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Climate as Spatial Planning Factor of the Una Sana Canton, Bosnia and Herzegovina

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Abstract

The main aim of this study is to determine the relationship between the development of certain economic activities and climatic characteristics of the Una Sana Canton. By the right estimation of the current spatial condition and its developmental potentials, there is defined a frame inside which sustainable development will be enabled to a certain area.

For the purpose of analysis of climatic characteristics of the Una Sana Canton, there was applied a quantitative method of analysis of meteorological date, as well as patterns by which mathematically is determined the type of climate: rainy factor, the drought and the summertime index. Results of the analysis indicate a high level of dependence of the economic activities development, first of all agriculture and tourism, on climate characteristics of the Canton.

Key words: meteorological date, the Una Sana Canton, spatial planning

Introduction

During the spatial planning at certain areas, meteorological date have great impact on planning decisions as they could be the cause of natural disasters and could influence the development of tourism, agriculture, and placement of industrial facilities. Climatic factor, among others, directly affects the hydrologic, biogeographic and soil conditions in the area. The most important climatic parameters of a settlement and area, such as: insolation, air temperature, frequency, wind direction and speed, air humidity, cloudiness, precipitations and so, are analyzed in the spatial planning process (Kicošev, Dunčić, 1998), what was the main starting point during this paper's work out. The Una Sana Canton is situated inside the net of coordinates 44°15, 2' and 45°13, 6' N and 15°44, 4' and 16°55, 5' E. With the surface of 4125, 0 km2 it comprises about 8, 1 % of the state territory of Bosnia and Herzegovina, in which it is situated in its northwest part. (Fig.1)

Due to its stretching direction northwest-southeast, the Canton is under the influence of the two main climatic belt zones, and these are: south parts of the north moderate belt and north parts of the subtropical belt in the north hemisphere, to which also contributes meridian direction of rivers' valleys which cut the relief. North, middle and east parts of the Canton are more under the influence of the

Figure 1. Geographical position of the Una Sana Canton

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continental climate, what is the characteristic of the north moderate belt. Concerning the global disposition of air masses, belts and sectors, there can be set aside the zonal disposition of annually and monthly isotherms, as well as isohyets, in the region of the Canton. However, the hypsometrical position, exposition and exposure to the general global air circulation, brought to disequilibrium in disposition of precipitations and temperatures on certain areas inside these zones. Meteorological date and appearances often can be the cause of natural disasters which are reflected through: drought, floods, hail, and snow. Obtained results of this work, with further researches, can give directions in setting aside spatial units that are the most suitable for the agriculture development, possible touristic valorization as well as the environmental protection in the region of the Una – Sana Canton.

Used methods

Regarding the surface of the Canton, the analysis of all climatic data and appearances would request a huge and specific work. This time, there were treated the average multiannual values of the air temperature, air humidity, and cloudiness, number of days with snow and wind for every municipality of the Canton. We analyzed the meteorological data of the Hydrometeorological Institute of the Federation of Bosnia and Herzegovina for 1961st to 1990th years. In this way, the main picture of the climatic characteristics of the Una Sana Canton as a whole has been obtained. At studying the climatic conditions of a certain area, special patterns may have a high importance as they are used, in mathematical way, to determine the type of climate. This time, for the region of the Una Sana Canton there were determined: the rain factor, the index of drought and summertime, and for the purpose of planning the economy development, especially agriculture and tourism. Presentation of the climatic data in this work was done textually, graphically and in tables. Of special importance there are climatologic maps which present, by isoline method, the arrangement and intensity of some climatic data.

Climatic Characteristics of the Una Sana Canton

During the determination of the thermal picture of the Una Sana Canton there have been worked out the average values of monthly temperatures for a long period, on the base of which was determined the annual flow of the air temperatures. In order to give the best in presenting climatic conditions of the Canton, there have been used meteorological data for areas of some municipalities for multiannual period. For the municipalities of Bužim, Cazin and Velika Kladuša, data were gained by interpolation of meteorological data, and for the municipality of Bosanski Petrovac, there have been used data from MS Drinić which until 1995 was in this municipality. According to data on average monthly air temperatures, during the 30-years period in some municipalities of the Canton, values were positive, and minimal temperatures appear after the winter solstice. When it's about the annual oscillation in the air temperature for each of the Canton's municipality, between the hottest and the coldest month, it counts 19°C to 20°C. Bosanski Petrovac has the smallest oscillation, about 17°C.

