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Posted Date: 27 January 2026

doi: 10.20944/preprints202601.2088.v1

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Theoretical and Methodological Approaches to Assessing the Natural Resource Potential of Agricultural Landscapes Using the Harrington's Desirability Function

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Abstract

The aim of this study is to develop theoretical and methodological approaches to assessing the natural resource potential of agricultural landscapes, which includes climatic, soil, land, biological, and water resources. The research methodology was based on the materialist theory of scientific knowledge, methods of mathematical modeling of natural conditions and processes, as well as the use of the Harrington's desirability function. Based on the study, a model of a system of dimensionless criteria and evaluation indicators has been developed, which are used to determine the natural resource potential of agricultural landscapes (a composite indicator). On this basis, the scale of coded values for specific indicators and the Harrington's desirability scale are calculated (complex indicator). The proposed mathematical model is a generalized Harrington's desirability function, which varies from 0 to 1 and is divided into seven subranges (scales): (0–0.17) – catastrophic; (0.17–0.27) – very poor; (0.27–0.37) – poor; (0.37–0.50) – satisfactory; (0.50–0.63) – average; (0.63–0.83) – good; and (0.83–1.00) – very good. These gradations correspond to the general approaches used in assessing the natural resource potential of agricultural landscapes. The proposed methodology and algorithm for assessing the natural resource potential of agricultural landscapes make it possible to determine the degree of desirability according to the value of its function, and can be used for predicting the state of the natural environment.

Keywords: assessment; natural resource potential of a landscape; Harrington's desirability function; desirability scale; assessment of natural resource potential

1. Introduction

To assess the natural resource potential of agricultural landscapes, it is necessary to take into account multiple criteria with different values and dimensions. This process is complex and is characterized by a large number of specific indicators, including climatic, soil, land, biological, and water resources of the natural system. Therefore, the assessment of natural resource potential belongs to the category of multi-criteria and multi-parameter problems [1].

Such problems include the assessment of the state and quality of the environment [2–4], ecosystems [5,6], economic indicators [6–10], public health [11–13], population safety in emergency situations [14–18], management processes [19,20], environmental parameters [21], industrial safety [22–25], and other characteristics [26–29], which have various measurement units – both qualitative and quantitative. Their integral assessment is often carried out using the Harrington's desirability function [30].

The natural resource potential of landscapes is studied by various authors using different methods: based on satellite data and monitoring data, cartographic and statistical methods.

Despite the large number of published studies and their theoretical and practical significance, many methodological aspects of these areas still require further scientific development. This has determined the objective of our study – to develop a theoretical and methodological approach for assessing the natural resource potential of agricultural landscapes using the Harrington's desirability function. This approach will be based on identifying the interrelations between the climatic, soil, land, biological, and water resources of the natural system, reflecting the interaction between internal and external environments. The result will be the development of a mathematical tool in the form of a calculation algorithm that reflects the sequence of actions for obtaining a generalized integral indicator based on the source data.

The use of the Harrington's desirability function to assess the natural resource potential of agricultural landscapes allows us, on the one hand, to use it as a basis for mathematical modeling, which provides structural analysis of assessment indicators and helps establish their relationships. On the other hand, the proposed approach creates opportunities for further improvement of this methodology based on scientific ideas about modern mechanisms of natural resources management.

2. Materials and Methods

The research materials on the assessment of the natural resource potential of agricultural landscapes are based on the methodological approach proposed by [1]. As part of this approach, a comprehensive model for assessing the agro-resource potential has been developed, consisting of four blocks. Its structure is shown as equation (1):

$$\begin{gathered} ARPL_i = f(ACR_i, SIR_i, ABR_i, WR_i); \\ ACR_i = f(\sum SBCT_{\mathrm{ci}}C^o, RB_i, CE_{\mathrm{o}i},;\ ET_{ci}, AC_{\mathrm{c}i}, CL_i); \\ SIR_i = f(C_{mi}, \overline{R}_i, ESF_{\text{п}i}, SI_i); \\ ABR_i = f(PP_i, CPP_i, MPP_i, RMPP_i, RPP_i, VP_i, PEP_i); \\ WR_i = f(SWSP_i, SWST_i, CISWS_i, WS_i), \end{gathered} \tag{1}$$

where $ARPL_i$ – agro-resource potential of landscapes; ACR_i – agro-climatic resources; $\sum SBCT_{\mathrm{ci}}C^o$– sum of biologically active temperatures above 10 °C; RB_i – radiation balance of the active surface of the near-ground layer of air and soil, kJ/cm²; $CE_{\mathrm{o}i}$ – total evaporation during biologically active periods of the year, mm; ET_{ci} – water consumption, i.e., the volume of water used in agricultural landscapes for plant transpiration and evaporation from soil; AC_{ci} – annual precipitation, mm; CL_i – climate favorability index; SIR_i – soil and land resources; C_{mi} – natural moisture supply of the soil and vegetation cover in agricultural landscapes; $\overline{R}_i$ – natural heat and moisture supply of the soil and vegetation cover in agricultural landscapes, characterizing the intensity of the cycle of matter and biological productivity of agricultural lands. It is determined by the ratio of heat and moisture resources and formalized by the radiation aridity index [31]; $ESF_{\text{п}i}$ – consumption of solar energy for soil formation processes in agricultural landscapes, directly related to the material and energy flux reaching the soil surface, i.e., dependent on the magnitude of the radiation balance of the active surface of the near-ground layer of air and soil (RB_i) and annual precipitation (AC_{ci}) [32]; SI_i – soil index, a complex indicator of soil fertility based solely on edaphic characteristics (the combination of physical and chemical soil properties affecting the productivity of the soil and vegetation cover of agricultural landscapes as a habitat). It is a mathematical model built by aggregating (combining homogeneous indicators and deducing generalizing indicators) [33]; ABR_i – agro-biological resources; PP_i – potential productivity, i.e., the maximum yield from agricultural landscapes theoretically provided by incoming photosynthetically active radiation (radiation balance – RB_i); CPP_i – climatic potentially possible productivity of agricultural landscapes; MPP_i – maximum possible productivity of agricultural landscapes; $RMPP_i$ – actual maximum possible productivity of agricultural landscapes; RPP_i – actual possible productivity of agricultural landscapes; VP_i – possible productivity of agricultural landscapes; PEP_i – production and economic productivity of agricultural lands for various types of agricultural landscapes; WR_i – water resources; $SWSP_i$ – specific water supply of the population; $SWST_i$ – specific water supply of the territory; $CISWS_i$ – complex indicator of specific water supply of the territory and the population; WS_i – water stress.

