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**Changes of selected agrometeorological indices
in Wielkopolska in years 1966-2005**

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1/ Introduction

Climate plays a pivotal role in agriculture due to its direct and indirect impact on agricultural production. One of the main goals of the COST 734 Action is an estimate of the possible effects of climate changes and variability on particular crops.

The aim of the Working Group 2 is, among others, the estimate of agroclimatic indices in order to determine past and present trends in climate change in various agricultural regions in Europe. Statistical analyses can indicate trends and rate of the observed climate changes and subsequently determine hazards faced by agriculture in the future.

Within the works conducted by the WG2, the delegation from Poland represented by IMGW OPO has undertaken the selection and analysis of agroclimatic indices with the purpose of determination of the magnitude and direction of climate changes and conditions for agricultural production in a region of Poland characterized by a highly developed agriculture.

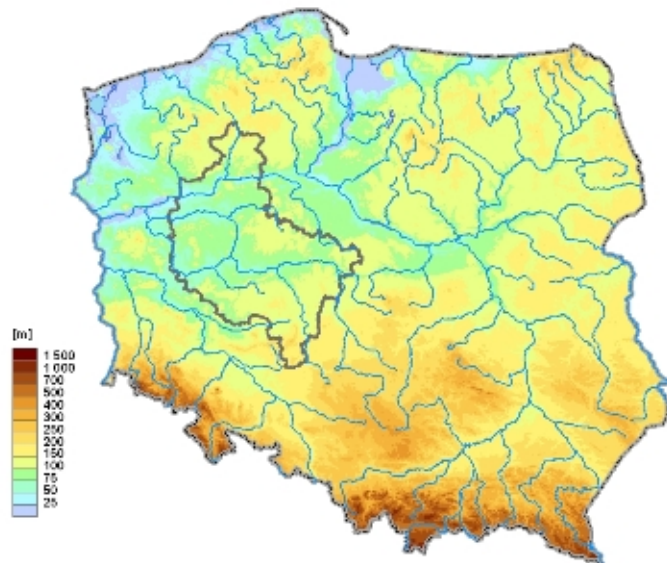
Below is a short characteristic of the selected research area with a special focus on those characteristics that are significant for yield and type of agricultural production. It is followed by results of analyses conducted within the first phase of the project and short description of the applied method.

2. Characteristic of the area of investigatins

The paper discusses the area of Wielkopolska Voivodship, which is almost equal in size to the Wielkopolska physicogeographical region.

Wielkopolska Voivodship is located in the central-west Poland (see the figure below); the area covers ca. 30,000 km², with the population of ca. 3.4 mln.

Two glacial periods formed Wielkopolska region surface features, its geological and soil conditions. The northern and central parts of Wielkopolska were under the influence of Würm glaciation. The lowlands here are home to numerous lakes of the Pomeranian, Poznańskie and Gnieźnieńskie lake districts. In the south formed by the Middle Poland glaciation, the land is flat, less diverse and with no lakes.



The highest elevation of Wielkopolska is Kobyła Mountain (264 meters), located in the south of the region, and the lowest point (25 meters) is located in the north-western part. The region includes the Wielkopolska Lakeland and Southern Wielkopolska Lowland in the Warta River basin.

Climate

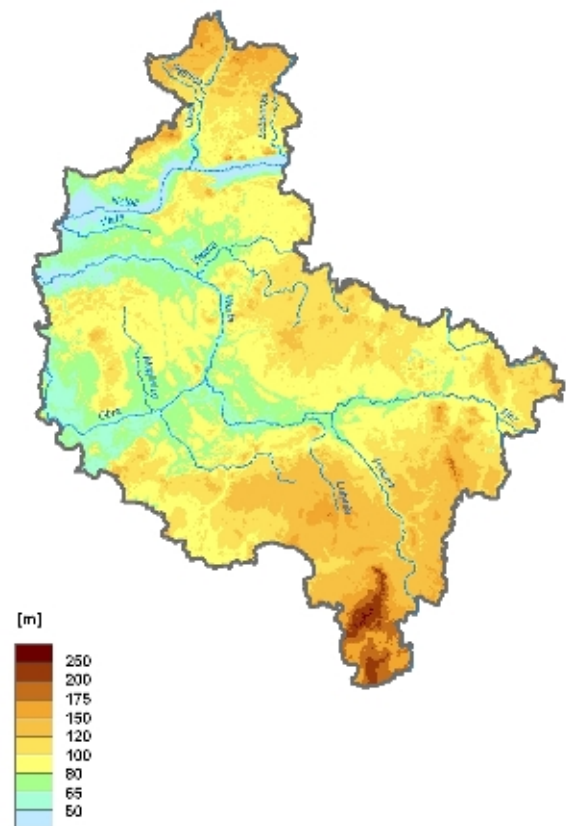
Wielkopolska Region (see the figure below) is located in the moderate climate zone with significant influence of oceanic climate, effects of which decrease towards the east. Compared to other Polish regions, Wielkopolska is characterized by a relatively early offset of spring and summer and a rather short winter.

