

CLIMATE AS A FACTOR OF POPULATION AND SETTLEMENTS DISTRIBUTION IN BOSNIA AND HERZEGOVINA

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Uneven spatial population and settlements distribution in Bosnia and Herzegovina, and the climate influence on modern demographic changes are shown in this paper. The genetical and typological climate analyse was made, using data from many published results of former climate researches and elaborated data from many weather stations in Bosnia and Herzegovina.

The demographic analyses are a result of population census from 1948-1991 and preliminary census results from 2013, which were used to evidence the latest changes of population movement and population density trough climate types of Bosnia and Herzegovina.

Key words: *climate, climate type, population, settlement, depopulation, Bosnia and Herzegovina.*

INTRODUCTION

Bosnia and Herzegovina is a country in Southeast Europe located in the western part of Balkan Peninsula. It covers the area between 42°33'00" and 45°16'30" N and 15°44'00" and 19°37'41"E. Bosnia and Herzegovina has an area of 51.209,2 km². The area of mainland is 51,197 km², while the area of sea is 12.2 km² (FZS Sarajevo 2008). Bosnia and Herzegovina is mainly mountainous country suggested by the fact that only 14 % of its area is located below 200 m above sea level and about 60% is located in the hypsometric belt between 500m and its highest peak Maglić, which is 2,386 m. Dinara mountain system by its basic orientation of morphostructural directions and above sea level altitude determines the climate and climate types in Bosnia and Herzegovina.

The climate together with relief, fertile soil and huge amount of available water is a leading natural factor for gathering of population in a given territory, including Bosnia and Herzegovina. The subject of the research is based on evidence that implies how and to what extent the climate affects the irregular demographic development, depopulation of certain areas and migratory movements of population in Bosnia and Herzegovina. In addition, the paper will show which climate types in Bosnia and Herzegovina are characterized by depopulation, and which climate types affect the growth and the development of settlements. We used the main assumption that the climate is important factor of the uneven density of population in other words the whole spatial demographic development in Bosnia and Herzegovina.

In order to prove all assumptions above, we use the analyses of the basic meteorological elements and occurrences using the cabinets research modes, the topographic position of settlements and its number of population, the interactive link between the climate and characteristics of settlements, the number of inhabitants certain climate areas and the density of settlement. In addition to the above in this paper are used the methods of content analyses, the method of statistics, the method of cause and comparison.

CLIMATE INFLUENCE ON SPATIAL POPULATION DISTRIBUTION IN BOSNIA AND HERZEGOVINA

Climate of Bosnia and Herzegovina

The climate of Bosnia and Herzegovina is determined by climate elements that are modified by geographic factors of which the most important are geographical position and relief. Bosnia and Herzegovina located in the southeastern part of Europe is under the constant influence of the northern branches of subtropical zonal sector and southern part of northern temperate zonal effect that together with hypsometrical relations modify into high-altitude azonal belts. In this natural diversity, across the territories of Bosnia and Herzegovina, is performed the intense shift of zonal geographic impacts of polar air from north and subtropical south. It is clear that Bosnia and Herzegovina located on the site of moderately warm climate because Bosnia and Herzegovina belongs to Atlantic sector which is supported by Azork anticyclone and Mediterranean in which the dominant role has Genoa cyclone. It is a climate with warm summers in southern areas and maximum precipitation in the cold part of year.

The flow of air masses disrupts relief and appears as the main climate modifier of Bosnia and Herzegovina. Dinaric mountain system modifies and weakens the flow of warm air from the south and north air from the north to the south. These factors are the main cause for divide of territory of Bosnia and Herzegovina into two climate region, the one in the north and the other in the south which are separated by orographic line consisted of Grmeč-Bjelašnica-Zelengora. The north climate region has continental character with cold winters and warm summers while in the southern climate region prevails Mediterranean climate with warm summers and moist winters.

Maritime and continental climates are defined by isohyets regime of colder and warmer part of year. In the maritime climate influence the isohyets regime reaches its maximum during the colder part of year while in continental influence is evenly distributed (Vemić, 1959). On the territory of Bosnia and Herzegovina where the azonal climate types are changing, the line that separates the southern and northern climate region are the highest mountains of Dinaric mountain chain.

