Archives of Hydro-Engineering and Environmental Mechanics 69 (2022), pp. 79–96, doi: 10.2478/heem-2022-0006

sciendo

Archives of Hydro-Engineering and Environmental Mechanics

Published since 1954 ISSN 1231–3726



Water Supply of the Ukrainian Polesie Ecoregion Drained Areas in Modern Anthropogenic Climate Changes

Lyudmyla Kuzmych[1], Oleh Furmanets[2], Serhii Usatyi[1], Oleh Kozytskyi[1], Nazar Mozol[1], Anna Kuzmych[2], Vitalii Polishchuk[1], Halyna Voropai[1]

[1]Institute of Water Problems and Land Reclamation of the National Academy of Agrarian Sciences of Ukraine; 37 Vasylkivska Str., 03022, Kyiv, Ukraine,
[2]National University of Water and Environmental Engineering, 11 Soborna Str., 33000, Rivne, Ukraine
Corresponding author: Lyudmyla Kuzmych, e-mail: kuzmychlyudmyla@gmail.com

(Received 02 November2022; revised 27 December 2022)

Abstract. The paper focuses on research on improving the water supply of drainage systems of humid areas in the context of anthropogenic climate change. The aim of the research is to elaborate on the ways for increasing the available water supply of drainage systems and restoring active water regulation on reclaimed lands in a changing climate. Reclaimed lands are the main factor of sustainable agricultural production in Ukraine and guarantors of its stability. The area of drained lands in Ukraine is about 3.2 million hectares, including 2.3 million hectares drained with the help of closed drainage; in an area of 1.3 million hectares a two-way regulation of the soil water regime is carried out. An increase in air temperature and uneven distribution of precipitation, which has a torrential, local character in the warm period, do not allow for the effective accumulation of moisture. The recurrence of droughts in different justified climatic zones of Ukraine has increased by 20–40%, which prevents sustainable agricultural production in the zone of sufficient atmospheric moisture, in particular the Polesie Ecoregion. In this paper, the analysis of water consumption of reclaimed lands in the Polesie Ecoregion of Ukraine is carried out, on the examples of the drainage system "Maryanivka" and the calculation of the water supply for the corn and winter wheat.

Key words: Drainage system, norm of water consumption; average annual discharge; volume of runoff; groundwater level, crop

1. Introduction

Effective use of the existing potential of the drainage systems of the humid zone of Ukraine in modern anthropogenic climate changes is an important condition not only for the implementation of intensive technologies for growing agricultural crops, but also for the preservation and formation of water resources in the region, the creation of favorable living conditions, and the protection of the rural population and rural areas from the manifestation of harmful effects water. The economic, ecological and

© 2022 Institute of Hydro-Engineering of the Polish Academy of Sciences. This is an open access article licensed under the Creative Commons Attribution-NonCommercial-NoDerivs License (http://creativecommons.org/licenses/by-nc-nd/4.0/).

social stability of the region of the humid zone of Ukraine depends on the efficiency of the use of drainage systems.

Drainage systems of Ukraine are located mainly in the Polesie Ecoregion on a total area of up to 3.2 million hectares, and include 1671 reclamation systems, comprising 835 drainage systems of unilateral action on an area of 1.6 million hectares (50%), 585 drainage systems of two-way action on the area of 1.1 million ha (34%), and 251 polder and water circulation systems on the area of 0.51 million ha (15%) (Korobiichuk et al 2017, Korobiichuk et al 2019, Kuzmych et al 2021, Rokochinskiy et al 2020).

The current state of the drainage infrastructure was formed in accordance with the specific stages of its development, and the main factors that determine and influence the functioning of drainage systems and the efficiency of the use of drained lands at the current stage are the water supply of drainage systems, transformational changes in the agricultural sector, and the technical state of the engineering infrastructure (Alfonso et al 2010, Basharin et al 2016, Dolid 1990, Korobiichuk et al 2020, Kuzmych et al 2021, Romashchenko et al 2019, Schultz 2008, Van Overloop 2006).

To improve the efficiency of using the potential drainage systems, a scientific justification is required, which requires an assessment of the impact of climate change on the water supply of reclaimed areas and the determination of directions for improving the water supply of drainage systems, establishing the current state of agricultural use of drained lands and the requirements of agricultural production to regulate the water-air regime of the soil.

2. Methods and Techniques

The research methods and techniques are based on the generalization of scientific knowledge and conducting experimental research on the water regulation of drainage systems of the humid zone and the water storage capacity of the reclaimed lands, taking into account the objectives and requirements of the Water Framework Directive 2000/60 / EC of the European Parliament and of the Council on establishing a framework for Community action in the field of water policy (Water Framework Directive 2000/60/EC 2000, Water Framework Directive review by the European Commission 2012).

Researchers were conducted at the area of Ukrainian Polesie Ecoregion (Fig. 1) on the reclaimed plots of the drainage system “Maryanivka” using remote sensing (satellite and unmanned aerial vehicle). The nature field method, the information-analytical one, the calculation-comparative one, and the mathematical-statistical methods were also applied. The basis for the methodology of calculating the water consumption of crops is the equation of water balance.

The drainage system (DS) “Maryanivka” is located in the Rivne region in the basin of the river Goryn, the water intake is a small river Zulnya (Datsko 2016). DS “Maryanivka” with a total area of 644 ha, by its functional purpose, is a



Fig. 1. Scheme of the drainage system "Maryanivka" location (Polesie Ecoregion, Rivne region, Ukraine)

hydro-ameliorative system of bilateral action on the area of 525 ha, the regulation of water runoff is provided for both drainage and humidification by means of pre-sluice.