The hottest month in a year and during the summer season is July with average temperature of 20°C in Bihać and in other towns of the Canton the temperature in July moves from 19°C to 19.5°C. Bosanski Petrovac has the lowest July's temperature with 17.1°C. One can conclude that the maximum temperatures appear with delay of a month after the summer solstice. Average multiannual temperatures vary from 7.9°C in Bosanski Petrovac to 10.6°C in Bihać. All four seasons are clearly expressed. Besides the warmer summer and colder winter, transitional seasons too can be felt. Spring when the temperature gradually rise and autumn when temperatures drop. Spring months: March, April and May, in average for this period, have an average temperature of 9.8°C and is equal with an

Table 1. *Average monthly temperature for multiannual period (°C)*

1961-1990	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Multi-annual average
USK	0.1	1.6	5.4	9.8	14.3	17.5	19.1	18.3	14.9	10.3	5.3	1.5	9.8

Source: According to data of HMZ BiH

Table 2. *Average temperatures by seasons on the region of Una Sana Canton for multiannual period*

Spring	Summer	Autumn	Winter
9.8°C	18.3°C	10.2°C	1.1°C

Source: According to data of HMZ BiH

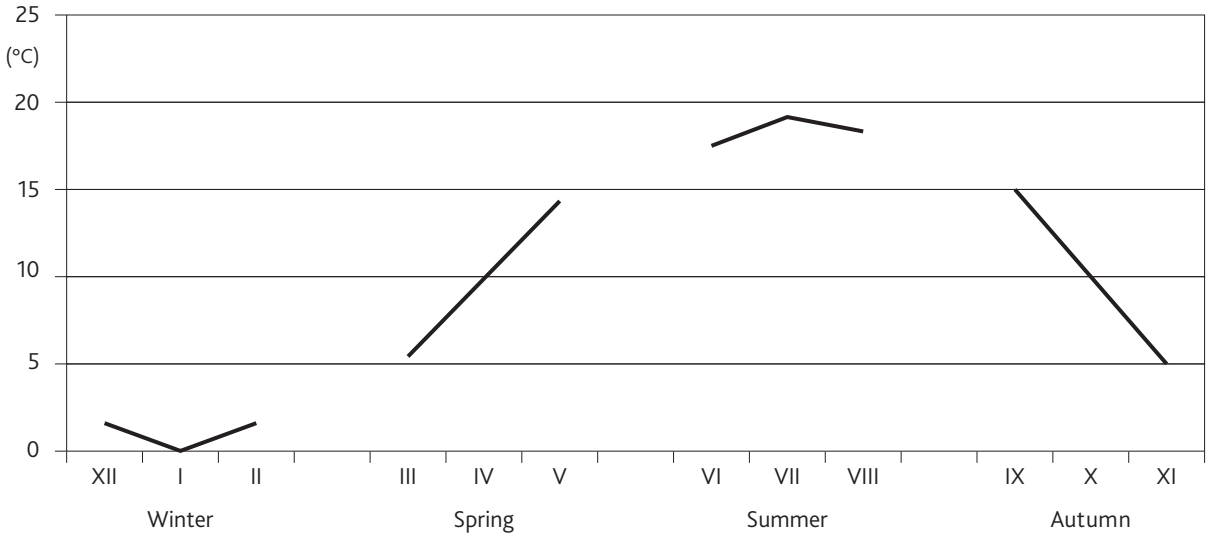

Figure 2. Graph of temperature changes depends on seasons

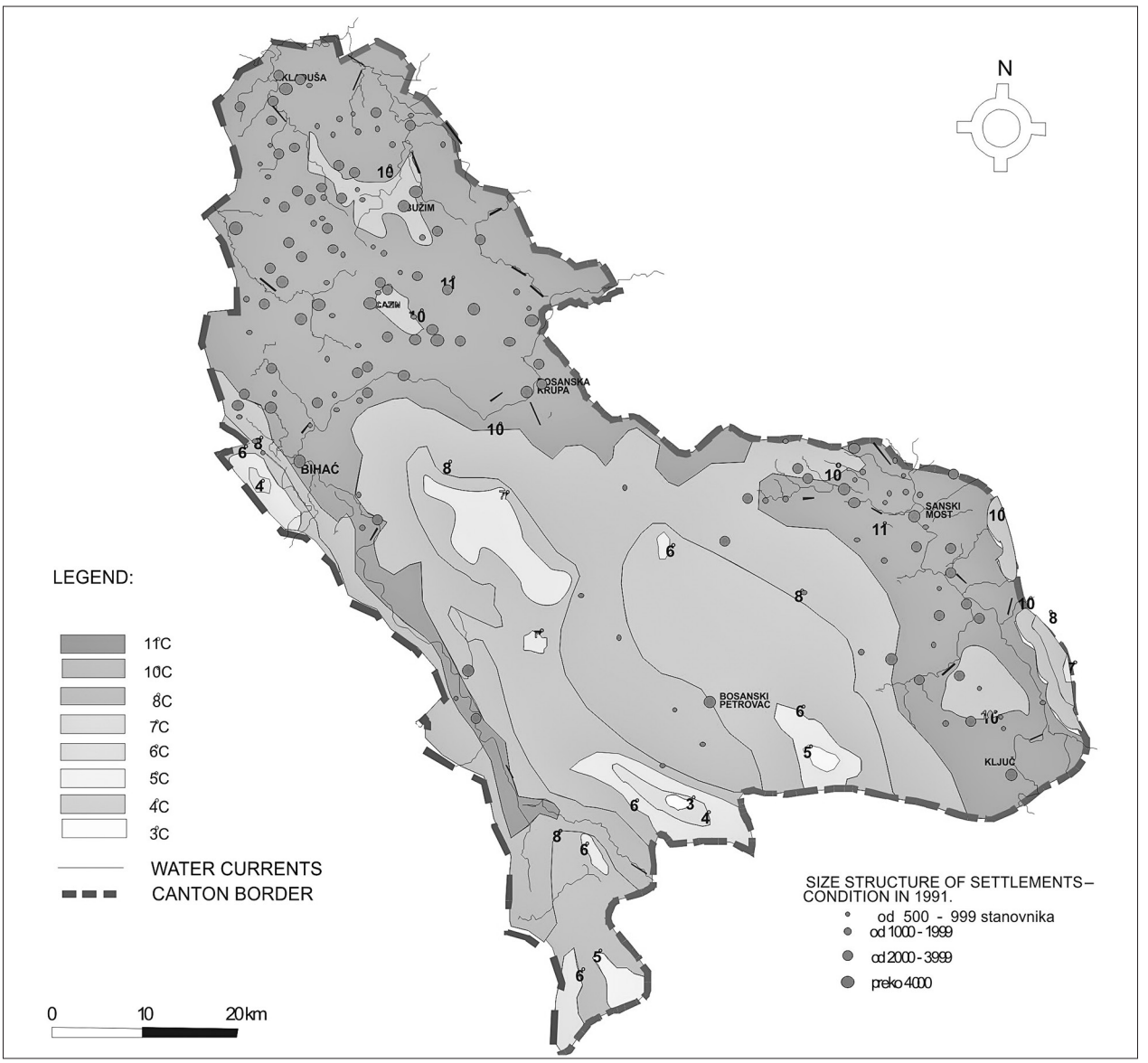

Figure 3. Map of average annual temperatures

average annual temperature. Temperatures in spring period grow from month to month for about 5°C. The hottest month is May with average monthly temperature of 14.3°C.

If we compared the temperature of the spring and autumn months can be observed some differences (Fig.2). September and October have higher temperature than spring period. Seasonal average temperature is 10.2°C, which is 0.4°C higher than the average spring temperature. Concerning that the heat is accumulated in the soil during the summer, and releases during the autumn and winter period, that is too, one of reasons why autumn is warmer than spring.