Geographic factors differentiate the climate of Bosnia and Herzegovina making it more complex and more harsher in relation to its geographic region. It is located at the geographic latitude of the Adriatic Sea and by its location it should be having a mild Mediterranean climate as is the case with Italy and southern France. However, the climate of Bosnia and Herzegovina is significantly changed due to the influence of relief, and so that the Mediterranean climate is located only in the southernmost parts of country. (Milosavljević, 1973)

Based on the genetic and typological classification of climate (Spahić, 2002) we can conclude that on the territory of Bosnia and Herzegovina are presented more climate types

such as: the moderate continental type, the moderate continental pre-mountain type, the mountain moderate continental type, the alpine type, the pre-mountain maritime type, the Adriatic type and the modified Adriatic type (Spahić & Zubčević: Karta klimatskih tipova Bosne i Hercegovine, Atlas svijeta, 1998).

Distribution of settlements and population by climate types in Bosnia and Herzegovina

From the previous chapter we concluded that relief vastly influences the climate in Bosnia and Herzegovina and together with relief reflects the spatial settlement of population. Relief by its vertical division caused the formation of seven climate categories with specific living conditions that dictates the processes of distribution and population gathering. In the following analysis are included results of the census of population, household and apartments from 1948 to 1991 and preliminary results of the census of population from 2013, according to these information it is possible to talk about the latest changes related to migration of population and density settlement trough climate areas of Bosnia and Herzegovina.

The moderate continental climate with the moderate cold winters is presented in the north of Bosnia and Herzegovina. The hottest areas are in northeast, while the mean temperatures decline towards south and southwest. The annual amount of precipitation in the mentioned climate type ranges from about 800 mm in the northeast up to 1,250 mm in the northwest. Snowfalls are regular occurrence during the winter period. The average air temperature of the warmest month (July) is between 20°C and 22°C while the temperature of the coldest month (January) average about from -1°C to -2°C. The annual average isotherm is between 10 and 12°C. Autumn and spring temperatures are uniform. Summer absolute temperatures can rise up to 40°C while winter lowest temperatures can drop to -35°C.

The moderate continental climate type, which covers the surface of 15,150 km² or 29.59% out of total surface, is area where is located 1944 settlements (settlements of rural type, urban settlements and cities), that is 35.3% of the total number of settlements in Bosnia and Herzegovina. The rural type of settlement is dominated in this area but there many urban settlements and cities such as Bihać, Banja Luka and Tuzla. According to the census of population from 2013, in this climate type the number of inhabitants was 1,138.

The pre-mountain moderate climate type is a climate similar to the previous one, with the difference that is its average temperature of the warmest month is lower than 22°C and coldest higher than -3°C. It is characterized by areas where the average temperature is ≥ 10 °C. This type of climate is a transitional zone between the moderate continental climate and mountain climate. In this climate not a single month is not dry, but it has higher level of rainfall in the colder period of the year. This climate type has mean July temperature that is lower than 20°C, and the average January temperature that is about -2°C on the territory of Bosnia and Herzegovina. The annual average precipitation is about 1,200 mm. The pre-mountain moderate continental climate type is characterized by fresher summer while the climate is further modified by topography of the terrain and height sea-level altitude.

The pre-mountain moderate continental climate type extends over 16,524 km² or 32.28% of total area of Bosnia and Herzegovina. In this area are located 2,369 villages or 39.2% of the total surface of Bosnia and Herzegovina. The rural settlements that counts less than 500 inhabitants are dominated in this area. According to the census of population in 2013 in this area are registered 1,712 settlements with less than 500 inhabitants, 1,263

settlements with less than 200 inhabitants, 912 settlements with less than 100 inhabitants and 131 village with less than 10 inhabitants. In the above are shown the settlements in which is listed at least one resident, but in this area there are also a large number of settlements that have been completely lost the population. Today, the settlement that is located in the pre-mountain moderate climate type, has the average of 443 inhabitants. It should be pointed out that the area of the city Sarajevo belongs to this climate type.

