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PROSPECTS AND PROBLEMS OF USING LOCAL WATER RESOURCES FOR IRRIGATION IN THE BASINS OF SMALL RIVERS OF THE FOREST-STEPPE OF UKRAINE

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Abstract. *On the example of a separate agricultural farm located in the basin of the small Manzhelia River within the Left Bank Forest Steppe, the approaches to the selection of potential sources of irrigation and the specifics of determining the volumes of local water resources intended to be used for irrigation, as well as the areas of possible irrigation in the absence of existing irrigation systems, are given. The results of the research indicate that the prospects for the development of land irrigation on farmland can be mainly provided subject to the combined use of surface runoff accumulated in ponds on the Manzhelia River and groundwater admissible for extraction, taking into account their quality. It was determined that influenced by a complex of anthropogenic factors, the river runoff sharply decreased compared to natural conditions, and the feeding of river course ponds during the entire low water period occurs only due to lateral inflow. Based on calculations it was determined that in average and low-water years, the volumes of surface and ground inflow to the cascade of ponds for the period from June to September are smaller than evaporation losses. Under such conditions, the use of the river runoff for irrigation is possible only due to the accumulation of flood and, partially, high water runoff. The calculations of flood runoff volume for March – April at the gate of the lower pond indicate the impossibility of using water from it for irrigation in very low-water years, as well as the dependence of runoff use for irrigation in low-water years on the pre-flood filling level of the ponds. It was determined that up to 0.8 million m^3 of water can be used for irrigation in medium-water years, and up to 1.4 million m^3 in high-water years, which will provide irrigation on an area of 400 and 700 hectares, respectively (having an irrigation rate of 2000 m^3/ha). The possibility of installing at least 40 water intake wells within the territory of the farm with a total flow rate of 20–24 thousand m^3/day and a total water intake during the irrigation period of about 1.5 million m^3 has been substantiated. This will make it possible to irrigate 750 hectares of land having an irrigation rate of 2000 m^3/ha, and at least 1000 hectares having an irrigation rate of 1500 m^3/ha. It is focused on the mandatory preliminary investigation of water quality for irrigation, which for many small rivers and aquifers is a limiting factor when using local water resources for the construction of irrigation systems.*

Keywords**:** *water resources, climate change, irrigation, groundwater, river runoff, river course ponds, water quality*

Formulation of the problem. Climate change, primarily the progressive increase in its aridity in all natural and climatic zones of Ukraine, significantly worsens the conditions of the natural water supply for crop production. It increases the need for irrigation on an increasing number of land plots [1–3]. The need to restore and increase the areas of actual irrigation is emphasized in the "Irrigation and Drainage Strategy in Ukraine for the period until 2030" [4].

At the same time, climatic transformations have a significant negative impact on the provision of the territories with water resources, which manifested in the reduction of the water content of rivers and reservoirs, their shallowing, lowering of the groundwater level, deterioration of water quality, etc. [5–7]. This makes it difficult to choose reliable sources of irrigation, especially in the basins of small rivers, due to the significant distance of potential irrigation areas from large reservoirs and irrigation canals.

Such a situation is now particularly typical for the territory of the forest-steppe zone of Ukraine. A significant increase in the average annual air temperature was recorded within its area, which exceeded the climatic norm (1961–1990) by almost 3.0°C in 2019 (one of the warmest years), and there was almost unchanged insignificant amount of precipitation. Thus, in 2019, its annual amount in the zone was 73 % of the norm on average, and in some regions, it did not exceed 50 % of the rate. Therefore, in recent years, in the forest-steppe zone, there has been a tendency both to restore irrigation of land on existing irrigation systems and to apply irrigation in new areas, primarily in Vinnytsia, Cherkasy, and Poltava regions, using different methods and sources of irrigation. In addition, the choice of the latter is a rather urgent problem from the point of view of providing the necessary water volumes of appropriate quality from them, especially in the context of the impact of climatic transformations on water resources.