Vegetation period, in average for the Canton, lasts for about 250 days, and that is when the temperatures are higher than 5°C. It starts around the middle of March (16 March), and finishes in 21 November. Taking in account the temperatures higher than 10°C, vegetation period lasts for about 180 days, starting in 15 April and lasting until 18 October.

Concerning the surface and position it takes, as well as relief characteristics of the Una Sana Canton, in this area vertical thermal gradient too is highly expressed.

The highest hypsometric levels in the Canton area have an average annual temperature of 30C, and the lowest levels 11°C (Fig. 3). In a range of 1700 m of relative height it comes to temperature change for 80C, means that with the increase of height on each 200 m, the average annual temperature decreases for about 1°C. Annual flow of relative air humidity is opposite proportional to annual flow of the air temperature. Average annual relative humidity in the Una Sana Canton amounts 77.4 %, what refers to the fifth degree on the scale (from 75.1 % to 80.0 %). This degree has characteristics of transitional maritime continental type (Milosavljević, 1973), and it assumes greater cloudiness as well. The greatest average values for the Canton appears during December 82.7 and January 82.1 %, it means in the winter period. The lowest humidity appears during May with amounts of 72.1%, and then it grows.

Here should be remarked that the increase in value of relative humidity, starting from spring towards summer season has a certain positive impact because it alleviates the droughts (Fig.4).

If analyze values of average monthly relative humidity in some municipalities, one can notice certain deviations. Mentioned differences come from the local morphologic specifics, physical characteristics of the surface, soil covered with forest vegetation and so. Bosanski Petrovac has the lowest relative humidity with 73%, and Ključ the greatest with 83%. Amplitude of value of the average monthly cloudiness follows the