According to the design features, DS "Maryanivka" consists of open drainage – canals and a closed collector – drainage network with an area of 535 hectares, based on pottery drainage. DS "Maryanivka" is a network of open canals with an average distance of 250–300 m. The role of the main canal is played by the canal OK-1, it also serves as a water intake, which drains water into the river Zulnya basin of the river Goryn. The average depth of the canal is 2.6 m, the width at the bottom is 1.5 m, and at the top – is 11.0 m.

On the basis of plans-schemes and geographical coordinates of fields, fragments of schemes of the DS "Maryanivka" (Fig. 2) were formed by superimposing on a satellite map of geographical coordinates of fields and scheme of the drainage system. These fragments make it possible to visualize the fields in the consideration of the

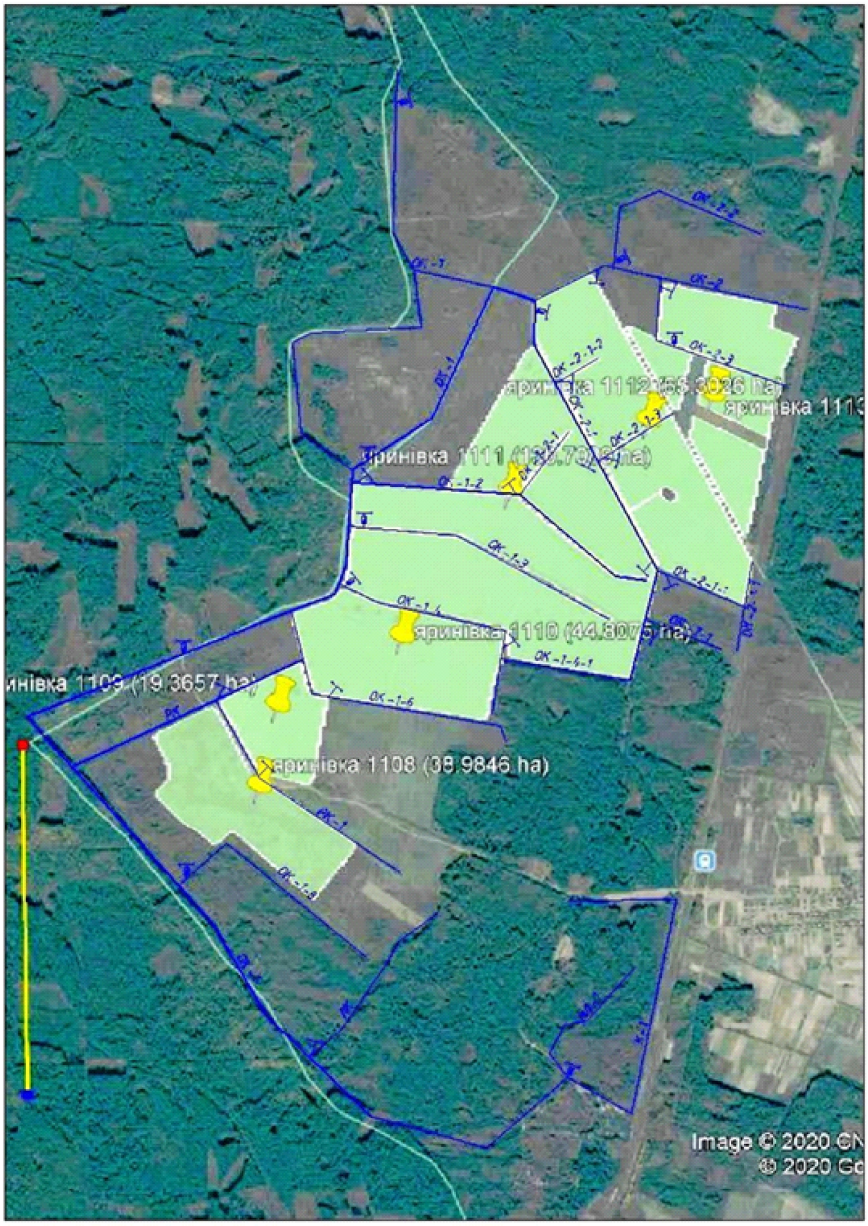


Fig. 2. The scheme of the studied fields at the drainage system "Maryanivka"

drainage system as a whole, as well as a clear vision of the protocol of inspections of the technical condition of the DS "Maryanivka" to determine the possibility of its involvement in regulating water and air regime.

The leading inter-farm network is represented by channels OK-1-2 and OK-2-1 (Fig. 2). The average depth of the channels of the wired network is 2.0 m, the width

at the bottom is 1.0 m, at the top – 9.0 m. Closed drainage is represented by pottery drainage, which was built with distances between drains of 20–26 m.

During field surveys and field research, the study of existing groundwater levels in the characteristic points of the area, where wells were laid, which are marked with yellow pointers (Fig. 2).

The relief of the territory of DS "Maryanivka" is slightly undulating with a smooth slope from southeast to northwest. Variegated soils, agrochemical, and physical properties are combined into 4 soil groups (Kuzmych et al 2021):

1) Sod podzolic soils – common on elevations. Drainage is not required due to the light mechanical composition and deep groundwater;
2) Turf gley soils – common in areas of the slightly elevated surface;
3) Turf gley carbonate soils – common on the flat surface of the plain with a developed microrelief;
4) Humus-turf and silty-swamp soils – distributed on a small area in closed depressions with the close occurrence of groundwater.