The moderate mountain continental type is characterized mainly for mountain morphostructures of the Central Dinarides and parts of Internal and External Dinarides with high sea level altitude above 900 m. It is a climate in which only four months have a mean temperature higher than 10°C while the average temperature of the coldest month can be significantly below -3°C. It means that in the mid-summer can be frost. This climate is characterized by long, very cold winters and very short, fresh summers. There are really only two seasons, winter and summer. The transitions from autumn to spring are very prompt and last for a short period of time. Pluviometric regime was influenced by the relief, in other words, the most precipitation occurs mainly in the lower pre-mountain maritime climate type. It is sparsely populated or totally uninhabited area in which are dominated small rural settlements with few inhabitants and houses. The mountain moderate climate type extends over 10,530 km² or 20.57% of the total area of Bosnia and Herzegovina. In this area are situated just 672 settlements, or 10.3% of the total number. The rural settlements that count less than 200 inhabitants dominate in this area. Census of 2013 registered 453 settlements with less than 200 inhabitants, 381 village that has less than 100 inhabitants and 61 village that has at least one but less than 10 inhabitants. The climate type of settlement today has an average of 175 inhabitants.

The pre-mountain maritime climate type is characterized by warm summers and cold winters, where during the year the coldest months have an average temperature lower than 0°C. These areas have a mean monthly temperature of the warmest month of July higher than 18°C (hot summer), and the average January temperature of the air lower than -3°C (very cold winter). During the year 1,750 mm of rainfall occurs in this area, counting that these values spatially and quantitatively widely varies. The main maximum of precipitation falls in the period of the second half of autumn, while a major minimum of precipitation is a time-bound for the second half of summer. The pre-mountain maritime climate type covers an area of 4,037 km², or 7.89% of the national territory. In this area are located 345 settlements, or 6.8% of the total number of settlements in Bosnia and Herzegovina. The settlements of rural type that count less than 500 inhabitants dominates in this area. According to the census of population in 2013, in the pre-mountain maritime climate type, the settlement had an average of about 300 inhabitants.

The area of high Herzegovina is characterized by modified Mediterranean climate in other words the Adriatic climate. The modified Adriatic climate type differs significantly from pre-mountain maritime type and especially from mountainous moderate continental type. This type of climate has a mean monthly temperature of the warmest month up to 23°C. In places that have this type of climate the average air temperature during the year are slightly lower compared to the Adriatic type that is characteristic for southernmost part of Bosnia and Herzegovina. Compared to the Adriatic (maritime) climate, summers are more fresher and the winters colder. The relief influenced by its vertical diversity on the formation of this type of climate. The annual precipitation in this subtype is 1,750-2,000 mm maximum in winter, with the dry summer period, which lasts about three months. The

climate in the higher Herzegovina and southwestern mountainous area is becoming mountainous with features of Mediterranean climate. The air temperature decreases with the increasing altitude and distance from the sea. As in the low Herzegovina, autumn is warmer than spring, but the variations in temperature are increased.

