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FOREST RECLAMATION AS A TOOL FOR CLIMATE ADAPTATION OF AGRICULTURAL LANDSCAPES

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Abstract. *Against the backdrop of intensifying climate challenges and the degradation of agricultural landscapes in Ukraine, agroforestry and land reclamation measures are coming to the forefront as important tools for adapting to and mitigating the effects of climate change. This article justifies the relevance of developing a network of field-protective forest strips and agroforestry programs within the agricultural sector. It presents an analysis of the latest research in the field of agroforestry, which demonstrates that protective plantings increase soil resilience and boost crop yields. The aim of the study is a comprehensive assessment of the functioning of the system of protective forest strips in part of the territory of the Kurisovska Territorial Community in Odesa Oblast as an example of* *agroforestry adaptation. Mapping materials, statistical data on crop yields, and costs associated with establishing forest belts were used. The results showed that the existing area of field-protection plantings in the study area (total area of 3,991.77 ha, of which 3,888.68 ha is arable land) provides protection for approximately 2,220.44 ha of arable land, while unprotected land accounts for 42.90 %. The economic impact of creating new field buffer strips covering an area of 43.88 hectares (48.76 km) has been calculated: the total capital costs of the project amount to 5.158 million UAH, and the additional annual grain yield increases by 4 q/ha (for winter wheat by 4–5 q/ha) compared to unprotected plots. Taking into account the discount rate, the real value of future cash flows (revenues) and total costs (operating and capital) in the model area was determined, which over 50 years amounted to 124.51 million UAH and 18.78 million UAH, respectively. Over the 50-year period, the project's net profit amounted to 105.72 million UAH (an average of nearly 27.50 thousand UAH/ha), indicating long-term economic viability under the established conditions. Based on an analysis of the data obtained, conclusions were drawn regarding the need to strengthen agroforestry and land reclamation policies to enhance the effectiveness of climate adaptation in the agricultural sector.*

Keywords: *shelterbelts, agroforestry reclamation, climate adaptation, biodiversity conservation, economic efficiency.*

Problem statement. In the current context of intensifying climate challenges and increasing human pressure on natural ecosystems, the issue of effective adaptation to climate change has become a priority for the scientific community and government institutions. Climate change now requires society to adopt more flexible and integrated approaches to the use of natural resources, particularly land. According to the latest research by the Intergovernmental Panel on Climate Change (IPCC), rising average annual temperatures and changes in precipitation patterns may, in the near future, lead to irreversible transformations of agroecosystems, particularly in arid regions.

Many years of experience in agricultural production show that the use of agronomic measures alone, even the most advanced ones, does not ensure the stability of agricultural landscapes. This underlines the need to seek alternative land-use strategies, among which the implementation of afforestation measures plays a significant role. Against a backdrop of increased likelihood of droughts, declining soil moisture and the degradation of arable land, afforestation emerges as a promising tool for adapting to climate change, which simultaneously promotes decarbonisation and enhances the resilience of agroecosystems.

Analysis of recent research and publications. Among the key sources on agroforestry, monographs and textbooks stand out [1, 11], which describe in detail the methods for establishing protective forest strips and their impact on agroecosystems. In particular, [1] sets out guidelines for the location and composition of field protection strips depending on the region's topography and soils. Also noteworthy are the dissertation studies [4, 5], which analyze the structure and effectiveness of existing buffer strips in the Forest-Steppe region of Ukraine and propose optimal planting designs for agricultural landscapes.

Another important topic is the assessment of the economic efficiency of agroforestry and land reclamation measures. For example, in [6] and [7], methodologies for determining the payback period of protective plantings through additional crop yields are substantiated. The analysis carried out shows that even when the costs of establishing the strips (planting material, maintenance) are taken into account, the net economic benefit from their operation becomes noticeable as early as the first few years (usually after 10–15 years).

At the same time, despite a significant number of theoretical studies, an analysis of recent research and publications indicates the absence of a unified approach to the impact of field protection strips on crop productivity, particularly in the southern regions of Ukraine. Thus, existing studies lay the groundwork for further practical work in this area, and there is a pressing need for applied research in this field.

The purpose of this study is to evaluate the effectiveness of the system of field-protection forest strips in part of the Kurisovska territorial community (Berezivsky District, Odesa Oblast) and to determine their impact on agricultural productivity.

Materials and Methods. The study focused on a portion of the Kurisovska rural territorial community, which is located in the Southern Steppe of Ukraine and has corresponding soil and climatic conditions. The study area covers 3,991.77 hectares (3,888.68 hectares of arable land). The relief is predominantly plateau-like, and the soils consist of low-humus meadow soils and saline chernozems.