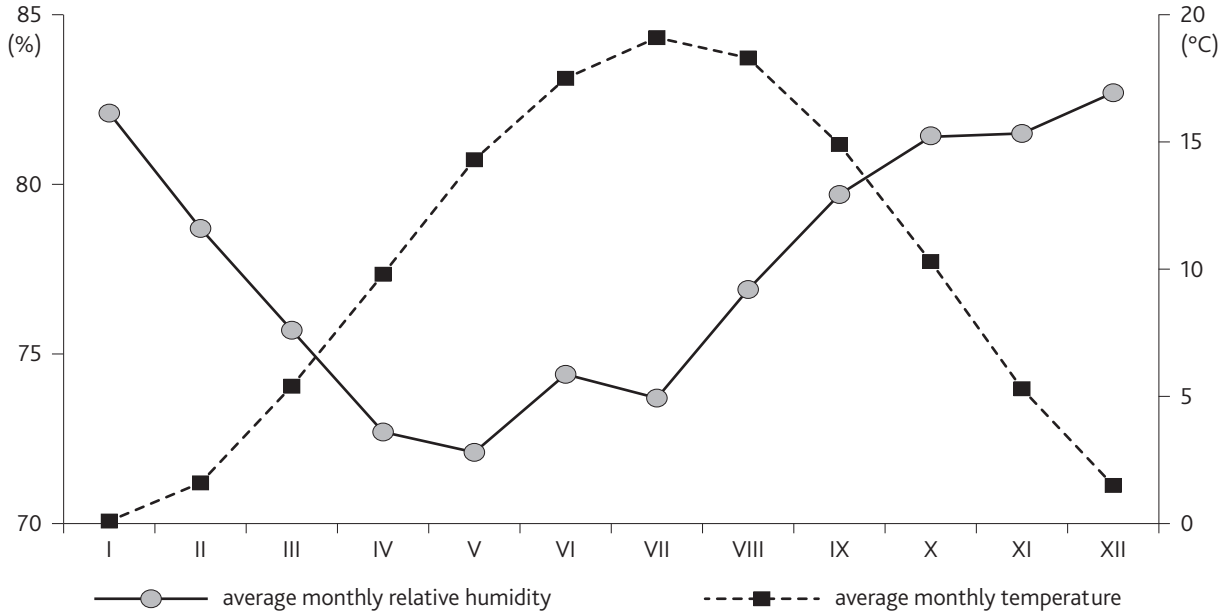

Figure 4. Comparative analyses of the annual flows of relative humidity and air temperature for the region of the Una Sana Canton

Table 3. *Annual flows of relative humidity (%) for 30-years period*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
USK	82.1	78.7	75.7	72.7	72.1	74.4	73.7	76.9	79.7	81.4	81.5	82.7	77.4

Source: According to data of HMZ BiH

Table 4. *Average monthly cloudiness for multiannual period*

Decade	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
USK	7.6	6.9	6.3	6.1	5.3	5.1	4.2	4.5	5.6	6.3	6.3	7.2	5.9

Source: According to data of HMZ BiH

growth of relative monthly humidity, and is in opposite relation to the air temperature.

Months with the greatest cloudiness are January and December, and average cloudiness for the winter season amounts 7.2. This condition is under direct influence of winter in the north hemisphere, which general characteristic is increased cloudiness of polystratus type. This cloudiness is a consequence of prevailed flows of humid winds from the west quadrant, and of increased relative humidity. The lowest cloudiness on seasons is linked with summer and it amounts 4.6. Cloudiness during the autumn period amounts 6.1 and in average is larger than in spring season, which is characterized with 5.9 one tenth. Concerning that average annual cloudiness amounts 5.9, one can conclude that the area of the Una Sana Canton is counted into more cloudy regions and that belongs to subtype moderate cloudiness, which is defined by isoneph values of 55.0 up to 60.9 %. Analyzing cloudiness in some municipalities of the Una Sana Canton, one can conclude that average annual values moves from the lowest of 4.4 in Velika Kladuša up to 6.51 in Bosanska Krupa. Months with the most sunny days in average for the Canton region are July (8.6) and August (9.6), what is in direct connection with cloudiness. With the growth of cloudiness and average monthly relative humidity, declines the number of sunny days, and grows the number of cloudy days. Most of them appear during December (17.4) and January (15.3). Instable sunny and cloudy days during the spring season are brought in connection with sudden breakout of wind from the south, which brings the weather change in this area.

In the Una Sana Canton annually 1172.8 mm of precipitations secrete and that quantity varies if we observe some of municipalities of the Canton. The quantity and annual distribution of precipitations in this area are conditioned mainly by latitude, distance from the sea, relief structure, and movement of the air masses. Sanski Most has the smallest quantity of precipitations during the year 986 mm. When going towards the south and west that quantity increases, and the greatest values are recorded in Bihać and Bosanski Petrovac. Hypsometric levels above 1000 m receive more than 1,750 mm of precipitation annually, and average annual temperatures in these areas moves from 3°C to 7°C. It comes, by that, to change of the climatic conditions where continental climate transfer to pre-mountain, and on the highest mountain tops into mountain type of climate. Maximum of falls in the region of the Una Sana Canton in average appears in warmer period of year. The greatest amount of rain falls during the period from April to August and in November. In the season's fall distribution, dominates summer period with 104.9 mm, then autumn with 102.8 mm of falls. In average, in spring, on the territory of the Una Sana Canton fewer precipitations are secreted than during autumn, and that quantity amounts 99.8 mm. In period from April to September, more than 600 mm of the atmosphere deposit is fallen what is about 53 % of the total annual quantity of precipitations. According to these data, the annual rain regime of this area belongs to out-tropical pluviometrical regime, and yet the continental.