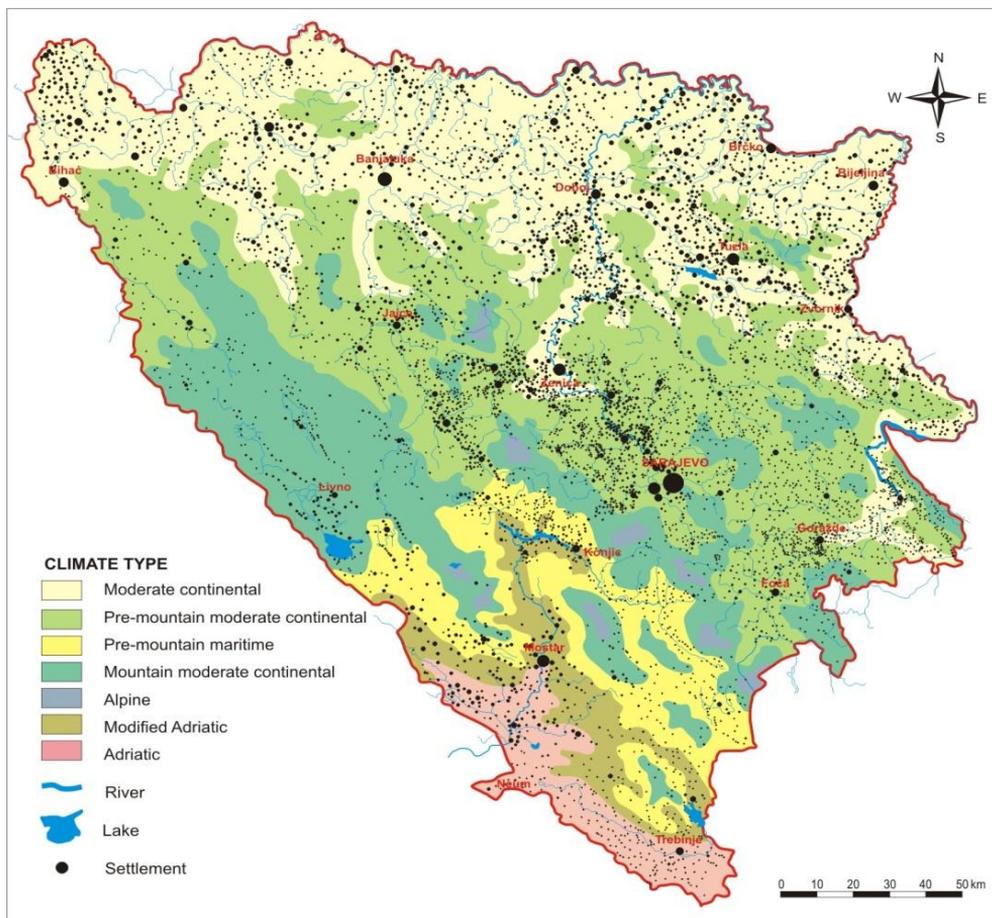


Fig. 1: Settlements distribution by climate types in Bosnia and Herzegovina

Data source: Popis stanovništva, domaćinstava, stanova i poljoprivrednih gazdinstava 1991, Prvi rezultati za stanovništvo, domaćinstava, stanove i poljoprivredna gazdinstva – po opštinama i naseljenim mjestima, Statistički bilten br. 220., RZS, Sarajevo, 1991;

Topografska karta 1:200000, J.P. Geodetski zavod BiH, Sarajevo;

Atlas svijeta, za osnovne i srednje škole, 1998:Karta klimatskih tipova, "Sejtarija" Sarajevo, 18-20.

The modified Adriatic climate type expands on 2,582 km² or 5.04% of the national territory. In this area are located 256 settlements that usually gather less than 500 inhabitants. In this type of climate are located 153 settlements that according to a census of population in 2013 had less than 200 inhabitants or 188 settlements with less than 100 inhabitants, and even 21 settlements being completely depopulated.

In southern parts of Bosnia and Herzegovina, due to the proximity of the Adriatic Sea, the Adriatic climate is represented. Average temperatures in January of this climate type are high (3 to 6°C), while the summers are hot and dry where the absolute maximum temperature reaches up 45°C. The average absolute minimum air temperature ranges from -4.9 to -8.7°C, while the absolute minimum temperature falls to -17°C. The average temperature of the warmest month is higher than 23°C. Mean annual temperatures range from 14 to 16°C. This geographic region is characterized by bright, clear and dry summer and mild and rainy winters. This climate type expands on low Herzegovina that coordinates with the lower course of the Neretva from Trebižat and the basin of Popovo polje. This type of climate is characterized by a substantial annual rainfall with the strong seasonal variation, where the summer has the least amount of rainfall. The annual precipitation, mainly winter, is 1,250 to 2,000 mm. Snow is rare in this area, although not impossible occurrence.

In the Adriatic climate type, which covers 1,956 km², or 3.82% of the total area, are located 239 settlements or 4.1% of the total number of settlements. The settlements are located mainly around the peripheral area of karst fields where dominates the settlements of rural type that gather less than 200 inhabitants.

Alpine climate type covers only 418 km² area of Bosnia and Herzegovina. These are areas of the highest mountain peaks with the height limits above 1,700 meters, where the average July temperatures range from 2 to 4°C. This type of July thermal regime can be defined with chilly summers, with the relatively low average July temperatures. During the winter, in these hypsometric levels of medium January temperatures are more than -10°C, and less than -3°C, which means that they have the characteristics of a very cold winter. The main maximum of precipitation is in the second half of autumn while the main minimum of precipitation is in the second half of summer. The area is uninhabited due to high sea level altitude and unfavorable climate (see Figure 1 and Table 1).

