowledge and preparedness on natural hazards and climate change.

Guidelines for Safer Housing Sector Practice

One of the best ways to increase awareness amongst the population and local authorities on building in landslide prone areas is to provide them with simple guidelines for housing practice, especially in rural and sub-urban areas. The Australian 'GeoGuides for Slope Management and Maintenance' AGS 2007e and the 'Introduction to Landslide Stabilisation and Mitigation, Appendix C (USGS)', are very illustrative and useful examples for local administrations and other stakeholders.

Improvement of the Legislation

It is necessary to include the legal obligation for local communities (cities/municipalities) to use the data obtained from both the geological surveys when developing the land use/urban planning documents. Land use and urban planning documents have to be additionally reviewed after the events of May 2014 for all municipalities with areas of high and medium landslide susceptibility and risk.

In regard to construction activities it is necessary to implement a number of activities:

- Introduce mandatory geotechnical surveys prior to the design and construction of facilities listed under Article 7 of the Law on Geological Surveys (Official Gazette of the RS 110/13).
- Develop the landslide risk and early warning systems programme, specifically in local communities, and strengthen cooperation between local and state authorities. This activity must be accompanied by adequate local capacity building and education activities.
- Introduce recovery and remedial development measures in the areas prone to landslide reactivation, especially in populated areas and in zones where main infrastructure facilities are situated.
- Comply with the Law on Geological Surveys of the FBiH (Official Gazette FBiH 9/10 and 14/10) that stipulates measures and obligations to be undertaken in compliance with the geological surveys prior construction activities.
- Comply with the Law on Spatial Planning and Construction (Official Gazette RS 40/13).
- Comply with the Law on Spatial Planning and Land Use in the FBiH (Official Gazette of FBiH, 02/06, 72/07, 32/08, 4/10, 13/10 and 45/10).
- Comply with the Rulebook on Geotechnical surveys and Testing and Organisation and Content of Geotechnical Engineering Missions (Official Gazette FBiH 60/09).

b. Structural Measures

It was very difficult (or not technically possible), considering the scale of the PRLA, to make suggestions for functional structural measures for the housing sector for the entire territory of BiH. The scale of the PRLA was only informative, since further more detailed analysis was required if structural measures were to be proposed for every single area/location. The only site specific zoning map scale that can be used for statutory design purposes and it is the only one that can be adopted at the level of site investigation prior to the design phase of stabilisation works.[36] The second reason for this engineering approach relates to the quality of the landslide data used in the PRLA for BiH: most of the basic landslide data was omitted (> 75%), except for the location of landslides (point data). In terms of structural measures this kind of 'point like' information was useless for planning, cost-benefit analysis and making recommendations on appropriate remedial measures for site specific areas/locations.

Structural measures generally focus on reducing the consequences of landslide occurrences and are strongly dependant on the landslide mechanisms and material involved, the causative and trigger factors, the mechanical properties of the landslide material and bedrock, the stage of activity etc. They could be implemented during the pre-failure stage (i.e. marginally stable slopes, with a factor of safety close to 1). Yet to be effective one must first identify the most important controlling process affecting the stability of the slope and second one must determine the appropriate technique to be applied in sufficient force in order to reduce the influence of that process. The remedial measures must be designed to fit the condition of the specific slope under study.

This would entail a number of indicative levels of study and activity:

- **reconnaissance** to establish the broad topography, evidence of past instability and geology on a regional scale or as a screening process to aid in determining the scope of subsequent studies;
- **walk-over/mapping** to establish the site or area specific topography and detailed observation of relevant features, such as outcrops, topographic form and evidence of past instability, while some initial subsurface investigation may also be required;
- **preliminary design** to provide sufficient data to enable the concept design to be selected from possible alternatives based on the risk management requirements;
- **detailed design** to enable the design of risk control measures to be optimised in order to sufficiently remove any uncertainty over the design and ensure that its suitability; and
- **construction** to confirm the design assumptions and allow for sufficient modification to the design in order to address any departures from the assumed geotechnical model.

36 See Soeters and van Westen 1996

Not all levels of study will be applicable for every project. For example, in some cases completion of a walk-over investigation may be sufficient to allow for a detailed design to be completed satisfactorily (such as for shallow landslides). Investigations for more complex projects may be completed in stages (for different levels) to allow for the geotechnical model to be progressively refined and any uncertainties reduced. The levels of study form a continuum and furthermore the scope will vary from project to project. Some remedial measures are very expensive and require a significant amount of time to implement. Some do not, but most slope engineering techniques require a detailed geotechnical investigation and analysis of the soil properties and a thorough knowledge of the soil and rock mechanics.

The suggestion on the applicability of various methods of investigation is given in AGS 2007d[37] for different types of slopes.

Table 26: Application of site investigation methods for slope classes (Fell et al., 2000)

SITE INVESTIGATION METHOD	NATURAL SLOPES			CONSTRUCTED SLOPES				
	Small/ Shallow	Medium	Large	Existing Cut	Existing Fill	New Cut	New Fill	Soft Clay
Topographic mapping and survey	A	A	A	A	A	A	A	A
Regional geology	A	A	A	A	A	A	A	A
Geological mapping of project area	B	B	A	A	B	A	B	C
Geomorphological mapping	A	A	A	B	B	B	B	D
Satellite imagery interpretation	D	D	C	D	D	D	D	D
Air photograph interpretation	A	B	A	C	C	C	C	C
Historic record	A	B	B	A	B	B(2)	B(2)	B(2)
Dating past movements	B	C	B	D	D	D	D	D
Geophysical methods	C	C	B	C	C	C	D	C
Trenches and pits	B	A	B	B	B	B	B	C
Drilling/boring	C	A	A	C	B	B	B	A
Downhole inspection	C	B	B	C	D	C	D	D
Shafts and tunnels	D	C	B	D	D	D	D	D
Insitu testing of strength and permeability	C(3)	C(3)	C(4)	D	B(3)	C	C	A(3)
Strength and permeability monitoring pore pressures, rainfall, etc	C	A	A	A	A	C	C	A(5)
Monitoring of displacements	C	B	A	B	B	B(5)	C(5)	A(5)
Laboratory testing	C	A	B	B	B	B	C	A
Back analysis of stability	C	B	A	C	B	B(2)	C(2)	C(2)

NOTES: (1) A – Strongly applicable, B – Applicable, C – May be applicable, D – Seldom applicable.
(2) In similar areas.
(3) SPT, CPT, CPTU.
(4) Permeability.
(5) During construction.

The following flow chart provides a very general introduction to the basic principles and techniques that can be used for landslide stabilisation and mitigation. The factor of safety (FS) of a slope is the ratio of the resisting forces (F_r) to the driving forces (F_d). If the factor of safety is less than or equal to 1 (i.e. $FS \leq 1$) then the slope is or will fail because the driving forces will equal or exceed the resisting forces. If FS is significantly greater than 1 then the slope will remain quite stable. However, if FS is only slightly greater than 1 any small disturbance may cause the slope to fail (marginally stable slope). For example, if FS = 2 then the slope has resisting forces that are twice as large as the driving forces and will therefore remain extremely stable. If, on the other hand, FS = 1.05 then the strength of the slope is only 5% greater than the driving forces and consequently any slight undercutting, steepening, very heavy rainfall or seismic activity can easily cause it to fail.

37 See Table C2, Fell et al., 2000

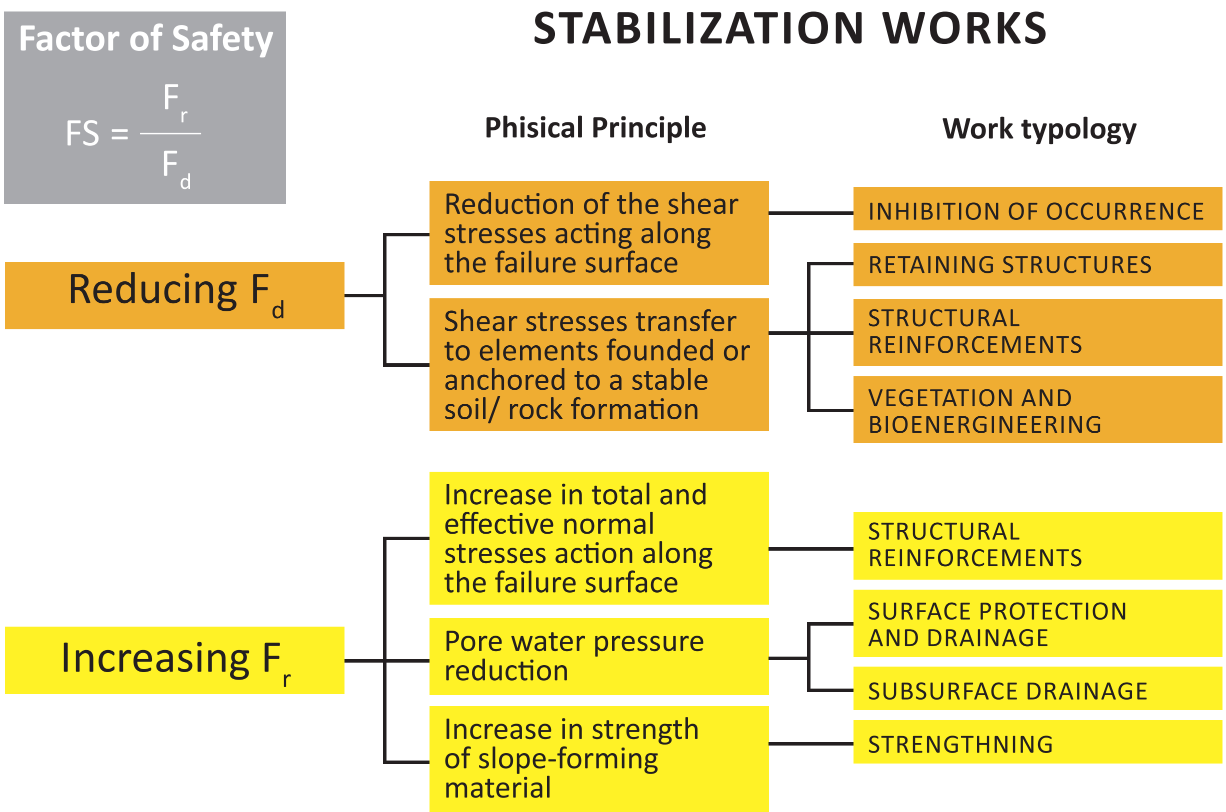


Figure 42: The basic principles of stabilisation works design - physical and work technology principles.

Information relevant to the types of structural measures can be found in the 'The Australian GeoGuides for Slope Management and Maintenance' AGS 2007e, the 'Introduction to Landslide Stabilisation and Mitigation', Appendix C USGS and in many other geotechnical books.

A brief summary of structural measures at the site specific level is given below.

Water, Drainage and Surface Protection

Water (ground and surface water) usually plays a critical part in initiating a landslide[38] and it is for this reason that it is a key factor in limiting the effect of water. Groundwater is likely to rise after heavy rain, but can also rise when human interference upsets the delicate natural balance. Inappropriate disposal of effluent and wastewater may result in the ground becoming saturated. The result is equivalent to a localised rise in the groundwater table and may have the potential to cause a landslide. The techniques listed below could be considered to limit the destabilising effects of rising groundwater as a result of development.

Surface water drains (dish drains or table drains) are often used to prevent scour and limit inflow to a slope.

Surface protection is sometimes used in addition to surface water drainage in order to prevent scour and minimise water inflow to a slope.

Sub-soil drains are often constructed behind retaining walls and on hillsides to intercept groundwater. Their function is to remove water from the ground through an appropriate outlet.

Deep, underground drains are usually only used in extreme circumstances when the landslide risk is assessed as beyond tolerance and other stabilisation measures are considered to be impractical. They work by permanently lowering the water table in a slope.

38 Guidelines for Landslide Risk Management, *Australian Geomechanics*, Vol 42 No 1, March 2007. Practice Note, 2007, AGS (2007c).

Retaining Walls

Retaining walls are used to support cuts and fills. Retaining walls have to withstand the weight of the ground on the high side, any water pressure forces that develop additional load (surcharge) on the ground surface and sometimes swelling pressures from expansive clays.

Gravity walls are so-called because they rely on their own weight (the force of gravity) to hold the ground behind in place.

Formed concrete and reinforced blockwork walls should be built so that the backfill can drain.
Concrete 'crib' walls should be filled with clean gravel or 'blue metal' with a nominated grading.
Masonry walls (natural stone, brick or interlocking blocks) of more than about 1m in height should be wider at the bottom than at the top and include specific measures to permit drainage from the backfill.

Flattening or reducing the slope angle or other slope modification reduces the weight of material and reduces the possibility of stream/river undercutting and construction loading.

Benches are a series of 'steps' cut into a deep soil or rock face for the purpose of reducing the driving forces.

Removal of soil from the head of a slide is a method that reduces the driving force and thereby improves stability.

Reducing the height of the slope of a cut bank reduces the driving force on the failure plane by reducing the weight of the soil mass; this commonly involves the creation of an access road above the main road and the forming of a lower slope through excavation.

In BiH structural measures can be implemented following the second stage, namely after inventory/mapping, detailed analysis and identification of priority areas/locations. It should be agreed by the relevant stakeholders at the entity/municipal level. The PRLA for BiH targeted the housing sector and the structural measures proposed and applied within the frame of the project 'Landslide Disaster Risk Management in BiH' should be extended to the municipalities.

3. PHYSICAL PLANNING AND DEVELOPMENT MEASURES

Measures in the field of spatial planning are by nature non-structural and preventive. By creating different types of spatial and urban planning documents (strategic and detailed plans) and their implementation the negative effects of floods and landslides in the housing sector in BiH can be greatly decreased. The existing legal framework in the field of spatial planning in BiH (at the entity, cantonal and BD level) provides a good basis for reducing the risk of floods and landslides in relation to the housing fund. By consistent implementation of legislation and preparation of compulsory spatial planning documents (required by law), which amongst other things define the use of the space, as well their implementation floods and landslides would certainly represent a lesser risk to the housing sector in BiH. This risk would be further reduced through changes to the legislation in the field of spatial planning in the direction of changing the methodological framework (regulations on the content of spatial planning documents), the introduction of financial instruments (cost-benefit analysis of the legalisation on residential buildings in risk areas), strengthening the control mechanisms (more frequent inspections at the local government level) and tightening the penal policy (illegal housing construction as a criminal offense).

The planning and development of space comprises a set of activities aimed at determining the use, organisation, regulation and protection of space through the development of plans and monitoring their implementation. In this way (planned development) creates favourable conditions for life, work and human health and the long-term management of natural resources. Spatial planning is based on an integrated approach (integrated planning) that combines all important factors of development to ensure that changes in the space resolve any conflicts within the space. The issue of vulnerable areas such as flood plains, landslides and the issue of climate change constitute an integral part of an integrated approach to planning.