During the summer huge amount of precipitation is secreted as showers in short time interval. Very important climatic factor is snow cover too. Temperatures of snow surfaces are usually lower than the temperatures of soil without a snow, so that temperatures while the snow cover is still on are usually negative. Regarding that, snow cover has a great influence on air temperature, humidity and cloudiness. Annu-

Table 5. *Average monthly precipitation quantities in mm (1961 - 1990)*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ Multi-annual average
USK	78.8	82.7	88.4	105.7	105.4	109.2	102.0	103.7	95.1	99.0	114.2	88.6	1172.8

Source: According to data of HMZ BiH

Table 6. *Average number of days with snow cover*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
USK	7.4	6.7	4.4	1.9	0.2	-	-	-	-	0.5	3.2	6.2	30.5

Source: According to data of HMZ BiH

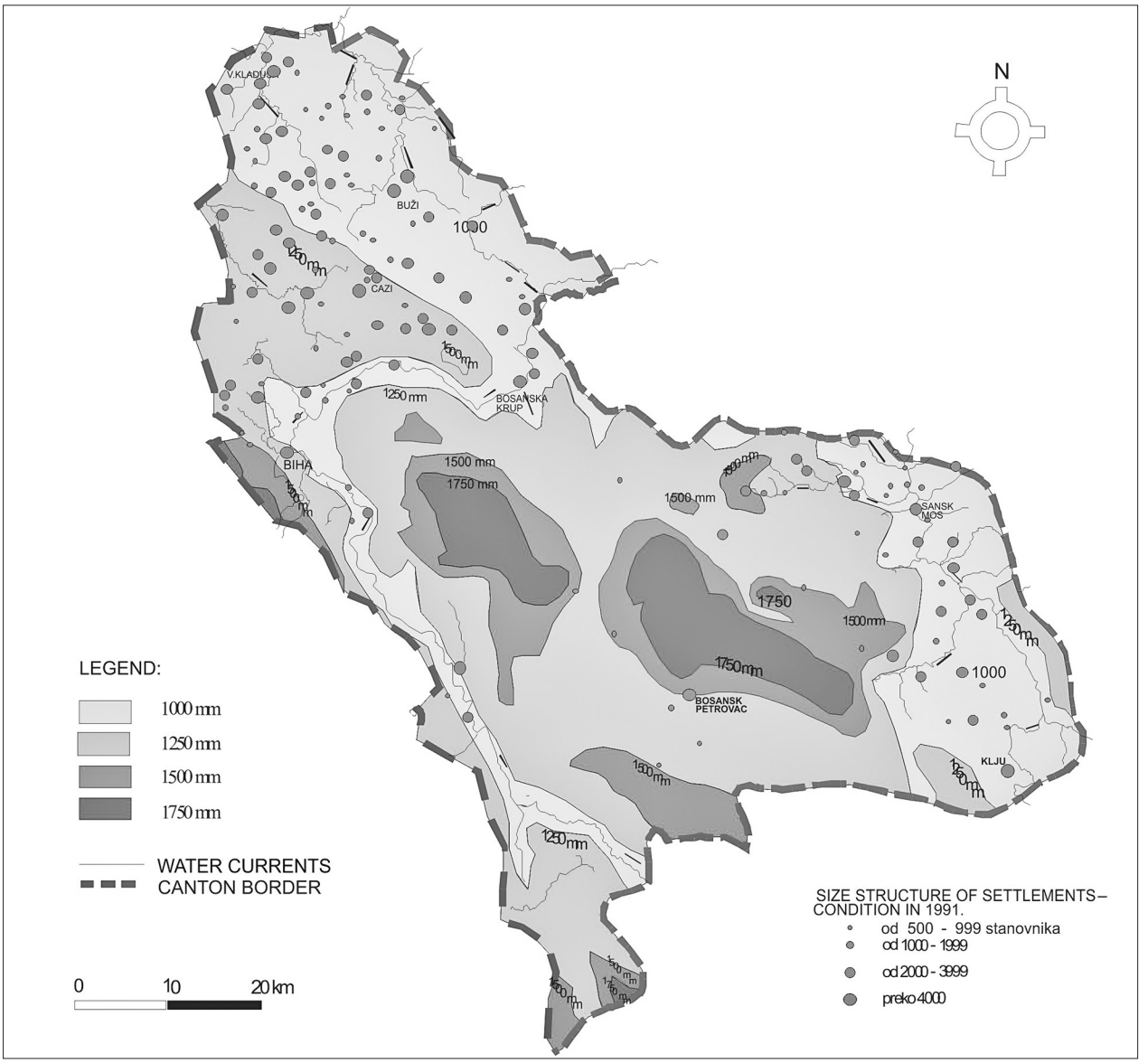

Figure 5. Average annual precipitation quantities

al flow of snow precipitations is characterized by opposite proportional relation with annual flow of rainy days. General characteristics of thermal regime in some parts of the Canton have a significant impact on season's flows. The largest number of days with a snow cover happens during the winter period, in average 6.8 days. Spring has 2.2 and autumn 1.8 such days. Annually, in the region of the Una Sana Canton there are in average 30.5 days with a snow. That number varies when some parts of the Canton are in question. Bosanski Petrovac has the largest number of snowy days in a year: 37 and Velika Kladuša has the smallest one: 25.2.

The height of snow varies when some parts of the Canton are in question. It depends on the sea level and relief structure but also on conditions of certain climatic parameters. The height of snow cover is larger on mountains and it stays longer, especially on north slopes of the mountains of Grmeč and Osječenica. Analog to isotherm disposition, there