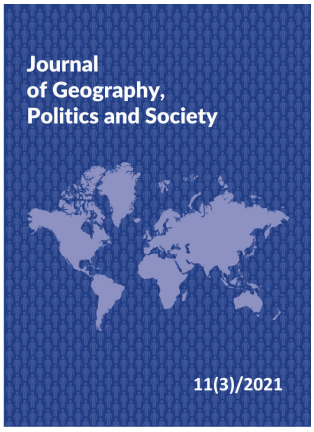

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CLIMATIC CONDITIONS OF THE DEVELOPMENT OF TOURISM AND LEISURE ON THE ŻUŁAWY ALLUVIAL PLAIN

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Abstract
Based on the data for the years 1981–2014 from two meteorological stations located in the central and northern part of the Żuławy Alluvial Plain, the climatic conditions for the development of tourism and recreation in this area were analyzed. The factors contributing to this type of activity are the average temperatures in the fall and winter months higher than in central Poland and lower temperatures in the summer months, a relatively small number of hot and very hot days, as well as ice and very ice days. The central part of the analyzed area is characterized by lower precipitation totals, lower relative humidity, lower number of steamy days, lower cloud cover, and a high number of days with less than 50% cloudiness than the northern part, which is favorable to tourism in this area. Due to the small number of days with snowfall and snow cover over 8 cm thick, the possibility of skiing here is limited.

Key words
climate, tourism, Żuławy Alluvial Plain.

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1. Introduction

The area under study, located in the northern part of Poland, is a vast alluvial plain with a territory of approximately 1,700 km^2 (Kondracki, 1988) and clear natural boundaries, which form the west, south, and east edges of the moraine hills of the Kashubian, Starogardzkie, Iławskie and Elbląg Uplands, and from to the north, the dune embankment of the Vistula Spit (Fig. 1). This region is not very diversified in terms of hypsometry. Depressions with a total area of 465 km^2 (Augustowski, 1976) mainly cover the northern and eastern part of the area, with the lowest point – 1.8 m below sea level located in the eastern part near Druzno lake. The monotonous landscape of the Żuławy Alluvial Plain is diversified by numerous drainage ditches and canals as well as embankments of the main watercourses. Due to very good soils (meadows, brown soils, and muck soils), agriculture is the dominant function in this area, especially the cultivation of cereals, rape, and sugar beet (Protection Program ..., 2018). However, in recent years there has been an interest of local authorities in the development of tourist functions in

