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## CLIMATE CHANGES IN THE PEAT BOG AREAS OF WESTERN POLISSYA AS ILLUSTRATED BY THE WEATHER STATION AT THE SARNENSKA RESEARCH STATION

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**Abstract.** *An analysis of long-term data on average daily air temperature shows that during the period of large-scale land reclamation–1962–1988– a decrease in these values was observed, both compared to the long-term average for 1946–2024 and to the average value for the period prior to large-scale land reclamation–1946–1961. The increase in the area of the evaporating surface caused by land reclamation led to an increase in the intensity of total evaporation and, consequently, to a decrease in air temperature. The average decrease in the mean daily air temperature during the growing season and over the year was, in both cases, 0,1 (°C). In turn, the increase in total evaporation during the period of large-scale land reclamation led to a 48,5 mm increase in precipitation during the growing season compared to the amount that fell before reclamation; on an annual basis, this figure amounts to 57,0 mm. Thus, overall, large-scale land reclamation on drained lands has resulted in positive climatic changes, and the current climate warming in the Polissya region is not associated with these reclamation efforts.*

*An analysis of current climate changes shows that the average precipitation during the growing seasons of 2015–2024 is 33,6 mm lower than during 1999–2014. It should be noted that there has been a fairly significant decrease in precipitation during the active growing season for agricultural crops–June through September–which is generally a negative phenomenon for agricultural production. The average monthly air temperature during the growing season in the s of 2015–2024 increased by 0,5 (°C) compared to 1999–2014, and by 0,8 (°C) per year.*

*Climate changes over the past decades, characterized by a significant increase in heat availability during the growing season, make it possible to grow crops that are non-traditional for the Polissya region – economically attractive forest-steppe and steppe crops such as grain corn, soybeans, and sunflowers– which have recently been rapidly replacing crops previously traditional for this region, such as winter rye, buckwheat, oats, perennial grasses, and others.*

**Keywords:** *Western Polissya, climate change, large-scale land reclamation, precipitation patterns, air temperature, hydrothermal conditions*

**Research relevance.** Current climate changes in Ukraine have been noticeable over the past 20–30 years and are occurring most intensively in the Polissya region. According to leading climatologists, the boundaries of climatic zones

have shifted by at least 200 km, and some estimate the shift to be as much as 400 km [1, 8, 9].

An assessment of changes in the average annual air temperature shows that the greatest increase was recorded in the Polissya region–by

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2,3 °C (34,3%)—followed by slightly smaller increases in the Forest-Steppe region—by 1,4 °C (16,3%)—and in the Steppe region—by 1,4 °C (15,9%) [10, 17].

There are various opinions and assertions regarding the causes of rapid climate change specifically in the Polissya region. As for the impact of land reclamation, there are differing views within the scientific community regarding its effect on climate change. According to some researchers, the current climate warming in the Polissya region may be linked to large-scale land reclamation carried out in the 1960s and 1970s [7, 18]. In contrast, there are claims that the impact of large-scale land reclamation on current climate change is minimal [3, 4, 5]. Using a specific site as an example—namely, the “Chemerne” peat bog complex at the Sarny Experimental Station of the Institute of Water Problems and Land Reclamation of the National Academy (IWPaLR) of Agrarian Sciences (Rivne Region)—and drawing on long-term meteorological observation data, this claim can be confirmed or refuted.

#### **Analysis of Recent Studies and Publications.**

It is well known that wetlands significantly mitigate the effects of climate change, act as buffers against extreme natural phenomena such as droughts and floods, regulate humidity, air temperature, and ground surface temperature, and absorb and sequester carbon. At the same time, disturbed wetland ecosystems are vulnerable to climate change [11, 12, 14]. Due to warming, they lose more and more water, dry out, and begin to release previously “stored” carbon, exacerbating the greenhouse gas problem. The drying up of wetlands leads to the degradation and loss of valuable ecosystems that make Polissya so unique [8, 10, 11, 13, 14]. That is why, recently, both in scientific circles and at the government level, there has been a growing consensus on the advisability of partially restoring wetlands in the Polissya region. As one practical means of achieving this, it is proposed to carry out the partial renaturalization of drained peatlands in the Polissya region that are currently used for agricultural production [5, 15].

**The aim of this study is** to assess climate changes in the peatland complexes of the Western Polissya region, using the weather station of the Sarny Experimental Station of the IWPaLR of the National Academy of Agrarian Sciences (NAAS) as a case study over a long-term period.