Western atmospheric circulation dominates in Wielkopolska. The mean annual air temperature is ca. 8.0 C°, with the extremes of +38° C and -29° C.

The growing season lasts ca. 220 days and is one of the longest in Poland. Precipitation values are low and with high temporal variability. The mean annual precipitation totals are the highest in the western parts amounting to 550 mm with decreasing tendency toward the east where it drops locally below 500 mm. Northern and southern parts of Wielkopolska are characterized by slightly higher precipitation values. In the central part of the region the mean monthly precipitation totals oscillate from ca. 75 mm in July to little above 20 mm in February. Snow cover is not dense and on the average lasts ca. 40 days.

A very adverse climate characteristic for agriculture recurring every 2-3 years is periods with no or little rain lasting for several weeks. During summer these periods are accompanied by a sunny and warm weather leading to development of atmospheric drought followed by soil moisture loss and hydrological drought.

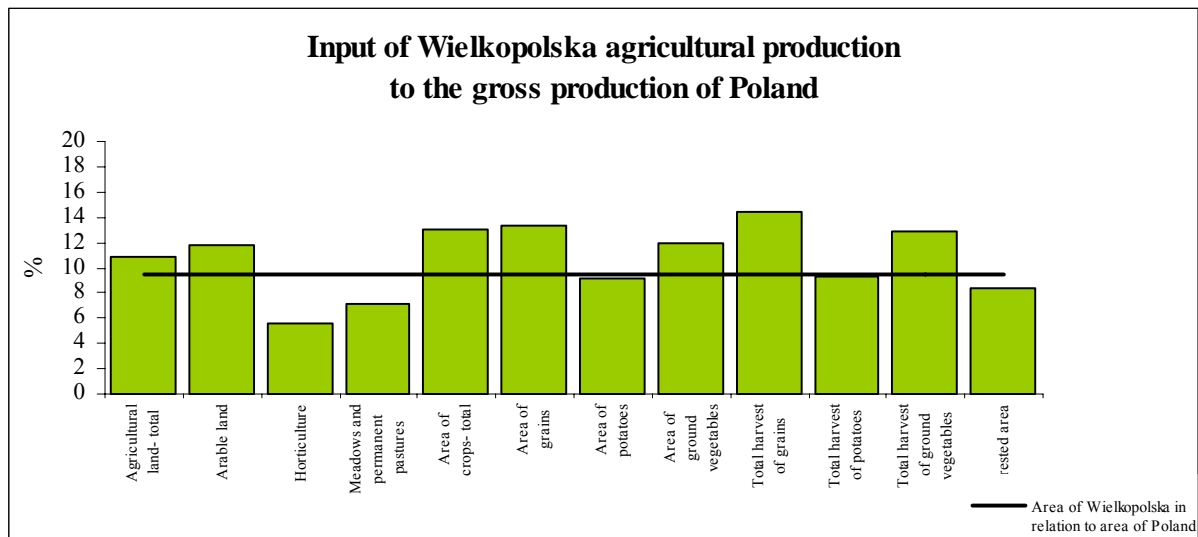
Precipitation deficit is the cause of very poor water resources in the region. In the eastern central parts of Wielkopolska, the total annual runoff value for some areas is lower



than 600 mm. In Europe lower values can be found only in the steppe zone around the Black Sea and in the area of the Hungarian Lowland.