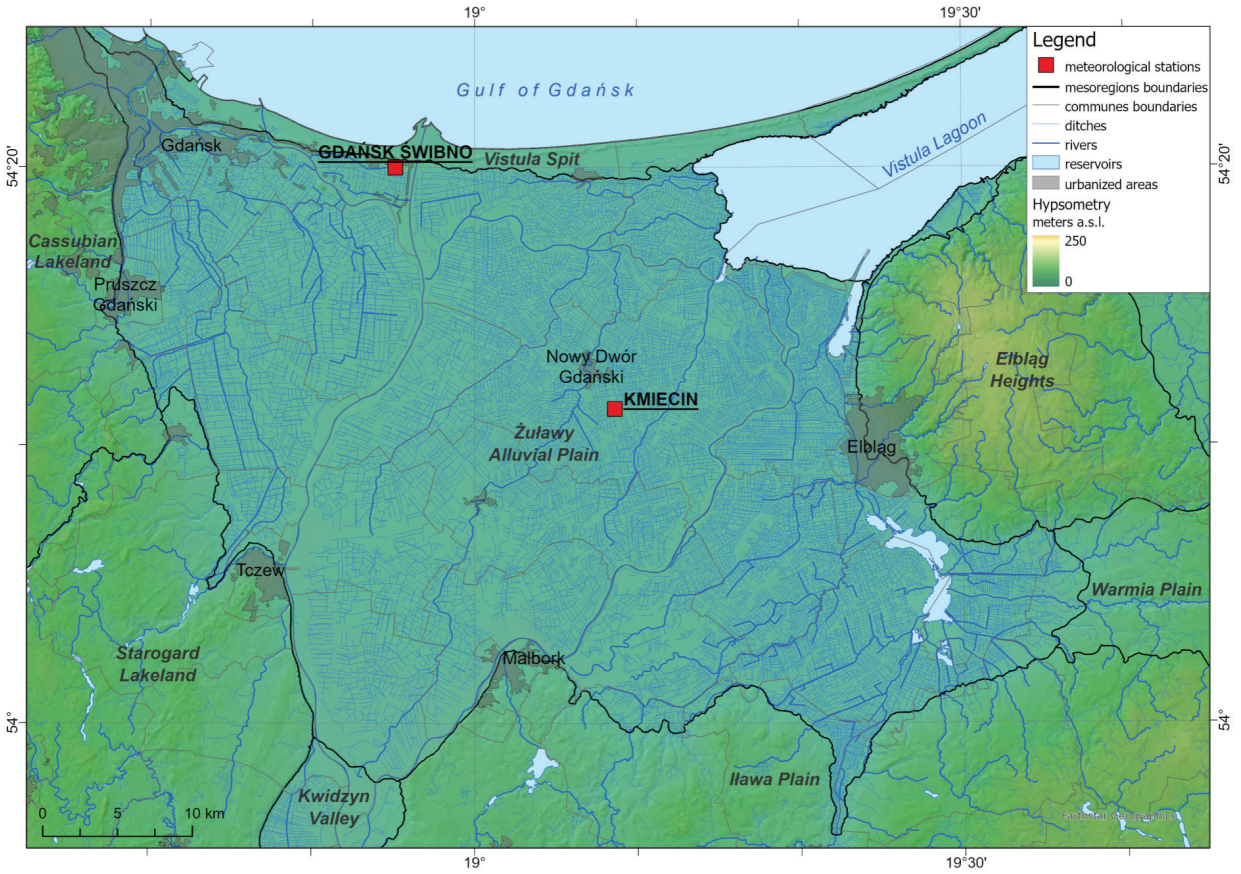

Fig. 1. Topography and location of meteorological stations on the Żuławy Alluvial Plain

Source: own study based on the MOGC Public Data and Solon, 2018.

communes. This is evidenced by K. Nowicka's (2019) analysis of strategic documents carried out in rural communes of the Pomeranian Voivodeship, which showed that one-third of them have issues related to the development of tourism in their strategic or operational goals. In addition to agritourism, these documents mention cycling, hiking, canoeing, sailing, Nordic walking, and geocaching as touristic activities that may be promoted in this region. Also, the values of cultural and natural heritage may attract visitors.

The greatest values of cultural heritage in this area include the traces of Mennonite settlement, arcaded houses, churches, currently few windmills, and historic hydro-technical structures. Based on these artifacts of the region's rich history, the authorities of various levels and various associations are trying to shape the identity of local communities (Paprot-Wielopolska, 2018), which in connection with the promotion of communes by organizing various events, bringing closer local traditions, rituals, art, artistic craftsmanship or cuisine, contributes to the development of tourism in this area.

Interest in the development of tourism in this region is also evidenced by investments implemented in recent years in Żuławy Wiślane, such as a modern yacht marina in Błotnik, built in 2012 as part of the „Żuławska Loop" project, which involves the construction of a network of ports and sailing marinas and mooring bridges along the Żuławy section of the Vistula, the Nogat and the Szkarpawa (Błotnik – Marina, 2021; Pętla Żuławska ..., 2018) or the development of the northern part of the Vistula Cycling Route (Powstaną Dwa ..., 2017). The ditch of the Vistula Spit may contribute to the expansion of the tourist offer in the region in the future, especially that in recent years there has been a significant increase in passenger shipments in the port of Elbląg (Puzdrakiewicz, Połom, 2021). The suburbanization processes taking place, especially in the western part of the Żuławy Alluvial Plain, may also contribute to the increased interest in tourism and recreation in the analyzed area. G. Masik (2018) included the Nowodworski poviat, the Gdańsk poviat and the northern part of the Tczew poviat in the functional zone of the Gdańsk-Gdynia-Sopot Metropolitan Area. These poviats are fully or partially located in the area of the Żuławy Alluvial Plain. In 2006–2016 there was a significant increase in the number of inhabitants (by 17%) and the number of newly built apartments

(by 33%). New, professionally active residents may probably be more willing to spend their free time actively.

The terms tourism and recreation used in this study require some explanation. In view of numerous ambiguities and difficulties in defining the term tourism (Liszewski, 2013), in this study, tourism is considered to be all forms of activity undertaken in free time, aimed at getting to know new areas, their inhabitants, and culture or leisure (recreation).