**Materials and Methods.** This study utilized data from instrumental meteorological observations conducted since 1946 at the weather station of the Sarny Experimental Station of the IWPaLR (the only such station in

Ukraine), which is located directly on a peatland complex. This provides data—unique in Ukrainian agricultural land reclamation science—on the climatic characteristics of peatland complexes in the Western Polissya region, as well as the nature and patterns of their changes over a long period.

**Research Results and Discussion.** The initial phase of land drainage work at the Sarny Experimental Station coincided with the period of the Western Expedition led by Lieutenant General Y.I. Zhilinsky, which lasted over 30 years—from 1872 to 1902—and encompassed a total of over 8 million hectares of once-impassable swamps in the Polissya region [6]. In the territory of the former Volyn Governorate alone, a network of drainage canals was constructed across an area of over 500 thousand hectares. Even by modern standards, a vast amount of surveying, topographic, and engineering-hydropromeliorative work was carried out in a relatively short period of time, mostly by hand in the conditions of impassable swamps. The land reclamation canals built by the Western Expedition are still in operation today, notably the Khvoshchivansky Main Canal within the land reclamation system of the Sarny Experimental Station of the IWPaLR of the National Academy of Agrarian Sciences (NAAS). Even modern agricultural land reclamation science relies to a significant extent on the scientific and practical work of a team of talented and dedicated scientists and engineers who, in the late 19th and early 20th centuries, laid the foundations for the reclamation of wetlands in the Ukrainian Polissya.

The Sarny Experimental Station was established on the “Chemerne” peat bog complex, the drainage of which began precisely with the Western Expedition’s construction of the first drainage canals. The first phase of draining the station’s marshlands took place between 1912 and 1917; during this period, approximately 120 hectares of the marshland were drained. The second stage of draining the peatland massif on which the station is located was carried out between 1924 and 1938, when it operated as part of the Second Polish Republic. The area of drained land during this period increased to 260 hectares of peatlands and 15 hectares of mineral soils.

The first reconstruction of the station’s land reclamation system took place in 1959–1961, and the second in 1974–1976.

The station’s land reclamation system is located in the western, most marshy part of the Ukrainian Polissya and lies directly within the “Chemerne” peat bog complex of the Sarny Experimental Station (Rivne region).

In terms of morphological characteristics, botanical composition, and hydro-physical and agrochemical properties, this complex is typical of the Western Polissya—a deep, medium-ash, non-floodplain, hypnum-sedge bog of the lowland type.

The system includes a drained area, a water recipient, open canals (main, collector, upland, and catchment) with hydraulic structures, and a closed regulating network. The water recipient is the Sluch River, located at a distance of 5 km from the system.

Of the agricultural land, lowland-type peat soils cover 355 hectares, while mineral soils cover 115 hectares (predominantly sod-podzolic sandy loam).

Peat soils range in thickness from 0,5 to 5,0 m; they are well decomposed (decomposition degree exceeding 40%); they are medium- to high-ash (17–28% ash); and, in terms of botanical composition, they are predominantly sedge-sphagnum. The filtration coefficient ranges from 0,5 to 1,0 m/day. The water-holding capacity of peat soils ranges from 300 to 800%; the soil density is 0,260–0,342 g/cm<sup>3</sup>.

The peat is underlain by oxic sandy loams; the acidity of the peat soil ranges from 4,1 to 5,5.

Mineral soils consist of sod-podzolic clay-sandy soils on sandy deposits with a humus content of 2,1–2,4% and a pH of 4,5–5,4.

Groundwater levels over the past 3 years during the growing season in the land reclamation system ranged from 41 to 117 cm.

The weather station at the Sarny Research Station is the only one in Ukraine located directly on a peat bog complex and has been operating continuously since 1946 (data from 1912 were partially lost during World War II).

To assess the potential impact of large-scale land reclamation on current climate change, the period of instrumental observations—1946–2024—has been divided into the following stages:

- the period prior to large-scale land reclamation—1946–1961;
- the period of large-scale land reclamation—1962–1988;
- the period of winter-spring (I–III) warming—1989–1998;
- the period of a steady increase in monthly and annual average daily air temperatures—1999–2014;
- the current period – 2015–2024

Data on air temperature and precipitation for the specified periods are presented in Tables 1–2.

