VALORIFICATION OF THE ECONOMIC POTENTIAL OF RARAU MASSIF BASED ON CLIMATE CONDITIONS

VALORIFICAREA POTENTIALULUI ECONOMIC AL MASIVULUI RARĂU PE BAZA CONDIŢIILOR CLIMATICE

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Abstract. *The Rarau Massif is a mountain area exploited for tourism purposes since 1928, but recent climate change requires a reanalysis of the new weather conditions to propose a new economical capitalizing plan. In this paper we analyzed the main meteorological elements (temperature, precipitation, speed and frequency of wind) recorded by the Rarau meteorological station to highlight the economic potential of the area. In the Rarau massif, the air temperature during the summer months has increased, which is favourable for mountain tourism. This hypothesis is also supported by the decrease of the amount of rainfall during the summer. Our analysis shows that the heating of the air is due to the warm wind, predominantly in the east - west direction with relatively slow speeds (2 m/s). Instead, the temperatures have decreased in January - February which supports the construction of one of the longest winter sports slope in Romania.*
Keywords: climate change, sustainable development, Rarau development

Rezumat. *Masivul Rarău este o arie montană exploatată în scop turistic din 1928, dar schimbările climatice din ultimul timp impun o reanaliză a noilor condiţii meteorologice pentru a propune un nou plan de valorificare economică. În lucrarea de faţă am analizat principalele elemente meteorologice (temperatură, precipitaţii, viteza şi frecvenţa vântului) prelevate de la staţia meteorologică Rarău cu scopul de a evidenţia potenţialul economic al zonei. În masivul Rarău, temperatura aerului în lunile de vară a crescut, ceea ce este favorabil turismului montan. Această ipoteză este susţinută şi de scăderea cantităţii de precipitaţii în timpul verii. Analiza noastră arată că încălzirea aerului se datorează vântului cald, preponderent pe direcţia est–vest cu viteze relativ mici (2 m/s). În schimb, în ianuarie - februarie temperaturile au scăzut, ceea ce susţine construcţia uneia dintre cele mai lungi pârtii pentru sporturile de iarnă din România.*
Cuvinte cheie: schimbări climatice, dezvoltare durabilă, dezvoltare Rarău

INTRODUCTION

The tourism is a way of capitalizing the natural resources, the climate, the curative qualities of the mineral and thermal waters and in the case of mountain tourism, the beauty of the landscapes during the summer or sports on snow in the winter.

In some tourist areas, the natural environment is the predominant factor that attracts tourists. The natural framework could be threatened by climate change (Ivanescu *et al*., 2016; Ivanescu *et al*., 2018), which has as effect the decreasing of number of

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tourists. In the case of forested mountainous areas, this can have a major impact on the forest vegetations and fauna. That is why, in the last few years, thorough tourism studies take into account the effects of climate change that has become a topic of interest in all important places of the world. The importance of this topic derives from the fact that these climate changes have produced many negative effects on natural ecosystems. Moreover, the climate changes and pollution affect the buildings, statues and wall painted of monuments from historic cities. The tourism sector is the most affected by the heat waves that occur in the warm season, the small amount of precipitation, the decrease of snow persistence during the winter and, especially, by the extreme phenomena such as floods, tornadoes etc (Bodale *et al*., 2017). Weather factors that have a major impact on tourism are temperature, precipitation and winds.

The Rarau Massif has been exploited for tourism since 1928 by building the Rarau cottage that had a strong contribution for geographic and geological researches and meteorological measurements in this area. After 2014, when the road infrastructure was modernized by building *TransRarău road*, alongside with the accommodation conditions improvement, a new approach is required. The *TransRarău road* ensures auto access in Rarau Massif from Moldova Valley through DJ175B (from Pojorîta side) and from Bistrita Valley (D175A from Chiril side). Furthermore, Suceava County administration is prepared to modernize a new way of access from the east part of Campulung Moldovenesc to the ski slope (DJ175A). Starting from these premises, in this paper, we propose a new climatic bulletin to be included in the future master plan of developing the Rarau tourist area, which should offer a new opportunity for tourists based on analysing the climatic factors.

MATERIAL AND METHOD

In the present paper, we analyzed the modification of these climatic factors that influence tourism in the Rarau Mountain range, one of the most important tourist area from Moldova. For this purpose, we analysed the temperature, the amount of precipitation, frequency and the speed of wind recorded by Rarau meteorological station during the period 1991-2000 versus the climatologically average of the period 1961–1991. We used statistical processing tools, specialized graphics and presentation programs: Excel and Matlab.

RESULTS AND DISCUSSIONS

Relief is an important genetic factor of climate that influence the meteorological conditions, especially due to the altitude. This is the main reason why weather in the mountains is more difficult to analyze (Barry, 2008; Oancea, 2010). In general, for population the easiest way to perceive weather is temperature that depends on solar radiation, air circulation, the slope of the relief, the slope exhibition against the sunstroke, which determines the angle of incidence of solar radiation.