Housing is an important function within a space and is therefore subject to spatial planning and protection in terms of disasters such as floods and landslides. Housing development is generally prohibited outside the zones defined by spatial planning documents (urban areas, building land/zones, residential zones, residential commercial zones, etc.). The spatial plans of local government units are the most important type of spatial plans in terms of regulating housing construction within the territory of BiH. The following table shows the coverage of the territory of BiH by local government unit spatial plans (municipalities and cities).

Table 27: Coverage of the territory of BiH by adopted local government unit (LGU) spatial plans for the period 1996–2015.

Entity/district	Number of local governments with adopted spatial plans LGU	Total Number of local governments	%
Federation of BiH	30	80	37.50
Republika Srpska	19	64	29.69
Brčko District	1	1	100
TOTAL	50	145	34.48

The legislative framework that regulates the preparation of spatial planning documents and their implementation is of great importance in this respect.

a. Overview of Spatial Planning Legislation in BiH

Spatial planning in BiH comes under the exclusive constitutional competence of the entities and cantons, while BD has full competence over spatial planning within its territory. Due to this division of responsibility the relevant laws and regulations are adopted by the entities and cantons. It should be noted that competence over spatial planning in the FBiH is divided between the entity and the cantonal level.

Republika Srpska

The Law on Spatial Planning and Construction (Official Gazette of RS, 40/13) governs spatial planning in RS. It should be noted that the preceding laws failed to cover the phenomenon of climate change and adaptation measures. Only Article 11 of the Law of May 2013, under the general principles of spatial planning, states that, "appreciation of climate change is valid" (the third principle - "harmonisation of natural values with human activity").[39]

Article 14 of the aforementioned law also defines the areas of natural risk as affected areas recognised by their natural characteristics, such as floodplains, landslides, avalanches, earthquakes etc. The section of the Law that governs the legalisation of buildings (Article 154) states that, "for buildings constructed, reconstructed or upgraded without a building permit the subsequent building permit cannot be granted if the building was built on land unsuitable for construction, such as landslide, swampy land, land exposed to floods and other disasters, etc.".

Article 7 of the Rulebook on the Method of Drafting, Content and Development of Spatial Planning Documents (Official Gazette of RS, 69/13) specifies principles similar to those of the Law (taking into account climate change and protection from disasters and technical failures). Under the rulebook, natural risk zones (seismic risk areas, landslide zones, flood areas, etc.) must constitute an integral part of the textual and graphical sections of spatial planning documents.

39 Article 11 states that spatial planning, amongst others, is based on the following principles: harmonisation of natural values with human activity (use of renewable energy sources, construction of energy efficient buildings, proper selection of the location and the inclusion of bioclimatic factors, taking into account climate change, protection from earthquakes and other disasters or technical failures, etc.).

Federation of Bosnia and Herzegovina

According to the 1994 Constitution of the FBiH, competence over spatial planning is divided between the federal and cantonal levels. Exclusive competence of the FBiH is referred to in the third chapter of the Constitution where it states "planning and reconstruction and land use policy at the federal level"; the cantons have exclusive competence over, inter alia, the adoption of regulations on the use of local land, including zoning.

Since the constitutional provisions are not clear with regard to the competence over spatial planning in legal practice it resulted in the adoption of the 'umbrella' Law on Spatial Planning and Land Use in the FBiH (Official Gazette of FBiH, 02/06, 72/07, 32/08, 4/10, 13/10 and 45/10) and the cantonal laws on urban planning. The laws refer to particularly vulnerable areas (flood areas, barren land and landslide areas) yet there is no reference to climate change and the need for adaptation measures. However, over the past two years four cantons have adopted the new laws (West Herzegovina Canton, Zenica-Doboj Canton, Central Bosnia Canton and Livno Canton/Canton 10).

In the section covering urban plans and detailed plans in the Federal Decree on a Single Methodology (in the FBiH) for the preparation of planning documents, which was adopted in 2006 and 2007 (at the cantonal level), it states that analysis of the restrictions in the area (landslide, flood areas, areas of soil subsidence, etc.) constitutes an integral part of the document. However, this Decree makes no reference to the necessity for spatial planning documents to include climate change and climate adaptation measures in textual and/or graphic sections.

Brčko District

The Law on Spatial Planning and Construction (Official Gazette of BD, 29/08) governs spatial planning in BD. This Law is very similar to the Law on Spatial Planning and Construction in RS.

The section of the Law covering the development of spatial plans makes references to measures for the rehabilitation of devastated areas, landslide and flood areas; however, no reference is made to climate change and the necessity of adaptation measures. It should be noted that the Government of BD has not adopted Rulebook on the Method of Drafting, Content and Adoption of Spatial Planning Documents. Therefore no official methodology for the development of spatial planning documents exists in the District.

b. Non-Structural Measures

Overall, the existing legal framework in the field of spatial planning in BiH provides a good basis for reducing the risk of floods and landslides in relation to the housing sector. However, the problem of a lack of implementation and violations (non-compliance) of spatial planning documents should be emphasised in particular. This illegal practise means that there is an absence of the necessary protective infrastructure facilities and the continuation of illegal housing construction in restricted areas (flooded areas and landslide area). In this respect, the Law in the RS even emphasizes that, "for the subsequent buildings that are constructed or reconstructed or upgraded without a building permit the building permit cannot be granted if the structures were built on land unsuitable for construction, such as landslide, swampy land, land exposed to floods and other disasters, etc.".

According to the BiH water laws, it is explicitly forbidden to build any structure in flood prone areas (1/100), except for facilities which serve to protect people and goods from floods. However, a significant number of structures have been identified. It was impossible to identify illegal buildings because even the local government bodies had no statistical data on illegal building. It should be noted that building permits were obtained for a certain number of structures in these zones based on the premise that the structures would be built in line with the detailed plans (regulations and allotment plans). These plans envisaged the construction of different flood protection engineering structures in the vicinity of the houses; however, this was not how the plans were executed in reality.

The risk of flooding and landslides to the housing sector could be reduced through amendment of the legislation in the field of spatial planning. These changes should encompass the methodological framework (regulations on the content of spatial planning documents), the introduction of financial instruments (cost-benefit analysis of the legalisation of residential buildings in risk areas), strengthening the control mechanisms (more frequent inspections at the local government level) and tightening policy on penalties (illegal housing construction as a criminal offense).

In this respect there are a number of key recommendations (measures) that should be followed.

- The mandatory obligation to prepare risk maps for areas/zones exposed to the risk of flooding and/or landslides in the Rulebook on the Method of Drafting, Content and Development of Spatial Planning Documents in RS and the Federal Decree on a Single Methodology in the FBiH. This is because these regulations define the content of spatial planning documents in RS and the FBiH. The future rulebook of BD should also define this obligation to prepare these maps.
- Tighten the sanctions and introduce additional mechanisms (the dissolution of local authorities or making plans at the expense of local budgets) for the failure to adopt mandatory strategic spatial planning documents at the local level (local government land use plans and urban plans).
- Increase the frequency of inspection supervision for implementation (at least once a year) of regulation plans in areas at risk of flooding and landslides (resulting in the prevention of housing construction prior to the construction of the necessary planned protective infrastructure).
- Introduce cost-benefit analysis for the legalisation of illegally constructed residential buildings in areas at risk of flooding and landslides (resulting in the removal of the population or protection of risk areas).
- Introduce mandatory geomechanical soil testing for all planned residential buildings in areas at risk of landslide, regardless of their gross building area.
- Introduce/tighten sanctions against the illegal construction of residential buildings in areas at risk of flooding and landslides (imprisonment of 2 to 3 years along with the fine).

The time frame for the proposed changes above to the legislation would be one year in the case of recommendation No. 2 and three years for the other recommendations.

However, there are a number of non-structural measures in the field of spatial planning that do not necessarily imply change to the existing legislation and which can be applied as of now:

- Create or take from other sources risk maps of areas/zones exposed to the risk of flooding and/or landslide during the preparation of strategic spatial planning documents.
- Use an integrated approach when preparing spatial planning documents for areas at risk of flooding and landslide, especially in the preparation of regulation plans.
- Instigate inspection control for implementation of detailed spatial planning documents.
- Implement the existing prohibition over construction of residential buildings in zones of one-century water (1/100).
- Prohibit the legalisation of illegally constructed residential buildings that are located in areas at risk from flooding and landslide.
- Prohibit the connecting of illegally constructed residential buildings located in areas at risk from flooding and landslide to public utility networks.
- Instigate sanctions against illegal housing construction in areas at risk of flooding and landslide according to the most severe penalties defined in the existing laws.
- Demolish illegally constructed residential buildings that are located in areas at risk from flooding and landslide.

Most of these measures should be implemented at the local government level (municipality), since residential construction comes primarily under the jurisdiction of local government.

8. RISK INFORMATION SYSTEM

a. Introduction

All institutions recognised as stakeholders for this Assessment have developed or are in the process of developing information systems, to a larger or a lesser extent. Therefore, a water information system is in place in all water sector bodies. Its development began in 2004. Some of the modules (water use, water protection etc.) were developed gradually. In the urban planning sector, all relevant ministries and authorities have their own databases. The geology sector also has its own databases.

Geodetic administrations in all of the entities are the holders of the Infrastructure of Geospatial Data (IGSD), which is the most important spatial information system at the entity level.

Infrastructure of geospatial data relates to digital spatial data and spatial data services corresponding to the territory of an entity under the competence of

- bodies and organisations of the entity administration,
- bodies and organisations of the cantonal administration (in FBiH),
- local government bodies,
- public companies,
- legal entities entrusted with the management of spatial data, and
- legal entities that use information and services covered by the IGSD and provide public services on the basis of the spatial data.

However, data on human activity within this space should be stored in one place and there are legal prerequisites that enable this. This Assessment has produced much data on housing, water management, geology, land use and other sectors that are interrelated and may have an impact or be influenced by an impact of one of the risks (floods –landslide or both simultaneously); this was the case with the events of May 2014.

In some cases, data sources were paper documents and thus the data produced has additional value.

b. Information on the Legal Framework for the Geodatabase in Republika Srpska

The Law on Spatial Planning and Construction (Official Gazette of RS, 40/13) and bylaws of RS require the establishment of spatial planning and a development information system. Physical planning documents are produced in digital format (CAD or GIS) in accordance with a special regulation on the methodology of data collection for a uniform spatial information system. The Law also specifies that the Ministry of Spatial Planning, Civil Engineering and Ecology of RS controls and coordinates the process of the establishment and maintenance of a uniform spatial information system at the entity level (USIS). The Rulebook on the Content and the Methodology of Data Collection and Processing has been adopted (Official Gazette of RS, 95/13). This Rulebook defines the content and methodology of data collection and processing as well as the monotype forms that keep track of the data at all levels of spatial planning in RS.

The USIS is established for the collection, rational use and processing of data that is relevant to spatial planning, land use and environmental protection. USIS is established and maintained in compliance with Directive 2007/2/EC of the European Parliament and the Council for Spatial Information Infrastructure (INSPIRE).

The content and structure of the spatial information system incorporates

- data on physical/spatial planning documents of the RS,
- data on local government physical/spatial planning documents,
- satellite photographs of the area of RS and aerophotogrammetric photographs,
- statistical, cartographic, analytical and planning data,
- infrastructure data,
- data on economic resources,
- data on construction land,
- information about architectural and natural heritage,
- data on illegal construction,
- information on the endangered areas (landslides, flood areas),
- data on completed geotechnical and other research works,
- a register of polluters,
- personnel data and institutions within the spatial planning sector,
- a registry of issued building permits and usage permits for facilities,
- a registry of licenses issued to individuals and legal entities,
- a registry of energy performance certificates in the building sector, and

- other information relevant to physical planning in RS and for the operation and maintenance of USIS.

The metadata records are stored and maintained by USIS.

Data is recorded in formats that allow for sharing and exchange between various software platforms. Vector data should meet the INSPIRE Directive rules and international standards for spatial information and metadata collection, such as ISO standard 19101-2005, Geographic information - reference black level model, CDS (Catalogue of Data Sources), CEN/TC 287 etc. For raster data the *.geotif format is provided (with a resolution of at least 300 dpi for full colour), while for text data the formats doc or pdf are required. An attribute table that is linked to graphics should be created in a database application or another application that allows conversion into dbf format. Vector data is recorded in various layers, depending on the theme and geometry. All of the mentioned data is recorded in defined formats and stored as a database.

c. Information on the Legal Framework for the Geodatabase in the Federation of Bosnia and Herzegovina

The Law on Spatial Planning and Land Use in the FBiH (Official Gazette of FBiH 02/06, 72/07, 32/08, 4/10, 13/10 and 45/10) and bylaws require the establishment of spatial planning and a development information system.

The Law specifies that the Ministry of Spatial Planning and other relevant ministries linked to the spatial planning sector are responsible for the establishment and coordination of a uniform information system.

The Government, at the proposal of the Ministry, made the stipulation that the content and the holders of the spatial information system along with the data collection and processing methodology establish uniform forms to keep track of the data at all levels of spatial planning in the FBiH.

According to the Law, a single form shall be maintained as part of the uniform spatial information system that includes data on the

- physical/spatial planning documents of the FBiH;
- physical/spatial planning documents of the cantons and municipalities;
- excerpts from the cadastre, natural resources with qualitative and quantitative characteristics, etc.;
- infrastructure systems;
- construction land;
- architectural and natural heritage;
- threats to the environment (illegal construction and soil, water and air pollution, etc.);
- areas where the risk from the effect of disasters and/or war is especially strong (seismic characteristics of the terrain, disturbances to the stability of the soil, flooded areas, the potential for fire, areas exposed to the possible influence to technical disasters and excessive pollution due to damage to factories, etc.);
- personnel data and institutions within the spatial planning sector; and
- other information relevant to the planning and maintenance of the uniform spatial information system (data that is compatible to the data of the Institute for Statistics of the FBiH).

Details of the type and scope of data contained within the information system are defined in the Decree on Content and Holders of the Uniform Information System. The Decree defines the content, methodology of data collection and processing along with the monotype forms that keep track of the data at all levels of spatial planning within the FBiH.

d. Information on the Legal Framework for the Geodatabase in Brčko District

The Law on Spatial Planning and Construction in BD (Official Gazette of BD, 29/08) requires the establishment of uniform spatial planning and a development information system for the purposes of planning, land use and the protection of space within the District.

The Department for Public Register of the Government of BD performs the tasks of designing, creating and managing the uniform geographical information system (GIS), which is considered to be of special interest to the Government. The uniform GIS system is a system comprised of GIS subsystems administered within the Government of BD. These systems are subsystems that together comprise a complete system. This form of spatial information system is the equivalent of the infrastructure of geospatial data at the entity level.