To study the distribution of land use, a cartographic analysis was carried out using GIS software and data from the State Land Cadastre. A diagram showing the location of the study area's land blocks (Fig. 1) was drawn up, along with a separate diagram showing the location of existing forest strips within these blocks. The analysis of field indicators utilised the results of observations on plots with and without forest strips. Crop yields were determined based on data from the State Statistics Service of Ukraine [8, 10].

To assess the economic efficiency of establishing (or restoring) field protection strips, the classical method of evaluating the net present value of investment projects was applied. The costs of establishing plantations include the cost of planting material, planting work and maintenance. Revenues were calculated based on the additional grain yield resulting from the establishment of the forest strips.

Research results and discussion. In Ukraine today, forest reclamation, as one of the key forms of the rational use and restoration of natural resources, plays an extremely important role in ensuring the environmental sustainability of agricultural landscapes. The establishment and maintenance of protective forest plantations not only help to reduce the negative anthropogenic impact on the environment, but also increase the productivity of agricultural land use.

The system of forest-land reclamation plantations plays a significant ecological and economic role in shaping the agricultural landscape, and its contribution is particularly noticeable during droughts and dry winds. Field-protective forest plantations alter the structure and speed of wind flows, preventing the development of wind erosion, which is particularly relevant in the open steppe and forest-steppe regions of Ukraine. The average wind speed in the forest-steppe zone ranges from 3.1 to 3.4 m/s, whilst in the south-eastern Steppe it reaches 4.1 m/s. Thus, within the zone of effective influence of forest strips (0–25(30) H), a 30–50 per cent reduction in wind speed and a 15–20 per cent decrease in the intensity of turbulent exchange are observed [1]. Furthermore, by retaining surface runoff, afforestation significantly reduces the intensity of water erosion, whilst preserving soil structure and optimising its aeration and water regime.

Regardless of their design, field-protecting forest strips promote snow accumulation and the even distribution of snow cover across fields, which reduces the intensity of soil freezing and optimises the rate at which the soil thaws. It has been shown that in fields protected by forest strips, air humidity increases by 3–5 per cent, whilst individual forest strips reduce non-productive evaporation of soil moisture by 12–22 per cent, and interacting systems of strips by 25–35 per cent [1, 3].

Field-protecting forest strips, whilst occupying a negligible area within the agricultural landscape, are an effective, long-term and environmentally safe means of biological soil improvement. They preserve and enhance soil fertility by increasing the content of humus and essential mineral nutrients (nitrogen, phosphorus, potassium), whilst optimising its structure and properties.

The scientifically sound establishment of agroforestry systems will help increase crop yields by an average of 15–20 percent, depending on the design features of the forest strips and the climatic conditions of the area. Furthermore, provided that the effects of the forest strips overlap, the coefficient of photosynthetically active radiation utilisation by cereal crops increases by 10–90 per cent, and grain yields may increase by 1.5–2 times compared with open fields [1].

In light of the above, it is worth noting that, in order to ensure the environmental sustainability of agricultural landscapes and to enhance the productivity of agricultural land use in the context of climate change, it is now of paramount importance to both systematically maintain existing field-protection forest strips and establish new ones. According to various estimates by researchers [5], in order to achieve a comprehensive agroforestry and land reclamation effect on agricultural land, it is advisable to increase the area designated for field-protection forest strips by 2 to 3 times (to approximately 800,000 hectares), depending on the specific climatic conditions in Ukraine.

To test the hypothesis regarding the advisability of expanding the area of field-protection forest plantations, we conducted a study of the ecological and economic effectiveness of their practical implementation using a specific case study. A section of the territory of the Kurisivska community in the Berezivskyi district of the Odesa region, which is typical of steppe conditions, was selected as the model site. The use of this site provides an opportunity for further assessment of the ecological and economic effectiveness of implementing field-protection forest plantations in other similar areas within this natural and climatic zone.

The study area is characterised by a temperate continental climate with subtropical features. According to data from the ‘Serba’ weather station, the average annual rainfall is 460 mm, of which 272 mm falls during the growing season (April–September), whilst the average annual temperature during this period is +18.4°C.

Agricultural production takes place on arable land with a total area of 3,888.68 hectares, most of which is leased. The total number of land parcels (shares) is 380. Field tracks cover an area of 29.32 ha. Furthermore, in accordance with the land-sharing scheme, provision has been made to increase the area of field tracks by 6.51 ha in order to ensure access to each land parcel.

The system of protective forest plantations within the Kurisivska community consists mainly of field-protection forest strips, supplemented by a smaller number of ravine-side, ravine-and-valley, and water-conservation plantations. The total area of field-protection forest plantations is 78.47 ha.