The features of choosing potential sources of irrigation, determining the volume of local water resources that can be used for irrigation, as well as the area of possible irrigation under transformed climatic conditions in the forest-steppe zone were considered on the example of LLC "Promin-Lan", a separate agricultural farm located in the basin of the small Manzhelia River within Kremenchuk (until 2020 – Globynsk) district of Poltava region.

Analysis of recent research and publications. Some scientific works [1; 2; 5–16] were devoted to certain aspects of climate change and the resulting decrease in water resources available for use, which negatively affects the natural water supply of soils in various physical and geographical zones of Ukraine. Ukrainian climatologists observe the gradual "migration" of climatic zones to the north (on average by 100 km when average annual air temperature increases by 1°C) [9; 10]. A significant increase in air temperature and the frequency of abnormally high temperatures in the summer months led to a sharp increase in evaporation from the land and water surface, which, having a relatively stable amount of precipitation, negatively affected the water balance of river catchments. The decrease in river runoff and the shallowing of water bodies has become a characteristic phenomenon for almost all plain regions of Ukraine [13–16]. For example, the runoff coefficient (the ratio of the runoff layer to precipitation) of the Irpin River for the period from 2015 to 2019 decreased by 1.7 times compared to the period before 2010 [17].

The shallowing of surface water bodies and the depletion of groundwater, the reduction of fresh water available for use is recognized by the recently adopted Water Strategy of Ukraine for the period until 2025 [18] as one of the main problems in the area of water use, protection, and restoration.

The issue of using the flow of small rivers to ensure the development of irrigation in their basins, taking into account the transformation of climatic conditions, the current ecological state of water bodies, their water (hydrological and hydrochemical) regime, etc., is currently poorly researched, and the available publications mainly relate to determination and evaluation of the changes in some of these indicators or characteristics, rather than the actual water resource potential of small rivers and underground waters. The implementation of the procedure for assessing the impact on the environment of planned activities related to the design and construction of irrigation systems, following the Law of Ukraine "On Environmental Impact Assessment" [19] became a certain stimulus for researching determining the latter and possible volumes of its use for irrigation.

It should be noted that in Ukraine at the end of the 20th century and the beginning of the current century, there were more than 63.000 small rivers (about a third was in the forest-steppe zone), 93 % of which had a length of less than 10.0 km with the prevailing catchment areas from 200 up to 500 km^2 [20; 21]. Significant transformations of the water regime in catchment areas caused by climate change and economic activity have caused a significant deterioration in the ecological condition of small rivers. Regulation of their runoff as a result of the construction of numerous ponds and reservoirs led to a sharp decrease in river runoff, degradation of rivers, and sometimes to their complete disappearance [14–16; 22–26].

In this regard, the use of runoff from small and medium-sized rivers for irrigation nowadays requires the study of both conditions of surface runoff formation and its quantitative and qualitative assessment as well as its intra-annual distribution. The same applies to groundwater.

The purpose of the research is to quantitatively assess local water resources and determine the prospects for the development of irrigation with surface and underground water at the LLC "Promin-Lan" farm of the Kremenchuk district in the Poltava region.

Research materials and methods. Today, the farm cultivates about 1.7 thousand hectares of leased land, scattered on both sides of the Manzhelia River near the village of Vesela Dolyna. The Manzhelia River is a right tributary of the Psel River and belongs to the Middle Dnieper sub-basin of the Dnieper River basin area. The length of the river is now 23 km, and the catchment area is 117 km^2. The river bed is winding, 0.5–3.0 m wide, on average 2 m. The river is fed through snow, rain, and soil. Surface rain and melt inflow come mainly through numerous ravines and gullies, as well as small streams, which mostly dry up in the low water periods. The Manzhelia River is an anthropogenically altered water body due to its significant regulation with ponds (11 ponds). A cascade of four ponds has been arranged on the river flowing through the farmlands. As of the end of 2019, only one pond from the four ones was filled with water – № 4 (Fig. 1).