The general characteristics of the clime in Rarau should be studied on two levels of altitude. We focused the present study on the upper level that includes the top of the massif from 1200 m to 1650 m. This presents the most important characteristics for

tourism. We analysed the radiation balance in order to understand the thermal characteristics. In the Rarau Massif, the direct sunlight has a peak in June at 12.00 PM. During winter, in December at 12.00 PM, due to the Earth's axis angle only 15 % of direct radiation is recorded. Therefore, the global radiation is minimal in winter's mornings (0.03 cal/cm^2/min) and maximum at 12.00 PM in summer's days (1.0 cal/cm^2/min). At high altitudes, the annual maximum value of global radiation is found between 1200 – 1400 m (110 kcal/cm^2/year) and decreases towards the top of the massif (107 kcal/cm^2/min). The reflected radiation depends on vegetation, which covers the soil surface. Areas covered by coniferous forests present an average albedo of 10–18 %, while for pastures, the average albedo is of 19–20%. The land surface, absorbs 30% from radiation when is covered by snow and up to 90 % when there is vegetation (Rusu, 2002).

Sunstroke on the northern slope is less (12 %) than on the southern side where it is 14%. However, because of its position, the sunshine is only 51-70% of the total sunstroke as opposed to the southern slope, which is sunny (91–100 %) (Chirita *et al*., 1977).

Temperature is the most important meteorological element because it influences a series of physical, chemical and biological processes. Moreover, its distribution is more stable than precipitation. Consequently, temperature influences both tourism and human activity, which indirectly influence the tourism.

At the Rarau meteorological station, placed at 1650 m altitude above sea level, the average annual air temperature between 1961–2000 was 2.4 ^{o}C and the annual air temperature amplitude was 18.1 ^{o}C. The annually average temperature values for the studied period are presented in table 1 and the monthly temperatures average are given in table 2 for the same period.

Table 2 shows that the lowest monthly temperature is in January and the warmest month is July when a temperature of 11.7 ^{o}C was recorded at the Rarau meteorological station. In the last decade, the variation of temperature recorded on the Rarau massif is given in figure 1. This figure shows that the monthly lowest temperature is in January (10.1^{o}C) and the highest in August (13^{o}C). In all summer months the temperature is higher than the climatological average.

Table 1

Annually average temperature values recorded by Rarau meteorological station

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Average of annually temperature (^{o}C)	2.2	1.7	3.2	2.0	1.6	1.5	2.0	3.1	3.6

Table 2

Monthly average temperature recorded by Rarau meteorological station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Average of monthly temperature (^{o}C)	-7.4	-6.8	-3.6	1.5	6.8	10.1	11.7	11.6	8.2	3.6	-1.3	-5.6

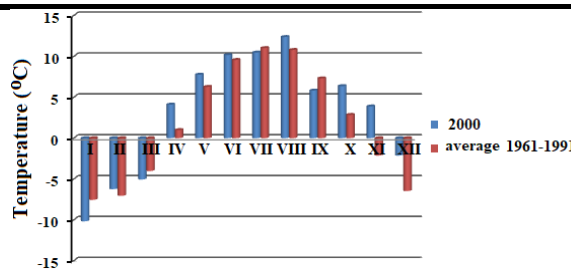


Fig. 1 Monthly temperature in 2000 versus average from 1961-1991 recorded by Rarau meteorological station

Table 3

Annually average precipitation values recorded by Rarau meteorological station from 1992 to 2000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Average of annually precipitation(mm)	861	769.7	463.9	695.8	696.8	668.4	935.7	847.4	776.1

Table 4

Monthly average precipitation values recorded by Rarau meteorological station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Average of monthly precipitation (mm)	44.1	42.7	47.0	85.1	136.4	158.9	152.7	116.6	68.9	48.5	41.9	43.1

In terms of precipitations on Rarau Massif, the annually average of rainfall, in mm, is given in table 3 and the average monthly in table 4 from 1992 to 2000.

Table 4 shows that the amount of precipitation during summer months (June and July) is higher than the one in the winter months due to the anti-cyclonic regime, which prevents the formation of the thermal convection. Starting March, the precipitation increases progressively until summer and then gradually decreases. In 2000, the variation of precipitation amount compared to the climatologically norm is given in figure 2. In this figure, there is an oscillation of the rainfall compared to the norms, with the highest rainfall being in August (154.1 mm) and the lowest in November (6.9 mm). This variation is similar to previous years, which shows a reduction for rainfall during the spring and early summer and an increasing in August and September.