1. Average daily air temperature based on data from the Sarny Research Station of the IWPaLR, °C

Period	Months												Spring (IV–IX) (average)	Year (average)
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Before land reclamation, 1946–1961	–4,4	–4,5	–0,3	7,4	13,5	17,5	18,8	17,4	12,5	6,4	1,9	–1,8	14,5	7,0
Period of large-scale land reclamation, 1962–1988	–5,9	–4,7	0,0	7,6	14,1	16,9	18,1	17,0	12,6	7,3	2,2	–2,3	14,4	6,9
Winter-spring (I–III) warming period, 1989–1998	–2,3	–1,1	1,9	7,9	14,4	17,7	18,8	18,2	12,1	7,3	1,1	–3,0	14,9	7,8
Period of sustained increase in monthly and annual average daily air temperatures, 1999–2014	–3,7	–3,0	1,8	9,1	14,6	18,1	20,3	18,7	13,1	7,5	3,3	–2,1	15,7	8,1
Current period, 2015–2024	–2,7	–0,5	2,6	8,5	14,1	19,6	20,2	19,8	14,1	8,1	3,0	–0,4	16,1	8,9
Average annual values of average daily air temperatures for the observation period (normal), 1946–2024	–4,3	–3,3	0,9	8,0	14,1	17,7	19,0	17,9	12,8	7,3	2,3	–2,0	14,9	7,5

Continuation of Table 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Deviation from long-term averages (+ increase, – decrease)														
1946–1961	-0,1	-1,2	-1,2	-0,6	-0,6	-0,2	-0,2	-0,5	-0,3	-0,9	-0,4	0,2	-0,4	-0,5
1962–1988	-1,6	-1,4	-0,9	-0,4	0,0	-0,8	-0,9	-0,9	-0,2	0,0	-0,1	-0,3	-0,5	-0,6
1989–1998	+2,0	+2,2	+1,0	-0,1	+0,3	0,0	-0,2	+0,3	-0,7	0,0	-1,2	-1,0	-0,1	0,2
1999–2014	+0,6	+0,3	+0,9	+1,1	+0,5	+0,4	+1,3	+0,8	+0,3	+0,2	+1,0	-0,1	+0,7	+0,6
2015–2024	+1,6	+2,8	+1,7	+0,5	0,0	+1,9	+1,2	+1,9	+1,3	+0,8	+0,7	+1,6	+1,1	+1,3
Temperature deviations in the period after 1999														
2015–2024 compared to 1999–2014	+1,0	+2,5	+0,8	-0,6	-0,5	+1,5	-0,1	+1,1	+1,0	+0,6	-0,3	+1,7	+0,4	+0,7

2. Average precipitation for various periods based on data from the weather station at the Sarny Research Station of the IWPaLR, mm

Period	Months												Spring–Fall (April–September) (average)	Year (average)
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
Before land reclamation, 1946–1961	25,6	25,2	25,3	30	47,2	73,3	76,4	64,7	40,4	49,2	46,1	34,6	332,0	538,0
Land reclamation period, 1962–1988	36,2	31,2	28,0	43,9	59,8	83,6	79,8	59,4	54,1	40,5	39,2	39,4	380,5	595,0
Winter-spring (I–III) warming period, 1989–1998	18,7	23,7	22,9	39,9	52,2	64,8	98,2	56,0	75,5	39,4	37,2	36,9	386,6	565,4
Period of steady increase in monthly and annual average daily air temperatures, 1999–2014	24,3	27,7	25,2	22,2	41,0	58,2	78,3	52,1	40,4	27,8	27,1	24,7	292,2	448,8
Current period, 2015–2024	29,0	23,4	25,9	26,0	50,6	42,5	69,1	39,2	31,3	39,5	29,6	42,0	258,7	448,1
Average annual values of average daily air temperatures for the observation period (normal), 1946–2024	28,5	27,3	26,0	33,9	51,3	68,8	79,8	56,0	48,4	39,4	36,7	35,5	338,1	531,5
Deviation from long-term averages (+ increase, – decrease)														
1946–1961	-29	-21	-0,7	-3,9	-4,1	4,5	-3,4	8,7	-8,0	9,8	9,4	-0,9	-6,1	6,5
1962–1988	+7,7	+3,9	+2,0	+10,0	+8,5	+14,8	0,0	+3,4	+5,7	+1,1	+2,5	+3,9	+42,4	+63,5
1989–1998	-9,8	-3,6	-3,1	+6,0	+0,9	-4,0	+18,4	0,0	+27,1	0,0	+0,5	+1,4	+48,5	+33,9
1999–2014	-4,2	-0,4	-0,8	-11,7	-10,3	-10,6	-1,5	-3,9	-8,0	-11,6	-9,6	-10,8	-45,9	-82,7
2015–2024	0,5	-3,9	-0,7	-7,9	-0,7	-26,3	-10,7	-16,8	-17,1	0,1	-7,1	6,5	-79,5	-83,5
Changes in precipitation levels since 1999														
2015–2024 compared to 1999–2014	4,7	-3,6	0,1	3,8	9,6	-15,7	-9,2	-12,9	-9,1	11,7	2,5	17,3	-33,6	-0,8