In terms of hydrogeology, the area of the land plots of Promin-Lan LLC belongs to the Dnieper-Donetsk artesian basin, in particular the Dnieper artesian basin of the II order with the spread of some aquifers and complexes in the Neopleistocene, Pliocene, Kharkiv, and Kaniv-Buchatsk deposits within the zone of active water exchange.

Research on determining potential sources of irrigation, volumes of surface and underground water that can be used for irrigation farm plots, as well as the areas of possible irrigation included determining the runoff of the Manzhelia River, assessing the impact of anthropogenic factors on the state of water bodies, the presence of groundwater for irrigation and the quality of surface and underground waters regarding their suitability for irrigation, establishing modern morphometric and bathymetric parameters of artificial reservoirs in the river course, determining the expediency and possibility of cleaning the riverbed, silted and overgrown reservoirs to increase the river runoff.

Methodologically, the research was based on field surveys of water bodies and their adjacent territory, system and cartographic data analysis, Earth remote sensing materials, and hydrological calculations. Assessment of water quality for irrigation according to agronomic criteria was carried out by the provisions of DSTU2730:2015 [27].

Research results and their discussion. The performed hydrological calculations show that the natural runoff of the Manzhelia River is characterized by significant unevenness of its distribution throughout the year. The spring period accounts for more than 70% of the annual runoff, while in the summer months, it is less than 5%. It was determined, that under the influence of a complex of anthropogenic factors, the river

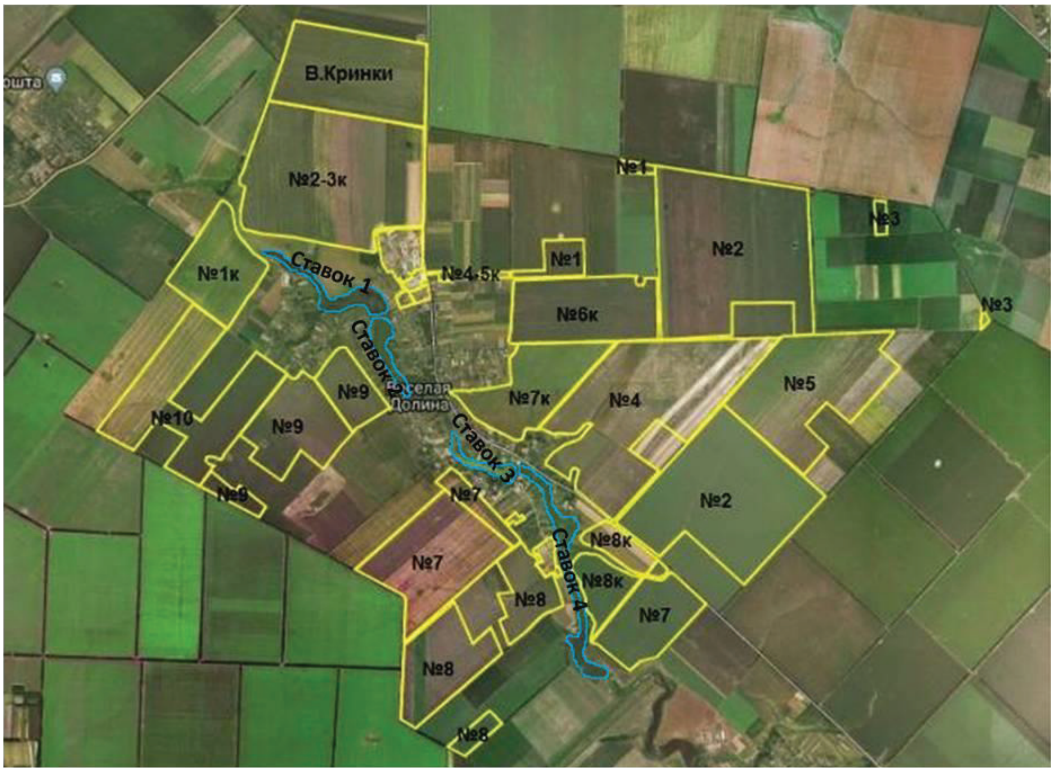

Fig. 1. Scheme of field location within the land plots used by Promin-Lan LLC and ponds on the Manzhelia River near the village of Vesela Dolyna of the Kremenchuk district in the Poltava region