Within each land block, the area of agricultural land (arable land) protected by the PLN has been determined, making it possible to establish the total protected area within the study area as 2,220.44 ha. At the same time, unprotected land accounts for 42.64% of the study area, with land parcels No. 3 and No. 4 characterised by the highest percentages of unprotected land – 62.67% and 47.56% respectively (see

Fig. 2).

Fig. 1. Map showing the layout of land parcels within part of the Kurisivska community in the Berezivskyi district of the Odesa region

Using the results of recent studies [7, 8], the specialized software Digitals XE build 31.03.2026, and, taking into account natural and climatic conditions (prevailing wind directions, terrain, etc.), as well as the characteristics of tree and shrub species, buffer zones of effective influence of field-protective forest plantations were determined (0–10 H / up to 250 m; 10–20 H / 250–500 m) on agricultural land within the Kurisov community. Based on this, a model of the impact of field-protective forest plantations on agricultural land (arable land) within the Kurisov community has been developed (Fig. 2).

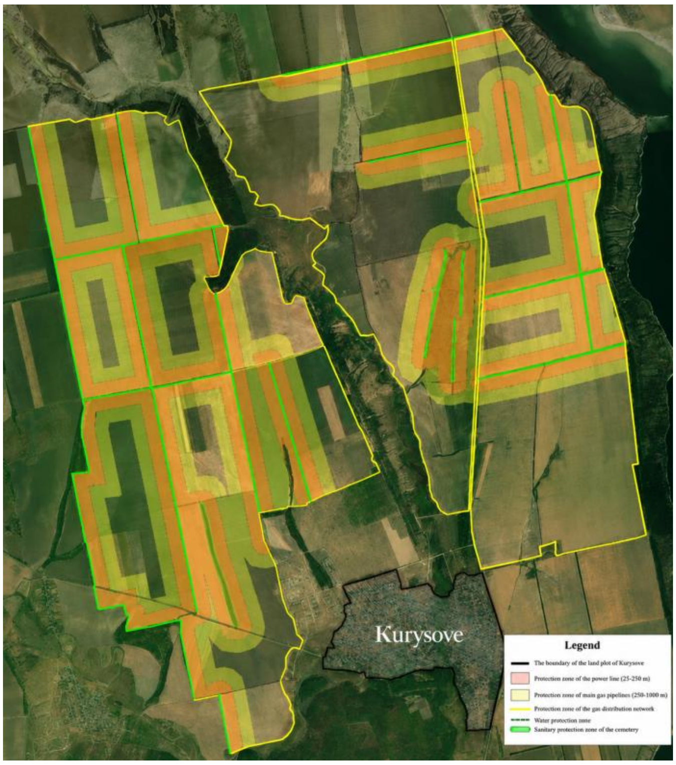

Fig. 2. Model of the impact of existing field-protection forest plantations on agricultural land (arable land) in the Kurisovska community in the Odesa region

Although the zone of effective influence of the PLN on adjacent land was determined on the assumption of a satisfactory agroforestry and land reclamation condition of the forest strips, a detailed analysis of their condition indicates that, in some cases, significant negative changes are observed. In particular, remote sensing techniques have revealed the formation of gaps, a reduction in the planned width, the loss of key tree species, the ageing of stands, insufficient natural regeneration, as well as damage caused by pests and diseases and unauthorised felling. Together, these factors lead to a deterioration in the protective function of forest belts and a reduction in their ecological resilience.

In light of the above, and with the aim of improving the microclimate of the fields and protecting crops from the adverse effects of natural and climatic factors, we have developed a project to establish additional field-protection forest plantations on all model land parcels, covering a total area of 43.88 ha (Table 1). We have designed field protection strips with a total length of 48.76 km, taking into account the directions of prevailing winds, the terrain, the soil cover of the study area, the multi-layered structure of the plantations, the use of drought-resistant tree and shrub species, and so on (Fig. 3).

Table 1.

Land area of part of the Kurisovska community, hectares

No.	Type of land	Land block				Total
		№ 1	№ 2	№ 3	№ 4	
1	Arable land (land shares (parcels))	801,51	1040,58	952,46	1050,25	3844,80
2	Field-protection forest strips (existing)	10,86	24,37	26,13	17,11	78,47
3	Field-protection forest strips (planned)	5,95	15,06	11,06	11,81	43,88
4	Field roads (existing)	7,96	6,77	7,06	7,53	29,32
5	Field roads (planned in accordance with land parcelling)	1,57	1,99	1,40	1,55	6,51
Total area of the land parcel		**826,53**	**1087,03**	**995,33**	**1082,88**	**3991,77**