According to the Law, the data listed below comprises the uniform GIS database of BD:

- policy on spatial planning in BD, the spatial plans of the entities of BiH and the spatial plans of the territorial units of the entities that border with the District;
- the legal status, ownership and actual state of real estate, their owners, users, holders of deeds and holders of other related rights as well as the real estate market and trends relevant to spatial planning, implementation of plans, the formulation and implementation land and fiscal policies, etc.;
- geodetic plans, topographic and special maps of space within the District and bordering areas;
- locations, settlements, squares, streets and numbers of houses;
- topographic marks and the numbers of cadastral and construction lots, areas, agricultural or forest plantations, etc;
- goods used by the public;
- a registry of activities and facilities that cause or may cause environmental pollution;
- protected areas and buildings and other protected areas;
- illegal construction of buildings and the illegal change of use of buildings and/or land;
- requests submitted for location approval, approval for construction or the change of use of buildings or land, and approval for the use of buildings and the decisions issued upon these requests;
- decisions of the relevant inspection bodies within the building sector;
- completed detailed town planning requirements, technical documents, main, preliminary and conceptual designs for the construction of buildings or other works;
- statistical areas, circles and other statistical units, statistical reports and spatial information;
- analyses, studies, expert opinions, reports, information, development plans and programmes as well as other scientific, professional and informative documents that are entirely or to a large extent related to matters referred to in terms of the responsibilities of the Department for Public Register of the Government of BD;
- laws and bylaws, mandatory and optional standards, norms and other technical rules used in planning, design and construction;
- development plans and programmes of the entities that perform economic or non-economic activities within the District; and
- other facts, plans, programmes and other documents that are relevant to spatial planning, designing, construction, environmental protection and resources in public use.

e. Application of the Information System in the Flood and Landslide Risk Assessment for the Housing Sector in Bosnia and Herzegovina

The Flood and Landslide Risk Assessments for the housing sector in BiH information system adopted a specific framework taking into consideration several issues related to the administrative levels of the entities. This information system is intended to present a better understanding of the legislation concerning its components and structure.

The information system allows the entities to collect, store, share, distribute, analyse and update data and information on housing sector risks in a more efficient manner.

Thus, this information system is mainly comprised of a number of thematic areas:

- database model,
- list of data with attributes,
- type of database,
- software suggested for usage, and
- proposed web applications.

Firstly, according to the standards used by the different entities, the database was prepared using the ArcGIS tool in the form of a geodatabase. It supports all of the various types of GIS data, such as attribute data, geographic features, raster data, utility and transportation network systems, GPS coordinates and survey measurements. By storing GIS data in a geodatabase, users may benefit from its superior data management capacity to leverage spatial information.

Secondly, the list of data used for this Assessment and allowed to be distributed was developed together with its appropriate attributes in the form of the vector and raster data format. In addition, in order to have several links between the different data it is necessary to create schemes using ArcGIS Diagrammer. This is presented in the graphics of the project database.

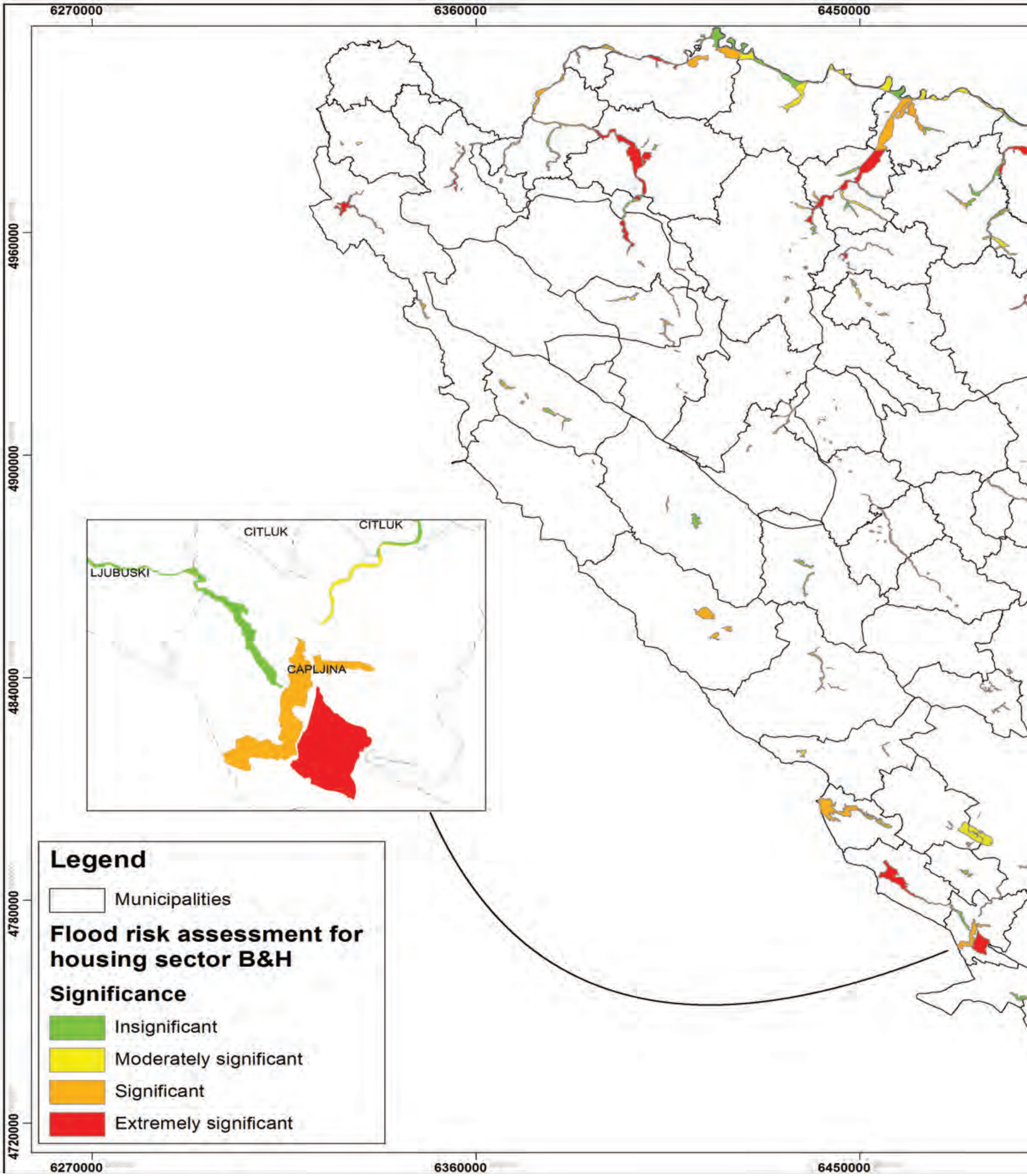
Thirdly, the data and results that were allowed to be distributed can be provided to the Federal Administration for Geodetic and Property Affairs of the FBiH, which can only accept to host this data at the level of the FBiH. Similarly, the Administration for Geodetic and Property Affairs of Republic Srpska can only host such data at the entity level. Since this project covers the entire territory of BiH a web application (http://eufloodsrecoveryhra.com/) is set to host all of the data used that resulted from this project.

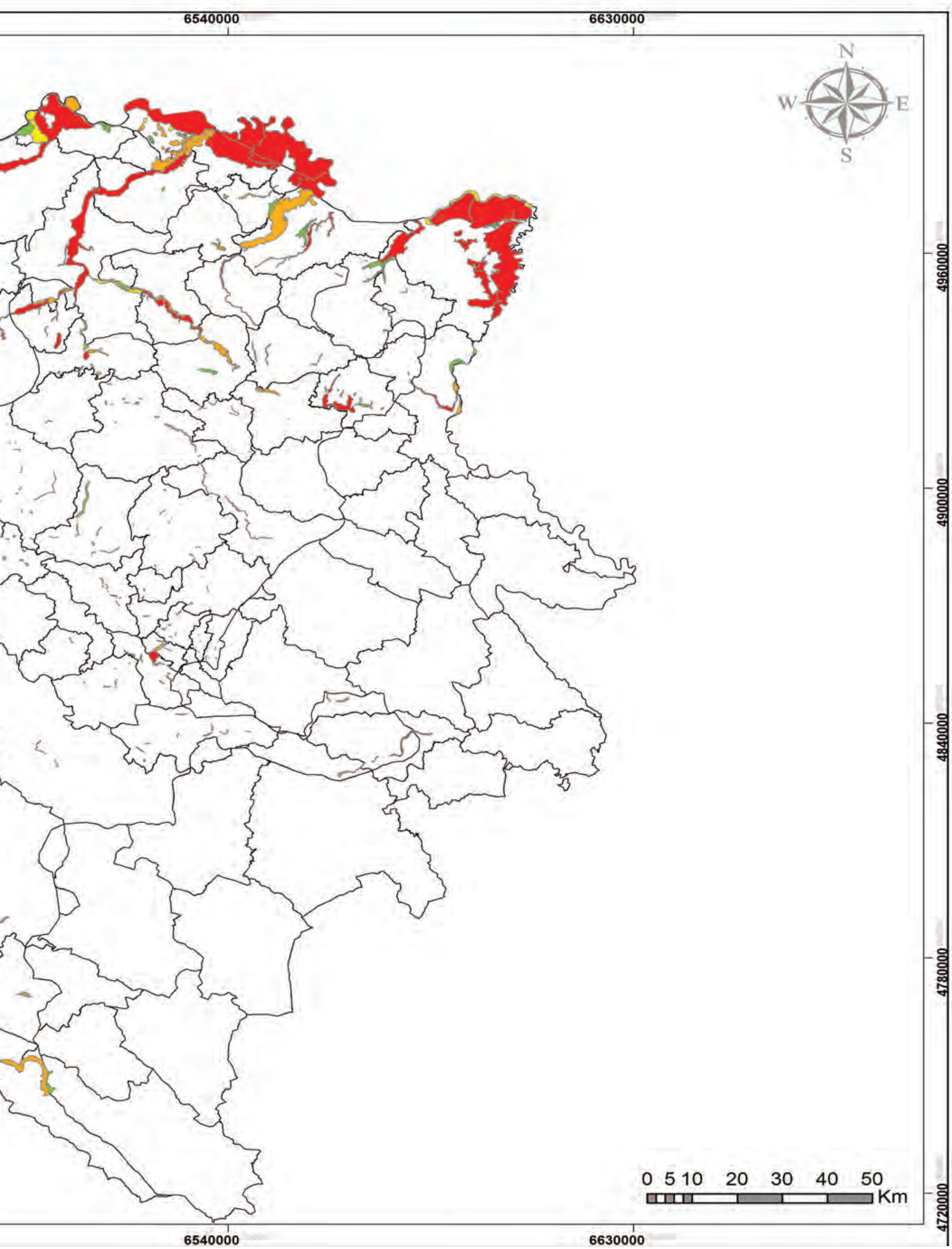
The name of the web application is MangoMap. It is a platform that hosts all types of GIS data and provides several options and tools and enjoys a certain level of freedom when presenting such data. It allows for the switching of basic maps, e.g. the Google Earth map, open street map etc. It also includes the attribute tables that are directly linked to those edited in the shapefiles, including a brief description of the data presented. It can control the availability of the data on the Internet by selecting the required limitations.

This platform is also equipped with GIS tools such as measuring tools, zoom in/out and switch on/off for the different layers listed in the key. This is in order to facilitate the use of the required data. There is also the option to download a Map in PDF format and to custom colour the scheme, layout etc.

ANNEXES

Annex 1: Map of the Flood Risk Assessment for the Housing Sector within the territory of BiH.