The analysis and systematization of existing approaches to the assessment of the natural resource potential of agricultural landscapes have shown that the above mathematical toolkit, based on a set of evaluation indicators with different measurement units, requires the conversion of these indicators to an integral indicator, which can be fully characterized using the Harrington's desirability function.

To assess the natural resource potential of agricultural landscapes, in accordance with Shelford's law of tolerance [34], it is advisable to apply bilateral constraints, which are characterized by a monotonically increasing dependence of desirability on numerical values of the indicators. In this case, the Harrington's function takes a sigmoidal form, expressed by formula 2:

$$NRDS_i = exp[-exp\,(-SPI_i)], \qquad (2)$$

where SPI_i – the scale of coded values of specific indicators of natural resources and potential of agricultural landscapes; $NRDS_i$ – the desirability scale of the natural resource and potential of agricultural landscapes, expressed in a conditional or dimensionless form.

When using the Harrington's function, the desirability scale is usually divided into five categories: (0.8–1.0) – very good, (0.63–0.8) - good, (0.37–0.63) – satisfactory, (0.2–0.37) – poor, (<0.2) – very poor.

After calculating all the specific desirability function indicators ($NRDS_i$), they are aggregated into a generalized criterion, the generalized desirability function (GDF_i), which, in the absence of weight coefficients, is determined using formula 3:

$$GDF_i = \sqrt[n]{\prod_{i=1}^{n} NRDS_i}, \qquad (3)$$

where n – is the number of indicators of natural resources or potential of agricultural landscapes.

An extreme manifestation of the integral approach used in assessing the natural resource potential of agricultural landscapes is the construction of an average geometric function consisting of many different indicators.

3. Results

The interaction and interdependence of agro-climatic, soil and land, agro-biological, and water resources are highly diverse and complex, requiring a scientific rationale for choosing the most significant natural resource indicators to create mathematical models on the basis of improving scientific understanding of the modern natural resource potential in order to satisfy human needs.

The improvement of the methodology for assessing the natural resource potential of agricultural landscapes was carried out using the systemic and functional approach based on the materialist theory of scientific knowledge. Within its framework, five integral functions have been identified — climatic, soil, land, biological, and water resources – each formed by the main environmental-forming factors, which require the development of their mathematical model when creating their algorithms.

To develop a mathematical model for assessing the natural resource potential of agricultural landscapes, including climatic, soil, land, biological and water resources, E.S. Harrington's desirability function as been used for the first time [30], which is based on linear and nonlinear

doi:10.20944/preprints202601.2088.v1

geometric mean equations [35] derived from the Euclidean concept [36], which involves converting the real values of their parameters into a unified dimensionless numerical scale with fixed limits from 0 to 1, followed by mapping the individual quantitative scales into a generalized quality criterion scale.

Based on the indicators of natural resources, a generalized integral indicator of the natural resource potential of agricultural landscapes (NRPL$_i$) has been determined, which is calculated using formula (4):

$$NRPL_i = \sqrt[n]{\Pi_{i=1}^{n} GDF_i} = \sqrt[n]{ICRI_i \cdot CISR_i \cdot CLRI_i \cdot CIBR_i \cdot IWRI_i}, \quad (4)$$

where $ICRI_i$ – a complex indicator of climatic resources; $CISR_i$ – a complex indicator of soil resources; $CLRI_i$ – a complex indicator of land resources; $CIBR_i$ - a complex indicator of biological resources; $IWRI_i$ – a complex indicator of water resources.

Based on an indicative analysis and using the developed Harrington's desirability scale, it is proposed to divide this scale in the range from 0 to 1 not into five, but into seven subranges for assessing the natural resource potential of agricultural landscapes: catastrophic – (0-0.17); very poor – (0.17-0.27; poor – (0.27-0.37); satisfactory – (0.37-0.50); average – (0.50-0.63); good – (0.63-0.83), and very good (0.83-1.00).

A mathematical model of indicators characterizing the climatic, soil, land, biological and water resources of the natural system is used as the basis for developing an algorithm for the natural resource potential of landscapes.

3.1. Methods for Assessing Climatic Resources of Agricultural Landscapes

Climatic resources of the natural system ($CRNS_i$) that perform an important environment-forming function include the following parameters: air temperature (AT_i), relative humidity (RH_i), air humidity deficit (IAH_i), and atmospheric precipitation (AP_i), within the framework of which the information base of the study is formed to determine integral baseline indicators that characterize the energy balance of the natural system [37].

The sum of biologically active air temperatures ($\sum SBCT_i C^o$) is an integral indicator of the ambient temperature regime, which is determined using formula 5:

$$SMAT_i = AT_i \cdot ND_i \rightarrow \sum SBCT_i C^o = \sum_{i=1}^{n} SMAT_i \ ; \qquad RSAT_i = \sum SBCT_i C^o \,/\, SMPSAT_i, \quad (5)$$

where AT_i – average monthly air temperature, °C; ND_i – number of days in a month; n – number of months; $SMAT_i$ – sum of monthly air temperatures above 10° C; $\sum SBCT_i C^o$ – sum of biologically active air temperatures above 10° C; $SMPSAT_i$ – sum of maximum possible air temperatures above 10° C; $RSAT$ – relative sum of biologically active air temperatures above 10° C.