Agriculture

Despite moderate natural conditions the agriculture in Wielkopolska is very well developed compared to other regions of Poland. It is characterized by a high agral culture, high yields and production equipment of high quality. The figure below shows the input of Wielkopolska Voivodship agricultural production to the gross production of Poland.



3/ Methodology

The first phase of the WG2 includes the analysis of the climatic water balance and its components - precipitation and potential evaporation.

The collected and analyzed data concerns the period of 1966-2005, divided into two sub-periods: 1966-1985 and 1986-2005. In Poland, the trend of the visible climate warming began after 1980. Therefore, the indices calculated for the two decades of 1986-2005 reflect the conditions of the currently observed climate warming. The indices calculated for the preceding two decades, on the other hand, serve as the reference values that enable to estimate the scale of the occurring changes.

All indices and measurement points have their corresponding monthly values, mean annual totals and mean period total values were also calculated.

Precipitation is characterized by mean monthly totals based on measurements taken by weather stations.

The values of mean monthly evaporation totals were calculated as values of indicatory evaporation based on Bac equation:

$$E = 3d\sqrt{v} + 0,344T$$

where:

E – indicatory evaporation [mm], conventional value of the maximum possible evaporation in a given surface given its constant water saturation

d – mean value of air humidity deficiency in hPa at the altitude of 2 m, i.e. value characterizing atmosphere potential to absorb water vapor,

v – average wind speed [m/s] at the altitude of 10 m, indicating rate of exchange between air saturated with water vapor and less saturated air,

T – monthly total of solar radiation [kWh] indicating total thermal energy on surface.

The Bac equation is based on long term field measurements, it was tested and is one of the methods used for describing climate and agroclimate conditions in Poland.

Monthly values of precipitation and potential evaporation were the basis for the values of climatic water balance (CWB). It was received using the equation:

$$CWB = P - E$$

where:

CWB – climatic water balance [mm],

P – precipitation [mm]

E – evaporation [mm].

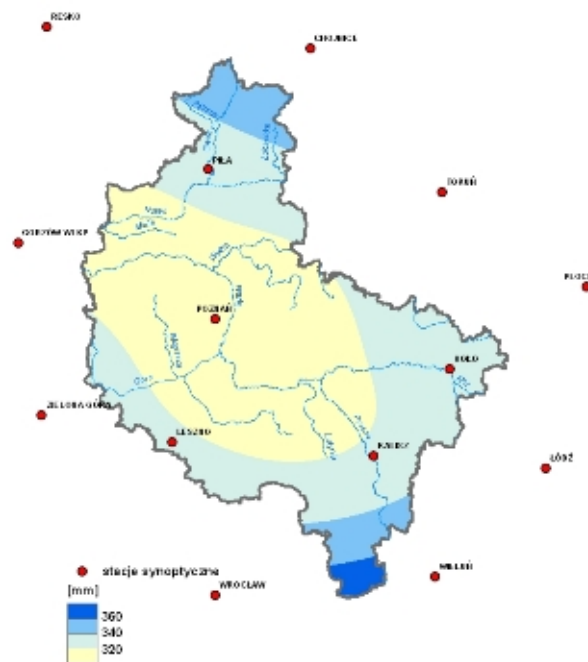
The results were then ordered in tables and presented using GIS. The results were interpolated using the spline method.

In the area of the Wielkopolska Voivodship there are five weather stations, measurements of which were the basis for calculations and analysis. Similar calculations were conducted for additional nine weather stations located outside the Wielkopolska Voivodship. The results were used for interpolation of the received values.

4/ Characteristics of long-term agroclimactic indices (1966-2005)