Taking into account the natural and climatic characteristics of the Kurisovska community, which is situated within the Southern Steppe, we have opted for a combined planting scheme for field-protection forest strips, utilising a selection of drought-tolerant tree and shrub species. This scheme is characterised by an openwork structure and involves the creation of a three-row forest strip, where the first and third rows consist of Tatar maple (Acer tataricum L.) in combination with golden currant (Ribes aureum Pursh.), and the second row consists of common oak (Quercus robur L.). Planting is carried out with an inter-row spacing of 3.0 m × 1.5 m within each row, resulting in a total strip width, including one inter-row, of 9.0 m. The recommended number of planting units per kilometre of the strip is 742 seedlings for common oak, 742 seedlings for Tatarian maple and 742 seedlings for golden currant.

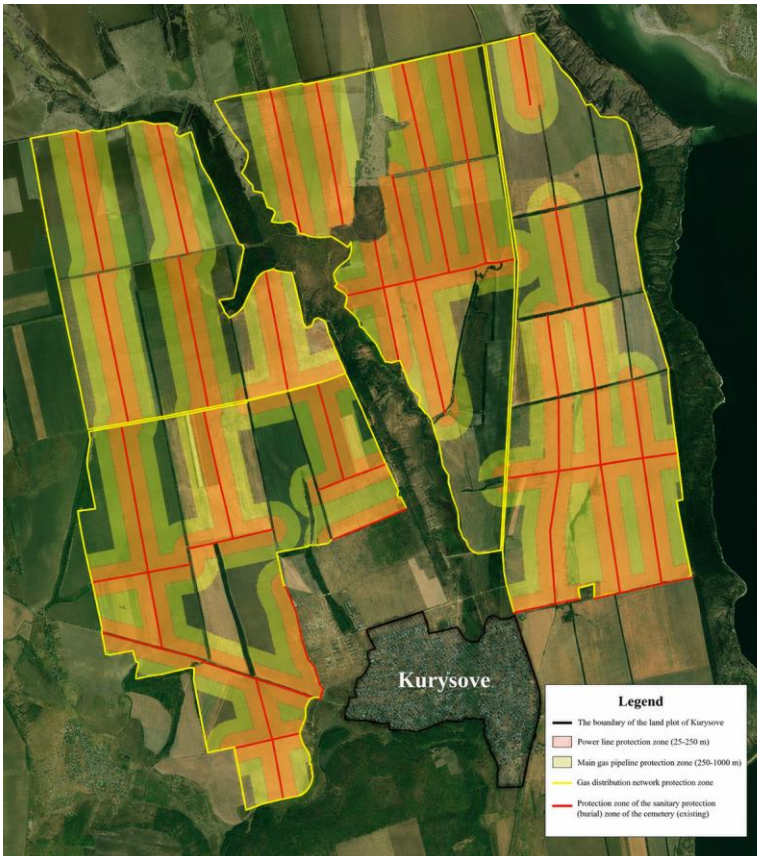

Fig. 3. Model of the impact of the proposed PLN on agricultural land (arable land) in the Kurisovska community, Odesa Oblast

According to the project, the proposed field-protection forest plantations, covering a total area of 43.88 hectares, will be established on arable land (land parcels) held in private ownership. To implement this project, it is necessary to purchase the relevant land area, which will be used to establish field-protection forest strips. Based on data from the monitoring of land relations in Ukraine, published fortnightly by the State Geocadastre since 1 July 2021, we have established the average value of arable land in the Lyman Agricultural District (which includes the territory of the Kurisivska community) at 31.32 thousand UAH/ha. Accordingly, the total cost of purchasing land to create field-protection forest strips amounts to 1,374.28 thousand UAH (Table 2).

Taking into account, according to data from the State Statistics Service of Ukraine [8], the average selling price of cereals in the Odesa region (7,543.8 UAH/t) and the production costs per unit of cereal and legume crops (7,066.0 UAH/t), it was determined that the lost income from agricultural production in the area designated for the power line corridor amounts to 72,122.57 UAH annually.

Table 2.

Estimated cost of land acquisition for the creation of field-protection forest strips

№ з/п	Land parcel	Area, ha	Amount of lost agricultural produce (including production costs)		Average price of arable land in the Lyman Agricultural Production Cooperative, UAH/ha	Monetary valuation of land, UAH
			t	UAH		
1	№ 1	5,95	20,47	9779,61	31318,99	186347,97
2	№ 2	15,06	51,81	24753,10	31318,99	471663,94
3	№ 3	11,06	38,05	18178,57	31318,99	346387,99
4	№ 4	11,81	40,63	19411,29	31318,99	369877,23
Total		**43,88**	**150,95**	**72122,57**		**1374277,14**

Based on the planting scheme for field-protection forest strips, market prices for planting stock for these strips and the cost of earthworks involved in planting the forest strips, we have calculated that the cost of establishing field-protection forest strips amounts to 52,747 UAH per 1 km.