An analysis of data on average daily air temperature for the time periods specified above shows that during the period of large-scale land reclamation (1962–1988), there was a slight

(0,1 (°C)) decrease in this value compared to its average (both for the annual period and the April–September period) during the period prior to large-scale land reclamation (1946–1961).

The average precipitation totals for various periods, based on data from the weather station at the Sarny Experimental Station of the Institute of Water Problems and Land Reclamation of the National Academy of Agrarian Sciences, are presented in Table 2.

The period 1989–1998 was characterized by winter-spring (January–March) warming, while since 1999, warming has occurred throughout the entire calendar year. The highest precipitation occurs in July–74,8 mm.

Based on data from the last decade (2015–2024), annual precipitation has decreased by 83,5 mm compared to the long-term average and by 79,5 mm for the April–September period. The average daily air temperature for the annual period and the April–September period has

increased by an average of 1,1 (°C) and 1,3 (°C), respectively, which is a very significant indicator.

The increase in the area of the evaporating surface, caused by land reclamation, led to an increase in the intensity of total evaporation and, consequently, to a decrease in air temperature. The increase in total evaporation during the period of large-scale land reclamation led to an increase in total precipitation during the growing season by 48,5 mm compared to the amount that fell before reclamation, and by 57 mm per year. An analysis of the research data suggests that large-scale land reclamation on drained lands resulted in positive climatic changes, and the current climate warming in the Polissya region is not associated with these reclamation efforts. Regarding climate changes after 2000, the average

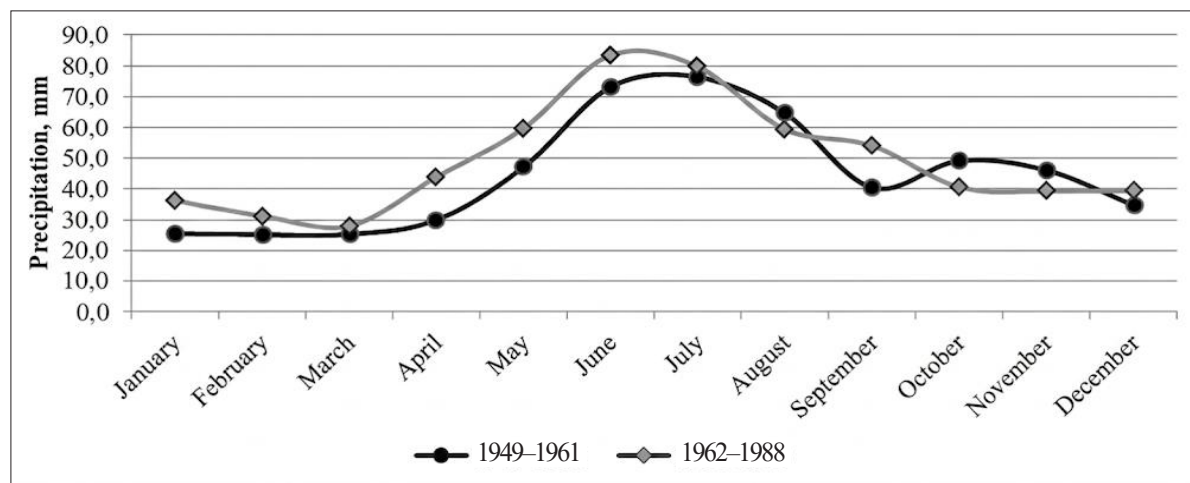


Fig. 1. Precipitation trends for the periods 1946–1961 and 1962–1988, “Chemerne” peat bog complex, Sarny Experimental Station of the IWPaLR