One of the elements deciding about taking up outdoor physical activity, including tourism, is weather conditions. The impact of meteorological elements may cause positive or negative functional, metabolic or morphological changes in the human body (Kozłowska-Szczęsna et al., 1997). On the one hand, unfavorable meteorological conditions may discourage tourists from taking up a tourist or recreational activity, and on the other hand, limit or prevent it. The aim of this article is to characterize the climatic conditions of the Żuławy Alluvial Plain in terms of tourism or recreation opportunities.

In the literature on the subject, there is no analysis of the climatic conditions of the analyzed area from the point of view of the possibility of practicing various forms of tourism. Much, although very generalized, information about the climate stimulus of the Żuławy Alluvial Plain can be found in the study by T. Kozłowska-Szczęsna et al. (1997). K. Błażejczyk and A. Kunert (2011) conducted a detailed analysis of Poland's biometeorological and bioclimatic indicators, including the Żuławy Alluvial Plain in the coastal region. The climate of the South Baltic coast was analyzed by M. Miętus and his team (Miętus et al., 2004). U. Radzka and E. Dragańska (2015) characterized in detail the bioclimatic conditions of tourism and recreation in the Warmińsko-Mazurskie voivodeship, whose western edges include the eastern part of the Żuławy Alluvial Plain. Studies referring to other regions with a seaside location in Poland may be a certain reference to the climatic conditions in the Żuławy Alluvial Plain considered in the context of their tourist use. The analysis of bioclimatic conditions, taking into account both the characteristics of individual meteorological elements of biometeorological importance and bioclimatic complex indicators for the Hel Peninsula, was carried out by M. Owczarek (2005). E. Kalbarczyk and R. Kalbarczyk (2007) presented a detailed and comprehensive assessment of the climate in Central Pomerania in terms of tourism development. The annual course of biometeorological indicators on the southern Baltic coast from Greifswald to Gdynia was described by M. Świątek (2014). Analyses of bioclimatic conditions on the Polish coast of the Baltic Sea, which covered the Vistula Spit with the Świbno station in Gdańsk, are the works of M. Owczarek (2012) and M. Owczarek et al. (2019). Data from the station in the Żuławy Alluvial Plain was not used in any of the studies mentioned. Taking up the topic should be considered justified.

Basic characteristics of meteorological elements were used to assess the conditions in the Żuławy Alluvial Plain , such as:

- the annual and monthly air temperature averages;
- the annual and monthly mean numbers of sweltering days (tmax≥30°C), hot days (25°C≤tmax≤30°C), ice days (tmax <0C) and very ice days (tmax≤-10°C);
- the annual and monthly average relative humidity of the air at 12 UTC (f);
- the annual and monthly average number of sultry days (with water vapor pressure e ≥ 18.8 hPa at 12 UTC).
- the average annual and monthly value of the total cloudiness at 12 UTC;
- the average annual and monthly number of days with total cloudiness ≤ 50% at 12 UTC;
- the average annual and monthly number of days with cloud cover = 100% at 12 UTC;
- the average annual and monthly precipitation totals;
- the average annual and monthly number of days with precipitation ≥0.1 mm, including days with snowfall;
- the number of days with snow cover thickness of at least 8 mm.

As mentioned earlier, the Żuławy Alluvial Plain does not border directly on the Gulf of Gdańsk, and are separated from it by a narrow dune strip of the Vistula Spit. When discussing the climatic conditions for the development of tourism in this area, it is impossible to ignore what is characteristic of the coastal zone. Therefore, the study used data for the years 1981–2014, published in the IMWM-PIB database, coming from two stations (Fig. 1). Located in the central part of the region, the Kmiecin climatic station represents the climatic conditions characteristic of the vast Żuławy delta. Thanks to the data from the Gdańsk-Świbno synoptic station, it is possible to characterize the climatic conditions of the northern part of the region and the coastal belt.

2. Climatic conditions of the Żuławy Alluvial Plain

2.1. Air temperature

The average annual air temperature in Gdańsk-Świbno is higher than in Kmiecin (8.1 and 7.8°C, respectively) (Table 1). Such a situation is typical of most of the year, except for April and May, when the Kmiecin station is slightly warmer than the Gdańsk-Świbno station. Such a course of air temperature in the analyzed area is influenced by the vicinity of the Baltic Sea and the Gulf of Gdańsk, which in spring have a cooling effect on the narrow coastal zone. In the remaining months, the average monthly air temperatures are higher in Gdańsk-Świbno, than the temperatures at the Kmiecin station by 0.2–0.7°C. July is the warmest month with average temperatures of 17.8°C in Kmiecin and 18.0°C in Gdańsk-Świbno. January is the coldest at both stations (–1.9°C in Kmiecin and –1.2°C in Gdańsk-Świbno). In Kmiecin, the average monthly temperature in December is negative (–0.3°C) and in Gdańsk-Świbno it is positive (0.2°C).