runoff decreased sharply compared to natural conditions, and the constructed artificial river course ponds turned into closed reservoirs, the feeding of which during the entire low water period occurs only due to lateral inflow, that is, from the local part of the catchment directly adjacent to them. Inflow from the upper reaches of the catchment occurs only during floods and heavy rain floods. Selective in-situ measurements in the beds of the ponds proved that the latter are silted up on average up to 30–40 cm in the central part and up to 50–70 cm in the near-dam areas. There are no bottom drains in the ponds, so they are not washed. Due to significant siltation and frequent drying out of reservoirs, the main sources of soil and pressure feeding are silted up and mudded.

The value of the natural average annual runoff, determined based on the regionalized map of the average long-term runoff module, built based on long-term observations at stationary hydrological stations, for each pond and side tributary, is given in Table 1.

The rates given in Table 1 show the average multi-year values of runoff, however, its volumes significantly differ both by year and in different months and seasons throughout the year. Thus, according to the observation data at the Myrhorod hydrological station in the basin of the Khorol River, on average for the long-term period since 1919, 58.9% of the runoff, i. e. more than half, arrives in March – April period. During the next six months of the growing season (from May to October inclusive), only 25.2% of the annual runoff arrives, and the part of the runoff for the last three months of the period is only 7.3%.

The possibility of using surface water from the cascade of ponds in the river course of the Manzhelia River largely depends on the water content of the year, the levels of pre-flood filling of the ponds, and the groundwater tables. The assessment of the intra-annual runoff distribution of the Manzhelia River was made based on zoned values (as a percentage of the annual) for the Vorsklo-Pselsky hydrological district [28]. Calculations were made for four ranges of river water content: high (P = 25%), medium (P = 50%), low (P=75%), and very low (P = 95%). The results of calculations for different cross-river points are shown in Fig. 2. It was determined that under the current anthropogenically changed conditions of runoff formation, the inflow of water to the dam site of the lower pond № 4for four months from June to September will be 45 thousand m^3 in a high-water year, in a medium-water it will be 31 thousand m^3, in a low-water year it will be 23 thousand m^3, and in an extremely low-water year, it will be 14 thousand m^3 (Table 2).

Table 2 shows the results of calculating the inflow to the ponds in the summer-autumn period, taking into account the annual distribution of the runoff of the Manzhelia River and the actual catchment areas of each of the ponds, testify that even in high-water years, the total lateral inflow during the warm period of the year to all four ponds in the village Vesela Dolyna will be only 192.000 m^3. In extremely low-water years, when the greatest need for irrigation arises, the total inflow into the ponds will be 115.000 m^3, in particular, for the entire summer period – only 26.000 m^3. The total area of the four ponds is about 50 hectares, and the total evaporation in the basin during the summer period is equal to 220 mm, accordingly, the evaporation from the surface of the ponds will be 110 thousand m^3, which is more than four times higher than the inflow to the ponds. A practically zero balance of summer inflow and evaporation will be observed only in high-water years.

In the case of restoration of the natural flow of the river as a result of clearing the riverbed and ponds from the source of the river to the dam site, the corresponding volumes of runoff for the period from June to September will increase to 211 thousand m^3 in a high-water year, to 149 thousand m^3 in a medium-water year, in low water-year – up to 106 thousand m^3 and in extremely low water-year – up to 66 thousand m^3.