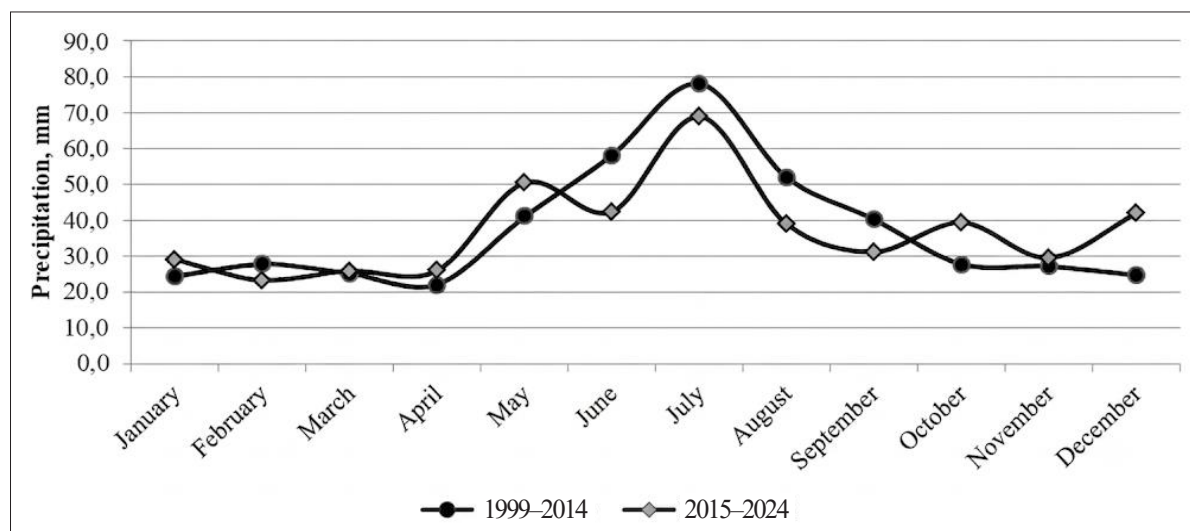


Fig. 2. Precipitation trends for the periods 1999–2014 and 2015–2024, “Chemerne” peat bog complex, Sarny Experimental Station of the IWPaLR

precipitation for the April–September period during 2015–2024, as recorded at the Sarnensk Research Station weather station, decreased by 33,6 mm compared to the 1999–2014 period. The decrease in precipitation during the 2015–2024 period, compared to the 1999–2014 period, was observed during the active growing season—June through September—which, overall, is an unfavorable factor for agricultural production against the backdrop of rising average daily temperatures. Regarding temperature patterns, the average monthly air temperature for the April–September period rose by +0,4 °C, and by +0,7 °C over the annual period, which is a fairly significant increase.

Thus, based on data from the weather station at the Sarnensk Research Station of the IWPaLR, climate changes in the “Chemerne” peat bog complex over the past decade are

due to a significant decrease in precipitation during April–September against the backdrop of a general increase in average monthly air temperatures. The results obtained from instrumental observations are fully consistent with the general trends of climate change in the Belarusian Polissya region.

The data in Figures 3–4, based on observations from the Sarnenskaya Research Station weather station, show that air temperatures have been rising most rapidly since the beginning of 2000, and this process continues to the present day; furthermore, the increase in average daily temperature is occurring against a backdrop of decreasing precipitation.

Overall, climate change is moving toward aridification, and based on key climate indicators, the Polissya region now more closely resembles—in the classical sense—the Forest-Steppe zone.

