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Methodological approaches to optimization of use of slope lands

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The purpose. To study processes of formation of landscape-recreational complex of cities, actual state of use of the specified lands, and also directions of optimization of land-use. **Methods.** Generalizations, simulation. **Results.** Principles of incorporation of aspects of lands in uniform landscape-recreational terrains, and also ecological, economic and legal mechanisms of overcoming of the crisis phenomena concerning protection and use of these lands are offered. **Conclusions.** System of protection of landlandscape complex should be based on ecological monitoring, including ecologo-legal provision and ecological audit of natural management (ecological mechanism). Economical mechanism of protection of lands needs to be improved. It should be linked to rent policy in land-use and compensating payments caused by loss of valuable lands.

Key words: slope soil, Ts.E. MirtskhulavaHydromechani cal Erosion Model, optimization of crop rotations location.

At the stage of environmental and economic substantiation of crop rotation and land management during the development of a land management project, the task of spatial optimization of crop rotation is presented [12, 13]. A possible tool for solving the problem is combinatorial optimization [8, 15], which makes it possible to form groups of agricultural fields for different types of crop rotation (field, soil protection, fodder, etc.) on sloping lands with maximization of economic indicators - net profit, level of profitability of production, from application of restrictions on soil protection grounds - soil losses due to water erosion, mineralization of humus under agricultural crops, etc.

The purpose of the work is to work out approaches to optimizing the spatial placement of crop rotation on sloping lands.

Objects, methods and conditions of research. The object of the study was the selection of the agricultural area "Kolos 2000" within the boundaries of village councils Rogan and Zelenyi Kolodyaz (Kharkiv and Chuguevsky districts of the Kharkiv region).

The algorithm for solving the problem of crop rotation optimization for agroformation with environmental restrictions was as follows:

• the establishment of areas, angles of surfaces, humus content and potential soil losses due to water erosion under the influence of rainfall for agro-forming grounds [3, 7, 9, 10]; establishment of values of soil protection coefficients for agricultural plants and the balance of humus under them [1, 11, 21]; setting the cost structure (in particular, the percentage for mineral fertilizers and fuel and lubricants), the full cost price and the selling price for plant products [18]; the establishment of average yields, needs separately in nitrogen, phosphorus and potash fertilizers by economic reference books [17, 19, 20];
• the division into species - non-eroded, weak, medium and strong, determined by the value of potential soil losses, respectively -> 2, 2 - 5, 5 - 10 <10 t / ha annually;
• formation of scenarios of connection degree of erosion with ecological and economic indicators: increase of expenses for fertilizers and fuel and lubricants with increasing degree of erosivity [2, 4];
• reduction of crop yields on eroded soils [16];
• Calculation of ecological and economic indices of production of a separate agricultural crop for various degrees of erosion;
• preparation of differentiated soil protection properties of crop rotation and calculation of such indicators: ecological (balance of humus, soil protection coefficient); economic indicators (full cost, profitability level, net profit, costs of ensuring a simple reproduction of fertility (deficit-free balance of humus and minerals) and overall profitability and net profit taking into account environmental costs) as the average arithmetic contribution of each crop;
• consolidation of crop rotation in the lands by choosing targeted functions based on combinatorial optimization:
  - for economic indicators of the economy: maximization of net profit or maximization of average profitability;
  - for economic indicators of the economy taking into account environmental costs: maximization of net profit or maximization of average profitability;
  - for ecological indicators of the economy: minimization of potential soil losses due to a shower.

For a number of possible constraints: the value of full cost, soil losses due to water erosion, mineralization of humus.

The result of the above algorithm is the typology of lands under the types of crop rotation. 1. Calculation of indicators for the optimization model:

1.1. Costs for crop production [14]:

$$PS=Z+H+A+T_r+V_N+ +V_O+V_M+V_Z+O+S_T+I+V_{ZV} \quad (1)$$

where Z - pay with accruals, UAH; H - the cost of fuel and lubricants, UAH; A - amortization deductions, UAH; Tr - cost of capital and current repairs and maintenance, UAH; V_N - cost of seeds, UAH; V_O- cost of organic fertilizers, UAH; V_M- cost of mineral fertilizers, UAH; V_Z- costs of plant protection products, UAH; O - land rent, UAH; C_T- insurance payments, UAH; I - other expenses, UAH; V_{ZV} - total production costs, UAH.

1.2. Costs of mineral fertilizers (for scenario № 1):

$$B_M=B_N K_N+B_{P2O5} K_{P2O5}+B_{K2O} K_{K2O}, \quad (2)$$

where B_N, B_{P2O6}, B_{K2O}- the cost of nitric, phosphoric and potash fertilizers respectively, K_N, K_{K2O}, K_{P2O5} - coefficients to the rates of mineral fertilizers, depending on the degree of soil erosion [2].

1.3. Costs of fuel and lubricants (for scenario № 1):

$$H=0,025 \Delta i_p B_M, \quad (3)$$

where 0,025 - coefficient, which takes into account the increase in the cost of cultivating crops depending on the relief, as a percentage of 1% increase in the working slope; Dip - difference of working slopes on project variants,%; B_M - the cost of mechanized works, UAH (in our case, the cost of fuel and lubricants used). The initial (zero) value of the slope of the surface of the site is 1.75% (1 °).