1. Catchment areas and water inflow rates of the Manzhelia River before the specified cross river points

Pond №	Distance from the mouth of the Manzhelia River, km	Total catchment area, ha	Local catchment area, ha	Natural average annual runoff, m^3/s	Local (lateral) average annual runoff, m^3/s
Pond dam №0	22.7	2251	2251	0.038	
Pond dam №1	20.5	3376	1125	0.057	0.019
Pond dam №2	19.6	3626	250	0.062	0.004
Pond dam №3	18.3	4102	476	0.070	0.008
Pond crossing dam № 4	16.3	5218	1116	0.089	0.019
Pond dam №4	15.9	5600	382	0.095	0.006

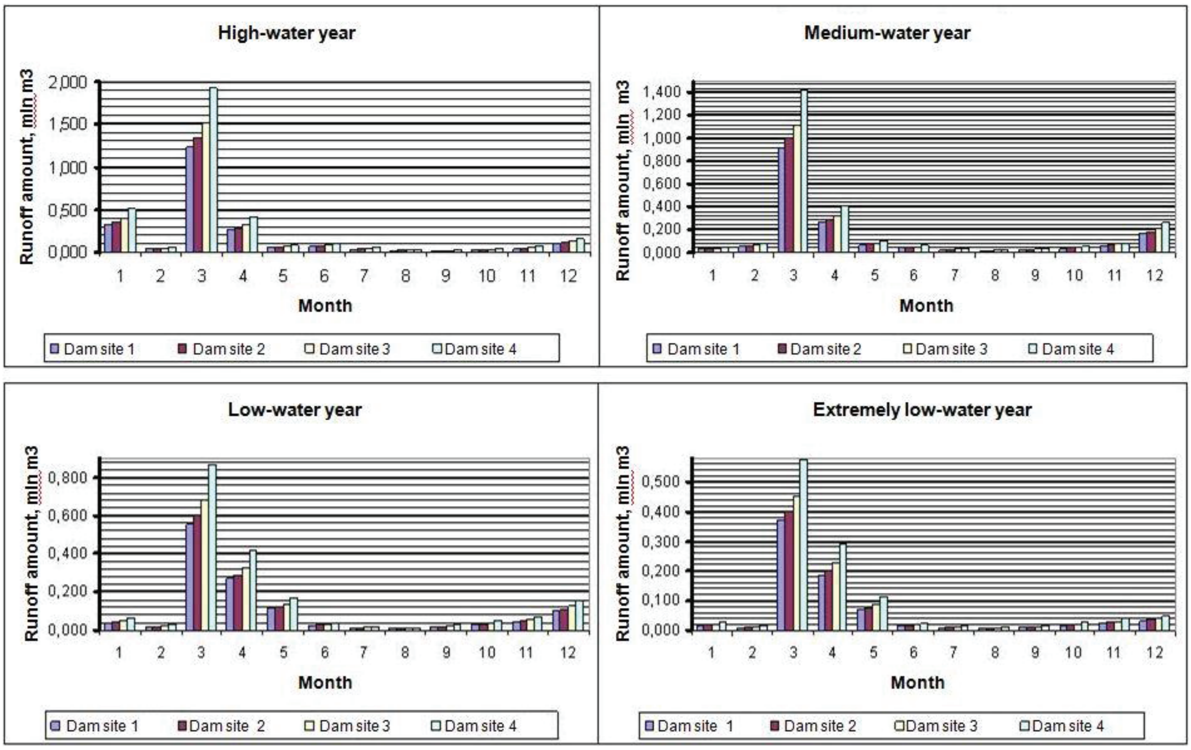

Fig. 2. Intra-annual distribution of the Manzhelia River runoff in the specified cross river points in different water content years, million m^3

2. Distribution of intra-annual inflow to river course ponds on the Manzhelia River for the period from May to November, million m^3