The radiation balance of the active surface is the most important climate-forming factor and the energy basis for transpiration and physical evaporation of the soil and vegetation cover, and is calculated using formula 6:

$$RB_i = 4.1868 \cdot \left[13.39 + 0.0079 \cdot \sum SBCT_i > 10^o C\right],$$

$$MPRB_i = 4.1868 \cdot \left[13.39 + 0.0079 \cdot \sum SMPSAT_i > 10^o C\right], \quad (6)$$

$$RRB_i = RB_i / MPRB_i,$$

where RB_i – radiation balance of the active surface of the near-ground layer of air and soil of agricultural landscapes, kJ/cm²; $MPRB_i$ – maximum possible radiation balance of the of the active surface of the near-ground layer of air and soil of agricultural landscapes, kJ/cm²; RRB_i – relative radiation balance of the active surface of the near-ground layer of air and soil of agricultural landscapes.

The sum of air humidity deficit is a complex value that reflects both the heat and moisture content of the air, which allows it to be used more widely than other humidity characteristics to assess the climatic conditions and resources of the natural system. It is determined using formula 7:

$$MADAI_i = IAH_i \cdot ND_i \rightarrow \sum ADAH_i = \sum_{i=1}^{n} MADAI_i \;; \quad RADAH_i = \sum ADAH_i \,/\, SMPSAT_i, \tag{7}$$

where IAH_i – average monthly air humidity deficit, mb; ND_i – number of days in a month; n – number of months; $\sum_{i=1}^{n} MADAI_i$ – total monthly air humidity deficit during periods with air temperature above 10° C; $\sum ADAH_i$ – total air humidity deficit during periods with air temperature above 10° C; $SMPSAT_i$ – total maximum possible air humidity deficit during periods with air temperature above 10° C; $RADAH_i$ – relative total air humidity deficit during periods with air temperature above 10° C.

Evaporation is a conditional value that characterizes the maximum (potential, not limited by water reserves) evaporation and is a function of air temperature and relative humidity. It is determined sing formula (8) and consists of two blocks [38]:

$$ME_i = 0.0018 \cdot (AT_i + 25)^2 \cdot (100 - RH_i) \rightarrow TE_i = \sum_{i=1}^{n} ME_i \;; \quad RSTE_i = TE_i / MPTE_i, \tag{8}$$

where $(AT_i + 25)^2$ – the first block that takes into account the nonlinear relationship between ME_i and AT_i, characterizing the thermodynamic state of the air and serving as one of the key climatic parameters of the environment that integrates multiple factors of climate formation in spatial and temporal aspects; $(100 - RH_i)$ – the second block represents the deficit of relative humidity and characterizes the potential ability of the air to evaporate moisture and absorb vapor from the surrounding environment at a given temperature. It is one of the thermodynamic parameters that determines the evaporative capacity of the natural environment; RH_i – average monthly relative air humidity, %; n – number of months; ME_i – monthly evaporation, mm; TE_i – total evaporation during periods with air temperature above 10 °C, mm; $MPTE_i$ – maximum possible evaporation during periods with air temperature above 10 °C, mm; $RSTE_i$ – relative total evaporation during periods with air temperature above 10° C.

The total water consumption in agricultural lands, which is determined using formula 9 [39], is one of the integral indicators of the climatic resources of the natural environment, along with the radiation balance of the active surface, that perform an important ecological function in accordance with the laws of energy conservation of the natural environment. It is calculated using formula 9:

$$TWCAL_i = 10 \cdot RB_i \cdot L^{-1}; \quad MPTWCAL_i = 10 \cdot MPRB_i \cdot L^{-1}; \quad RTWCAL_i = TWCAL_i / MPTWCAL_i, \tag{9}$$

where $TWCAL_i$ – total water consumption by agricultural lands, mm; $MPTWCAL_i$ – maximum possible total water consumption by agricultural lands, mm; $RTWCAL_i$ – relative total water consumption by agricultural lands.

Atmospheric precipitation (AP_i), as a climatic indicator performing an environment-forming function, represents a key element in the moisture cycle. Together with temperature and relative humidity, it largely determines the heat exchange processes and characterizes the climatic resources of the natural environment. It is determined using formula 10:

$$\sum AAAP_i = \sum_{i=1}^{n} AP_i; RADAH_i = \sum AAAP_i \,/\, MPAAP_i, \qquad (10)$$

where RH_i – monthly atmospheric precipitation, mm; n – number of months; $AAAP_i$ – annual atmospheric precipitation, mm; $MPAAP_i$ – maximum possible annual atmospheric precipitation, mm; $RADAH_i$ – relative annual atmospheric precipitation, mm.

The natural humidity coefficient is one of the most important climatic indicators, allowing for the assessment of moisture availability, taking into account climatic factors. It is defined as the ratio of annual precipitation to evaporation [38] and is calculated using formula 11:

$$NHC_i = AC_i/TE_i;\ RNHC_i = NHC_i/NYC_{maxi}, \qquad (11)$$

The hydrothermal index or "aridity index" *(RDI_i)* represents the ratio of the radiation balance of the active surface *(RB_i)* to the heat expenditure on evaporation of atmospheric precipitation ($HCE_i = L{\cdot}AP_i$), where L is the latent heat of vaporization, numerically equal to 2.5 kJ/cm². This index characterizes the energy balance and largely determines the intensity of biochemical and geochemical processes in the soil and vegetation cover. It is calculated using formula 12 [31]:

$$RDI_i = RB_i/L \cdot AP_i;\ RRDI_i = RDI_i/RDI_{maxi}, \qquad (12)$$

where RDI_{maxi} is the maximum possible value of the hydrothermal index in a given natural and geographical zone.