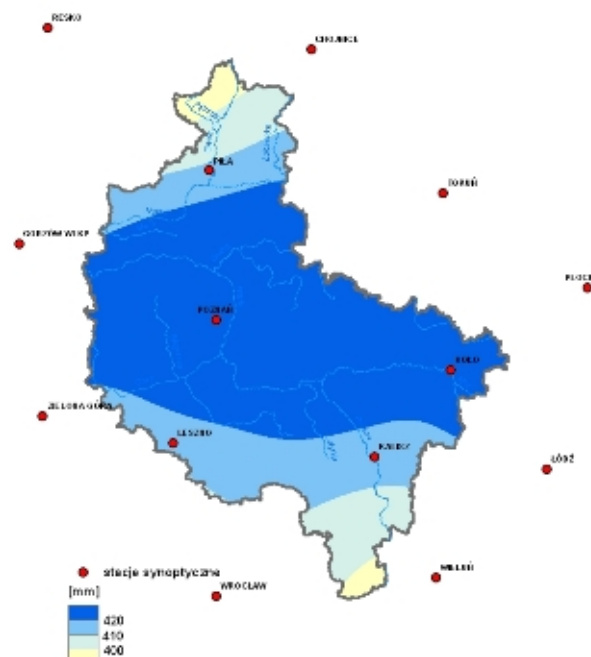
4.1. Precipitation

The lowest mean annual precipitation values – below 520 mm are noted in the central and eastern parts of the region. The highest values – above 580 mm are registered in the northmost and southmost parts of the region (see the figure to the right). Spatial distribution of precipitation values for 6-month periods is characterized by almost identical pattern. Precipitation totals for vegetation season vary from below 320 mm in the central part to above 360 mm in the south. During winter season precipitation totals fluctuate from below 190 mm to over 230 mm locally in north and west. Vegetation period precipitation totals amount to 60% of the annual precipitation totals.



4.2. Potential evaporation

The highest values of potential evaporation – above 530 mm are observed in the east-west oriented belt in central part of the region. The lowest values – below 510 mm are noted in south and north (see the figure to the right). Spatial distribution of evaporation values of 6-month period is generally similar. During vegetation season



evaporation totals are between above 420 to below 400 mm. Winter season evaporation totals vary from above 110 mm in the south (the warmest zone) to below 100 mm in the north. Vegetation period evaporation totals amount to 80% of the annual evaporation total.

4.3. Climactic water balance

Values of climactic water balance are the lowest, both in annual and seasonal totals, in the central part of the region and its surrounding areas, where precipitation totals are the lowest and evaporation values are the highest. Consequently, this region suffers from water scarcity especially during the growing season.

In case of annual values, climatic water balance is negative in the central part of the region. The values here fall below -20 mm. The highest values of over 60 mm are noted in the south and north of the region (see the figure to the right). Vegetation season values of climactic water balance are negative for the whole analyzed area. They vary from below -100 mm to over -40 mm. Winter season values are above zero for the whole area and vary from below 80 mm to over 120 mm.