The annual average number of hot days is clearly higher in Kmiecin (23.9) than in Gdańsk-Sobieszewo (16.1) (Table 2). Hot days are recorded at the analyzed stations in the months from April to September, and the greatest number of them occurs in August (on average 8.0 in Kmiecin and 5.3 in Gdańsk-Świbno). The average number of hot days in July is slightly lower (7.4 and 4.9 in Kmiecin and Gdańsk-Świbno, respectively). About 2–3 such days may occur at both stations in May and June.

At both stations, sweltering days are rarely observed. On average, in the summer season, there are 2–3 such days, the earliest ones in the analyzed period were recorded in May; they also occurred in September. In the analyzed period, the highest air temperatures were recorded at both stations on August 10, 1992. In Kmiecin it reached 36.3°C, and in Gdańsk-Świbno 35.8°C. In general, the number of hot and sweltering days in the Żuławy Alluvial Plain should not limit tourist and recreational activity in this area.

Ice days, with the maximum temperature not exceeding 0°C, are recorded at the analyzed stations in the period from November to March (Table 3). In April, in the analyzed period, ice days occurred sporadically and only at the station in Kmiecin. The average annual number of ice days at both stations is similar, slightly higher in Kmiecin (28.8) than in Gdańsk-Świbno (26.6). The largest number of such days occurs at both stations in the winter season, with a maximum in January (an average of 10.0 days in Kmiecin and 9.1 in Gdańsk-Świbno), in February a slightly higher number of ice days characterizes the station in Gdańsk-Świbno.

Very ice days occur in the analyzed area extremely rarely. In the winter season, their average annual

Tab. 1. Average monthly and annual air temperature in Kmiecin and Gdańsk-Świbno, 1981–2014

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Kmiecin	–1.9	–1.4	1.9	7.1	12.4	15.2	17.8	17.3	13.1	8.3	3.3	–0.3	7.8
Gdańsk-Świbno	–1.2	–0.7	2.3	7.0	12.2	15.4	18.0	17.6	13.5	8.7	3.7	0.2	8.1

Source: own study based on the IMWM-NRI Public Data.

Tab. 2. Average monthly and annual number of hot and sweltering days in Kmiecin and Gdańsk-Świbno, 1981–2014.

Air temperature	Station	Apr	May	Jun	Jul	Aug	Sep	Annual
hot days ($25°C \leq t_{max} \leq 30°C$)	Kmiecin	0.6	2.8	3.8	7.4	8.0	1.4	23.9
	Gdańsk-Świbno	0.3	2.2	2.5	4.9	5.3	0.9	16.1
sweltering days ($t_{max} \geq 30°C$)	Kmiecin	–	–	0.2	1.7	1.6	0.1	3.5
	Gdańsk-Świbno	–	0.0	0.4	1.4	0.8	0.0	2.6

Source: own study based on the IMWM-NRI Public Data.

Tab. 3. Average monthly and annual number of ice and very ice days in Kmiecin and Gdańsk-Świbno, 1981–2014

Air temperature	Station	Nov	Dec	Jan	Feb	Mar	Apr	Annual
ice days ($t_{max} < 0°C$)	Kmiecin	2.0	7.2	10.0	7.5	2.0	0.0	28.8
	Gdańsk-Świbno	1.5	6.1	9.1	7.7	2.1	–	26.6
very ice days ($t_{max} \leq -10°C$)	Kmiecin	–	0.3	0.9	0.6	–	–	1.8
	Gdańsk-Świbno	–	0.2	1.0	0.3	–	–	1.5

Source: own study based on the IMWM-NRI Public Data.

number does not exceed two. While in January at both stations you can expect one very ice day every year, in December and February very ice days are recorded every 2–5 years, depending on the station. In Kmiecin, the absolute minimum in the analyzed period was recorded on January 11, 1987, when the temperature dropped to -23.0°C. In Gdańsk-Świbno, the cold record was recorded on January 7, 2003, when the thermometer showed -19.0°C. The low number of ice and very ice days in the Żuławy Alluvial Plain is not a factor limiting the practice of such forms of tourism as cycling, hiking, or Nordic walking.