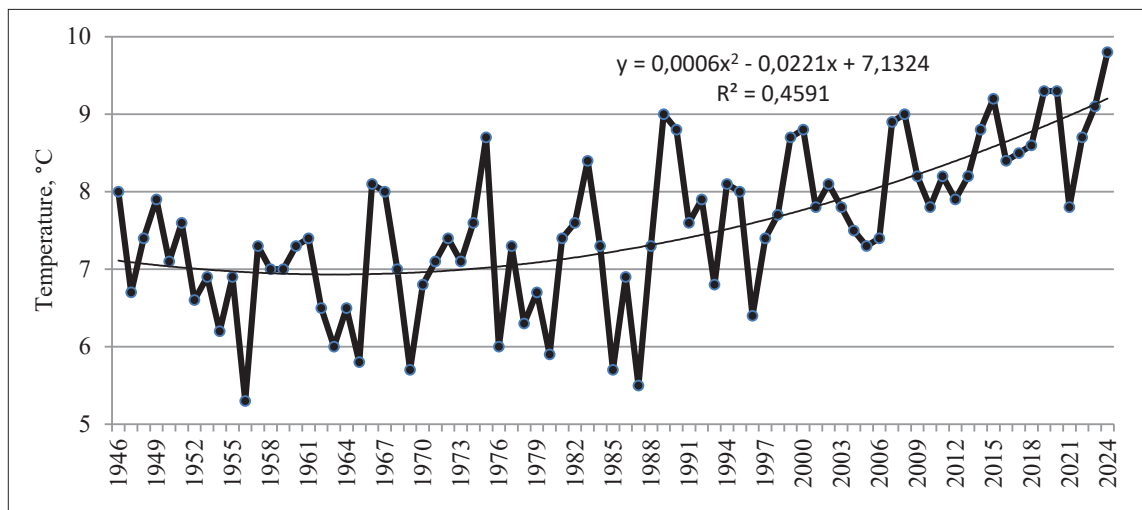


Fig. 3. Trends in average annual air temperature for 1946–2024

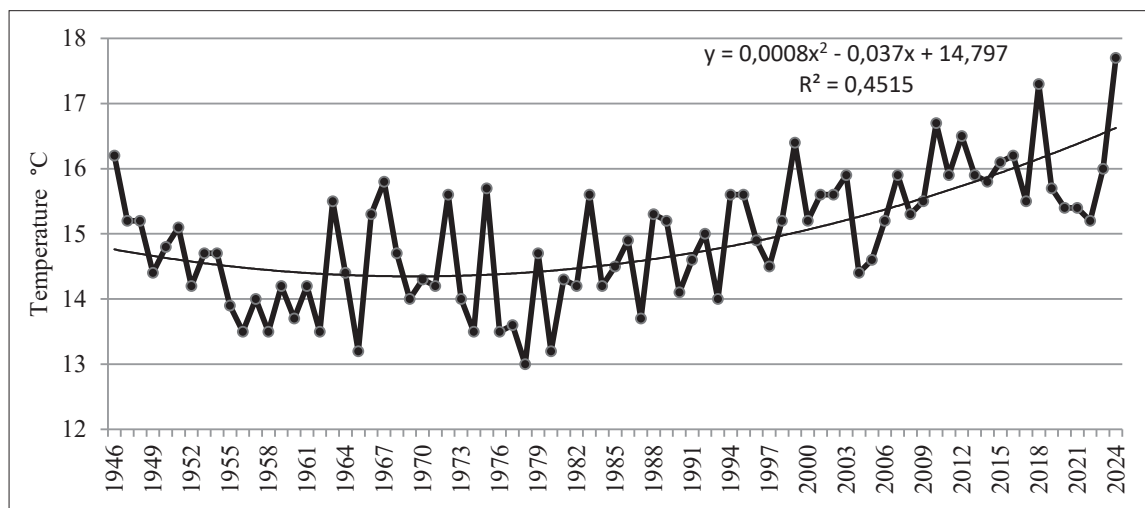


Fig. 4. Trends in average monthly air temperature for April–September, 1946–2024

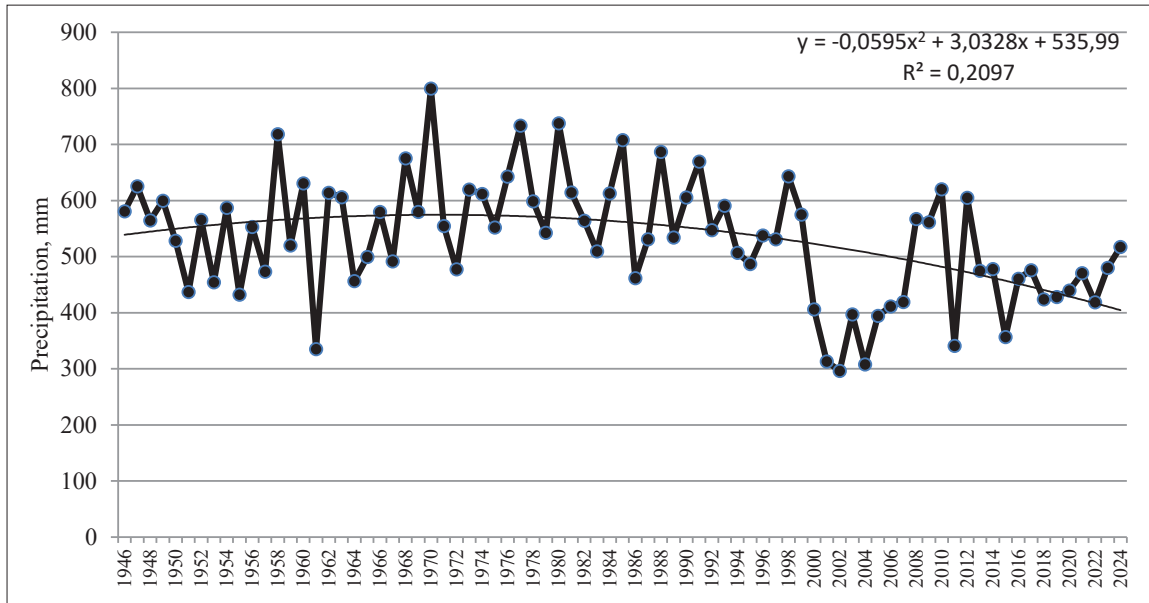


Fig. 5. Trends in annual precipitation for 1946–2024

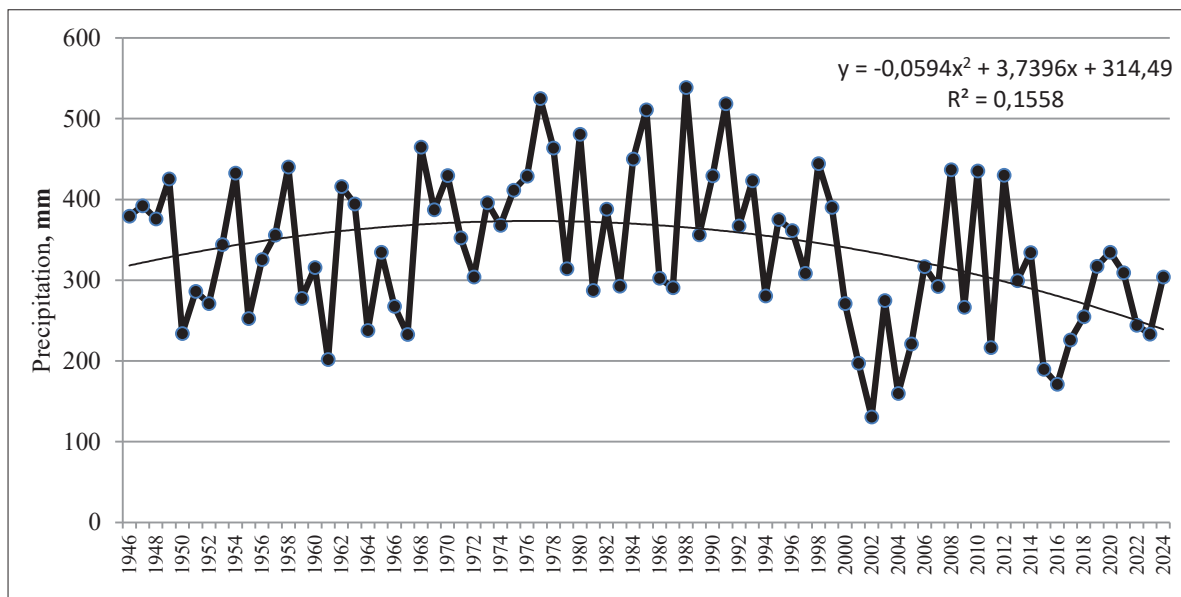


Fig. 6. Trends in precipitation for April–September during 1946–2024

As for the impact of current climate change on agro-industrial production, thanks to a significant increase in heat availability during the growing season, it is already possible to successfully grow crops that are non-traditional for the Polissya region – economically attractive agricultural crops typical of the forest-steppe and steppe zones, such as grain corn, soybeans, and sunflowers – which are rapidly replacing crops previously typical of this region, such as winter rye, buckwheat, oats, perennial grasses, and others.

However, a very cautious approach is needed when cultivating these crops in the Polissya region. In many cases, crop cultivation technologies are mechanically transferred from the Steppe and Forest-Steppe zones without taking into account the region's soil and climatic characteristics, which often leads to a decrease in their yield. First and foremost, a particularly careful approach is required when selecting varieties and hybrids best adapted to the specific soil and climatic conditions of the Polissya

region. In the Polissya region, given the less favorable hydrothermal conditions, preference should be given to early-maturing hybrids of corn, sunflower, and soybeans. As recent studies show, the difference in yield between individual hybrids of corn, sunflower, and soybeans can be as high as 2–3 times.

At the same time, economically attractive crops such as corn, soybeans, and sunflowers are demanding in terms of soil moisture, so given the trend toward decreasing precipitation in the Polissya region, their cultivation on large areas will inevitably require the restoration of irrigation systems, a significant portion of which are currently not functioning properly.