1.3. Net profit:

$$NP=V_P K_{EZV} – PS, \quad (4)$$

where V_P - value of gross output, UAH; K_{EZV} - coefficient of reduction of crop yields on eroded soils (for scenario No. 2) [16].

1.4. Profitability level:

$$R=NP/PS 100 \quad (5)$$

2. Loss of soil due to water erosion under the influence of a shower:

The calculation of potential soil losses due to water erosion under the influence of a shower of 10% of safety was carried out on the basis of hydromechanical model of erosion Ts.E. Myrtshulawi for agroforestry (W_{x2T}).

$$W_{x2T}=W_{x2T} C P \quad [3, 7, 9, 10], \quad (6)$$

where W_{x2T} - potential soil losses due to a shower; C - soil protection coefficient of agricultural crop (for crop rotation, as the average arithmetic contribution of each crop) [11]; P - coefficient of agrotechnical measures.

The limitation on soil loss can not be lower than the maximum value of soil loss for the site multiplied by the minimum value of the soil protection coefficient.

3. The balance of humus under a culture is determined by the system of equations [1, 21]:

3.1. Humicification of roots and root crops:

$$Q=U K_{ezb} k_p k_g, \quad (7)$$

where U - crop of agricultural crop, t / ha; K_{ezb} - coefficient of reduction of crop yields on eroded soils (for scenario number 2) [16]; k_p - coefficient of accumulation of poppy-root residues relative to the crop of crops; k_g - the residual rubberization coefficient.

3.2. Humus mineralization:

$$V=G H d_v k_m k_k, \quad (8)$$

where G-content of humus in the soil,%; H - depth of the arable layer, cm; d_v - density of soil compaction, g / cm3; k_m - coefficient of mineralization of humus; k_k - relative index of biological productivity.

3.3. Humus loss due to erosion:

$$V_2=B_E G, \quad (9)$$

where B_E - soil loss due to erosion, t / ha; G- content of humus in the soil,%.

3.4. Humus balance:

$$B_g =Q – V_1 – V_2. \quad (10)$$

4. Environmental costs.

For both scenarios, the cost of humus balance recovery is calculated. For the second scenario, loss of nutrients is calculated as the difference between the need for fertilizers for soils of varying degrees of erosion and for non-irrigated soils. Indirect costs (shortage of gross output) under the conditions of the first scenario is not expected. In the second, these costs will be reflected in lowering economic performance [6].

Results and discussion. We use the indicator of potential soil losses due to the shower to optimize the spatial arrangement of crop rotation types on agroformation sites.

The formulas above have calculated the economic and environmental production rates for individual crops. Some of them are shown in the table. 1, from which it is possible to make an implicit assumption of the existence of a dependence between the soil protective factor of the plant and the level of profitability and net profit, respectively - inversely proportional and directly proportional. More profitable cultures have a significant negative response to the decline in fertility.

There are 3 contrasting soil protection properties for the forest-steppe part of the Kharkiv region: I - peas, winter wheat, sugar beet, wheat yar, soybeans, winter wheat, corn for grain; II - peas, winter wheat, spring barley, soybeans, winter wheat; III - peas, winter wheat, wheat yar. The coefficient of erosion hazard according to I, II and III crop rotations is equal to 0.61; 0.52; 0.51 Economic and environmental indicators of production for these crop rotations are calculated (Fig. 1).

According to data from Fig. 1, b and 2 it is possible to substantiate the conclusion about the low economic profitability of the low-eroded and negative for medium-green soils, if the yield reduction index reliably characterizes the level of fertility of the used sloping soils.

Ultimately, economic and environmental performance will be calculated when combined with field indicators during combinatorial optimization. As a result of this procedure, a combination of fields with crop rotation numbers will be found which gives the extremum of the desired function with the given ecological limitations and the number of fields under crop rotation.

Optimized spatial placement of crop rotation is shown in Fig. 3 (search was carried out with the objective function of maximizing the level of profitability of production in the first scenario).

Here are the economic and environmental indicators of production in different areas of optimization tab. 2.

From the table above, one can conclude that the direction of optimization with the search for maximum profitability of production is similar to the direction of minimizing soil losses due to erosion. The level of profitability of production of crop production is due to the exploitation of natural fertility, which leads to an increase in indirect costs (cost of shortage of production) of losses. Among all the possibilities of optimizing this situation is the improvement of the crop properties of the seed material. With an increase in its value in 2 - 3 times the forecast growth of yield can be 40 - 100%.

We will analyze possible options for improving the economic and environmental performance of crop production. Obvious directions are the compensation of the influence of limiting indicators - mineralization of humus, water-erosion safety of crop rotation, the level of fertility of eroded soils. In order to improve the balance of humus under the plant, an increase in the yield of cultivated crops is required [5].

Conclusions.

Spatial placement of crop rotation can not be based on one of the groups of criteria - ecological or economic. Combined optimization is a rational and universal tool for spatial optimization of placement of crop rotation. In order to increase the economic and ecological indices of crop production on sloping lands, it is necessary to reduce the value of the anti-erosion index of agricultural crops (intermediate crops, agrotechnical and forest-melioration measures, etc.), increasing the fertility of eroded soils, and increasing the yield of cultivated crops.

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