Table 1: Settlements distribution by climate types in Bosnia and Herzegovina

Climate type	Area (km ²)	% of total land area of B&H	Number of settlements	% of total settlement number in B&H
Moderate continental	15.150	29,59	1.944	35,3
Pre-mountain moderate continental	16.524	32,28	2.369	39,2
Mountain moderate continental	10.530	20,57	672	10,3
Alpine	418	0,82	0	0,0
Pre-mountain maritime	4.037	7,89	345	6,8
Modified Adriatic type	2.582	5,04	256	4,3
Adriatic	1.956	3,82	239	4,1

Data source: Atlas svijeta, za osnovne i srednje škole, 1998:

Karta klimatskih tipova, "Sejtarija" Sarajevo, 18-20;

Stanovništvo po naseljenim mjestima, Statistički bilten br. 257., FZS, Sarajevo, 1998;

Topografska karta 1:200000, J.P. Geodetski zavod BiH, Sarajevo;

Population movement

According to some areas of Bosnia and Herzegovina, the movement of total population is extremely uneven so we can single out areas with the population decline such as the

south-west of Bosnia and high-Herzegovina belonging mostly to mountain climate type and areas of population growth, which belong to moderate continental climate in recent years to the Adriatic climate type, that cover the area of northern Bosnia, the Sarajevo-Zenica basin and low-Herzegovina.

In the analyzed period, the most of the population is gathered in the area of northern Bosnia, which is dominated by moderate continental climate. In this area with a trend of continuous increase which covers 29.59% of the total area, lives over 50% of the total population of Bosnia and Herzegovina. The Census of 2013 registered 58.3% of the Bosnian population in this area.

Until 1991 the continuous increase in population records an area that is characterized by the pre-mountain moderate continental climate. According to the last census in this area there was a decline in population and the decline in the percentage of the total population of Bosnia and Herzegovina. Pre-mountain maritime type records the increase in population only until 1971, but also the continued decline in the percentage of the total population from 1948 to the present.

During the analyzed period, the modified Adriatic climate type is largely maintained the same percentage share of the total population of Bosnia and Herzegovina, but it is also important to single out that this number reached the highest value according to census of 2013.

Only the southernmost part of Bosnia and Herzegovina, or low-Herzegovina, which is characterized by a Mediterranean climate or the Adriatic climate type has continued population growth and the percentage of the total population since the beginning of the analyzed period until today. The moderate mountain continental type is characterized by demographic exodus during the analyzed period. Today in this area lives only 3.1% of the total population (see Table 2 and Figure 2).

Table 2: Population distribution by climate types in Bosnia and Herzegovina (1948-2013)

Climate type	1948.		1953.		1961.		1971.		1981.		1991.		2013.	
	∑ inh.	% inh. B&H												
Moderate continental	1410573	55,0	1574257	55,3	1754089	53,5	2047108	54,6	2304003	55,9	2456478	56,1	2211940	58,3
Pre-mountain moderate continental	667401	26,0	758861	26,7	947256	28,9	1098647	29,3	1223810	29,7	1321608	30,2	1049930	27,7
Mountain moderate continental	185897	7,2	197087	6,9	218349	6,7	214466	5,7	189137	4,6	167658	3,8	117305	3,1
Alpine	0	-	0	-	0	-	0	-	0	-	0	-	0	-
Pre-mountain maritime	95805	3,7	99899	3,5	121579	3,7	122305	3,3	114711	2,8	112365	2,6	103599	2,7
Modified Adriatic	126583	4,9	136498	4,8	150731	4,6	171985	4,6	195682	4,7	216487	4,9	197819	5,2
Adriatic	78049	3,0	80857	2,8	86488	2,6	91600	2,4	96913	2,3	102437	2,3	111029	2,9
Total	2564308	-	2847459	-	3278492	-	3746111	-	4124256	-	4377033	-	3791622	-

Data source: Publications of census results for analysed period were given in chapter Literature and sources