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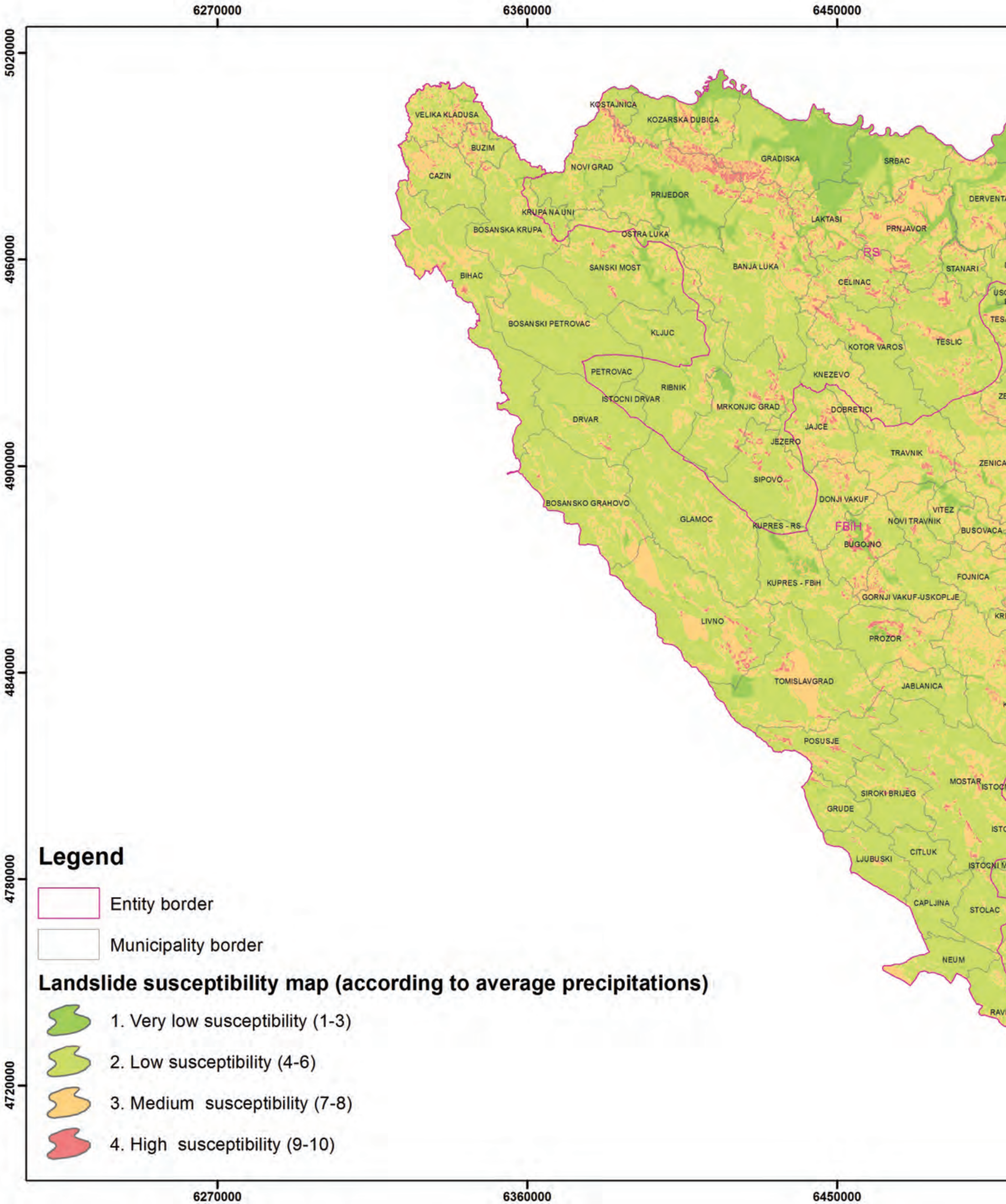
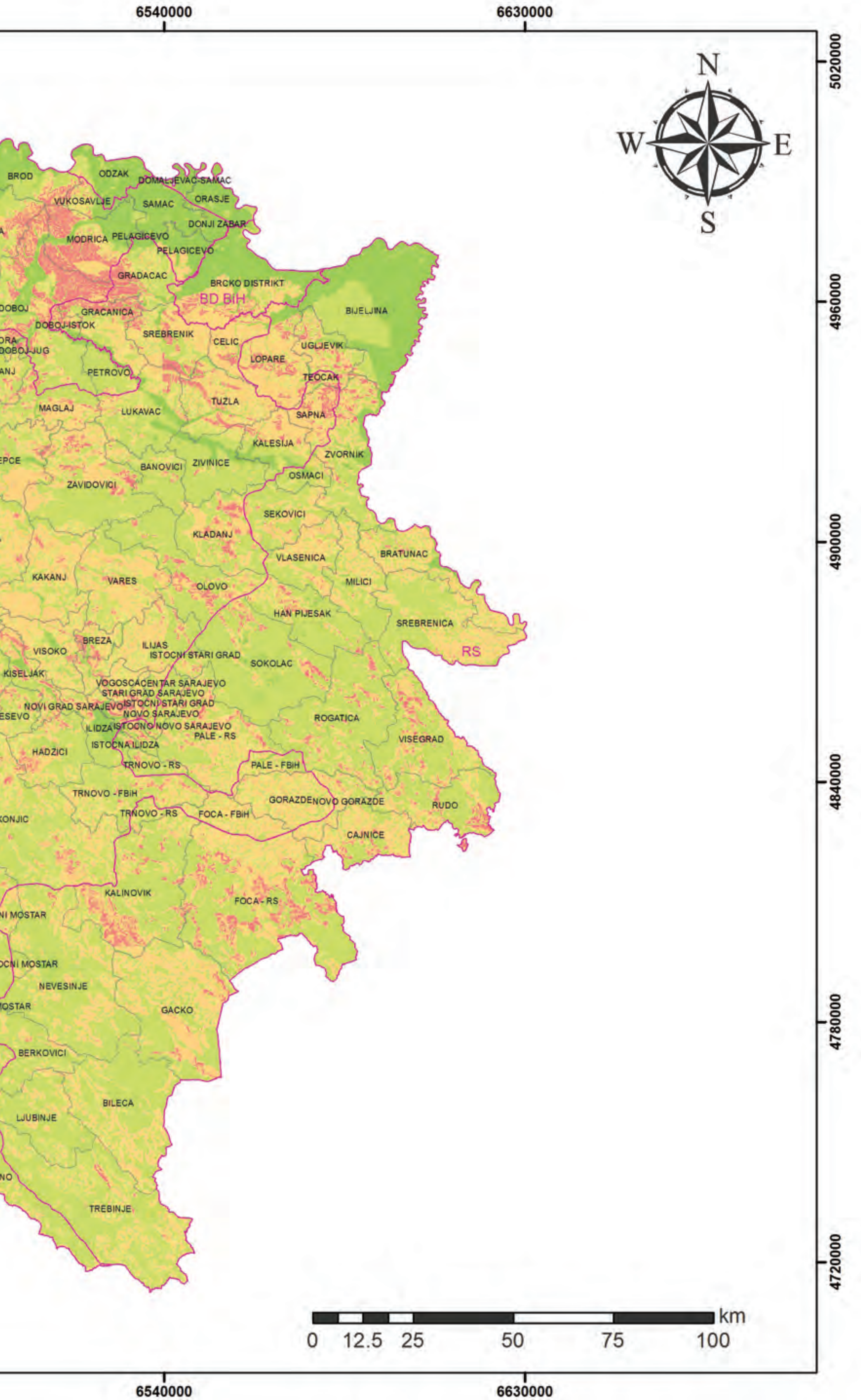
Annex 2: Landslide Susceptibility Map of BiH (according to average precipitation).

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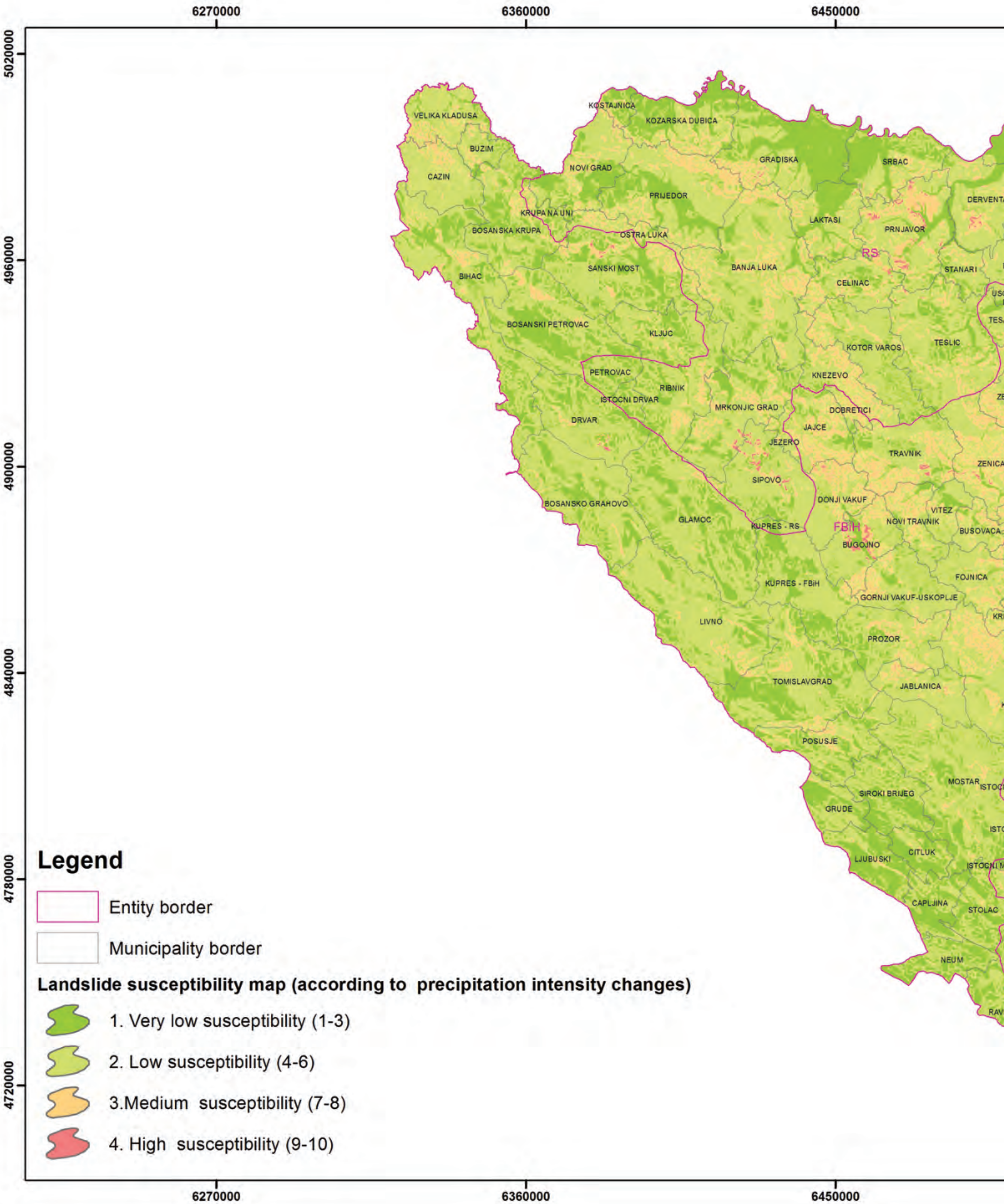
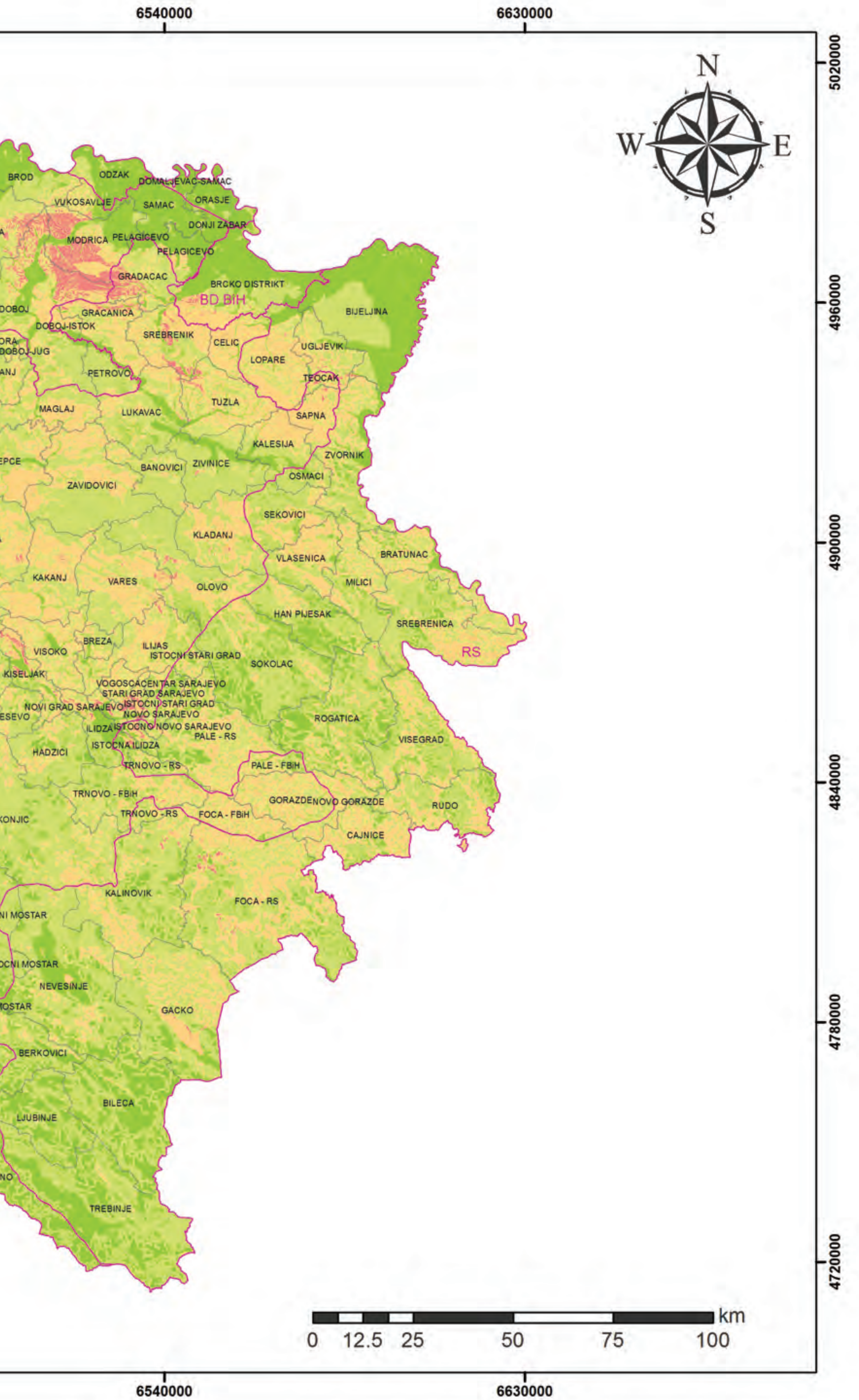
Annex 3: Landslide Susceptibility Map of BiH (according to changes in the intensity of precipitation).