The analytical membership function corresponding to this scale (also known as the Harrington's desirability function) for individual climatic resource parameters is expressed as (13):

$$\begin{gathered}
DFRSAT_i = \exp\left[-\exp\left(-RSAT_i\right)\right];\\
DFRRB_i = \exp\left[-\exp\left(-RRB_i\right)\right];\\
DFRADAH_i = \exp\left[-\exp\left(-RADAH_i\right)\right];\\
DFRSTE_i = \exp\left[-\exp\left(-RSTE_i\right)\right];\\
DFRTWCAL_i = \exp\left[-\exp\left(-RTWCAL_i\right)\right];\\
DFRADAH_i = \exp\left[-\exp\left(-RADAH_i\right)\right];\\
DFRNHC_i = \exp\left[-\exp\left(-RNHC_i\right)\right];\\
DF\overline{RR}_i = \exp\left[-\exp\left(-RRDI_i\right)\right],
\end{gathered} \qquad (13)$$

The generalized Harrington's desirability function for climatic resources ($GDFCR_i$) represents a geometric mean indicator of the climatic resource factors and is calculated using formula 14:

$$GDFCR_i = \sqrt[8]{DFRSAT_i \cdot DFRRB_i \cdots DFRNHC_i \cdot DF\overline{RR}_i}, \qquad (14)$$

3.2. Methods for Assessing Soil Resources of Agricultural Landscapes

The solar energy consumption for the soil formation process in agricultural landscapes is directly related to the material and energy flow reaching the soil surface, that is, it depends on the magnitude of the radiation balance of the active surface of the near-ground layer of air and soil (RB_i, kJ/cm²) and the annual total atmospheric precipitation (AP_i), determined using formula 15 [40]:

$$ESF_i = RB_i \cdot exp(-\alpha \cdot RDI_i); \qquad (15)$$

$$ESF_{maxi} = RB_i \cdot exp\left(-\alpha \cdot RDI_{opti}\right) \rightarrow RB_i \cdot exp(-\alpha \cdot 1.0) \rightarrow 0.6250 \cdot RB_i;$$

$$ESF_i / ESF_{maxi},$$

where α – indicator of completeness of radiation energy utilization in soil formation processes, numerically equal to 0.47; RDI_i – "radiation aridity index" or complex hydrothermal index; ESF_i – solar energy consumption for soil formation, kJ/cm²; ESF_{maxi} – maximum possible solar energy consumption for soil formation, at $RDI_{opti} = 1.0$, kJ/cm²; $RESF_i$ – relative solar energy consumption for soil formation.

To perform quantitative assessment of soil fertility, we recommend using an integral fertility index based on the "soil index" [33], which represents a modification that includes humus content ($\mathrm{HI_i}$), mineral nutrient reserves (NPK_i), hydrolytic acidity index (HA_i) and soil salinity index (SSI_i), and is calculated using formula 16:

$$SFI_i = HI_i + MNI_i + SAI_i + SSI_i = WF_{hl} \cdot f(HI_i) + WF_{mni} \cdot f(MNI_i) + WF_{sai} \cdot f(SAI_i) + WF_{ssi} \cdot f(SSI_i), \quad (16)$$

where WF_i – weight coefficients of steppe vegetation productivity; HI_i – indicator of humus influence on the generalized soil index; MNI_i – indicator of mineral nutrition influence on the soil index; SAI_i – indicator of soil acidity influence on the soil index; SSI_i – indicator of soil salinity influence on the soil index.

As a result of the comparative analysis of soil indices at $f(HI_i, MNI_i, SAI_i, SSI_i) = 1$ and at $f(HI_i, MNI_i, SAI_i, SSI_i) = 0$, weight coefficients of maximum vegetation productivity have been determined: WF_{hl}= 6.40; WF_{mni}= 8.50; WF_{sai}= 5.10; WF_{ssi}= 20.0.

A modification of the integral soil fertility indicator, based on the "soil index" [33], consists of four components and is calculated using formula 17:

$$\begin{aligned} HI_i &= 6.4 \cdot (HH_i + 0.2 \cdot FH_i)/600; \\ MNI_i &= 8.5 \cdot \sqrt[3]{NPK_i \cdot \delta}; \\ SAI_i &= 5.1 \cdot exp\{-[HA_i - 1]/4\}; \\ SSI_i &= 20.0 \cdot exp(-0.76 \cdot DSS_i) = 20.0 \cdot exp(-\alpha_i \cdot DSS_i), \end{aligned} \quad (17)$$

where HH_i – content of humate humus, t/ha or g/cm³; FH_i – content of fulvic humus, t/ha or g/cm³; $N_i = NC_i/NC_{maxi}$; $P_i = PC_i/PC_{maxi}$; $K_i = KC_i/KC_{maxi}$ – relative contents of nitrogen (N_i), phosphorus (P_2O_{5i}), and potassium (K_2O_i) in the soil; NC_{maxi}, PC_{maxi} and KC_{maxi} – maximum content of mineral nutrition forms available to plants in the soil (t/ha); NC_i, PC_i, KC_i – actual content of mineral nutrition forms available to plants in the soil (t/ha); δ – coefficient of assimilability of fertilizers by plants; HA_i – hydrolytic acidity, mg-eq/100 g of soil; DSS_i – soil salinization degree, % of dry residue; α_i – coefficient that takes into account the type of salinization.

Under the conditions of maximum humus reserves ($HH_i + 0.2 \cdot FH_i = 600\ t/ha$) and absence of a deficit of the basic mineral nutrition elements ($N = 1$, $P = 1$, K=1), with hydrolytic acidity H_{r} = 1 and soil salinization degree DSS_i = 0.30% of dry residue, the maximal values of the soil index will be as follows: HI_i=6.4 units; MNI_i = 8.5 units; SAI_i=5.1 units and $SSI_i = 20.0$ units, and the aggregated soil index is SFI_i = 40.0 units. Thus, the numerical range of the soil index characterizing soil fertility under natural conditions varies from 0 to 40.