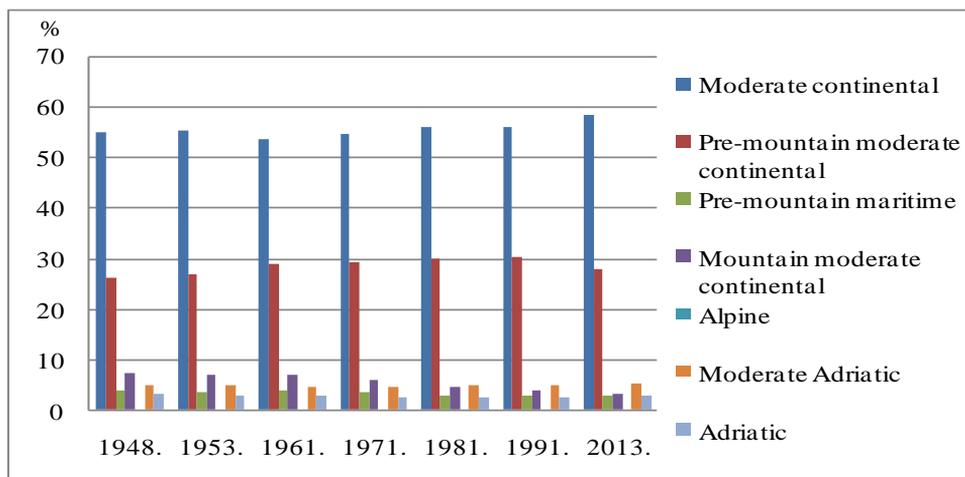


Fig. 2: Population distribution by climate types in Bosnia and Herzegovina (1948-2013)

Data sources: Data from Table 2

Population distribution is the main indicator of the density of population in a certain area. The number of inhabitants living in the unit area determines the general or geographical density. (Friganović, 1990). It is evident that from 1948 to 1991, except area which is characterized by moderate mountain continental climate type, recorded an increase in population as well as its density. During this period the climate type continuously increased the population, from 93 inhabitants per km² to 162 inhabitants per km². Caused by the decline of the total population in Bosnia and Herzegovina the population census 2013 registered 146 inhabitants per km².

The highest population growth in the period from 1948 to 1991 was recorded in the area of sub-mountain moderate continental climate. During this period the population density is doubled in this area. According to census from 2013, it is recorded higher decline in density of population in relation to the area of moderate continental climate.

A significant population growth was recorded in the area of the modified Adriatic climate type where the population density from 1948 to 1991 increased by 58%. Since then, this area records the decrease of 9%. The Adriatic climate type, also registers a continuous increase in population density. In addition, it is important to emphasize that this is the only area that today has more residents in relation to 1991. From this we can conclude that the northeastern most part of Bosnia which is basin of major rivers (the moderate and sub-mountain climate type) and an area of low-Herzegovina (Adriatic climate type), according to relief and climate characteristics offer the possibility of gathering the population and the growth and development of the settlements.

The pre-mountain maritime climate records a slight increase in population until 1971. Since 1971, population density in this area, is continuously declining, so today here live 26 inhabitants per km². In the analyzed period the mountain climate type mainly decreases in population. In this climatic region it is registered a lower population growth for the period 1948-1961. Since 1961 until 2013, when in this area lived 21 inhabitants per km², the population has been continuously decreasing, so according to the last census in this area were living only 11 inhabitants per km² (see Table 3 and Figure 3).

Table 3: Population density by climate types in Bosnia and Herzegovina (1948-2013)

Climate type	1948.		1953.		1961.		1971.		1981.		1991.		2013.	
	∑ inh.	inh./km ²												
Moderate continental	1410573	93	1574257	104	1754089	116	2047108	135	2304003	152	2456478	162	2211940	146
Pre-mountain moderate continental	667401	40	758861	46	947256	57	1098647	66	1223810	74	1321608	80	1049930	64
Pre-mountain maritime	95805	24	99899	25	121579	30	122305	30	114711	28	112365	28	103599	26
Mountain moderate continental	185897	18	197087	19	218349	21	214466	20	189137	18	167658	16	117305	11
Alpine	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Modified Adriatic	126583	49	136498	53	150731	58	171985	67	195682	76	216487	84	197819	77
Adriatic	78049	40	80857	41	86488	44	91600	47	96913	50	102437	52	111029	57
Total	2564308	50	2847459	56	3278492	64	3746111	73	4124256	81	4377033	85	3791622	74

Data source : Publication of census results for analysed period were given in chapter Literature and sources

According to the census of population, households and apartments in 1961 in Bosnia and Herzegovina has recorded just nine settlements that had less than 10 inhabitants. According to the census of 1971 the number of settlements with less than 10 inhabitants increased to 21, and in 1981 registered 52 settlements where lived less than 10 people. In 1991 the number of settlements with less than 10 residents amounted to 123 settlements. In Bosnia and Herzegovina, according to preliminary results of census of population, households and apartments from 2013, has registered 252 settlements in which is listed less than 10 inhabitants, 53 settlements with a population of less than 5 inhabitants and 6 settlements with a listed only one inhabitant.