Month	May	June	July	August	September	October	Total amount
High-water year, P=25%							
Dam 1	0.019	0.022	0.011	0.007	0.005	0.009	0.073
Dam 2	0.004	0.005	0.002	0.001	0.001	0.002	0.015
Dam 3	0.008	0.009	0.005	0.003	0.002	0.004	0.031
Dam 4	0.019	0.022	0.011	0.007	0.005	0.009	0.073
In total							0.192
Medium-water year, P=50%							
Dam 1	0.022	0.013	0.007	0.004	0.007	0.012	0.065
Dam 2	0.005	0.003	0.002	0.001	0.002	0.003	0.016
Dam 3	0.009	0.005	0.003	0.002	0.003	0.005	0.027
Dam 4	0.022	0.013	0.007	0.004	0.007	0.012	0.065
In total							0.173
Low-water year, P=75%							
Dam 1	0.037	0.009	0.005	0.003	0.006	0.010	0.070
Dam 2	0.008	0.002	0.001	0001	0.001	0.002	0.015
Dam 3	0.015	0.004	0.002	0.001	0.003	0.004	0.029
Dam 4	0.037	0.009	0.005	0.003	0.006	0.010	0.070
In total							0.184
Extremely low-water year, P=95%							
Dam 1	0.024	0.005	0.003	0.002	0.004	0.006	0.044
Dam 2	0.005	0.001	0.001	0.000	0.001	0.001	0.009
Dam 3	0.010	0.002	0.001	0.001	0.002	0.002	0.018
Dam 4	0.024	0.005	0.003	0.002	0.004	0.006	0.044
In total							0.115

Since the greatest need for irrigation water occurs in low-water years, the clearing of silted riverbed and ponds for irrigation is not very effective, as it will provide an insignificant additional water inflow in low water (by 83 thousand m^3) and extremely low water (by 52 thousand m^3) years. At the same time, cleaning the ponds from silting will allow increasing both their useful volume and the lateral inflow of runoff due to the opening of pressure-feeding sources. Thus, clearing the pond № 4 of siltation up to 0.6 m will increase its useful volume by 108.000 m^3.

Calculations have determined that in medium and low-water years, the volumes of surface and soil inflow to the cascade of ponds near the village of Vesela Dolyna for the period from June to September are very small, and evaporation losses are smaller. Under such conditions, the use of river runoff for crop irrigation is possible only due to the accumulation of surface and, partially, flood runoff.

The performed calculations show that in extremely low-water years (P = 95%) the runoff volume for March – April at the cross point of pond № 4 is only 870 thousand m^3, which is commensurate with the total volume of the cascade of four ponds within the village (865 thousand m^3), and in low-water years (P = 75%), the flood runoff volume will be 1.284 million m^3, that is, the transit runoff outside the cascade will be only 419 thousand m^3. Accordingly, in very low-water years, the use of water for irrigation will be impossible due to the need to provide partial water transit to downstream ponds. In low-water years, the possibility of using runoff for irrigation will be determined by the pre-flood filling level of the ponds. The use of runoff for irrigation in the volume of up to 400.000 m^3 will be possible only when the pre-flood filling of the ponds is more than half. In case of pre-flood emptying of the ponds to dead volume levels, water withdrawal for irrigation will be impossible due to the need to provide sanitary spring discharges and fill the downstream ponds.

In medium-water (P = 50%) and high-water (P = 25%) years, the volume of the river runoff for March – April will be 1.84 million m^3 and 2.35 million m^3, respectively. Taking into account that the filling of ponds will be high in medium and high-water years, up to 0.8 million m^3 of water can be used for irrigation in medium-water years, and up to 1.48 million m^3 – in high-water years, which will allow providing irrigation on an area of 400 and 700 hectares respectively, having an irrigation rate of 2000 m^3/ha).

Therefore, the calculations of the volume of flood runoff for March – April at the cross point of the lower pond indicate the impossibility of using water from it for irrigation in extremely low-water years, as well as show the dependence of the use of runoff for irrigation in low-water years on the pre-flood filling level of the ponds.

In low-water periods, the groundwater tables in the Manzhelia River basin in the summer-autumn period are below the usual banked-up water level of ponds. Thus, in the autumn of 2019, the recorded groundwater table in the area of the pond between the villages of Stepove and Vesela Dolyna was on average 2.0 m below the bottom of the pond, therefore, in cases of a significant decrease in groundwater tables, significant water losses may occur in the ponds due to intensive filtration on replenishment of groundwater.