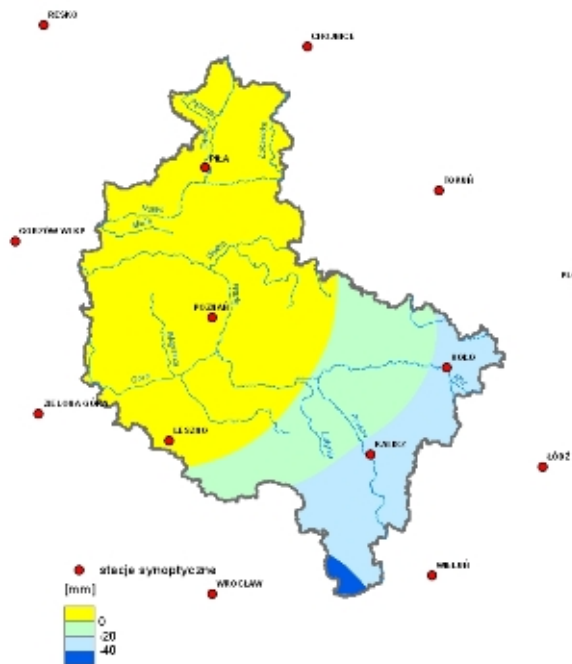


5/ Changes of agrometeorological indices observed in 20-year periods

5.1. Precipitation

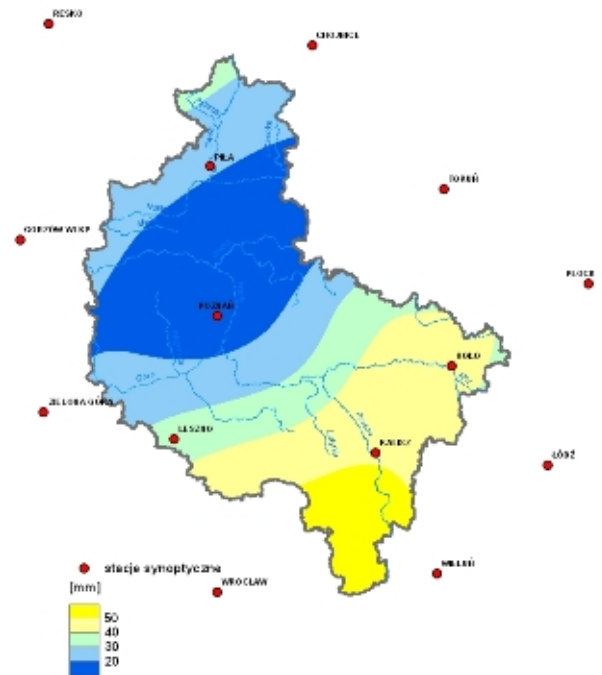
During the studied 20-year period, there was an increase of both mean annual and 6-month precipitation values in the central and north-western parts of the region. Small decrease of precipitation was, however, noted in the north of the region during winter season. In case of annual precipitation totals, the noted increase did not exceed 20 mm anywhere in the area, while there was a decrease of 60 mm in the south of the region (see the figure to the right). 6-month precipitation totals showed the same pattern; however, precipitation values of summer season dropped over 40 mm in the south and in winter season they dropped 20 mm.

It may be therefore said that the area where precipitation increase was noted both in annual and 6-month perspective is almost equal to the area with decreased precipitation. Still, in absolute values, the drop of precipitation values was higher than its increase.



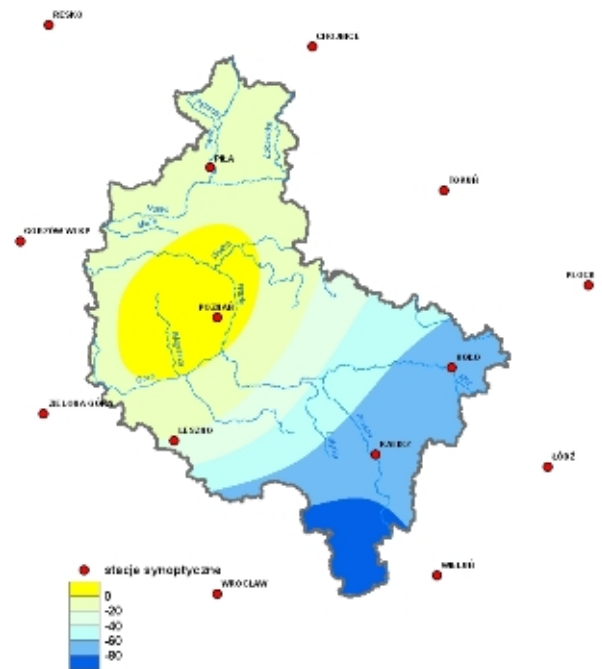
5.2. Evaporation

Evaporation values increased in both annual and 6-month totals in the whole area. Evaporation increase is a consequence of temperature increase during the last two decades. The highest increase of evaporation totals was observed in the south-east and south of the region. It reached 60 mm in annual values, 50 mm in warm season and over 10 mm in winter season (see the figure to the right). Warm season evaporation increase amounted to 60-80% of the annual evaporation total increase.



5.3. Climactic water balance

The only increase of climactic water balance observed within the last two decades was noted in the central part of the analyzed region. The values registered at the synoptic station in Poznań were as follows: annual increase: +14 mm, warm season: +7 mm, and winter season: +9 mm. All the other parts of the analyzed area registered a decrease of climactic water balance (see the figure to the right). It was particularly visible in the south and south-east of the region. The decrease was caused by a simultaneous influence of two adverse factors, i.e. drop of precipitation totals and higher evaporation. As a result, mean annual values of climactic water balance of the analyzed period are lower than those in the reference period of 1966-1985 by 150 mm, i.e. 30% of mean annual precipitation totals (vegetation season – over 80 mm, winter season – over 30 mm).



6/ Conclusion

During the last two decades the problem of water scarcity in the studied area became more acute. In the central part of the region, the adverse climactic water balance showed no significant changes, while water scarcity spread to new areas, particularly to the south-eastern part of the region. Mean annual precipitation total decrease and higher evaporation caused by the climate change contributed to the deterioration of conditions for agricultural development within the studied area.