Based on the cost of establishing field-protection forest strips per 1 km and taking into account the total length of the forest strips (48.76 km), it was calculated that the total cost of their establishment amounts to 2,571.71 thousand UAH. As, under this project, the field-protection forest strips will be established on arable land (land parcels (shares)) which, by virtue of their planned layout, form boundaries between plots, it is advisable to carry out land consolidation to reorganise the land parcels and ensure a more rational use of the territory.

The idea is that a field-protection forest strip is planned for a specific agricultural land use (in this case, a field), and a plot of land (or part thereof) of the required size is purchased to accommodate it. Once the exact location of the forest strip has been determined and the relevant area set aside for it, the land parcels affected by these changes must be re-categorised. Consolidation is carried out on the basis of a land management project or a detailed plan for the area, which provides for the optimal layout of agricultural land, roads, land improvement structures, etc.; once this has been drawn up, re-registration of the land parcels in the State Land Cadastre is a mandatory step.

Land consolidation (of land parcels or shares) must be carried out in accordance with key requirements: following consolidation, the area of the land parcels must remain unchanged, and the soil cover and topography must, where possible, remain unaffected. Furthermore, during consolidation, it is necessary to ensure that each land plot has access. Taking these requirements into account, we carried out the consolidation of land (land parcels), the results of which are presented in Fig. 4.

Fig. 4. An example of land consolidation (of land parcels) in land block No. 1 within the Kurisivska community

Based on market prices for the provision of surveying and land management services in the Odesa region, we have established that the average cost of drawing up a land management project for land consolidation is 3,000 UAH/ha. Accordingly, the total cost of such a project for the entire territory amounts to 1,140,000 UAH.

Thus, in our opinion, the total costs of the project to establish the Land Use Plan are most objectively determined using the formula:

$$PLN = C_{land} + C_{PLN\ set\text{-}up} + C_{land\ consolidation} + N_{pr},$$

where, C_{land} – monetary valuation of land for purchase for the establishment of the PLN, UAH; $C_{PLN\ set\text{-}up}$ – costs of establishing the PLN, UAH; $C_{land\ consolidation}$ – costs of developing a land management project for land consolidation, UAH; N_{pr} – amount of agricultural produce not obtained (taking into account production costs), UAH.

Therefore, based on the calculations carried out, the total cost of establishing field-protection woodland plantations within the Kurisivska community amounts to almost 5.16 million UAH (Table 3).

Table 3.

Total costs of establishing field-protection woodland plantations in the Kurisivska community

No.	Land parcel	Length of forest strips, m	Cost of creating forest strips, UAH	Cost of the land consolidation project, UAH	Total cost of the forest belt creation project, UAH
1	№ 1	6611,11	348716,22	219000	763843,80
2	№ 2	16733,33	882632,96	315000	1694049,99
3	№ 3	12288,89	648202,08	318000	1330768,64
4	№ 4	13122,22	692157,74	288000	1369446,27
Total		**48755,55**	**2571709,00**	**1140000**	**5158108,70**

Once the costs of establishing field-protection forest strips have been determined, it is advisable to assess their potential impact on the territory of the Kurisivska community. Research by forestry scientists indicates [4] that the positive agroclimatic effect of introducing these forest strips contributes to increased crop yields: grain yields rise by 4 q/ha, and winter wheat yields by 4–5 q/ha.

Using a methodology similar to that applied to existing field-protection forest strips (see Fig. 2), and taking into account the mixing scheme for the proposed field-protection forest plantations, we have identified the buffer zones within which they have an effective impact on the agricultural land use areas of the Kurisov community (0–10 H: up to 250 m; 10–20 H: 250–500 m). Taking into account the natural and climatic characteristics of the model area and the mixing scheme applied to the field-protective forest plantations, it is expected that the tree species will reach a maximum height of 18–20 m in 30 years. Based on these data, a model has been developed to assess the impact of the planned field-protection forest plantations on the arable land within the Kurisov community (see Fig. 3).

Thus, given the effective agroforestry and land reclamation impact of the PLN, the estimated additional volume of agricultural produce (converted to grain) amounts to 1,195.00 tonnes (Table 4). Taking into account the average selling price of cereals and leguminous crops in the Odesa region (7,543.8 UAH/t), it has been calculated that the positive impact of the PLN on adjacent agricultural land (arable land) generates an additional annual income of 9.01 million UAH.