Among the studied crops for cultivation are corn for grain and winter wheat.

The basis for calculating the project water consumption of crops is the equation of water balance (Alfonso et al 2010, Shang 2014):

$$D_i = E_i - (P_i - \Delta P_i)\,, \tag{1}$$

where:

D_i – the deficit of water consumption of agricultural crops for the i-th decade of the growing season, m^3/ha;
E_i – total evaporation, m^3/ha;
P_i – precipitation;
ΔP_i – discharge of precipitation to surface runoff and filtration.

The total evaporation (E_i) is calculated by the formula:

$$E_i = \varphi_i \cdot k_{6_i}^{\kappa} \cdot E_{0_i} + (1 - \varphi_i) \cdot k_{II_i} \cdot E_{0_i}, \tag{2}$$

where:

φ_i – the ratio of the coverage of the field by plants in this phase of its development to its critical value, according to which evaporation from the soil surface is practically absent;
E_{0_i} – an evaporation, m^3/ha, calculated by the formula:

$$E_{0_i} = 0.0006 \cdot (25 + t_i)^2 \cdot (100 - r_i)\,, \tag{3}$$

where:

t_i and r_i – the average daily temperature, °C, and relative humidity, %;
k_{6_i} – evaporation rate from the part of the field covered with vegetation;

k_{II_i} – evaporation rate with uncovered part of the field depending on the level of moisture by its precipitation, which is determined by the formula:

$$k_{II_i} = 0.33 + 0.01 \cdot P_i + 0.04 \cdot n_{p_i}, \tag{4}$$

where:

P_i – the sum of precipitation per decade, m^3/ha, is the number of days in a decade with precipitation $P > 10$ m^3/ha.

During calculating the norms of water consumption of agricultural crops (M_{jn}, m^3/ha), the amount of water consumption deficits for all decades of the wetting period is reduced by the amount of easily accessible moisture in the root layer of the soil at the beginning of the growing season (W_o):

$$M_{j_n} = \sum_{i=1}^{i=J} D_i^{\kappa} - W_{o_j}. \tag{5}$$

3. Results and Discussion

The results of analytical studies indicate that modern climatic changes are manifested in an increase in air temperature, the average annual indicator of which in the period 1991–2020, compared to the period 1961–1990, generally increased by 1.2° across Ukraine. At the same time, in the zone of drainage reclamation, its increase is more significant: in the western regions – by 1.2–1.3°C, in the north and in the center – by 1.4–1.5°C. The last decade is characterized by an increase in the minimum temperature in the cold period of the year and the maximum temperature in the warm period. As a result of such changes in the Polesie the duration of the warm period increased by 4–10 days, which causes the early recovery of vegetation of agricultural crops. At the same time, crops with early sowing dates are often affected by late spring frosts (Romashchenko et al 2019).

In contrast to the air temperature, the annual amount of precipitation during the same periods both in Ukraine in general and in the area of drainage reclamations changed insignificantly (by 5–10%).

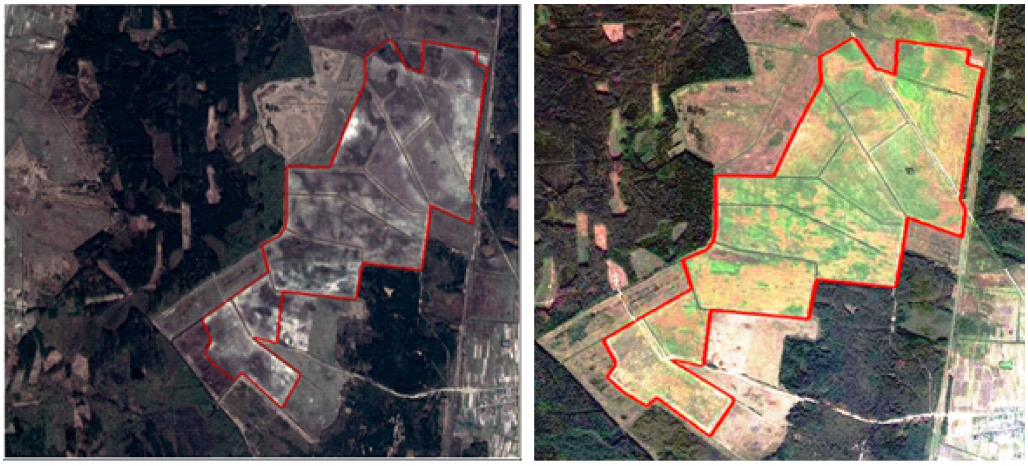
With insignificant changes in annual amounts of precipitation, there was a redistribution of their seasonal and monthly values, which is manifested in a decrease in the amount of precipitation in winter and summer and an increase in spring and autumn (Kuzmych et al 2021, Shang 2014, Su et al 2019).

At the same time, the structure of precipitation has changed, which, with a significant increase in air temperature in the cold period, is manifested in an increase in the frequency of rains and a decrease in snowfall, and an increase in the number of cases of wet and sleet; in the warm period – in an increase in the number of days with

showers, a decrease in the number of days with rains, an increase in the duration of the rain-free period.

Thus, increasing the water supply of reclaimed lands due to the effective use of existing engineering infrastructure of drainage systems, restoration, and reconstruction of individual areas, the introduction of effective new technologies of water management becomes a key condition for successful agricultural production.