From these results the relative weight coefficients of the soil index ($WFSI_i$), which characterizes the influence of humus reserves (HI_i), reserves of mineral nutrition elements (MNI_i), hydrolytic acidity (SAI_i) and soil salinization (SSI_i) indicators on soil fertility have been determined using formula 18:

$$\begin{gathered} WFSI_{HIi} = WF_{hl}/SFI_i = 6.40/40.0 = 0.160; \\ WFSI_{NPKi} = MNI_i/SFI_i = 8.50/40.0 = 0.213; \\ WFSI_{SAi} = SAI_i/SFI_i = 5.10/40.0 = 0.128; \\ WFSI_{SSi} = SSI_i/SFI_i = 20.0/40.0 = 0.500 \\ WFSI_{HIi} + WFSI_{NPKi} + WFSI_{SAi} + WFSI_{SSi} = \\ = 0.160 + 0.213 + 0.128 + 0.500 = 1.000, \end{gathered} \tag{18}$$

The mathematical model of the soil index (a dimensionless value in the range 0–1), composed of four blocks and having a relative weight coefficient, which is a modification of the "soil index" [33] that can be calculated using formula 19:

$$\begin{gathered} RESI_i = [0.160 \cdot (HH_i + 0.2 \cdot FH_i)/600] + 0.213 \cdot \\ \sqrt[3]{NPK_i \cdot \delta} + + 0.128 \cdot exp\{-[HA_i - 1]/4\} + 0.500 \cdot \\ exp(-0.76 \cdot DSS_i), \end{gathered} \tag{19}$$

E. Harrington's desirability function or desirability indicators for a particular parameter of soil resources, that is, the consumption of solar energy for soil formation ($RESF_i$), and the integral fertility indicator ($RESI_i$) are calculated using formula 20:

$$\begin{gathered} DFRESF_i = \exp\,[-\exp\,(-RESF_i)]; \\ DFRESI_i = \exp\,[-\exp\,(-RESI_i)], \end{gathered} \tag{20}$$

where $DFRESF_i$ – desirability function for solar energy consumption for soil formation; $DFRESI_i$ – desirability function for solar energy consumption for soil formation.

Based on the desirability function ($DFRESF_i$, $DFRESI_i$), derived from the individual soil resource parameters ($RESF_i$, $RESI_i$), the generalized Harrington's desirability function is calculated as the geometric mean of the individual soil resource desirability's ($GSRDF_i$) using formula 21:

$$GSRDF_i = \sqrt[2]{DFRESF_i \cdot DFRESI_i}, \tag{21}$$

3.3. Methods for Assessing Land Resources of Agricultural Landscapes

The main feature of land resources is that land is the primary factor of agricultural production and serves as the material environment for the formation of soil and vegetation cover.

Mustafayev Zh., Adilbektegi G., Kozykeyeva A. (2018) [40] have developed and tested a method for assessing the bioecological potential of agricultural lands, which primarily includes the assessment of soil and vegetation productivity. This method allows for the identification of patterns in the formation and functioning of natural systems depending on latitudinal and altitudinal zonality for effective use of agricultural lands and identification of their regional differences.

The method for assessing land resources is based on a system of integral criteria and indicators, such as the natural moisture coefficient (NHC_i), the "radiation aridity index" (RDI_i), the potential vegetation productivity ($PPVC_i$), energy consumption for soil formation (ESF_i), bioenergetic resources of the vegetation ($BRPB_i$) and soil ($BRSB_i$) cover biomasses of agricultural lands, which can be used to assess both soil differences and vegetation productivity.

3.3.1. Mathematical Modeling of Environmental Assessment of Productivity of Agricultural Landscapes Based on the Energy Resources of a Natural System

All processes occurring in the soil and vegetation cover are associated with energy use, where the intensity of biological processes in landscapes is largely determined by the coefficient of free energy utilization ($FEUF_i$) of the trophic system in which it is included, and is calculated as the potential vegetation productivity ($PPVC_i$) using formula 22 [41]:

$$PPVC_i = RB_i \cdot FEUF_i / CVOMY_i, \tag{22}$$

where $PPVC_i$ – potential plant productivity; $CVOMY_i$ – calorific value per unit of organic matter yield; $FEUF_i$ – coefficient of free energy utilization: $FEUF_i = PURRB_i/100$, where $PURRB_i$ is the coefficient of utilization of active photosynthetic radiation by plants.

The productivity of vegetation in landscapes ($PLPC_i$) depends not only on the energy resources of a natural system (RB_i) and the coefficient of free energy utilization ($FEUF_i$), but also on the moisture supply coefficient of agricultural lands ($CMSAL_i$), and is calculated using formula 23 [40]:

$$EPPC_i = PPVC_i \cdot CMSAL_i = (RB_i \cdot FEUF_i / CVOMY_i) \cdot (1/RDI_i), \tag{23}$$

where $EPPC_i$ is the ecological productivity of the plant community, taking into account the natural moisture supply of the landscapes.

Based on the mathematical models of ecological productivity of the vegetation cover ($EPPC_i$) and the potential plant productivity ($PPVC_i$), it is possible to determine the coefficient characterizing their ecological productivity ($CEPPC_i$), i.e. $CEPPC_i = EPPC_i / PPVC_i$.