Thus, based on data from the weather station at the Sarny Experimental Station of the IWPaLR, climate changes in the “Chemerne” peat bog complex over the past decade have been caused by a significant decrease in precipitation during the growing season against the backdrop of a general increase in average monthly air temperatures. The results obtained from instrumental observations are fully consistent with the general trends in climate change documented in Ukraine and in the belarusian Polissya region.

**Conflicts of interest:** the authors declare no conflict of interest.

**Use of artificial intelligence:** the authors confirm that they did not use artificial intelligence technologies during the creation of this work.

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**Conclusions.** Analysis of data on average daily air temperature shows that during the period of large-scale land reclamation–1962–1988–there was a decrease in this value, both compared to the long-term average for 1946–2024 as well as compared to the average for the period prior to large-scale land reclamation (1946–1961). The increase in the area of the evaporating surface caused by land reclamation led to an increase in the intensity of total evaporation and, consequently, to a decrease in air temperature. The average decrease in the mean daily air temperature during the growing season and over the year is, in both cases, 0,5 (°C). The increase in total evaporation during the period of large-scale land reclamation led to a 48,5 mm increase in total precipitation during the growing season compared to the amount that fell prior to reclamation. On an annual basis, this figure amounts to 57,0 mm.

An analysis of meteorological data for the last decade (2015–2024) shows that annual precipitation decreased by 83,5 mm compared to the long-term average and by 79,6 mm during the growing season. The average daily air temperature during the growing season has increased by an average of 1,2 °C and 1,4 °C, respectively, which is a significant indicator.

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**КЛІМАТИЧНІ ЗМІНИ НА ТОРФОБОЛОТНИХ МАСИВАХ ЗАХІДНОГО ПОЛІССЯ  
НА ПРИКЛАДІ МЕТЕОПОСТУ САРНЕНСЬКОЇ ДОСЛІДНОЇ СТАНЦІЇ****М.Д. Зосимчук<sup>1</sup>, канд. с.-г. наук, М.Г. Стецюк<sup>2</sup>, О.А. Зосимчук<sup>3</sup>, канд. с.-г. наук,  
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**Анотація.** Аналіз багаторічних даних по середньодобовій температурі повітря показує, що в період проведення широкомасштабної меліорації – 1962–1988 рр., спостерігалось зниження її величини, як порівняно з середньобагаторічними показниками – 1946–2024 рр., так і з середньою її величиною за період до широкомасштабної меліорації – 1946–1961 рр.

Викликане проведенням меліорації збільшення площі випаровуваної поверхні призвело до підвищення інтенсивності сумарного випаровування і відповідно до зниження температури повітря. Середня величина зниження середньодобової температури повітря за період вегетації і за рік складала в обох випадках в середньому 0,1 оС. В свою чергу збільшення сумарного випаровування в період широкомасштабної меліорації привело до збільшення суми випадання опадів за вегетаційний період на 48,5 мм порівняно з їх кількістю, що випадали в період до меліорації, в річному розрізі ця величина складає 57,0 мм. Отже в цілому в результаті проведення широкомасштабної меліорації на осушуваних землях відбулись позитивні кліматичні зміни, і сучасне потепління клімату в зоні Полісся не пов'язане з її проведенням.

Аналіз сучасних кліматичних змін показує, що середня кількість опадів за вегетаційний період 2015–2024 рр. порівняно з 1999–2014 рр. є меншою на 33,6 мм. Слід зазначити про доволі істотне зменшення кількості опадів у період активної вегетації сільськогосподарських культур – червень–вересень, що в цілому є негативним явищем для ведення сільськогосподарського виробництва. Середньомісячна температура повітря за вегетаційний період протягом 2015–2024 рр. порівняно з 1999–2014 рр. підвищилась на 0,5 оС та на 0,8 оС за рік.

Кліматичні зміни в останні десятиліття, які полягають у істотному збільшенні теплозабезпеченості вегетаційного періоду дають можливість вирощувати нетрадиційні для зони Полісся – Лісостепові та Степові економічно-привабливі сільськогосподарські культури, такі як – кукурудза на зерно, соя, соняшник, що останнім часом стрімко витісняють раніше традиційні для даного регіону культури – озиме жито, гречка, овес, багаторічні трави та ін.

**Ключові слова:** Західне Полісся, зміни клімату, широкомасштабна меліорація, режим атмосферних опадів, температура повітря, гідротермічні умови