is similar disposition of isohyets in the area of the Una Sana Canton. Larger amount of precipitations appears in the middle, extreme south, and in parts of the Plješevica area. According to the figure 5, areas up to 400 m above sea level annually receive 1000 mm in average, while the areas above 1,500 m receive more than 1,700 mm of precipitations.

The area of the Una Sana Canton and geomorphologic characteristics had an impact on complexity in wind distribution. Local winds originate as a consequence of differentiated heating of the bottom of valleys and contact slope sides, at which the valley and slope circulation are formed. The influence of the regional atmospheric circulation has a dominate season character. During the colder period of a year, north flows are established, originated from Arctic,

Table 7. *Average annual distribution of frequencies and the wind speed in the region of the Una Sana Canton*

Direction	N	NE	E	SE	S	SW	W	NW	C
%	10.9	4.9	6.1	6.8	5.9	8.6	8.9	10.6	37.3
m/s	1.7	1.6	1.1	2.2	2.3	1.8	1.5	1.5	

Source: According to data of HMZ BiH

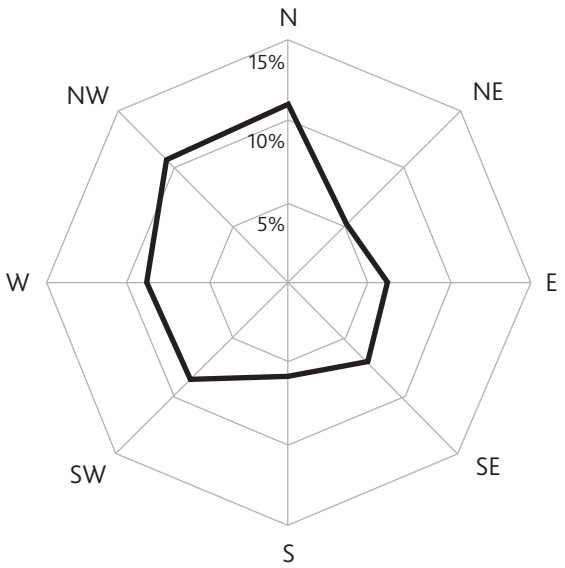

Figure 6. Graph of the wind's frequency (%)

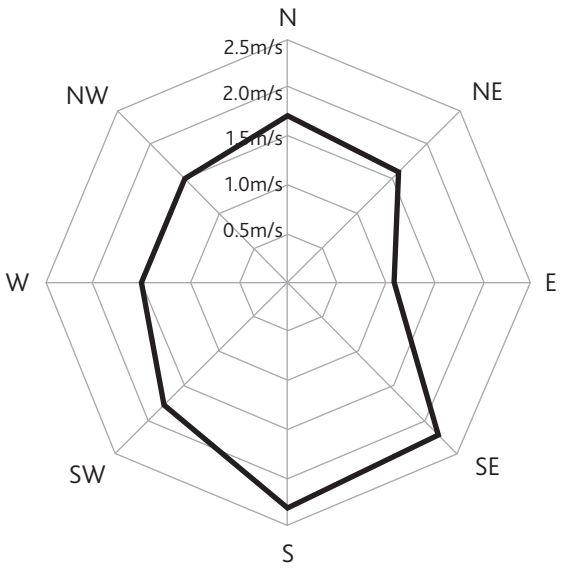

Figure 7. Graph of the wind's speed (m/s)

so-called Arctic air masses. These masses bring with themselves dry and cold air can lasted for several days and have an influence on decreasing the temperature and reducing cloudiness. In that period cold and clear weather condition is established. Flows from the west and northwest quadrant bring with themselves humid and warm maritime air during the whole year. These winds have a fall character and belong to the belt of southwest fen which is spread up to the most expressive tops of the Alps Dinaric Mountain System. In a spatial planning, the analysis on wind data takes significant place. This climatic factor, before all, has an impact on arrangement of industrial factories and settlements.