The coefficient characterizing the ecological productivity of the soil ($CEPS_i$) as a function of energy consumption for the soil-forming process, is determined using the dependence 24:

$$CEPS_i = RESF_i = ESF_i / ESF_{maxi}, \tag{24}$$

Based on the proposed approach for assessing the ecological productivity of soil ($CEPS_i$) and vegetation ($EPPC_i$) cover of landscapes, it is possible to determine the ecological productivity of agricultural lands ($EPAL_i$) using formula 25 presented in the form of a geometric mean equation:

$$EPAL_i = \sqrt[2]{CEPPC \cdot CEPS_i}, \tag{25}$$

3.3.2. Mathematical Modeling of Ecological Assessment of Agricultural Landscape productivity Based on Bioenergetic Resources of a Natural System

To assess the bioecological productivity of vegetation cover ($BEPLP_i$) of agricultural landscapes, the bioenergetic potential of plants ($BEPP_i$) can be used, which is calculated using formula 26 [41]:

$$BEPLP_i = RB_i \cdot FEUF_i / 100 \cdot BEPP_i, \tag{26}$$

where $BEPP_i$ – bioenergetic potential of plants, 2500 kcal/(m²·year); $FEUF_i$ – coefficient of free energy utilization, which under natural conditions equals 0.005 [42].

The mathematical model of bioecological productivity of the vegetation cover of agricultural landscapes ($BEPLP_i$), taking into account the coefficient of natural moisture supply of soil and vegetation cover (NHC_i), is expressed as follows (27):

$$BEPNMP_i = BEPLP_i \cdot NHC_i = (RB_i \cdot FEUF_i / 100 \cdot BEPP_i) \cdot NHC_i, \tag{27}$$

For bioecological productivity of soils, the relative energy consumption for the soil-forming process ($CEPS_i$) can be used. In this case, bioecological productivity of agricultural landscapes is determined using mathematical expression 28:

$$BEPAL_i = \sqrt[2]{BEPNMP_i \cdot CEPS_i}, \qquad (28)$$

3.3.3. Mathematical Modeling of Ecological Assessment of Agricultural Landscape Productivity Based on the Bioclimatic Potential of a Natural System

For the quantitative assessment of the bioclimatic potential of natural system landscapes, that is, the formation of the production process of vegetation and soil covers in landscape systems, the climatic index of biological productivity of landscapes ($CIBPL_i$) [43] and the energy consumed for soil formation (ESF_i), which is calculated using [32], were used.

The influence of heat and moisture on biological productivity of landscapes is expressed through relative values of the bioclimatic potential of a natural system, i.e., through the climatic index of biological productivity of vegetation cover of landscapes, according to [43], calculated using formula 29:

$$CIBPL_i = GCAT_i \cdot [100 \cdot (\sum SBCT_i > 10^oC\ /1000], \qquad (29)$$

where $CIBPL_i$ – climatic index of biological productivity of vegetation cover of landscapes; $\sum SBCT_i > 10^oC$ – sum of average daily air temperatures above +10 °C, reflecting the inflow of solar energy and the thermal supply of landscapes; 1000° C – sum of average daily air temperatures above +10 °C, equal to the sum of temperatures at the current boundary of irrigated agriculture; $GCAT_i$ – the *growth coefficient* determined by the annual atmospheric moisture index, which represents the ratio of productivity under the given moisture supply conditions to the maximum productivity under optimal moisture supply conditions, and is calculated using formula 30 [43]:

$$GCAT_i = 1.15 \cdot lg(20 \cdot MI_i) + 0.63 \cdot MI_i - MI_i^2 - 0.21, \qquad (30)$$

where $MI_i = AP_i / \sum ADAH_i$ – moisture index; AP_i – atmospheric precipitation, mm; $\sum ADAH_i$ – total air moisture deficit during the biologically active period of the year, mb.

The bioclimatic potential, expressed in points, is an integral indicator and serves as the key indicator for assessing the agroclimatic significance of the climate. It roughly reflects biological productivity of zonal soil types, as crop yield depends on soil fertility, and characterizes the favorability of the climate. This allows determining the potential value of the *climatic index of biological productivity of vegetation cover* for a natural system at $GCAT_i$ = 1.00 using formula 31:

$$PCIBPP_i = [100 \cdot (\sum SBCT_i > 10^oC\ /1000], \qquad (31)$$

The ratio of the *climatic index of biological productivity of vegetation cover* ($CIBPL$) to the potential value of the climatic index of biological productivity of vegetation cover ($PCIBPP_i$) of a natural system is characterized by the indicator of the *climatic index of biological productivity of vegetation cover* ($CIBPP_i$), which is calculated using formula 32:

$$CIBPP_i = CIBPL / PCIBPP_i, \qquad (32)$$

Thus, the climatic index of biological productivity of landscapes $CIBPL_i$ is determined based on the relative value of the climatic index of biological productivity of vegetation cover ($CIBPP_i$) and the relative energy consumption for soil formation ($\cdot\ CEPS_i$) using formula 33:

$$CIBPL_i = \sqrt[2]{CIBPP \cdot CEPS_i}, \qquad (33)$$

In order to combine (integrate) various indicators of the ecological productivity of agricultural landscapes based on the energy, bioenergetic, and bioclimatic potentials of a natural system, the desirability function or the Harrington's desirability index is determined using formula 34:

$$DFEPAL_i = \exp\left[-\exp\left(-EPAL_i\right)\right];$$
$$DFBEPAL_i = \exp\left[-\exp\left(-BEPAL_i\right)\right]; \qquad (34)$$
$$DFCIBPL_i = \exp\left[-\exp\left(-CIBPL_i\right)\right],$$

where $DFEPAL_i$ – desirability function of the ecological productivity of agricultural landscapes based on the energy resources of a natural system; $DFBEPAL_i$ – desirability function of the ecological productivity of agricultural landscapes based on the bioenergetic resources of a natural system; $DFCIBPL_i$ – desirability function of the ecological productivity of agricultural landscapes based on the bioclimatic resources of a natural system.