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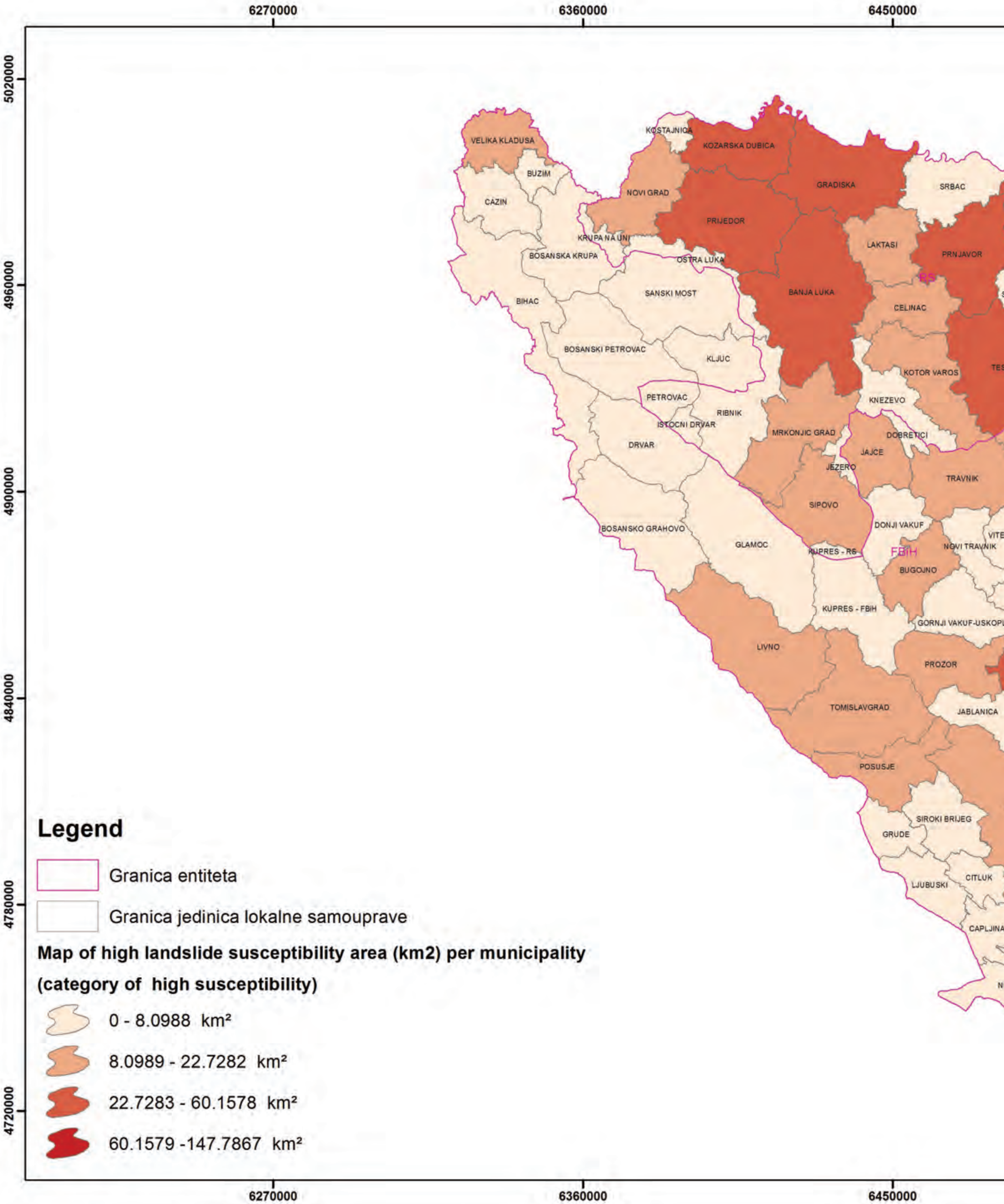
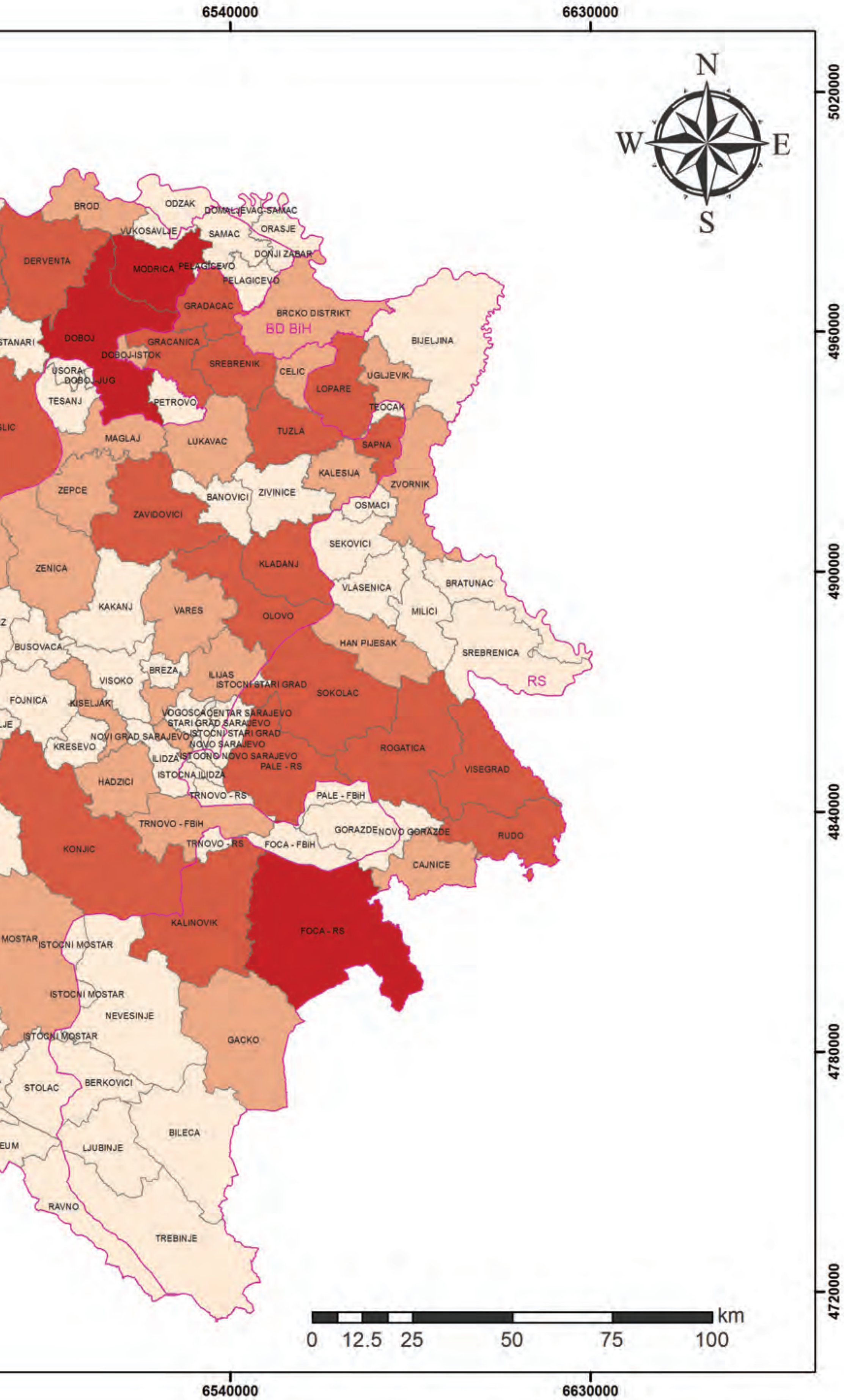
Annex 4: Map of Areas of High Landslide Susceptibility per municipality (km²) (category of high susceptibility).

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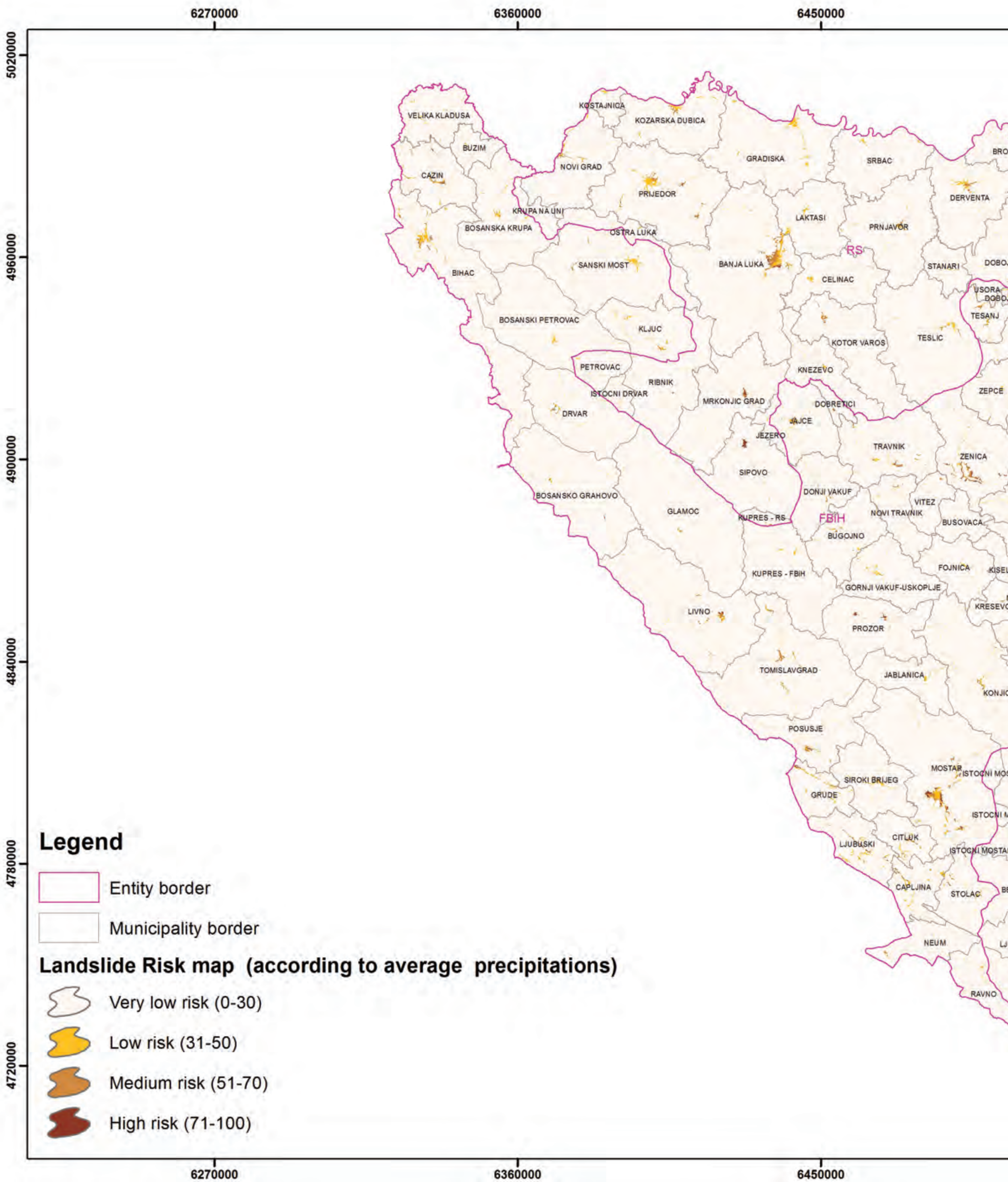
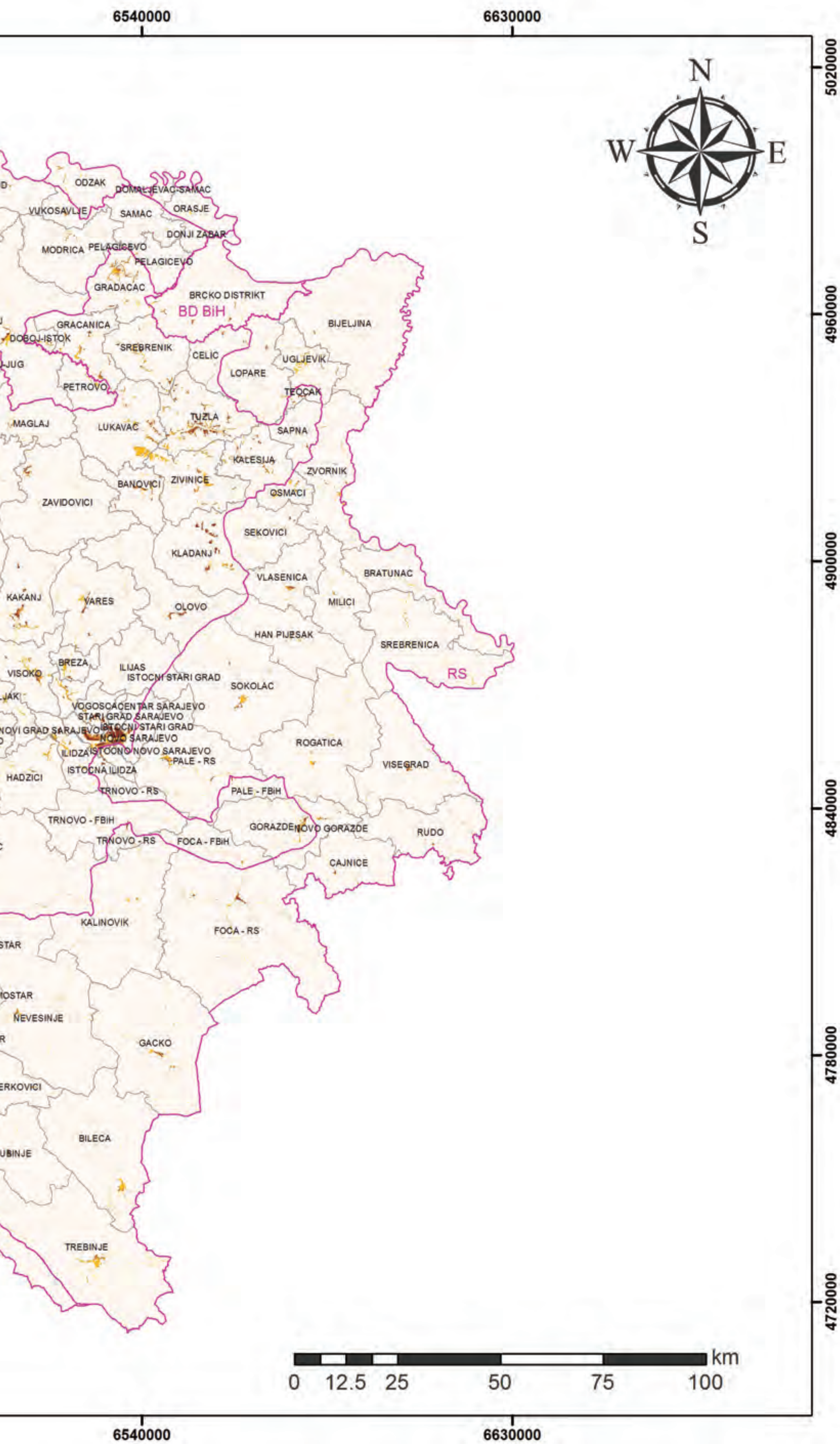
Annex 5: Landslide Risk Map (according to average precipitation).