2.2. Air humidity

Air humidity is an important meteorological element, influencing the conditions for tourism development, because its high values on days with the air temperature above 12°C intensify the feeling of warmth, while on days with low temperature they intensify the feeling of coolness (Kozłowska-Szczesna et al., 1997). The article analyzes the annual course of relative air humidity and the number of sultry days, i.e. when the water vapor pressure (e) is not less than 18.8 hPa. The latter indicator is the so-called Scharlau's criterion (after Kozłowska-Szczęsna et al., 1997), defining the conditions in which a person staying or doing light work outdoors has difficulty with dissipating heat from the body. The analyses were carried out for 12 UTC (in Poland, 1:00 p.m. in the cold half-year and 2:00 p.m. in the warm half-year), because one usually undertakes recreational and tourist activities in the open air in the middle of the day. This approach was also used by M. Owczarek (2005, 2012).

The northern part of the Żuławy Alluvial Plain is clearly wetter than the central part. The average annual relative humidity in Kmiecin is 71.7%. In Gdańsk-Świbno, it is higher, reaching the value of 75.8% (Table 4). The least humid month at both stations is August. The average relative humidity in this month at the station in Kmiecin is 62.4%, in Gdańsk-Świbno it is clearly higher – 68.9%. December is the month with the highest relative humidity in the analyzed area. This characteristic reaches the value of almost 82% in Kmiecin and 86.5% in Gdańsk-Świbno. The differences in relative humidity at both stations result from the location of Gdańsk-Świbno in the vicinity of the Gulf of Gdańsk, unlimited source of water vapor.

Sultry days at both stations are recorded in the period from April to October (Table 4). There is a clearly higher number of them in Gdańsk-Świbno (on average 48.5 per year) than in Kmiecin (19.9). As in the case of relative humidity, the proximity of an unlimited source of moisture determines the greater frequency of such days in Gdańsk-Świbno, especially in July and August, when statistically almost every second day in a month may be a sultry day. In Kmiecin, there is an average of 6–7 such days in these months.

2.3. Cloudiness

General cloud cover is one of the factors taken into account in the first place when it comes to making decisions about physical activity or engaging in various forms of tourism. Days with the cloudiness of ≤ 50% are considered the most favorable for sunbathing (Owczarek, 2005; Kozłowska-Szczęsna et al, 1997), whereas days with the full cloud cover (cloudiness = 100%) discourage people from outdoor activities. As in the case of air humidity, the cloud characteristics were analyzed based on data from 12 UTC.

Average annual total cloudiness at 12 UTC at both stations clearly differs, assuming the value of 55% in Kmiecin, and 66% in Gdańsk-Świbno (Table 5). In the annual course, there is an increase in total cloudiness in the winter season, when its values in Kmiecin in the period from November to February are above 60%, and in Gdańsk-Świbno they are even higher, exceeding 70%. The highest total cloudiness in Kmiecin is recorded in December (72%) and in Gdańsk-Świbno in November (77%). The most convenient conditions for tourism and recreation in the Żuławy Alluvial Plain in terms of cloudiness occur from April to September. In these months, the average total cloudiness in Kmiecin at 12 UTC does not

Tab. 4. Average monthly and annual relative humidity [%] and the number of days with water vapor pressure ≥ 62.4% a18.8 hPa (sultry days) at 12 UTC in Kmiecin and Gdańsk-Świbno, 1981–2014

Humidity	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Relative humidity [%] at 12 UTC	Kmiecin	81.5	78.9	73.7	68.1	64.1	65.4	63.8	62.4	68.1	72.4	79.6	81.9	71.7
	Gdańsk-Świbno	84.8	81.7	74.9	69.1	69.6	70.6	71.6	68.9	69.7	76.8	85.2	86.5	75.8
No of sultry days at 12 UTC	Kmiecin	–	–	–	0.5	1.8	3.1	6.7	6.2	1.4	0.2	–	–	19.9
	Gdańsk-Świbno	–	–	–	1.0	4.4	8.2	14.9	14.4	5.0	0.7	–	–	48.5

Source: own study based on the IMWM-NRI Public Data.