Table 4.

Area of effective influence and additional income resulting from the positive impact of the PLN on adjacent agricultural land (arable land)

No.	Land block	Total area of agricultural land (arable land), ha	Area of protected agricultural land (arable land), ha		Additional income resulting from the positive impact of the PLN on adjacent land	
			0-10 H up to 250 m (up to 30 years of stand maturity)	10-20 H 250-500 m (after 30 years of stand maturity)	t	UAH
1	№ 1	801,51	312,12	283,95	238,43	1798653,15
2	№ 2	1040,58	484,68	362,89	339,03	2557559,43
3	№ 3	952,46	491,75	276,6	307,34	2318511,49
4	№ 4	1050,25	464,60	310,91	310,20	2340116,94
Total		**3844,80**	**1753,15**	**1234,35**	**1195,00**	**9014841,00**

Based on the calculations carried out, it has been established that the proposed project to create additional field-protection forest plantations on model land parcels in the Kurisivska community (with a total area of 43.88 ha) is economically viable. At the same time, to assess the project's economic efficiency more accurately over a specific time period, it is advisable to apply a cash flow discounting mechanism, which allows the present value of future revenues and costs to be determined.

The creation of field-protection forest strips is a long-term investment (spanning 50 years). Discounting helps to understand when the project will start to generate a profit and what its overall economic efficiency will be. The application of the discounted cash flow approach is based on the use of a discount (capitalisation) rate, which is determined by the extraction method, i.e. the ratio of the typical (average) annual land rent to its market value. We have therefore discounted the revenues and costs associated with the investment project to establish field-protection forest strips on land in the Kurisov community in the Odesa region over a 50-year period (Table 5).

Table 5.

Discounting of revenues and costs within the investment project to create field-protection forest strips on the lands of the Kurisov community over a 50-year period *(excerpt)*

Years	Revenue from sales, UAH	Maintenance costs, UAH/year	Principal repayment, UAH (in equal annual instalments)	Interest payments on the loan, UAH (19.4%)	Investment costs, UAH	Discount factor (at a discount rate of 1.0327)	Discounted value of income in year *t*, UAH	Discounted value of all costs (both operating and capital) in year *t*, UAH	Net cash flow, UAH	Net cash flow, UAH/ha
1	300495	257170,9	103162,2	1000673,1	1103835,3	1,033	290979,7	1317910,5	-1026930,8	-267,1
2	600989	257170,9	103162,2	980659,6	1083821,8	1,066	563531,8	1257413,3	-693881,5	-180,5
3	901484	257170,9	103162,2	960646,2	1063808,3	1,101	818531,8	1199426,0	-380894,2	-99,1
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48	9014841	77151,3	103162,2	60040,4	163202,6	4,686	1923966,8	51296,8	1872670,0	487,1
49	9014841	77151,3	103162,2	40026,9	143189,1	4,839	1863045,2	45536,5	1817508,8	472,7
50	9014841	77151,3	103162,2	20013,5	123175,6	4,997	1804052,7	40089,5	1763963,2	458,8
Total			**5158108,7**		**30675272,5**		**124509727,2**	**18782644,5**	**105727082,7**	**27498,7**

The additional income from the project, resulting from the positive impact of the afforested strip on the adjacent agricultural land (arable land), is fully factored in from the 30th year onwards (until the canopies in the afforested strip have fully closed). Up to the 30th year, the additional income is calculated using a discrete approach. Based on the findings of forestry researchers [1, 4], maintenance costs in the first 5 years amount to 10 per cent of the total cost of establishing the buffer strips, and 5 per cent in the period from the 6th to the 10th year. From the 11th year onwards, approximately 3 per cent of the establishment cost is allocated annually to ensure proper maintenance of the field protection strips (including ploughing, thinning, and measures to protect against diseases and pests, etc.).

In the early years, a significant proportion of the financial expenditure consists of investment costs, in particular the repayment of the principal and interest on the loan (19.4 per cent); however, these gradually decrease over time until the loan is fully repaid within 50 years. We have determined the discount (capitalisation) rate for agricultural land within the Lyman Agricultural Land Use Planning Area to be 1.0327.

The calculations show (see Table 5) that in the initial stages (the first few years), the total costs associated with land acquisition and planting outweigh the income, resulting in a negative cash flow (income). However, as the forest strips mature and their positive agroforestry and land-improvement effects intensify (with increased crop yields and rising additional income), a shift towards positive net cash flows is observed.