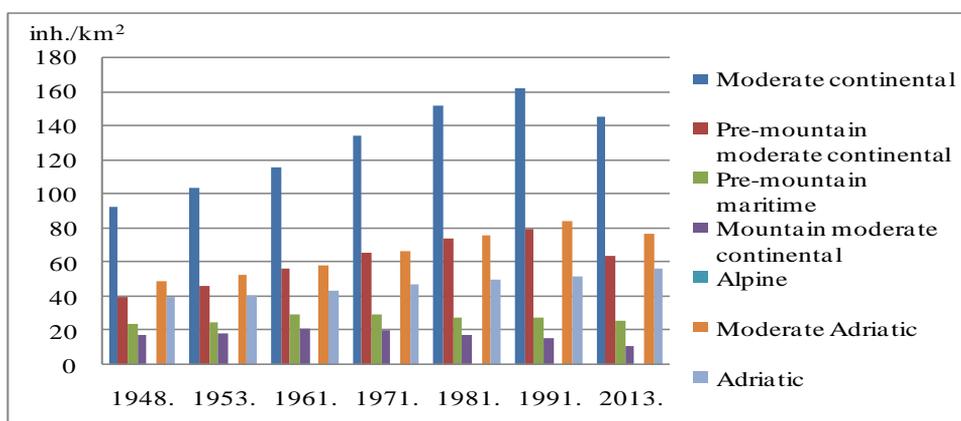


Fig. 3: Population density by climate types in Bosnia and Herzegovina (1948-2013)

Data source: Data from Table 3

The preliminary data of the census of 2013 talks about the extent of losses of the central mountain areas of Bosnia and Herzegovina. Evidence that the mountainous area of Bosnia and Herzegovina, which is characterized by harsh climate, loses residents are indicators of the population and settlements of municipalities located in the area. According to the last census of 2013, municipalities in which are registered settlements without population are: Kalinovik (24 settlements), Vareš (19 settlements), Višegrad (9 settlements), Bugojno (11 settlements), Donji Vakuf (10 settlements) Rogatica (5 settlements), etc. The reason for leaving these settlements mainly can be linked to the last events of the war and forced migration. After the cessation of war activities there was no return of the population in these areas which can be associated with poor socio-economic conditions and natural geographic (climate) conditions that are present in these areas.

CONCLUSION

The Bosnia and Herzegovina climate is defined by its geographic position and relief. The relief occurs as a climate modifier with structure and altitude, i.e. the expressed altitude thermal gradient, and this area is characterized with a colder climate concerning its geographic position. It has been determined that the relief has a strong influence on a climate in Bosnia and Herzegovina, and its mutual action reflects on the population, its distribution and demographic processes.

Based on genetical and typological climate classification we can conclude that seven climate types of continental and maritime characters are present in Bosnia and Herzegovina territory. The biggest area occupies the moderate continental climate and the pre-mountain moderate continental climate type, which gathers the most of Bosnia and Herzegovina population. The moderate continental climate type has the biggest medium size settlements, and records the increase in the percentage of the total population after 1991. The pre-mountain maritime climate type records the increase of the population only before 1971, and continued decline in the percentage of the total population from 1948 till today. The modified Adriatic climate type trough analysed period has mostly kept the same percentage share of the total population, but it's important to note that this number has listed the highest value by census from 2013. The Low Herzegovina, which is characterized by the Mediterranean climate or the Adriatic climate type has had from the beginning of the analysed period until today continued increase of the population number and percentage share in the total population.

The mountain moderate continental climate type continuously loose population trough analysed period of time. Today the mountain areas are almost unsettled or there are small rural settlements with few inhabitants and households. Settlements distributed at this mountain areas, are characterized by rural exodus. In war period (1992-1995), there were many dislocations, apropos forced population migrations. After the end of warfare, there was no important recurrence in the mountain areas, i.e. areas of rough climate.

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