The most often winds in the region of the Una Sana Canton, in average come from the direction of the north, then west and southwest (Fig.6). When talking about some municipalities, in the Ključ area the most often are winds from the southeast and southwest direction and in Cazin north and east winds. Apart from Cazin, in the area of Sanski Most and Ključ, the east winds are the least presented. On the whole, for the Canton area, south and southeast wind have the biggest average speed of 2.2 m/s and 2.3 m/s (Fig.7).

By the analysis of climatic parameters, above all the temperatures and precipitations (Fig.8), it is come to conclusion that in this area a moderate-continental type was formed, and that is, according to Köppen, moderate warm and humid climate type with a warm summer (Cfb) in lower hypsometrical levels and in greater part of the Canton as well. The climate is modified as the height increases, so at the south of the Canton, i.e. in areas of Grmeč, Osječenica and Plješivica, pre-mountain (Cfbx) and mountain (Df) climate are presented.

Climate as Spatial Planning Factor of the Una Sana Canton

Agriculture areas in the region of the Una Sana Canton comprise 194,125 ha or 52.10%, and they present a good basement for the agriculture production. The largest areas are under cultivation and pastures 105,286 ha, then under meadows and pastures 86,331 ha and orchards 2,508 ha (Korjenić, 2009). According to the register from 1991 in the region of the Una – Sana Canton there were 50,985 of the agriculture farms. The greatest number is consecrated in urban and sub-urban areas on quality lands in river valleys and up to 250 m above sea level. In this area there are the greatest shortening and fragmentariness of these farms as well. With increase of the sea level grows the size of these areas too, but with a higher participation of meadows and pastures. Concerning such a situation, the estimation of climatic conditions is of exceptional importance in a spatial planning, and in the

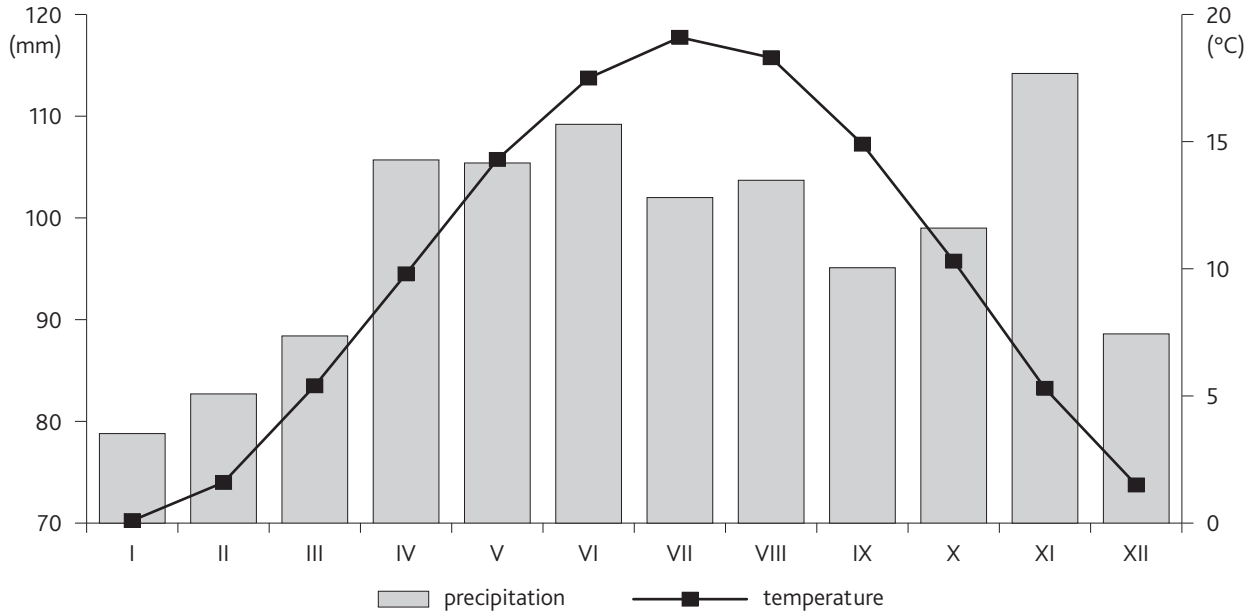

Figure 8. Graph of temperatures and precipitations in the Una Sana Canton

aim of development of agriculture production and the Canton itself.

By the analysis of climatic characteristics in the region of the Una Sana Canton, one can notice that this area has exceptionally favorable conditions for the agriculture development and upbringing of various plant cultures.