The generalized E. Harrington's desirability function for land resources of agricultural landscapes ($GDFLRL_i$) is calculated using formula 35:

$$GDFLRL_i = \sqrt[3]{DFEPAL_i \cdot DFBEPAL_i \cdot DFCIBPL_i}, \qquad (35)$$

3.4. Methods for Assessing Biological Resources of Agricultural Landscapes

To assess the biological resources of agricultural landscapes, the concept of reference yields proposed by [45,46] is applied. Based on this concept, seven categories of agricultural land yield have been formed: 1) potential yield and 2) climatic yield determined by energy resources; 3) maximum possible yield; 4) actual maximum possible yield; 5) actually possible yield; 6) possible yield, and 7) production and economic productivity of agricultural lands, which are limited by real limiting climatic indicators and agrochemical factors, as part of which methodological support has been developed allowing to determine the logical sequence of trends in the production process of a natural system relative to environmental conditions and agroclimatic materials [47].

The *potential productivity* of agricultural landscapes (PP_i, centners per hectare) is determined using formula 36 [41]:

$$PP_i = FEUF_i \cdot RB_i \cdot 10^8/4{,}19 \cdot CVOMY_i \cdot 100, \qquad (36)$$

where RB_i – radiation balance of the active surface of the near-ground layer of air and soil, kJ/cm²; $FEUF_i$ – coefficient of free energy utilization: $FEUF_i = PURRB_i/100$; $PURRB_i$ – coefficient of utilization of active photosynthetic radiation by plants in agricultural lands, equal to 1.0%; $CVOMY_i$ – calorific value of a unit of organic matter yield in landscapes, 4100 kcal/kg; 4.19 – conversion factor from kcal/kg to kJ/kg; 100 – conversion factor for centners per hectare (c/ha).

The *climatic potential productivity* of agricultural landscapes (CPP_i, c/ha), which will be limited by one of the uncontrollable factors of a natural system — the temperature regime of the soil and vegetation cover — is calculated using formula 37 [47,48]:

$$CPP_i = PP_i \cdot FT, \qquad (37)$$

where FT_i – the function of temperature influence: $FT_i = \sum SBCT_i > 10^oC\,/\,[0.5\,(\sum SBCT_{maxi} > 10^oC + \sum SBCT_{mini} > 10^oC)]$, $\sum SBCT_i > 10^oC$ – sum of biologically active mean daily air temperatures in a given year; $\sum SBCT_{maxi} > 10^oC$ – maximum value of biologically active average daily air temperatures required for forming vegetation biomass; $\sum SBCT_{mini} > 10^oC$ – minimum value of biologically active average daily air temperatures required for forming vegetation biomass.

The *maximum possible productivity* (MPP_i, c/ha), given the limitation of energy consumption for soil formation, is calculated using formula 38:

$$MPP_i = CPP_i \cdot FW_Q, \tag{38}$$

where FW_Q – the function of the influence of energy consumption for soil formation and agricultural productivity: $FW_Q = \{exp[-(1 - F_Q)]\}$, where F_Q – the function of potentially possible utilization of the radiation balance: $F_Q = [exp(-\alpha \cdot RDI_i)]/[exp(-\alpha)]$; α – indicator of completeness of radiation energy use in soil-forming processes, numerically equal to 0.47; RDI_i- "radiation dryness index," or a complex hydrothermal index.

The actual maximum possible productivity ($RMPP_i$, c/ha) of agricultural landscapes, under conditions limited by agrometeorological factors of soil and vegetation moisture supply, can be determined using formula 39:

$$RMPP_i = MPP_i \cdot FW_i, \tag{39}$$

where FW_i – the dimensionless function of the influence of moisture conditions on crop productivity (moisture coefficient), which is determined using formula 40:

$$FW_i = 1 - \left[1 - \left(TWCAL_i/TWCAL_{opti}\right)\right]^2, \tag{40}$$

where $TWCAL_i$ – total water consumption of agricultural lands; $TWCAL_{opti}$ – optimal total water consumption of agricultural lands.

Actual possible productivity (RPP_i, c/ha) of agricultural landscapes is limited by the degree of soil salinization and is calculated using formula 41:

$$RPP_i = RMPP_i \cdot exp[-k \cdot (SCS_i/MPSS_i - 1)^b], \tag{41}$$

where SCS_i – salt content in the soil; $S_{доп}$ – maximum permissible level of soil salinization ensuring the maximum possible productivity of agricultural lands; k – parameter characterizing plant sensitivity to toxic salts; b – parameter characterizing the type of soil salinization.

Possible productivity (VP_i, c/ha) of agricultural landscapes is limited by the level of natural soil fertility and the application of mineral fertilizers. It is determined using formula 42 by [45]:

$$VP_i = RPP_i \cdot FW_{Gum} \cdot FW_{\varepsilon f}, \tag{42}$$

where FW_{Gum} – the function of the influence of soil humus content on landscape productivity: $FW_{Gum} = \{\cdot\, exp[-\,(1 - F_{Gum})]\}$; F_{Gum} – the ratio of humus content in soil to its optimal value for crop cultivation, expressed in relative units: $F_{Gum} = HC_{mi}/HC_{opti}$, where HC_{mi} – humus content in soil, %; HC_{opti} – humus content in soil ensuring high crop yields depending on soil type, %; $FW_{\varepsilon f} = \{exp[-(1 - F_{NKP})]\}$ – generalized function of the efficiency of applying mineral fertilizers for agricultural lands, calculated according to the J. Liebig's principle, i.e. the law of minimum expressed as: $FW_{\varepsilon f} = min[FW_N, FW_P, FW_K]$; F_{NKP} – the ratio of the content of mineral fertilizers in the soil to their optimal values for crop growth, expressed in relative units [48].

Production and economic productivity of agricultural lands (PEP_i, c/ha) for various types of agricultural landscapes is limited by the actual level of technological risk inherent in the organizational and economic activities of agricultural enterprises and is determined using expression 43:

$$PEP = VP \cdot CTR, \tag{43}$$

where CTR – coefficient characterizing the level of technological risk inherent in organizational and economic activities; PEP – production and economic productivity of agricultural lands, c/ha.