Taking into account the discount rate, the real value of future cash flows (revenues) and total expenses (operating and capital) in the model area was determined, which over 50 years amounted to 124.51 million UAH and 18.78 million UAH, respectively. Over the 50-year period, the project's net profit amounted to 105.73 million UAH (an average of approximately 27.50 thousand UAH per hectare), indicating the economic feasibility of its implementation (see Table 5).

Thus, over the period under study, the project achieves a positive cumulative value, meaning it is economically viable from the perspective of long-term payback. This confirms that the establishment of field-protection forest plantations on the lands of the Kurisivska community not only contributes to improving the ecological condition and preserving the quality of land resources, but may also be a profitable investment over the long term.

Shade-providing forest stands play a crucial role in creating a favourable microclimate for the surrounding agricultural land. Thanks to a combination of biophysical processes, in particular the reduction in wind speed, shading of the soil surface and intensive transpiration by tree and shrub species, such plantations are capable of significantly lowering the air temperature in neighbouring areas. This effect is particularly important for the southern regions of Ukraine, where agricultural landscapes are subject to significant thermal stress during the summer months and frequent droughts.

The spatial extent of the cooling effect depends on factors such as the height of the forest belt, the density and species diversity of the plantations, the terrain, as well as the direction and intensity of prevailing winds. In the southern steppe and forest-steppe regions, where summer temperatures can reach levels critical for the cultivation of most agricultural crops, the presence of fully developed (multi-row) forest strips makes it possible to reduce daily temperature peaks in the fields by 1–3°C, and in some cases even more, depending on specific weather conditions [4]. At the same time, during the cold season, the air temperature within the zone of effective influence of the forest strips rises by 1–3°C. Overall, in winter, the soil temperature at the tillering node depth of winter crops in fields situated amongst forest strips exceeds the soil temperature in open fields by 3°C [1].

Thus, based on the results of scientific research [1, 4], specialised software from Digitals and the characteristics of tree and shrub species, a model has been developed to illustrate the effective impact of field-protection forest plantations on the microclimate of arable land in the Kurisivska community (Fig. 5).

Field-protective forest stands in Ukraine, particularly in its southern regions, not only protect agricultural land from wind erosion but also perform a number of additional beneficial functions. In particular, they serve as a source of tree seeds, provide edible fruit, supply timber and brushwood, and, thanks to the presence of honey-producing tree and shrub species, help to increase beekeeping productivity

[2, 9]. Furthermore, forest strips play an important aesthetic and health-promoting role, serving as recreational areas and creating favourable conditions for the psychological and emotional well-being of the local population. In areas characterised by a high degree of land fragmentation, they create spatial islands for the conservation and restoration of biodiversity, in particular by providing a refuge for many species of fauna.

At the same time, tree plantations effectively curb the spread of pesticides and other chemicals used to treat fields, thereby providing additional environmental safety [10, 11, 12]. In southern Ukraine, where climate risks are becoming increasingly acute, the establishment and maintenance of fully-fledged forest belts are becoming an integral part of adapting to climate change, preserving soil fertility and sustaining sustainable agricultural production.