Based on the results of reclaimed lands agromonitoring at the DS "Maryanivka" in 2020, data analysis and the use of geoinformation technologies for processing satellite images throughout the year, including the growing season, local relief depressions were identified with periodic flooding during periods of flooding and high water, as well as areas of disclosure of sandy soils, which contribute to a decrease in soil fertility (Fig. 3a). In addition, as can be seen from Fig. 3b, there is a significant unevenness of seedlings and a significant decrease in the yield of crops (corn for grain and winter wheat).



a b

Fig. 3. The images of degraded reclaimed lands of the DS "Maryanivka" (a) and areas with uneven emergence of crops (b)

The problem of humidification conditions in the territory of the DS "Maryanivka" were investigated in more detail using remote monitoring data (Fig. 4).

The dynamics of crop development are shown in the example of corn sowing in the 2021 season. The sowing date is May 25, the norm is 80,000 seeds per hectare. Hybrid – Limagrain Adeway. Predecessor – corn for grain, tillage – deep loosening in autumn.

Figures 4a and 4b were got after the snow cover came off, but before sowing the main crop. At the same time, during the spring period, local overwetting in micro depressions, which occurs due to the limited functioning of the existing drainage net-

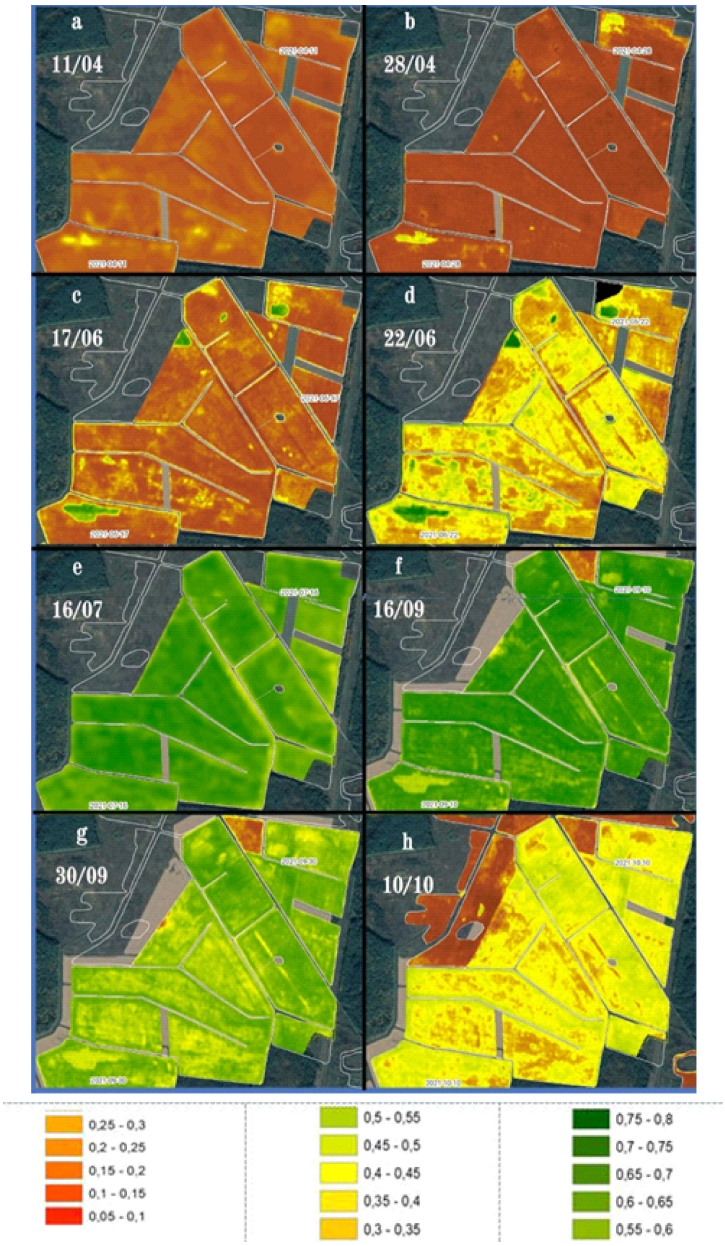


Fig. 4. Retrospective remote monitoring of the DS "Maryanivka" reclaimed lands by the NDVI

work, is clearly visible. In the places of accumulation of moisture already at this stage, the intensive development of unwanted vegetation begins, since the air temperatures are already high enough (Fig. 4a, 4b).

At the same time, after additional rainfall in late May-early June, the area of waterlogged areas increased several times (Fig. 4c). At this time, up to 15% of the surface area was flooded in the area. Crop seedlings were suppressed on more than 30% of the field area (Fig. 5).



Fig. 5. The state of the DS "Maryanivka" reclaimed lands on 01.06.2021

The Figure 5 shows the state of the territory during the crop growth period. Sowing is late due to a significant amount of precipitation that fell in a short period of mid-May, waterlogged areas are still well defined, in some locations on the plane of the cultivated fields, crop seedlings are visible, while the main background of the field remains undeveloped. The development of the main crop occurs unevenly, since the general background of moistening, and therefore warming is extremely uneven across the field plane.

This situation has a negative impact on the further development of the crop since even at the seedling stage the culture has a significant variation in development even within individual fields (Fig. 4c). The indicated trend of uneven development of corn at the beginning of the growing season is also clearly visible in the photo from 22.06 (Fig. 4d). At the same time, it is possible to distinguish at least three categories of fields – over moistened, with strong weeding (up to 5% of the projective cover), conditionally average, with moderate development of culture and weeding (up to 50% of the area) and areas where the development of sowing will be delayed due to less moisture resource.