Tab. 5. Average monthly and annual total cloudiness [%] at 12 UTC and the number of days with cloudiness ≤ 50% and equal to 100% in Kmiecin and Gdańsk-Świbno, 1981–2014

Cloudiness	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Total cloudiness [%] at 12 UTC	Kmiecin	68	64	53	46	45	51	49	48	48	52	70	72	55
	Gdańsk-Świbno	75	73	64	60	57	63	59	61	62	64	77	76	66
No of days with cloudiness ≤ 50% at 12 UTC	Kmiecin	11.8	11.9	17.4	19.6	21.2	18.8	20.2	21.2	20.0	18.0	11.3	10.1	201.6
	Gdańsk-Świbno	6.9	6.8	10.7	11.8	13.6	10.8	12.4	11.6	11.3	10.6	5.7	5.9	118.0
No of days with cloudiness = 100% at 12 UTC	Kmiecin	13.2	12.0	8.3	5.5	4.2	5.1	4.1	4.0	5.1	7.0	12.6	14.6	95.8
	Gdańsk-Świbno	10.6	9.3	7.4	4.4	3.9	4.0	3.1	2.6	3.8	5.6	10.1	10.7	75.4

Source: own study based on the IMWM-NRI Public Data.

exceed 50%. The exception is July, when this characteristic reaches on average 51%. The least cloudy months at this station are April and May. The average total cloudiness in Gdańsk-Świbno ranges from 57% to 62% in this period. Slightly higher values of the total cloudiness are recorded in June, when its average value reaches 63%. In the coastal belt, the most favorable conditions occur in May when average monthly total cloudiness is 57%.

The central part of the Żuławy Alluvial Plain is privileged over the coastal zone in terms of the number of days with cloudiness ≤50% annually, reaching 118.0 days and 201.6 days in Gdańsk–Świbno and Kmiecin, respectively (Table 5). From April to September, two-thirds of the days are characterized by such cloudiness in Kmiecin, and the highest values are observed in May and August (on average 21.2 days). The obtained results are only slightly higher than those presented by T. Kozłowska-Szczęsna et al. (1997). In the winter months, about 10–12 days are convenient for outdoor activities. The average monthly number of days with cloudiness ≤50% at 12 UTC in Gdańsk-Świbno ranges from 5.7 in November to 12.4 in July and 13.6 in May. These values, however, are similar to those obtained by Owczarek (2005) for Hel.

The average annual number of days with cloudiness = 100% in Kmiecin is higher than in Gdańsk-Świbno (95.8 and 75.4, respectively) (Table 5). Between November and February, the number of such days varies from 12 to almost 15 in Kmiecin, and from 9 to 11 in Gdańsk-Świbno. In the months of the warm half-year, the number of days with cloudiness = 100% ranges from 4.0 in August to 5.5 in April in Kmiecin, and from 2.6 in August to 4.4 in April in Gdańsk-Świbno.

2.4. Precipitation and snow cover

The average annual totals of precipitation at the analyzed stations are low (510.5 mm in Kmiecin and 557.4 mm in Gdańsk-Świbno) (Table 6) compared to the average annual precipitation total in Poland (623.7 mm), and in the South-Baltic coast (642.7 mm) (Limanówka et al., 2012). The lowest monthly totals of precipitation are recorded from January to March; in Kmiecin they do not exceed 20 mm, and in Gdańsk-Świbno 30 mm. The highest monthly totals of rainfall are noted in the summer

Tab. 6. Average monthly and annual precipitation totals and number of days with precipitation in Kmiecin and Gdańsk-Świbno, 1981–2014

Precipitation	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation totals [mm]	Kmiecin	19.1	12.4	18.8	27.2	51.3	67.7	68.3	73.6	61.4	47.8	37.2	25.5	510.5
	Gdańsk-Świbno	29.3	22.5	26.6	30.2	53.8	65.7	69.3	68.3	62.1	47.7	45.0	36.9	557.4
No of days with precipitation ≥ 0.1mm	Kmiecin	14.1	12.1	11.4	9.9	12.1	13.4	13.1	13.2	12.8	12.6	13.4	14.1	152.2
	Gdańsk-Świbno	17.1	14.5	14.0	12.0	12.8	14.3	13.1	14.1	13.1	14.9	16.4	18.0	174.3

Source: own study based on the IMWM-NRI Public Data.

months, in Kmiecin in August (73.6 mm on average) and in Gdańsk-Świbno in July (69.3 mm on average).

The average annual number of days with precipitation is also clearly lower in Kmiecin (152.2 days) than in Gdańsk-Świbno, where the characteristic reaches 174.3 days (Table 6). The annual course of the average monthly number of days with precipitation at the Kmiecin station is very even, with a minimum of less than 10 days in April and a maximum of 14.1 days in December and January. In Gdańsk-Świbno, the lowest number of days with precipitation is also observed in April and the highest in December (12.0 and 18.0 on average, respectively).