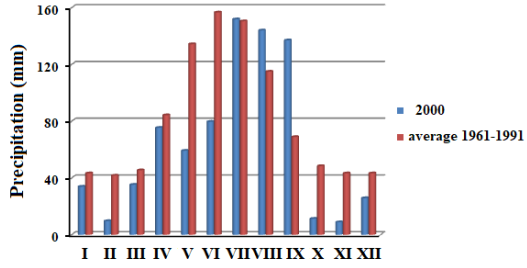
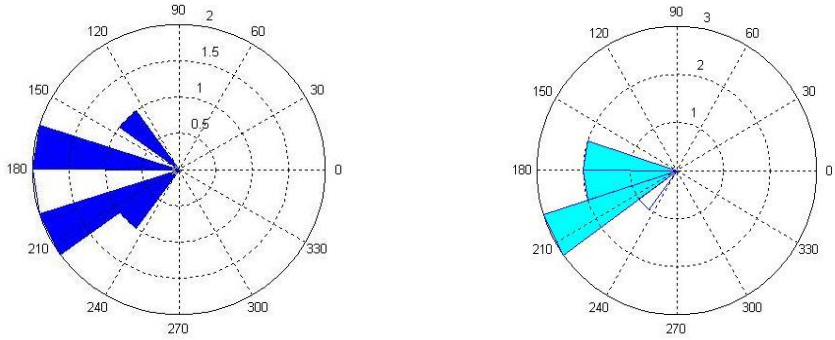


Fig. 2 Monthly precipitation in 2000 versus average from 1961-1991 recorded by Rarau meteorological station

The circulation of air masses in the Rarau Massif is generated firstly by the *western air mass* (45%), which causes mild and wet winters and generates a high degree of instability. Second, the *polar air mass* (30%) in the north-west direction generates temperature drops, increased nebulosity and precipitations in the form of showers. Third, the *tropical air circulation* accounts around 15% of the total circulation of the atmosphere and manifests itself in the south-west direction, producing warming, many precipitations in the cold season and unstable weather in the warm season. Finally, the *blocking air circulation* represents only 10% and is generating stable and warm weather (Rusu, 2002).

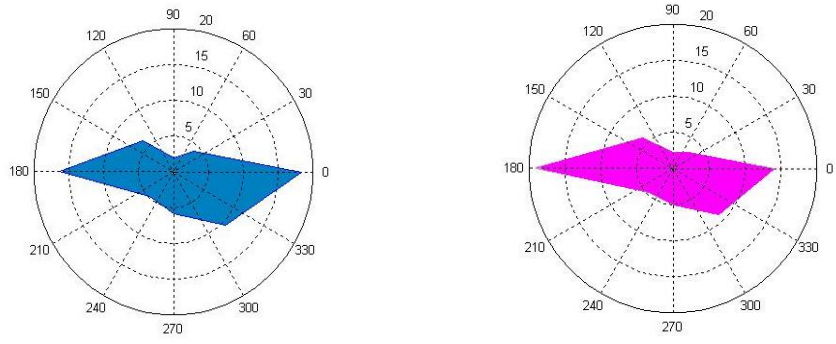
Wind is a meteorological element with a great role in balancing the atmospheric contrast and results from the difference in heating of the surface, which tends to balance the pressure in two masses of air. High velocity increases evaporation, while atmospheric calm produces vapour accumulations and uneven heating.

The wind speed in the Rarau Massif during July (around 2 *m/s*) is shown in figure 3(a), and in figure 3(b) during August (3 *m/s*). The wind speed is relatively small (fig. 3 a-b). The frequency of the wind in the Rarau Massif during summer is in both directions, from east and west sides (fig. 3 a-b). In July, the predominant wind is from the east (fig. 4a), and from west in August (fig. 4 b).



(a) (b)

Fig. 3 Wind speed recorded by Rarau meteorological station: in July (a) and in August (b)



(a) (b)

Fig. 4 Wind frequencies recorded by Rarau meteorological station: in July (a) and in August (b)

CONCLUSIONS

1. The monthly and annually temperatures in Rarau Massif are modest, which favours the maintenance of the vegetal and forest carpet. Negative monthly temperatures keep up around 5 months per year, but we can notice in the last decade a slight increase in temperature.

2. In the case of precipitation, there is a significant decrease in relation to climatological average, which shows that tourism is encouraged in the summer months.

3. During winter, it is observed a temperature decreasing that is beneficial for tourism, given an opportunity to build one of the longest ski slopes from Romania for practicing winter sports in the area on northern slop of massif. In winter, the snow layer is maintained at 40-50 cm.

4. In the Rarau Massif, below 10 meters in the atmosphere, the winds appear from the east and west direction with a relatively small speed, around 3 *m/s.*

5. Our results show that the summer months are best suited for tourism, having optimal temperatures for outdoor activities (balneal treatment, walks, camping or wildlife watching). Lack of wind also favours such activities. Moreover, winter sports can be practiced with great success in the frozen season.

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