In the summer, the sowing is gradually visually leveled off, as the culture has grown vigorously and gives a high general background NDVI, however, the trends noted at the beginning of the growing season clearly indicate the probability of under-harvesting (Fig. 4a, 4b). At the same time, waterlogged areas that were inten-

sively developed in the spring now have a lower vegetation index, since there is no corn in these locations.

At the end of the growing season, uneven ripening is noticeable. Early termination of vegetation now characterizes those areas where the development of corn was delayed in the spring, apparently due to a lack of moisture (Fig. 4).

The actual appearance of individual sections of the field in this period is shown in Fig. 6.

a)



b)



Fig. 6. The uneven ripening of corn: a) – control area; b) – area where corn development was delayed in the spring due to waterlogging

Also, it is often possible to notice the weak vegetation of the culvert in the canal strips (30–40 meters along the canals), which is probably connected with the uncontrolled outflow of water from the network of open canals and the corresponding lowering of the groundwater level.

The situation can be observed even more intensively in the photo from 10.10 (Fig. 4h).

As a result, the unevenness of moisture conditions within even elementary areas of the field leads to significant variability in the development of plants, which, depending on the biological characteristics of a particular crop, can more or less significantly reduce the total collection of products and the average yield.

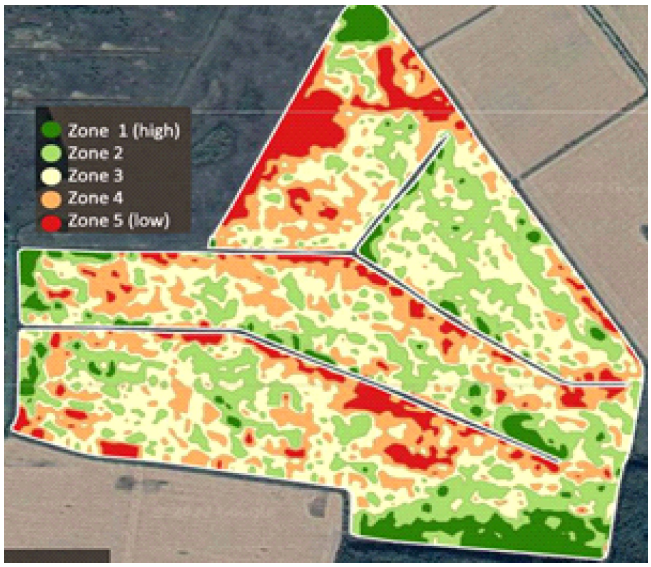


Fig. 7. Corn biomass before harvesting

The degree of heterogeneity of seeding development on a specific seeded field is conveniently estimated based on the graphical expression of the amount of biomass per unit area (Fig. 7). Classical vegetation indices (NDVI, NDRI, etc.) actually show the coverage of the field by vegetation, but do not give a sufficient idea of the type of this vegetation and the degree of its development. In the example of Fig. 4, it was shown how high NDVI at the beginning of the growing season can be caused by the development of weeding. Whereas the biomass cartograms, although they are the result of algorithmic processing of the same spectral images, take into account the type of vegetation and the intensity of the development of living vegetation, which is especially relevant in the case of consideration of corn, which is vigorous, in relation to all types of background vegetation (Su et al 2019).

The data presented in Figure 7 show that in the areas of overwetting, which were marked by a high weed background in the spring, the biomass of corn is extremely low. The same goes for the anchorage lanes and other problem areas noted above.

Since the biomass of a green plant does not always have a direct correlation with the yield of grain, it makes sense to analyze the change in yield along the plane of the

studied area in the complex. For this purpose, a partial mapping of threshing yield was carried out. (Fig. 8). Threshing was carried out on 15.11.

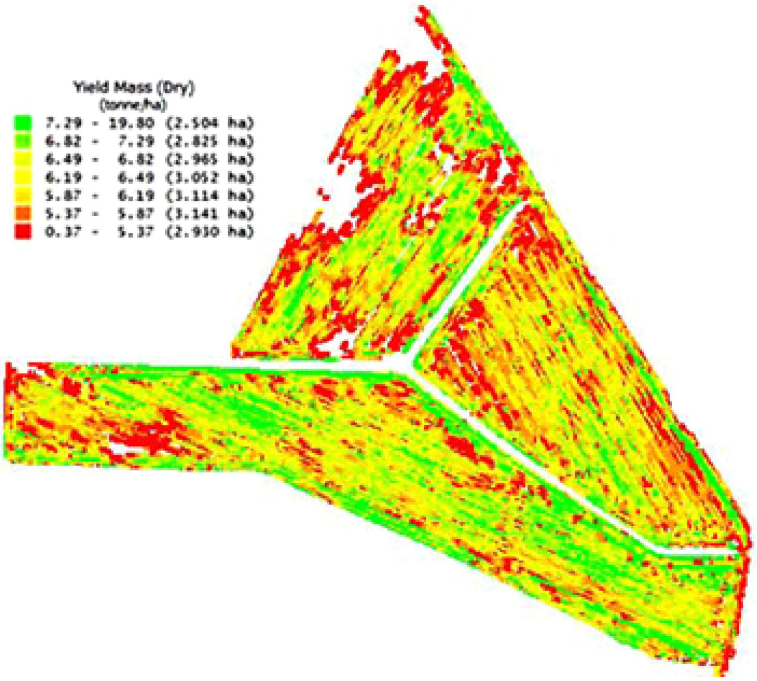


Fig. 8. Yield map, obtained when threshing the field, Case 8230

Waterlogged areas, where extremely low biomass was noted, did not form a cob at all, so yield data are not available (white gaps in the upper part of the figure). In general, it is possible to note a significant variability of corn grain yield by field (from 0 to 19.8 t/ha), while the general trend of higher yield correlates with areas of higher biomass.