The degree of humidity and aridity of certain area is determined by the rain factor[1]. The rain factor for the region of the Una Sana Canton amounts: f = 1172.8 mm / 9.8°C = 119.7. Regarding this data, one can conclude that the Canton area has a humid climate. If compares data on average long-term precipitation quantity and temperatures, it can be estimated the drought index as well in this area.

which are higher than the spring temperatures, are positively reflected on mature of late agro-cultures. However, for the plants adapted to moderate climate conditions, long vegetation period is a very favorable (250 days with temperatures higher than 5°C and 180 days with temperature values higher than 10°C). During the autumn season, stable weather is maintained which has a positive effect on the agriculture production and is suitable for maturing of fruits and performing seeding for the winter wheat. Distribution of precipitations by seasons has a great significance for agro-cultures, and especially during the vegetation period, when plants sprout, bloom and mature. Increase of values of relative humidity from the spring to summer season has certain posi-

Table 8. *Drought index by the municipalities of the Una – Sana Canton*

	Bihać	B.Krupa	S.Most	Cazin	V.Kladuša	Bužim	B.Petrovac	Ključ
Pg	1307.5	1231.4	986	1213	1162	1134.1	1267.1	1082
Tg+10	20.6	20.4	20.1	19.5	20.3	19.8	17.9	20.2
ISg	**63.5**	**60.4**	**49.1**	**62.2**	**57.2**	**57.3**	**70.8**	**53.6**

The whole area of the Una Sana Canton by the municipalities has drought index larger than 40. According to E. de Marton that data refers to areas with expressively good humidity, abundant drainage or flows and suitable area for the forest vegetation existence. Average annual temperature of 9.8°C, and especially average autumn temperatures (10.2°C)

tive impact because it alleviates the droughts. Larger quantity of precipitations is secreted during the vegetation period and a maximum of precipitations in average appears during the warmer period of a year. However, here should be mentioned that during the summer great quantity of precipitations is secreted as showers in a short time interval. These precipitations originate from cumulonimbus clouds and as they are attached appearance of stormy weather, they have a bad reflection on vegetation cover. Shower rains bring damage to productive land because

[1] Lang's rain factor is calculated by the pattern: f = Pg/Tg, in which Pg is – average annual quantity of precipitations in mm, and Tg – average annual temperature in oC (Spahić, 2002).

they hurry the erosion; evoke torrents and floods, to which must be paid special attention during the spatial planning.

Beside the agriculture production, the Una Sana Canton has good predispositions for tourism development as well. In various categories of protection, there have been included several localities and wider areas:

- water current of the Una River and Unac until Ripač as "The National Park of the Una River" has the highest level of protection;
- "The jungle area of Plješevica", reservation of nature;
- abundance of natural, untouched immemorial values, above all, geomorphologic and bio-geographic, causes the parts of the Grmeč Mountain to be protected as a regional nature park of national value with the level of protection: II – IV;
- valley of the Sanica and Sana River up to Sanski Most in recreational, that is in area of nature of national value with the level of protection: II – IV;
- valley of the Una River, from Ripač until Bosanski Novi is included in recreational and other nature areas, of national value with the level of protection: II–IV;
- Waterfall of Bliha is included in the nature reservation of local value with the level of protection: I.

Talking about climatic characteristics, one of the more significant parameters for tourism development is the summer time index[2]. On the base of this index there is performed the estimation of the touristic value of climate in certain area. This time it was determined the summer time index for Bihać as the administrative center of the Canton as well as the National Park which should be the bearer of the tourism development in this region.

$$IST_{Bihać} = 57.5°C + 735\ h - 325.8\ mm = 466.7$$

According to obtained results, the summer time index is less than 700. However, it is necessary to emphasize here, that, before all, special kinds of tourism must be set aside, and then what are the climatic conditions that are suited for such kinds of tourism. Concerning that in the region of the Una Sana Canton and especially of the Una National Park is planned to develop transit and recreational tourism, means various kinds of recreations such are: walk (recreational), mountaineering, rafting, kayaking, canoeing and canyoning, one can conclude that the obtained summer time index, that is climatic conditions, is favorable for the further development of this kind of tourism and recreation.

[2] Summertime index was brought in climatology by the English climatologist Polter and according to him, the index value higher than 700, the climatic conditions for tourism development especially summer, bathing tourism, is more favorable. It is estimated according to pattern: $IST = \Sigma T_{lm} + S_l - R_l$, in which ΣT_{lm} – sum of average monthly air temperature, S_l – sum of duration of Sun shining and R_l – average precipitation quantity. All these values reffer to summer months.

Conclusion

State of the atmosphere conditions in a longer period of time showed that the Una Sana Canton has favorable predispositions for the agriculture development and tourism as well. Outstanding good humidity and abundant drainage, long vegetation period, stable weather during the autumn season, as well as greater quantity of precipitation which is secreted during the vegetation period has a great importance for upbringing of various agro-cultures, while the summertime index of 466.7, directly implicates suitable climatic conditions for development, above all, of the recreational tourism.

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