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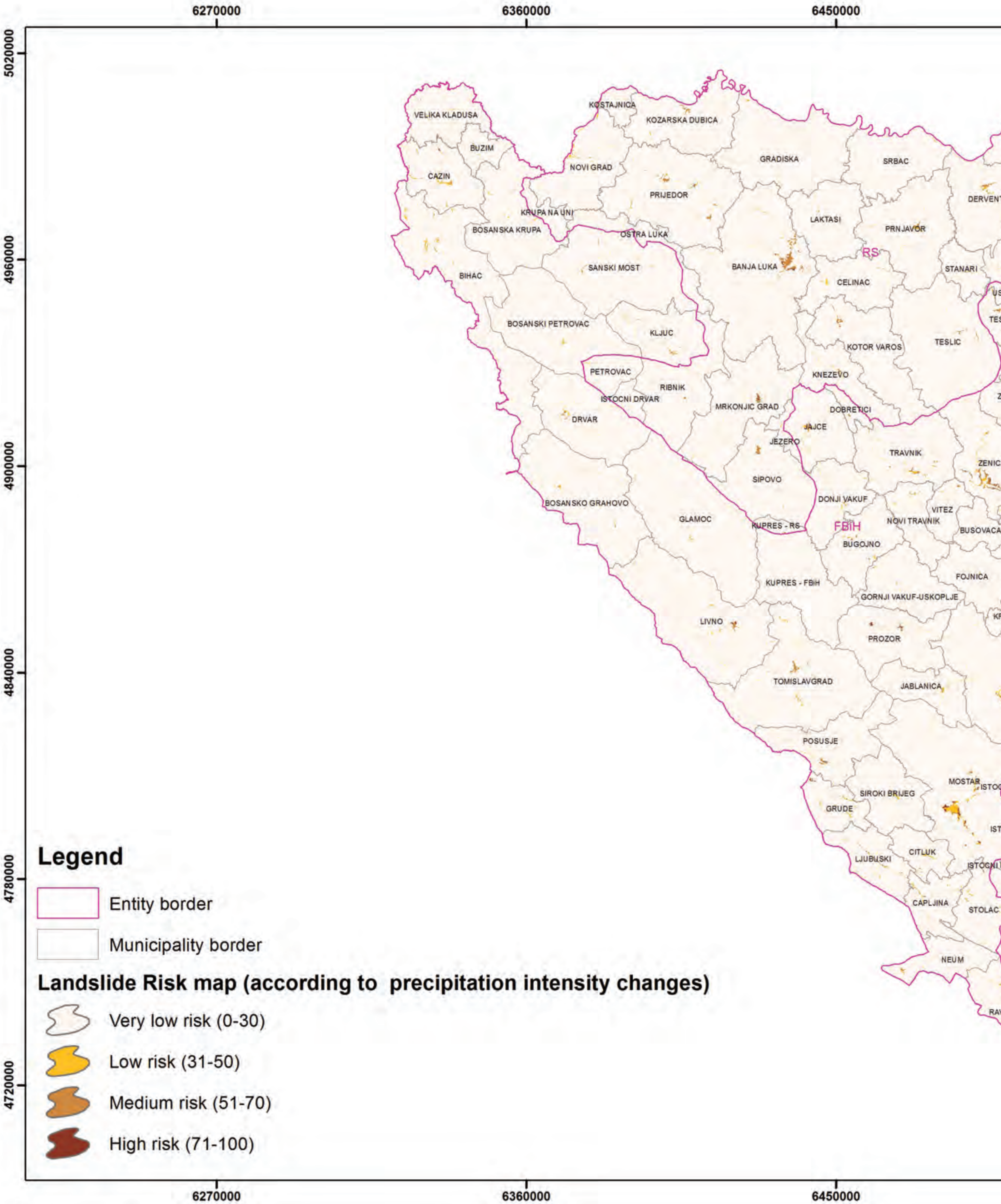
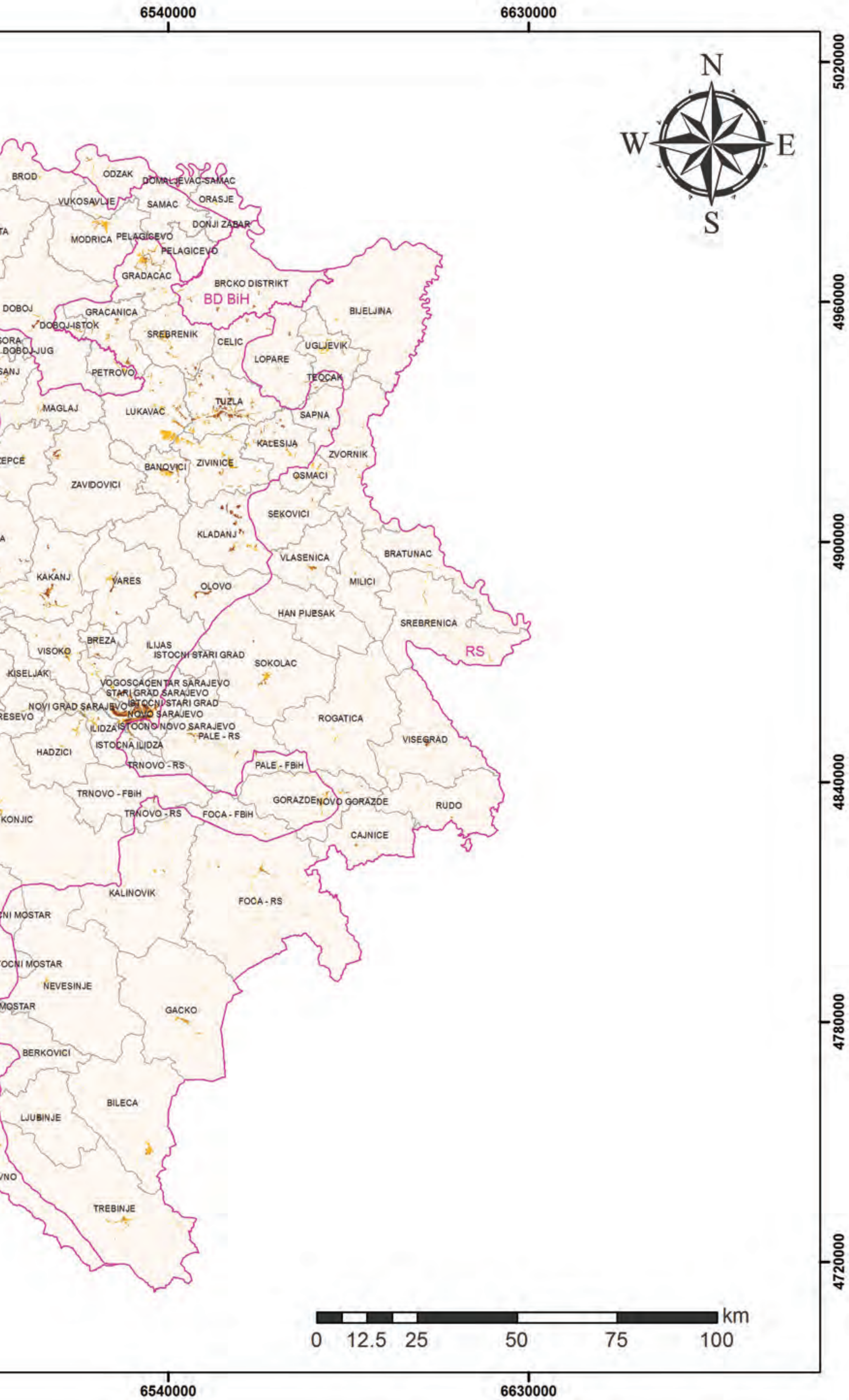
Annex 6: Landslide Risk Map (according to changes in the intensity of precipitation).

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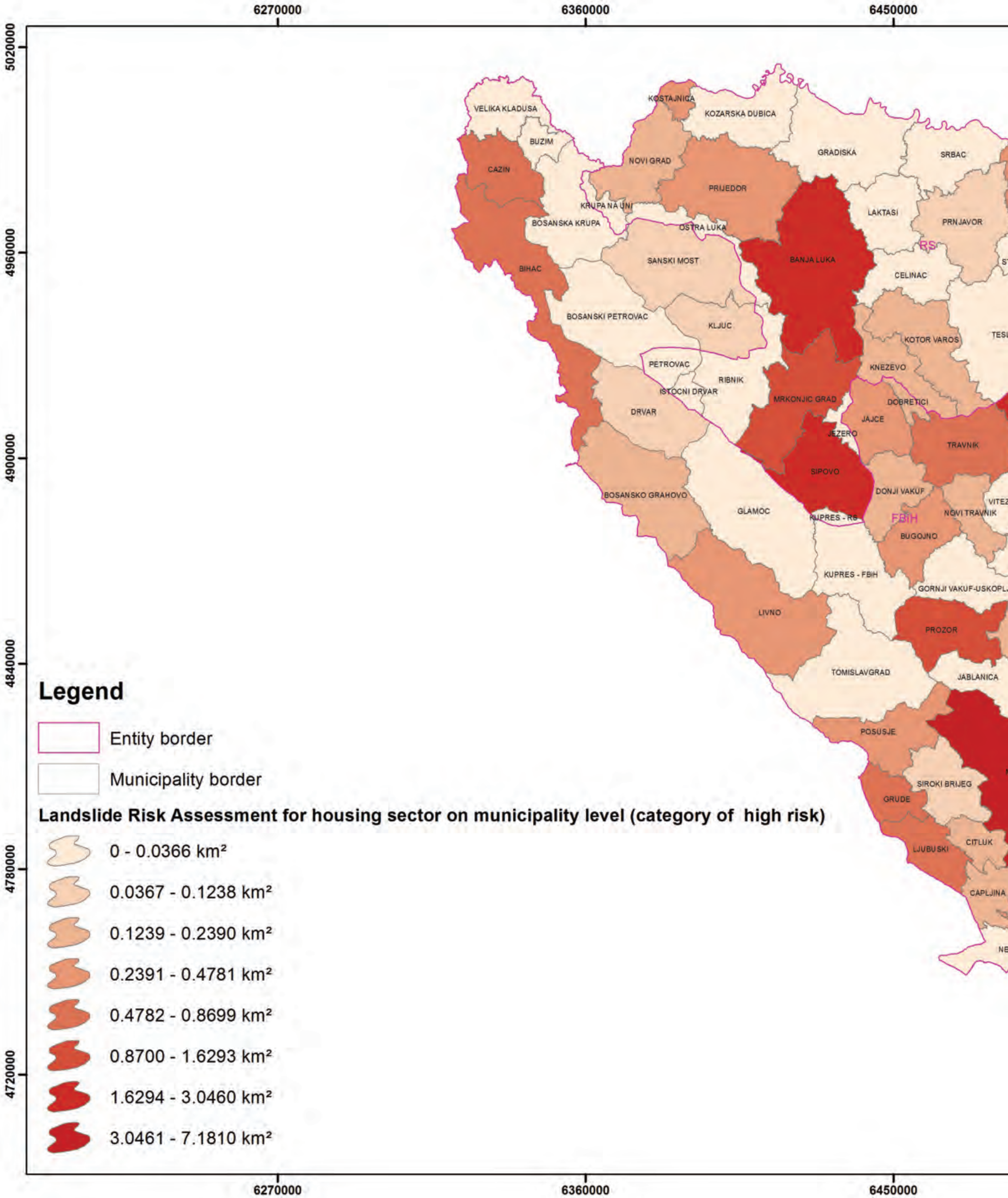
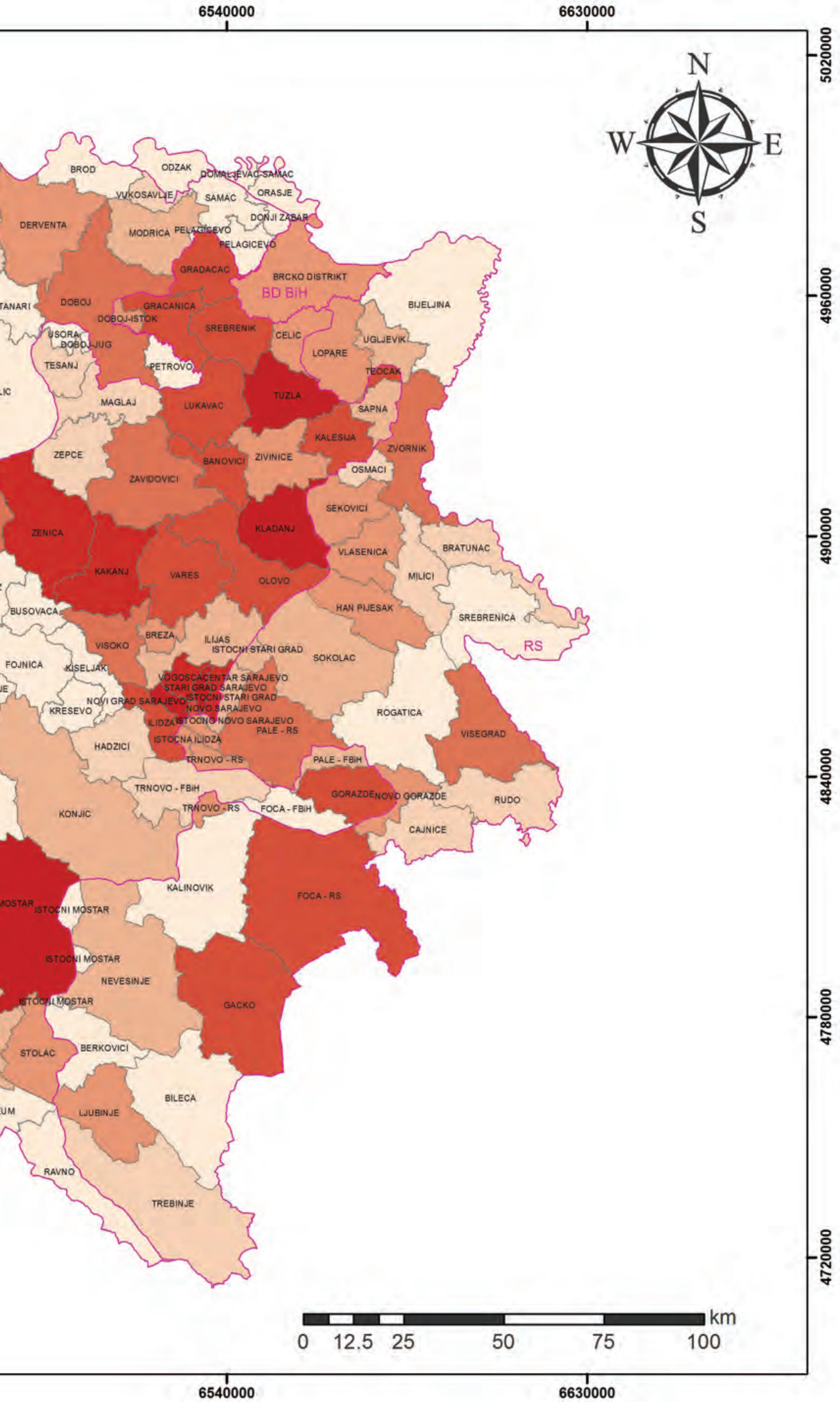
Annex 7: Landslide Risk Assessment for the Housing Sector at the Municipal level (category of high risk).