Considering the variety of hydrothermal conditions of individual years, it is expedient to analyze trends in biomass formation over a period of several years, while covering different crops and years with different moisture availability. This can be done based on the data of the average long-term productivity presented in the example of Fig. 9.

The indicator represents the averaged over a five-year period data of the formed biomass in graphic expression. The starting materials for its construction are the spectral data of the Sentinel 2a satellite monitoring. In this case, the average data for the years 2017–2021 are given, during this period the spectrum of crops was represented exclusively by corn and sunflower.

The presented results show that the trends of uneven seeding development observed by us are observed systematically and in years with different moisture supplies.



Fig. 9. The analysis of average multi-year performance data

At the same time, regardless of the specifics of the year, there are noticeable areas of better and worse moisture within the field, and, therefore, the existing reclamation system does not work fully.

The natural field surveys were carried out, which included investigation of the engineering infrastructure of the drainage system and hydrological research with the purpose of assessing the water availability of reclaimed lands and calculating the water consumption of agricultural crops grown on these lands.

Within the main channel OK-1 groundwater levels are at a depth of 2.6 m at a distance of 15 m from the channel and at a depth of 2 m at a distance of 95 m from the canal, respectively, in the channel area groundwater levels exceed the water level in the channel by 4 cm, and at a distance of 95 m – 60 cm (Fig. 10). The slope of the filtration water depression curve is 0.006 (6 m per 1 km).

In the section of the channel PK at a distance of 105 m from the channel, the depth of groundwater was 1.7 m, respectively, the excess of groundwater above the level of the channel – 1.16 m, the slope of the depression curve of filtration water – 0.011 m (Fig. 11).

According to the obtained statistical parameters, the ordinates of the three--parameter gamma-distribution curve are determined, on the basis of which the average annual water discharge of reclamation channels with different probability of excess is calculated. The values of the average annual discharge and the volume of runoff of reclamation channels for different probabilities of excess (P, %) are given in Table 1 and Table 2.

The results of the research and calculations showed that the value of the average annual discharge in the interfluve of the Goryn River and Sluch River changes depending on the water content of the year and is characterized by a significant variation in the indices of the intra-annual runoff.

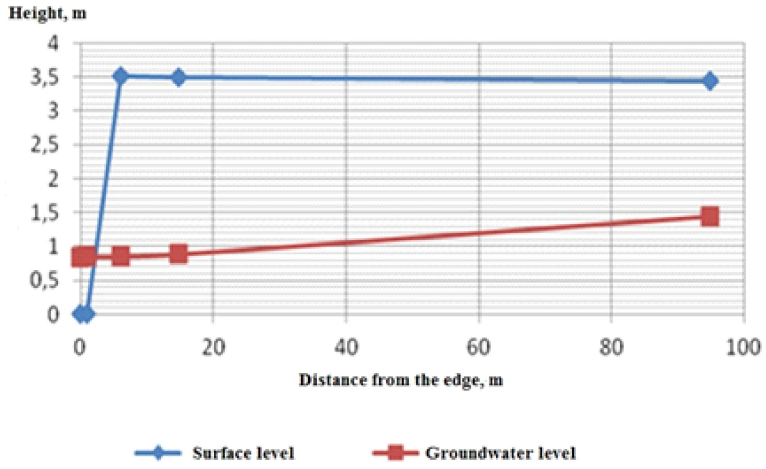


Fig. 10. Hydrogeological profile of the right-hand section of the channel OK-1

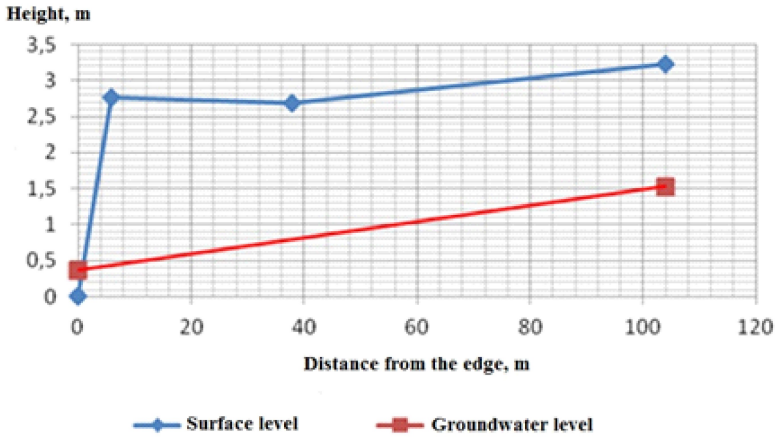


Fig. 11. Hydrogeological profile of the right-hand section of the channel PK

Thus, the average annual discharge entering the territory of the DS "Maryanivka" for medium-water years (50% rainfall per year) is 1430 thousand m^3, dry years (75%) – 1014 thousand m^3 and very dry years (95%) – 598 thousand m^3.