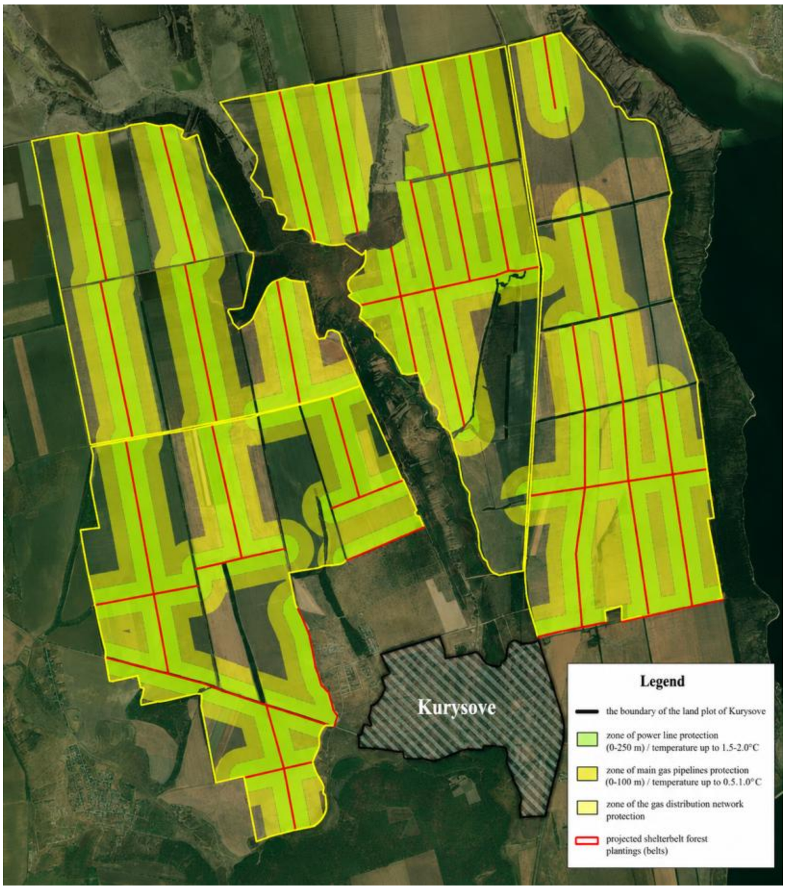

Fig. 5. Model of the effective impact of field-protective forest plantations on the microclimate of arable land in the Kurisov community, Odesa region

Conclusions and Prospects. Based on the study conducted, it can be noted that field-protective forest plantations significantly improve the microclimate of the agricultural land adjacent to them, ensuring increased humidity in the surface air layer and a more favourable temperature regime for the crops grown there. Conditions in the southern regions of Ukraine, which are increasingly affected by climate change and droughts, make forest-based land improvement measures extremely relevant, as they help the agricultural sector adapt and reduce the risk of yield losses. The protective forest stands created perform a number of important functions, including absorbing greenhouse gases, enriching the diversity of flora and fauna and preserving biodiversity, as well as acting as a barrier against wind erosion, retaining and evenly distributing snow cover, which has a positive effect on soil water balance and overall crop productivity.

The results of economic analyses show that projects to establish and restore field-protection forest plantations can be profitable investments in the long term. In the early stages, the costs of land acquisition and planting exceed the income generated; however, as the forest strips mature, their positive agroforestry impact intensifies, crop yields increase and, consequently, additional income rises. Discounting cash flows over a 50-year period demonstrates a positive cumulative result, confirming the economic viability of afforestation projects on the lands of the Kurisov community in the Odesa region. Thus, the comprehensive implementation of afforestation and land improvement measures, combined with an effective system for managing and protecting plantations, is capable not only of stabilising the environmental situation and improving the condition of land resources, but also of yielding tangible economic benefits over the long term.

Therefore, in order to achieve the maximum protective effect of forest belts, it is advisable to introduce comprehensive environmental, economic and legal instruments that will incentivise landowners and land users to conserve, restore and establish a system of field-protective forest plantations.

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ЛІСОМЕЛІОРАЦІЯ ЯК ІНСТРУМЕНТ КЛІМАТИЧНОЇ АДАПТАЦІЇ АГРОЛАНДШАФТІВ

Анотація. *В умовах загострення кліматичних викликів та деградації агроландшафтів в Україні на перший план виходять агролісомеліоративні заходи як важливі інструменти адаптації і пом’якшення наслідків зміни клімату. У статті обґрунтовано актуальність розвитку мережі полезахисних лісових смуг і агролісомеліоративних програм в межах аграрного виробництва. Наведено аналіз найновіших досліджень у сфері лісомеліорації, які свідчать про підвищення стійкості ґрунтів та збільшення* *врожайності сільгоспкультур завдяки захисним насадженням. Метою дослідження є комплексна оцінка функціонування системи захисних лісових смуг у частині території Курісовської ОТГ Одеської області як прикладу агролісомеліоративної адаптації. Використано картографічні матеріали, статистичні дані врожайності та витрат на створення лісосмуг. Результати показали, що існуюча площа полезахисних насаджень в досліджуваній території (загальна площа 3991,77 га, з яких орні землі 3888,68 га) забезпечує захист близько 2220,44 га ріллі, водночас незахищені угіддя становлять 42,90 %. Обчислено економічний ефект від створення нових полезахисних смуг площею 43,88 га (48,76 км): сумарні капітальні витрати проєкту становлять 5,158 млн грн, а додатковий щорічний урожай зернових культур зростає на 4 ц/га (озимої пшениці – на 4-5 ц/га) порівняно з незахищеними ділянками. З урахуванням ставки дисконту визначено реальну вартість майбутніх грошових потоків (доходів) та сукупних витрат (операційних і капітальних) на модельній території, які за 50 років склали 124,51 млн грн і 18,78 млн грн відповідно. За 50-річний період чистий прибуток проєкту склав 105,72 млн грн (середнє значення майже 27,50 тис. грн/га), що вказує на довгострокову економічну окупність за встановлених умов. На основі аналізу отриманих даних сформульовано висновки щодо посилення агролісомеліоративної політики задля підвищення ефективності кліматичної адаптації агросектору.*

Ключові слова: *полезахисні лісосмуги, агролісомеліорація, кліматична адаптація, збереження біорізноманіття, економічна ефективність.*