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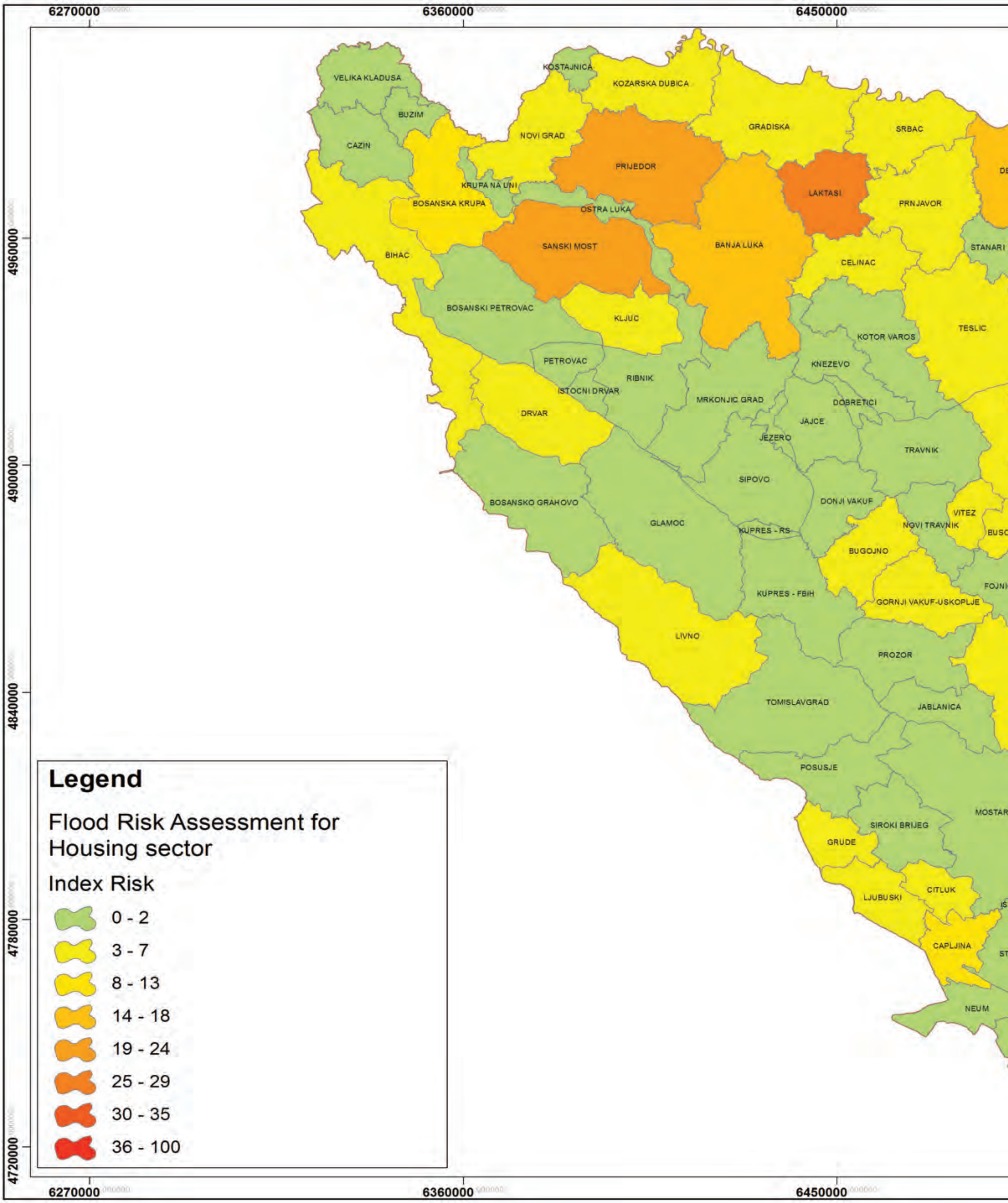
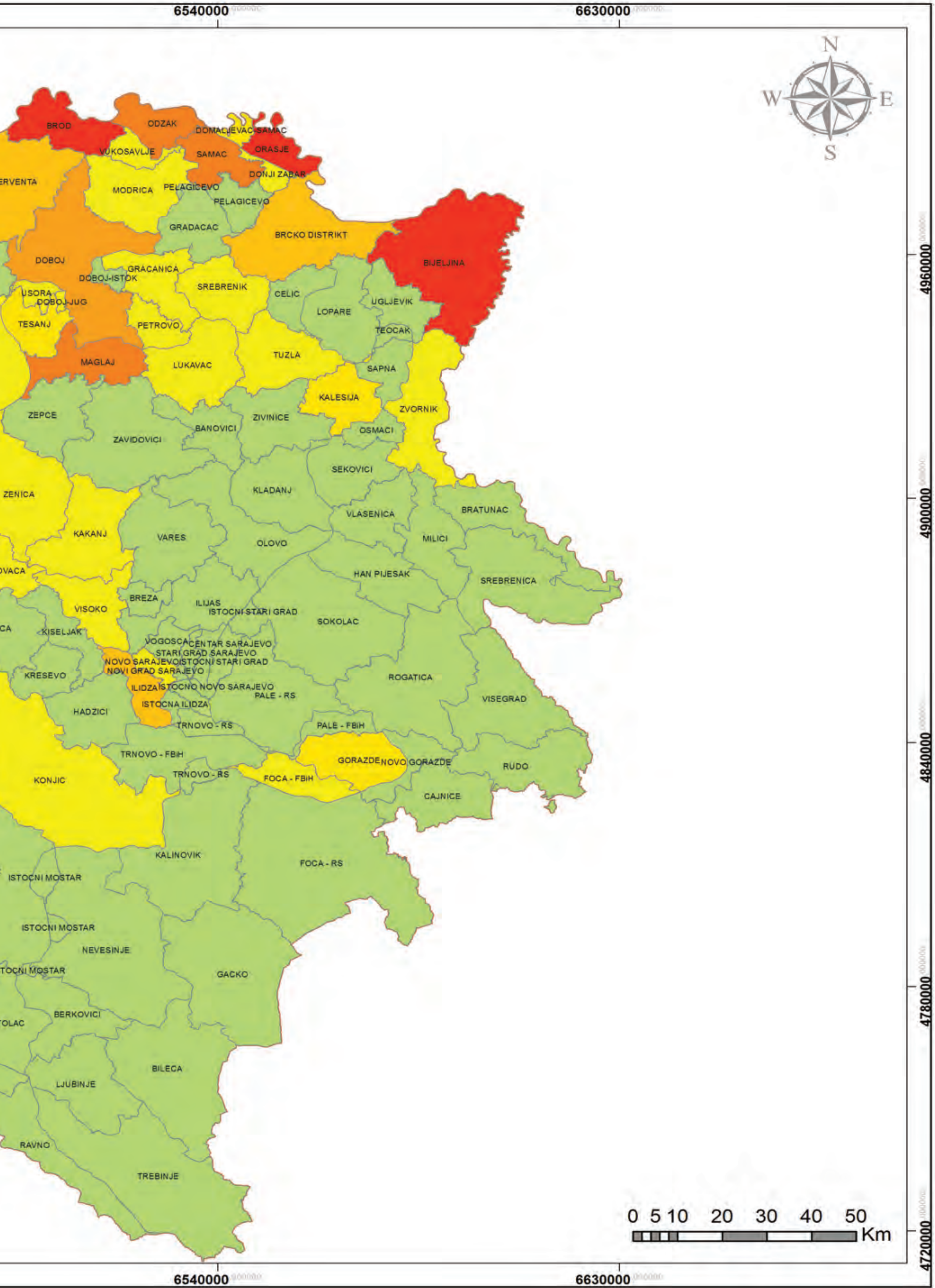
Annex 8: Relative Flood Risk Assessment for the Housing Sector per Municipality.

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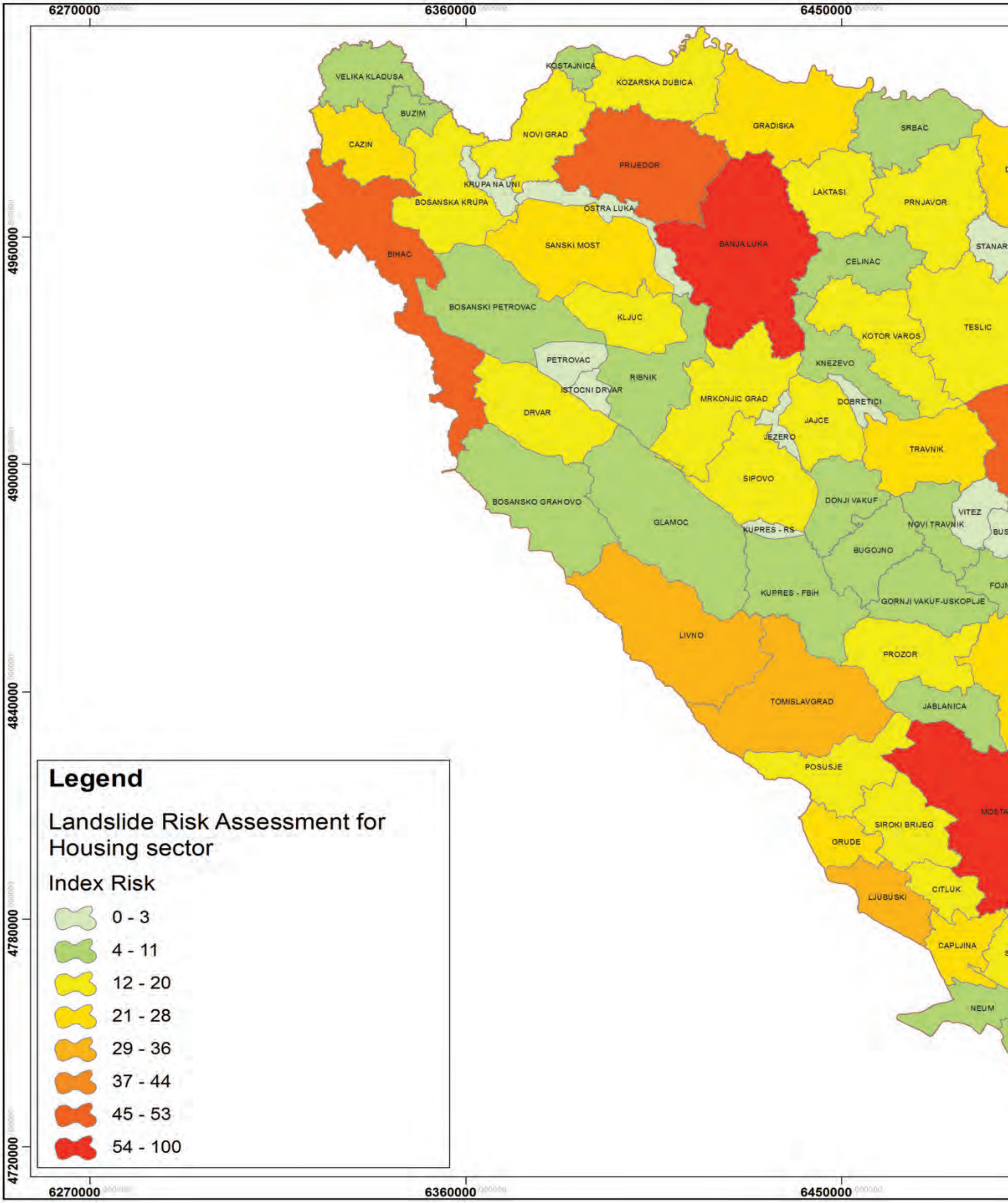
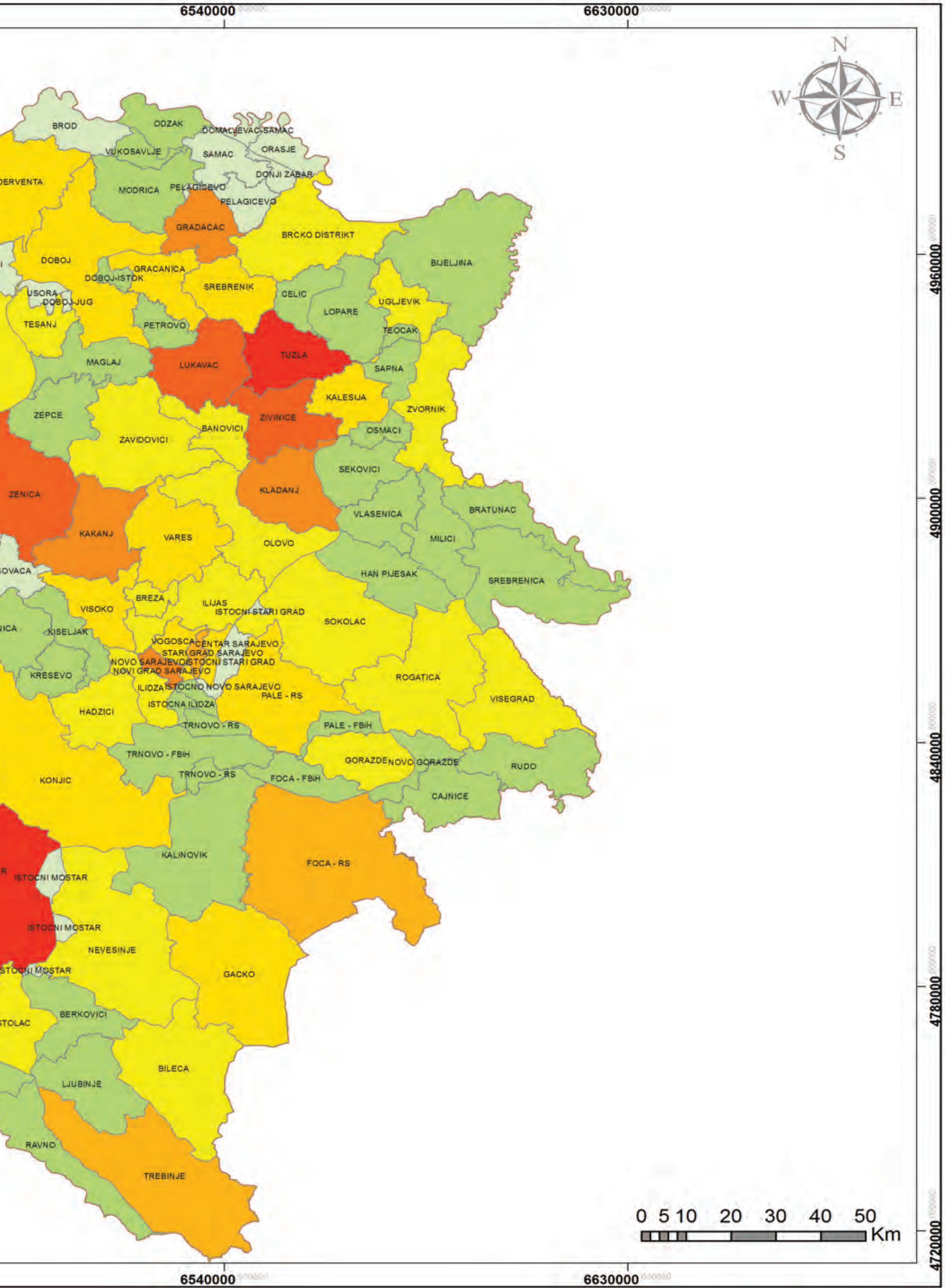
Annex 9: Relative Landslide Risk Assessment for the Housing Sector per Municipality.