Features of climatic conditions and hydrological regime in the river basins of Polesie Ecoregion are due to the high unevenness of river runoff in different years and significant unevenness of its intra-annual distribution. In the interfluve of the Goryn and Sluch rivers, the runoff in very high-water years (P = 5%) can be more than 5 times higher than the discharge of very low-water years, the recurrence of which is 1 time in 20 years. The main volume of discharge during the year is formed due to

Table 1. Probability of excess of the average annual discharge and the volume of runoff in the channel MK-2, the DS "Maryanivka"

	Provision P, %									
	1	3	5	10	25	50	75	90	95	99
Ordinate	2.604	2.154	1.95	1.658	1.256	0.904	0.6414	0.463	0.3784	0.255
Water discharge, l/s	34.0	28.1	25.4	21.6	16.4	11.8	8.4	6.0	4.9	3.3
Volume of runoff W, thousand m^3	1071	886	802	682	517	372	264	190	156	105

Table 2. Probability of excess of the average annual discharge and the volume of runoff in the channel OK-1, the DS "Maryanivka"

	Provision P, %									
	1	3	5	10	25	50	75	90	95	99
Ordinate	2.604	2.154	1.95	1.658	1.256	0.904	0.6414	0.463	0.3784	0.255
Water discharge, l/s	130.5	108.0	97.7	83.1	63.0	45.3	32.1	23.2	19.0	12.8
Volume of runoff W, thousand m^3	4116	3405	3083	2621	1985	1430	1014	732	598	403

thawed rainwater during the spring floods. In high-water and medium-water years, the spring flood period (March–April) accounts for about half of the juice per year. In low-water and very low-water years, the share of flood runoff may exceed 80% per annum. Relatively high runoff is also observed in May. In low-water and very low-water years, the runoff in May is about 10% per annum. The lowest water content is characterized by the period of summer low (May-August), which in the middle and low water years' accounts for about 2% of annual discharge, and in very low water – only 1.3%. A relatively high share of summer runoff (17.7%) is observed in high-water years, mainly due to intensive stormwater discharge. The slight increase in the boundary discharge in the autumn is due to relatively frequent and low-intensity siege precipitation. The increase in the share of spring runoff is largely due to numerous reclamation channels, which provide more intensive drainage of meltwater from reclamation systems to water intakes. The increase in the intensity of groundwater discharge is especially characteristic of the last decades after the cessation of operation of a significant number of channels and the dismantling of gates of control structures. As a result, the drainage discharge is not delayed in the channels and flows freely and intensively into the water intakes.

The average annual volume of discharge from the catchment of DS "Maryanivka" in very low water years is 598 thousand m^3. Of this volume, only 7.8 thousand m^3 is accounted for in the summer months. In May, the discharge is 63 thousand m^3.

Reclaimed lands are characterized by high groundwater levels and waterlogging of certain areas in the spring, which makes it virtually impossible to retain floodwaters in reclamation channels. Accordingly, to ensure two-way water regulation in the reclamation system, it is necessary to accumulate as much as possible runoff in reclamation channels in May, as well as to preserve flood runoff by installing a system of out-of-river ponds in places where there is no threat of flooding.

Based on the above method of calculating the project consumption of crops, we have calculated the norms of water consumption for crops at the DS "Maryanivka" (Table 3), which will be grown in years with different water supply (very low water (P = 95%), low water (P = 75%) and average (P = 50%).

Table 3. Norms of water consumption for growing crops in years with different natural moisture at the DS "Maryanivka"

No.	Planned crop for cultivation	Area		Project norm of water consumption for humidification on 1 ha, m^3/ha	Norm of water needs for moistening on all area, m^3
		ha	%		
The year with a moisture content of 95% (very low water)					
1	Corn for grain	400	100	2125	850000
2	Winter wheat	400	100	1615	646000
The year with a moisture content of 75% (low water)					
1	Corn for grain	400	100	1700	680000
2	Winter wheat	400	100	1020	408000
The year with a moisture content of 50% (average)					
1	Corn for grain	400	100	1445	578000
2	Winter wheat	400	100	850	340000

We note that in recent years the territory of Ukraine is characterized by a low natural moisture supply (50–95%), so to maintain the design modes of humidification, the agrarians must attract and use water resources for very low water (dry) years.

To determine the water supply of land plots for growing crops, the total discharge from the territory was used according to hydrological calculations and the project water supply of the territory on the basis of water consumption norm calculation.

Characteristics of the water supply of reclaimed lands of DS "Maryanivka" by surface and underground sources is given in the Table 4.

4. Conclusions

Water runoff at the DS "Maryanivka" is characterized by a very large unevenness. In high-water and middle years, the period of spring floods accounts for about half of the annual runoff, and in low-water and very low-water years, spring runoff can exceed 80% of runoff per year.

In low-water years, the runoff in May is about 10% per annum, and in the next 4 months, it is only 2.5% in total in low-water years and 1.6% – in very low-water.

Table 4. Level of the water supply at the DS "Maryanivka"

No.	Characteristics	Level of water supply of the year (water content) P, %		
		50% (average year)	75% (low water year)	95% (very low water year)
Corn for grain				
1	Total discharge from the territory (according to hydrological calculations), million m^3	1.43	1.014	0.598
2	Project water consumption required for moistening of reclaimed lands with an area of 400.00 ha, million m^3	0.578	0.68	0.85
Winter wheat				
3	Total discharge from the territory (according to hydrological calculations), million m^3	1.43	1.014	0.598
4	Project water consumption required for moistening of reclaimed lands with an area of 400.00 ha, million m^3	0.34	0.408	0.646

Accordingly, in low-water years the water volume from the DS "Maryanivka" for the same 4 months is 39.1 thousand m^3, and in very low-water – only 14.7 thousand m^3.