The average seasonal number of days with snowfall ranges from 37.4 in Gdańsk-Świbno to 43.6 in Kmiecin (Table 7). Snowfall is observed here from October to April, and occasionally in May. In the analyzed years, both stations recorded an average from 7 to 10 days with such precipitation, with the maximum in January.

The number of days with a snow cover thickness of at least 8 mm was analyzed, as ski tourism can be practiced in the presence of such a snow layer (Bednorz, 2010). In the analyzed years, on average from 20 (Kmiecin) to 24 (Gdańsk-Świbno) days suitable for skiing tourism were recorded in the Żuławy Alluvial Plain with the maximum in January and February (Table 7).

3. Discussion

The average annual air temperature at the level of 7.8–8.1°C in the Żuławy Alluvial Plain strongly corresponds to the results obtained by M. Owczarek and J. Filipiak (2016), who stated that the annual average air temperature did not drop below 8°C in the 21st century. From the perspective of tourism development, it is important that in autumn and winter the analyzed area, like other areas located in the coastal belt, is the warmest region of Poland, while in summer and spring, it is cooler than the rest of the country due to the cooling effect of the Baltic Sea (Marosz et al., 2011). Since the 1990s, an increase in air temperature in Poland has been observed (Marosz et al., 2011; Owczarek, Filipiak, 2016) and an increase in the duration of thermal spring and summer (Czernecki, Miętus, 2017). If these trends continue, the period of the year when conditions favorable for active forms of tourism and outdoor recreation in the Żuławy Alluvial Plain will be extended.

The average number of hot days (25°C≤tmax ≤30°C) in Kmiecin is clearly higher than in Gdańsk-Świbno, where thermal contrasts are mitigated by the vicinity of the Gulf of Gdańsk waters. In the central part of the Żuławy Alluvial Plain, hot days in July and August may constitute an average of 25% of the days a month, while in the northern part of the area under investigation there are about 5 such days noted during the warmest months. Sweltering days (tmax≥30C) are much less frequent. In July and August the maximum temperature exceeds 30°C once a month on average. The number of hot and sweltering days recorded in Gdańsk-Świbno is similar to that of Hel (Owczarek, 2005). In the winter season (December-February), from 7 to10 ice days (–10°C<tmax <0°C) are recorded in the analyzed area, and very ice days (tmax≤-10°C) occur only sporadically. The appearance of hot and sweltering days in the warm season and ice and very ice days in the cold season may be a factor limiting the possibilities of tourism and recreation development in the analyzed area. Positive trends in the average and maximum air temperature changes (Marosz et al., 2011, Owczarek, Filipiak, 2016) will cause a decrease in the frequency of ice and very ice days in the future, which will be a positive factor in terms of the development of tourism and leisure in this area. At the same time, the consequence of these trends will be an increase in the frequency of hot and sweltering days, which may limit tourist and leisure activity. The increase in the frequency of unfavorable thermal conditions at stations located in the coastal belt will also result from the increasing number of days classified as heat waves (Owczarek 2012; Owczarek, Filipiak, 2016). Taking into account the thermal

Tab. 7. Average monthly and annual number of days with snowfall and with snow cover ≥8mm in Kmiecin and Gdańsk-Świbno, 1981–2014

Precipitation	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
No of days with snowfall	Kmiecin	0.6	4.1	9.6	10.4	9.4	7.0	2.5	0.1	43.6
	Gdańsk-Świbno	0.4	3.3	7.9	9.3	8.7	5.4	2.3	0.1	37.4
No of days with snow cover depth ≥ 8mm	Kmiecin	–	0.2	3.0	7.1	6.8	3.3	–	–	20.4
	Gdańsk-Świbno	–	0.3	3.7	7.4	8.6	4.3	0.0	–	24.3

Source: own study based on the IMWM-NRI Public Data.

conditions and the trends in their changes, the season favorable for various forms of outdoor activity may extend from April to October, with some limitations in July and August. During these months, people staying outdoors in the afternoon hours may experience a burden of „strong or very strong heat stress" (Owczarek et al., 2019).