To use the accumulated volumes of runoff in the summer months, it is necessary to develop filling ponds, which should be filled during the flood period. Filtration losses and, accordingly, the intensity of the decrease of pond levels in the post-flood period depend on the groundwater table in the adjacent territory, which must be taken into account when planning water intake for irrigation.

The main technical measures to increase the water content of the Manzhelia River include the following:

– clearing and deepening to the base level of the riverbed in the upper reaches of the Manzhelia River;

– restoring the riverbed of the Manzhelia River between the Stepove and Vesela Dolyna villages with the construction of a tubular crossing in its river course;

– clearing and deepening to the base level of the southern part of river course pond № 1 (1/3 of the length and area) within the village of Vesela Dolyna in the middle course of the Manzhelia River, which will provide a decrease in the area of evaporation from the water surface while preserving its useful volume;

– clearing and deepening the pond № 3 within the village of Vesela Dolyna;

– restoring to service water culverts and discharge structures on ponds and in the Manzhelia river course within the villages of Syrenky and Stepove;

– restoring to service the culverts of ponds № 1, 2, 3, and 4 within the village of Vesela Dolyna in the middle course of the Manzhelia River.

Prospects for irrigation development on farmland in general can be based on the use of both surface and underground water. The availability of underground water and the possibility of its use for irrigation are determined, first of all, by the hydrogeological conditions of the territory and the suitability of water for irrigation in terms of its quality.

The analysis of the general hydrogeological conditions and filtration parameters of the main aquifers proves the possibility of using groundwater mainly from Lower Neopleistocene alluvial deposits, primarily on the right bank of the river and north of the settlement, i. e. within the distribution of this aquifer for irrigation of the land cultivated by Promin-Lan LLC near the village Vesela Dolyna. It is also possible to have a compatible water intake from Buchach sediments. Within the fields located to the east of the village (№ 2, 4, 5) and related to the V terrace, it is advisable to consider the prospects of using the water of the Pliocene alluvial horizon.

Taking into account water supply and water quality, the main potential source of irrigation with groundwater on the "Promin-Lan" farm can be an aquifer in the Lower Neopleistocene alluvial deposits, which lies at a depth of 30–40 m with an average capacity of 10 m. Its productivity allows local water intakes from the wells with a discharge rate of from 300 to 600 m^3/day (approximately at a distance of 300 m from each other) in the form of linear rows or concentrated points around the places of accumulation of produced water. Within individual fields with an area of 150–200 hectares, it is possible to arrange water intakes from 12–15 wells with a total discharge from 3.6–4.5 to 7.0–9.0 thousand m^3/day.

The use of groundwater for irrigation on the land of "Promin-Lan" LLC is possible provided that it is previously accumulated in storage tanks, the volumes of which are determined during irrigation design. It is advisable to arrange storage reservoirs near the places of groundwater extraction and the location of potential irrigation areas. As preliminary options, it is proposed to construct such reservoirs in the territory of dairy farms № 1 and № 2, as well as in the area of the natural decline in the western part of the village behind the garden near the field № 9. As of 2022 a groundwater storage reservoir and four water intake wells were built near farm № 2 (near the pond № 4).

Based on the water supply capacity of aquifers, territorial possibilities, and minimization of the general spatial decrease of groundwater tables due to water intake for irrigation, within the area of the farm, at least 40 water intake wells with a total discharge rate of 20–24 thousand m^3/day and a total water withdrawal during the irrigation period of about 1.5 million m^3 can be arranged. That will make it possible to irrigate 750 hectares of land with an irrigation rate of 2000 m^3/ha, and at least 1000 hectares can be irrigated with an irrigation rate of 1500 m^3/ha.

Based on the results of selective hydrochemical studies, it was determined that the limiting factor for the use of both surface and underground water for irrigation in certain areas may be its low quality due to alkalization (II class – limitedly suitable) and soil salinization (III class – unsuitable) according to DSTU2730:2015 [27], which requires additional assessment of water quality and implementation of water and irrigated land reclamation measures.