It is established that the design norm of water consumption for moistening of winter wheat for an average year of moisture supply ($P_{50\%}$) makes 1445 m^3/ha, for the low-water year ($P_{75\%}$) – 1700 m^3/ha, for the very low-water year ($P_{95\%}$) – 2125 m^3/ha.

It is established that the design rate of water consumption for moistening corn for grain for the average year of moisture supply ($P_{50\%}$) is 850 m^3/ha, for the low water year ($P_{75\%}$) – 1020 m^3/ha, for the very low water year ($P_{95\%}$) – 1615 m^3/ha.

It is calculated that on the lands of the DS "Maryanivka" for growing winter wheat requires moistening supply of 0.34 million m^3 in terms of an average year of moisture supply ($P_{50\%}$) and 0.646 million m^3 in terms of the very low water year ($P_{95\%}$); for growing corn for grain, 0.578 million m^3 is needed in the conditions of the average year of moisture supply ($P_{50\%}$) and 0.85 million m^3 in the conditions of a very low water year ($P_{95\%}$).

Taking into account the value of the average annual discharge of the DS "Maryanivka" and the rate of water consumption of growing corn for grain in the average water years ($P_{50\%}$) is possible on an area of 989 ha, in low water years ($P_{75\%}$) – 596 ha, in very low water years ($P_{95\%}$) – 281 ha; Growing winter wheat in the average water years ($P_{50\%}$) is possible on an area of 1682 ha, in low-water years ($P_{75\%}$) – 994 ha, in very low-water years ($P_{95\%}$) – 370 ha.

Ensuring the reclamation within the DS "Maryanivka" and regulation of groundwater levels in the summer is possible only through the accumulation of runoff in May and partial accumulation of flood runoff by installing additional tanks in areas where there is no threat of flooding.

References

Alfonso L., Lobbrecht A., Price R. (2010) Optimization of water level monitoring network in polder systems using information theory, *Water Resources Research*, **46** (12), 1–13.

Basharin D., Polonsky A., Stankunavichus G. (2016) Projected precipitation and air temperature over Europe using a performance-based selection method of CMIP5 GCMs, *Journal of Water and Climate Change*, **7** (1), 103–113.

Datsko L. V. (2016) Modern agricultural use of lands of the humid zone of Ukraine, *Reclamation and Water Management*, **103**, 41–47.

Dolid M. A. (1990) Optimal length conducting network of polder systems of Polissya of Ukraine, [in:] *Hydromelioration and hydro technical construction*, Lviv, 17–27.

Korobiichuk I., Drevetsky V., Kuzmych L., Kovela I. (2020) The method of multy-criteria parametric optimization, *Advances in Intelligent Systems and Computing*, Volume 1140, Automation 2020: Towards Industry of the Future, 87–97, doi.org/10.1007/978-3-030-40971-5, Available at: https://link.springer.com/chapter/10.1007/978-3-030-40971-5_9.

Korobiichuk I., Kuzmych L., Kvasnikov V. (2019) The system of the assessment of a residual resource of complex technical structures, *MECHATRONICS 2019: Recent Advances Towards Industry 4.0*, 350–357, https://doi.org/10.1007/978-3-030-29993-4_43.

Korobiichuk I., Kuzmych L., Kvasnikov V., Nowak P. (2017) The use of remote ground sensing data for assessment of environmental and crop conditions of the reclaimed land, *Advances in Intelligent Systems and Computing (AISC)*, **550**, ICA 2017: Automation 2017, 418–424, DOI: 10.1007/978-3-319-54042-9_39.

Kuzmych L., Voropay G., Moleshcha N., Babitska O. (2021) Improving water supply capacity of drainage systems at humid areas in the changing climate, . *Archives of Hydro-Engineering and Environmental Mechanics*, **68** (1), 29–40.

Rokochinskiy A., Korobiichuk I., Kuzmych L., Volk P., Kuzmych A. (2020) The system optimization of technical, technological and construction parameters of polder systems, *Advances in Intelligent Systems and Computing*, **1140**, Automation 2020: Towards Industry of the Future, 78–86, doi.org/10.1007/978-3-030-40971-5, Available at: https://link.springer.com/chapter/10.1007/978-3-030-40971-5_8.

Romashchenko M. I., Saidak R. V., Matiash T. V., Knysh V. V. (2019) Influence of climatic changes on moisture supply of the territory of Ukraine and production of agricultural products, *"Water for All": dedicated to World Water Day: International. scientific-practical Conference: thesis add.*, Kyiv, 179–180.

Schultz B. (2008) Water management and flood protection of the polders in the Netherlands under the impact of climate change and man-induced changes in land use, *Journal of Water and Land Development*, **12**, 71–94.

Shang S. H. (2014) A general multi-objective programming model for minimum ecological flow or water level of inland water bodies, *Journal of Arid Land*, **7** (2), 166–176.

Su X., Chiang P., Pan S., Chen G., Tao Y., Wu G., Wang F., Cao W. (2019) Systematic approach to evaluating environmental and ecological technologies for wastewater treatment, *Chemosphere*, **218**, 778–792.

Van Overloop P. J. (2006) Drainage control in water management of polders in the Netherlands, *Irrigation and Drainage Systems*, **20** (1), 99–109.

Water Framework Directive 2000/60/EC (2000) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32000L0060.

Water Framework Directive review by the European Commission (2012) http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0670&from=EN.