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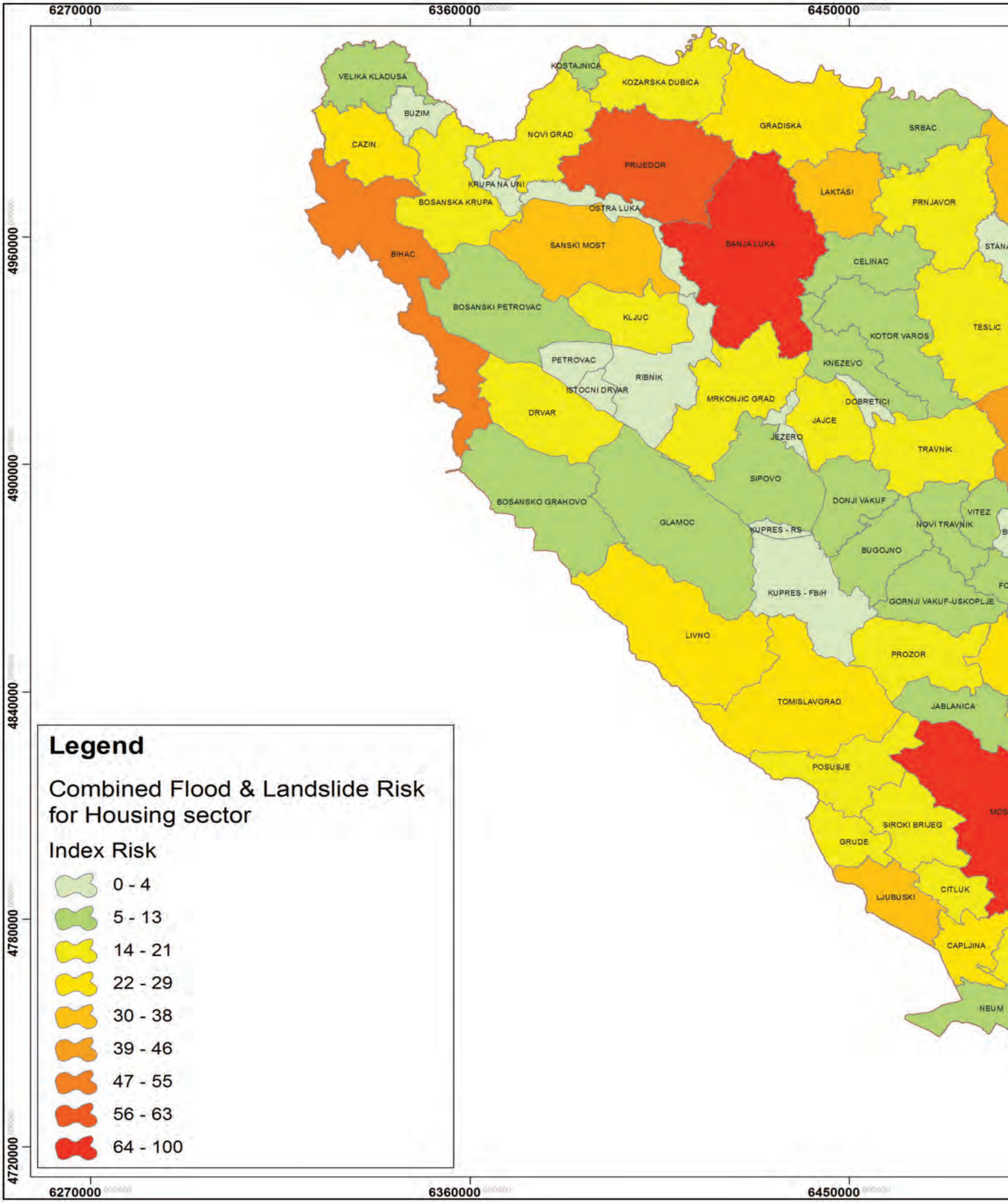
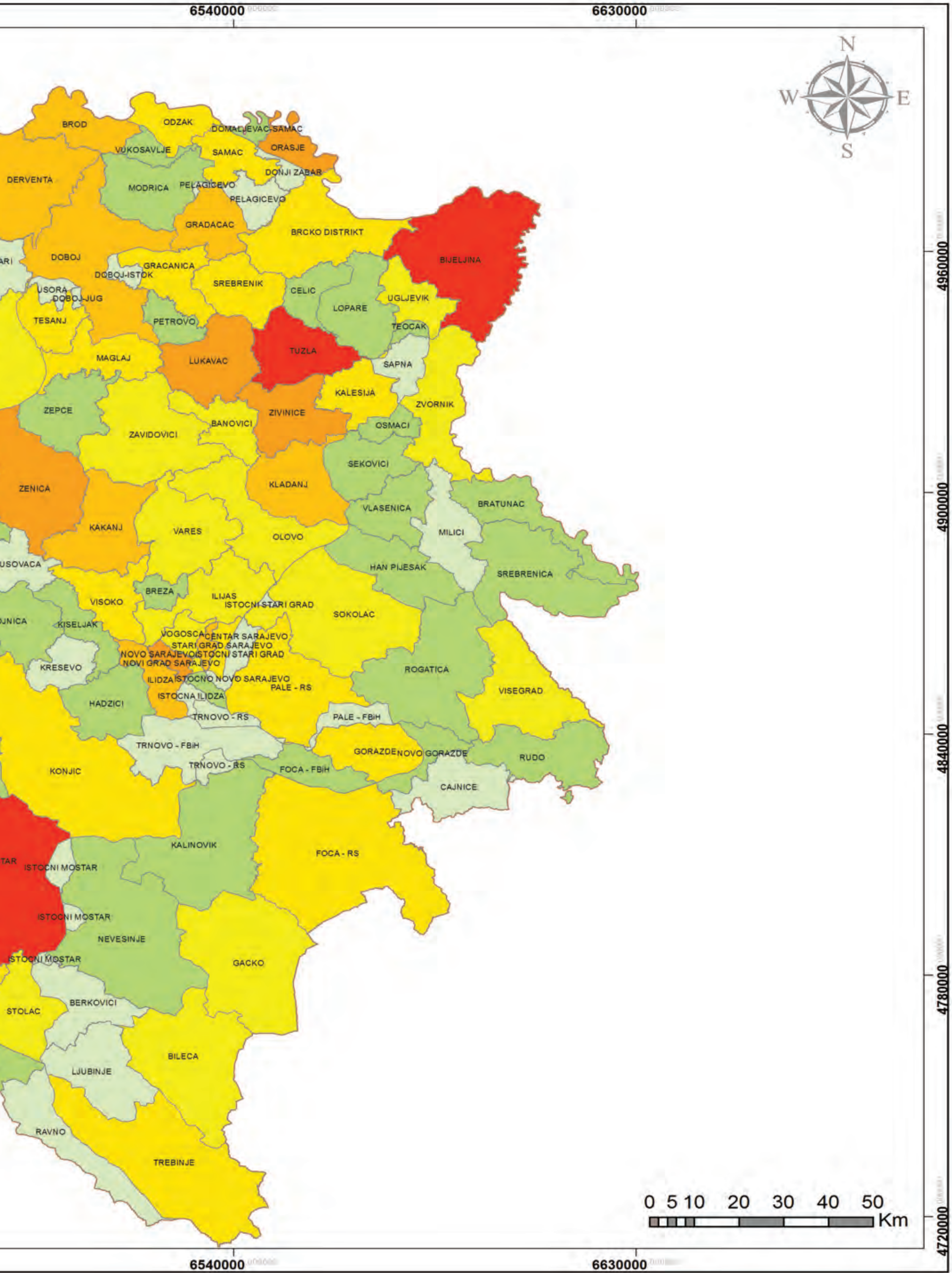
Annex 10: Relative Combined Multi-Hazard Risk per Municipality.

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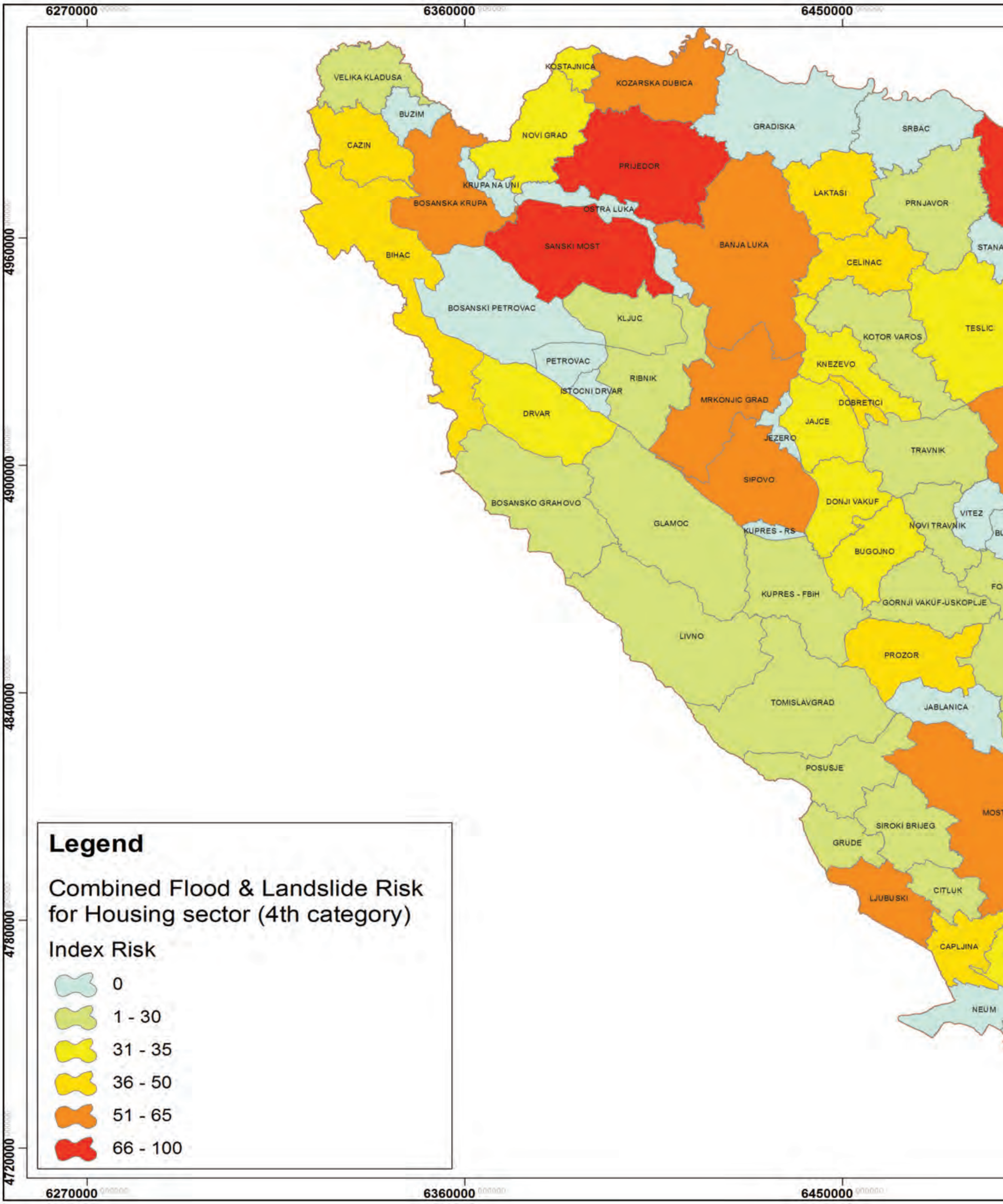
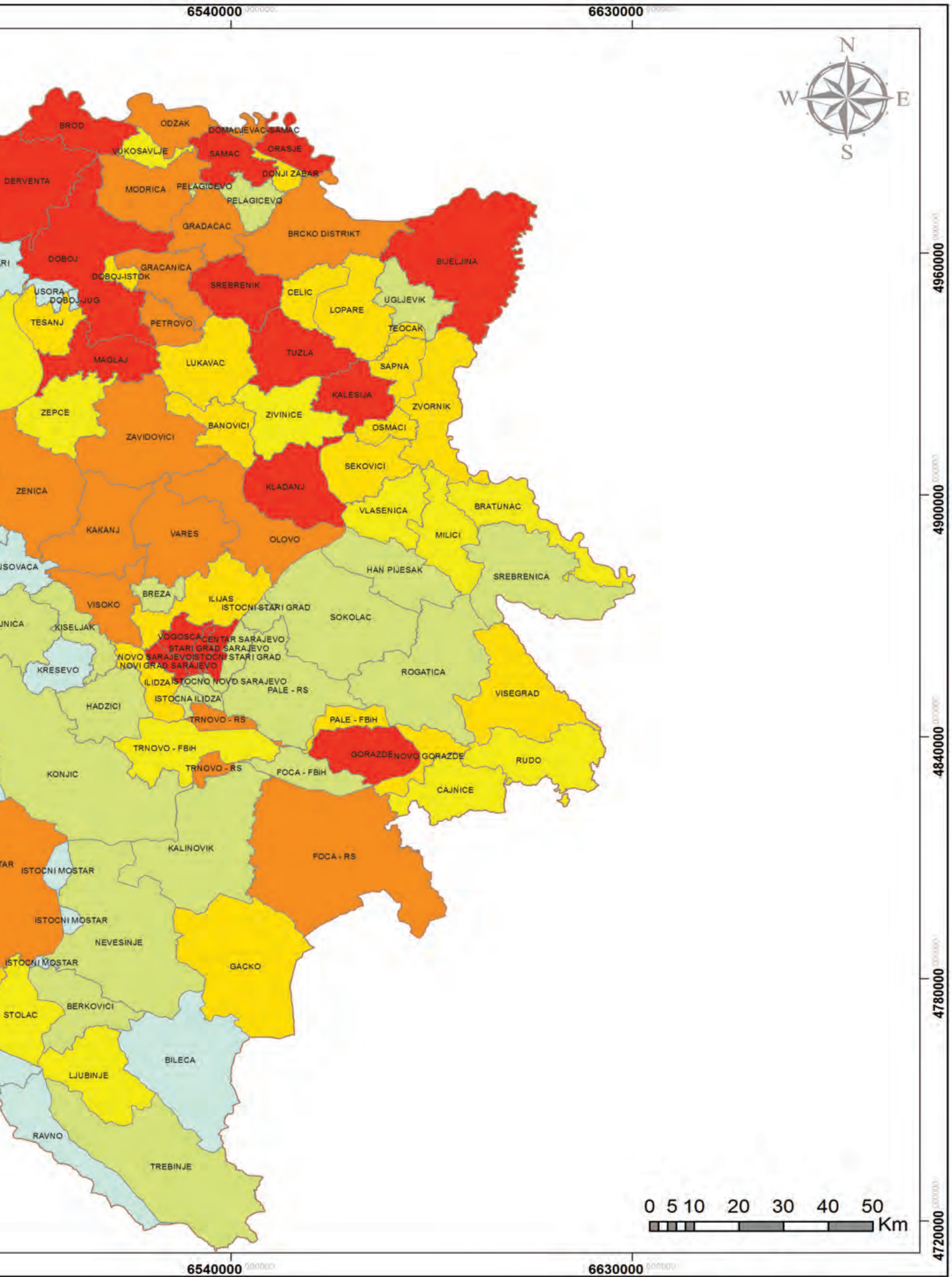
Annex 11: Relative Combined Multi-Hazard Risk per Municipality with Socioeconomic Analysis (category 4).

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VOGOSCA
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LJUBINJE
RAVNO
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LIST OF TABLES

LIST OF ANNEXES

(Footnotes)

1 Throught the UNDP project ‘Support to Recovery and Risk Mitigation in Bosnia and Herzegovina’.
2 Throught the UNDP project «Support to recovery and risk mitigation in Bosnia and Herzegovina»