Conclusions. The increase in the aridity of the climate in the forest-steppe zone of Ukraine leads to a growing need for irrigation, as the most effective means of minimizing the negative impact of climate change on the sustainability and efficiency of agriculture in this region.

The main limiting factors for the expansion of irrigation areas in the forest-steppe zone are the relatively low natural supply of local water resources in the basins of small rivers, the limited suitability of surface and underground water for irrigation due to soil alkalization and salinization, toxic effects on plants, as well as (primarily for drip irrigation systems) due to high iron content. In the basins of many small rivers, there is a high probability of a situation when small amounts of local water resources or their low quality will limit the areas of possible irrigation, up to the emergence of competition for water and conflict situations, especially in low-water periods.

The decision on the possibility, prospects, and scope of irrigation application in the basins of small rivers of Ukraine should be based on the results of a comprehensive assessment of the possible accumulated volumes of river runoff in artificial reservoirs and the amount of groundwater permissible for withdrawal, taking into account their quality. Therefore, priority should be given to the construction of drip irrigation systems in the areas located near water sources, such as ponds or suitable places for water storage reservoirs, primarily underground.

According to expert assessments, the available local water resources are sufficient to provide irrigation for 10–20 % (1.3–2.6 million hectares) of arable land in the Forest-Steppe zone.

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ПЕРСПЕКТИВИ ТА ПРОБЛЕМИ ВИКОРИСТАННЯ МІСЦЕВИХ ВОДНИХ РЕСУРСІВ ДЛЯ ЗРОШЕННЯ В БАСЕЙНАХ МАЛИХ РІЧОК ЛІСОСТЕПУ УКРАЇНИ

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Анотація. *На прикладі окремого агрогосподарства, розташованого в басейні малої річки Манжелія в межах Лівобережного Лісостепу, наведено підходи до вибору потенційних джерел зрошення та особливості визначення обсягів місцевих водних ресурсів, які можуть бути використані для поливу, а також площ можливого зрошення за відсутності існуючих зрошувальних систем. Результати досліджень свідчать, що перспективи розвитку зрошення земель у господарстві можуть бути пов'язані переважно з сумісним використанням накопиченого в ставках на річці Манжелія поверхневого стоку та допустимих для вилучення підземних вод з урахуванням їхньої якості. Визначено, що під впливом комплексу антропогенних чинників стік річки різко зменшився порівняно з природними умовами, а живлення руслових ставків упродовж усього меженного періоду відбувається лише за рахунок бокового притоку. Розрахунками визначено, що в середні за водністю і маловодні роки об'єми поверхневого і ґрунтового притоку до каскаду ставків за період із червня по вересень є меншими ніж втрати на випарування. За таких умов використання стоку річки для зрошення можливе лише за рахунок акумуляції повеневого і, частково, паводкового стоку. Розрахунки об'єму повеневого стоку за березень – квітень у створі нижнього ставу свідчать про неможливість використання води з нього для зрошення у дуже маловодні роки, а також залежність використання стоку для зрошення у маловодні роки від рівня передповеневого наповнення ставків. Визначено, що у середньоводні роки для зрошення можна буде використати до 0,8 млн м^3, а в багатоводні до 1,4 млн м^3 води, що дозволить забезпечити зрошення на площі 400 га і 700 га відповідно (при нормі зрошення 2000 м^3 /га). Обґрунтовано можливість влаштування у межах території розташування господарства не менше 40 водозабірних свердловин із сумарним дебітом 20–24 тис. м^3/добу та загальним водовідбором протягом зрошувального періоду близько 1,5 млн м^3. Це дозволить за норми зрошення 2000 м^3/га поливати 750 га земель, а за норми зрошення 1500 м^3/га – не менше 1000 га. Акцентовано на обов'язковому попередньому дослідженні якості води для зрошення, яка для багатьох малих річок та водоносних горизонтів є лімітуючим чинником використання місцевих водних ресурсів для влаштування зрошувальних систем.*

Ключові слова: *водні ресурси, зміни клімату, зрошення, підземні води, річковий стік, руслові ставки, якість води*