The average values of relative humidity are 75% and 71%, in Gdańsk-Świbno and Kmiecin, respectively. These values correspond to those calculated by M. Owczarek (2005) for Hel. Lower, both annual and monthly mean values of relative humidity in Kmiecin show that in terms of humidity conditions, the central part of the Żuławy Alluvial Plain is better for tourism and recreation throughout the year. This is also evidenced by the clearly lower number of sultry days in Kmiecin (around 19 a year) than in Gdańsk-Świbno (around 45 a year). This contrast may even deepen, because rising air temperatures will result in a faster evaporation rate, a higher water vapor content in the air (Limanówka et al., 2012), and a greater frequency of sultry days especially in close vicinity of the Gulf of Gdańsk.

The average values of the total cloudiness in Gdańsk-Świbno, both on an annual (66%) and monthly (57–77%) basis, do not significantly differ from those in Ustka and Hel (Woś, 2010). In Kmiecin, the values of this indicator are clearly lower throughout the year (annual average 55%), in April and May not exceeding 50%. The results are consistent with the research of J. Filipiak and M. Miętus (2009), who indicated the shores of the Gulf of Gdańsk as areas with the lowest cloudiness in Poland. This feature predestines the central part of the Żuławy Alluvial Plain as a good place to practice various forms of tourism and recreation, as does the average number of days with cloudiness below 50%. In Kmiecin, over 200 days a year are days with such cloudiness, while in Gdańsk-Świbno there are about 118 such days a year. However, the average number of days with cloudiness = 100% in Kmiecin is higher than in Gdańsk-Świbno, by an average of 20. If the tendencies of a decrease in total cloudiness, demonstrated by Filipiak and Mietus (2008) for Elbląg and Hel, and by Limanówka et al. (2012) for the whole of Poland remain, cloudiness will not limit the possibilities of tourism and recreation in the Żuławy Alluvial Plain.

The central part of the Żuławy Alluvial Plain receives less rainfall and has fewer rainy days than its northern part; however, the difference in the number of days with rainfall in favor of Kmiecin is clearly visible in the cold season. In the warm season, the pluvial conditions at both stations are similar. Analysis of the variability of precipitation sums, carried out by Limanówka et al. (2012), showed a growing trend of precipitation totals in the belt of the South Baltic Coastlines and the East Baltic Coasts. Similar trends regarding the increase in precipitation sums in this region and the increase in the number of days with precipitation were shown by M. Marosz et al. (2011). The persistence of such trends in the future may be a factor limiting tourism and recreation in the Vistula river delta.

The average annual number of days with snow conditions good for cross-country skiing in the range of 20–24 is lower by about 6–10 days than the analogous characteristics presented by E. Bednorz (2010) for the winter seasons 1960/1961–2007/2008. This is the effect of an increase in average air temperatures observed in Poland (Marosz et al., 2011; Owczarek, Filipiak, 2016), and thus the decreasing number of days with snow cover, especially in December and January (Czarnecka, 2012). It could be assumed that in January and February one can count on 6–8 days with snow cover enabling this kind of outdoor activity, but these are average figures. Winters during which snow cover has appropriate thickness occur in northern Poland once every few years. S. Paczos [1990, quoting: Woś, 2010] estimated the frequency of snow winters in the analyzed area below 20%, and M. Czarnecka (2012) indicated a decreasing number of days with snow cover over 5 cm thick, especially in December. In the light of these results, this form of tourism has no chance of development in the Żuławy Alluvial Plain.

4. Conclusions

The climatic conditions in the Żuławy Alluvial Plain are characterized by a certain spatial diversification, and their observed changes may favor tourism and recreation here in the future or may be a factor limiting this type of activity.

The Żuławy Alluvial Plain is distinguished by quite high average annual air temperatures and clearly warmer autumns and winters than in the rest of the country. In turn, springs and summers are cooler. There are few hot and sweltering days, as well as ice and very ice days here. Such a course of temperatures, with thermal contrasts lower than in the interior, may favor the development of hiking and cycling, as long as the number of hot and sweltering days does not significantly increase in the future. In the central part of the investigated area, the relative humidity, and especially the number of sultry days, is clearly lower than in its northern part, as is the total cloudiness and the number of days with cloudiness ≤ 50%. These factors are also beneficial to the development of tourism and recreation. In

the analyzed area, lower amounts of precipitation are observed, and in Kmiecin also the number of rainy days. Such a situation encourages spending free time outdoors. However, this factor, especially during prolonged periods without rainfall, may limit the possibility of sailing due to the decreasing water level in the streams. The possibility of practicing winter sports, especially skiing, is limited here due to the small number of days with snowfall and, above all, the very low number of days with snow cover at least 8 cm thick.

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