The *desirability function* or *Harrington's desirability index* for an individual parameter of biological resources, by categories of agricultural land yield, is expressed as follows (44):

$$\begin{aligned} DFCPP_i &= \exp\{-exp[-(CPP_i/PP_i)]\}; \\ DFMPP_i &= \exp\{-exp[-(MPP_i/PP_i)]\}; \\ DFRMPP_i &= \exp\{-exp[-(RMPP_i/PP_i)]\}; \\ DFRPP_i &= \exp\{-exp[-(RPP_i/PP_i)]\}; \\ DFVP_i &= \exp\{-exp[-(VP_i/PP_i)]\}; \\ DFPEP_i &= \exp\{-exp[-(PEP_i/PP_i)]\}, \end{aligned} \tag{44}$$

where $DFCPP_i$ – desirability function of the *climatic potential productivity* of agricultural landscapes; $DFMPP_i$ – desirability function of the *maximum possible productivity* of agricultural landscapes; $DFRMPP_i$ – desirability function of the *actual maximum possible productivity* of agricultural landscapes; $DFRPP_i$ – desirability function of the *actual possible productivity* of agricultural landscapes; $DFVP_i$ – desirability function of the *possible productivity* of agricultural landscapes; $DFPEP_i$ – desirability function of the *production and economic productivity* of agricultural landscapes.

The generalized E. Harrington's desirability function for biological resources of agricultural landscapes ($BRAL_i$) is calculated using formula 45:

$$BRAL_i = \sqrt[6]{DFCPP_i \cdot DFMPP_i \cdot DFRMPP_i \cdot DFRPP_i \cdot DFVP_i \cdot DFPEP_i}, \tag{45}$$

3.5. Methods for Assessing Water Resources of Agricultural Landscapes

The assessment of water supply of territories and population within river basin catchments is methodologically complex. and is associated with the formation of a research base on the basis of long-term information and analytical data on hydrological regimes of rivers and water use organization, conditioned by various factors influencing the formation and utilization of water resources [49].

In global practice, the *sustainability index* (SI_i) is used to assess water supply across economic sectors. It is represented by equation 46 [50]:

$$SI_i = WIV_i/RWR_i, \tag{46}$$

where WIV_i – volume of water taken from natural sources, km^3; RWR_i – volume of available water resources, km^3.

According to the *World Water Assessment Programme* ($WWAP$), to determine the level of water supply in river basin catchments, the term *"water stress"* (WS_i) is widely used, calculated using equation 47 [51]:

$$WS_i = (WIV_i/RWR_i) \cdot 100, \tag{47}$$

where WIV_i – volume of water taken from water sources, km^3; RWR_i – volume of available renewable water resources, km^3.

An important characteristic used to analyze the distribution of water resources within river basins is the water resources utilization factor ($WRUF$) calculated using equation 48 [52]:

$$WRUF_i = FWC_i/RWR_i, \tag{48}$$

where FWC_i – total water consumption, km^3; RWR_i – volume of renewable water resources, km^3.

One of the most common approaches for assessing *water supply of population* in European practice is the M. Falkenmark's criterion (CMF_i, m^3 per capita/year), calculated using equation 49 [53]:

$$CMF_i = RWR_i / PS_i, \tag{49}$$

where RWR_i – volume of renewable water resources, m^3; PS_i – number of people living in the given territory, persons.

In assessments of *water supply of population* within river basin catchments, *specific water supply per capita* ($SWSP_i$, thousand m^3 per capita/year) is traditionally used, calculated using equation 50 [54]:

$$SWSP_i = RWR_i / PS_i, \tag{50}$$

where RWR_i – volume of renewable water resources, thousand m^3; PS_i – number of people living in the given territory, persons.

In assessments of *territorial water supply* in river basin catchments, the *specific water supply of the territory* ($SWST_i$) is traditionally used, calculated using equation 51 [55]:

$$SWST_i = RWR_i / CARB_i, \tag{51}$$

where RWR_i – volume of available water resources, km^3; $CARB_i$ – area of the river basin catchment, km^2.

A new approach to the *integrated assessment* of water supply of both population and territories within river basin catchments is the comprehensive index of specific water supply supply ($CISWS_i$) calculated as the geometric mean of the indicators using formula 52 [56]:

$$CISWS_i = \sqrt{SWP_i \cdot SWST_i}), \tag{52}$$

where $SWP_i = RWR_i / PS_i$ – specific water supply per capita, km^3/person; $SWST_i = RWR_i / CARB_i$ – specific water supply of territories, km^3/km^2.

Based on the structural and system analysis of *integral criteria and indicators* corresponding to the requirements of E. Harrington's desirability function, the following indicators were selected for further use in assessing the *water supply* of river basin territories: the *sustainability index* (SI_i), the *water resources utilization factor* ($WRUF$), the index of specific water supply of population – M. Falkenmark's criterion (CMF_i), the index of specific water supply of territories ($SWST_i$), and the comprehensive index of specific water supply ($CISWS_i$). It should be noted that the *sustainability index* (SI_i) and the *water resources utilization factor* ($WRUF_i$) are *dimensionless values* with fixed limits ranging from 0 to 1, while the index of specific water supply of population – M. Falkenmark's criterion (CMF_i), the index of specific water supply of territories ($SWST_i$), and the comprehensive index of specific water supply ($CISWS_i$) require conversion into a unified *dimensionless numerical scale* with fixed limits from 0 to 1.

To determine the *relative values* of individual indicators of water supply of population (CMF_i) and territories ($SWST_i$), as well as the value of the comprehensive index of specific water supply ($CISWS_i$), the corresponding transformations were performed within the framework of the *coded values* of individual parameters, i.e., their values were expressed in a conditional scale:

– relative index of water supply of population ($RCMF_i$): $RCMF_i = CMF_i / 20\,000$, where 20 000 represents a high level of specific water supply of population, m^3 per capita/ year;

– relative index of water supply of territories ($RSWST_i$): $RSWST_i = SWST_i / 80\,000$, where 80 000 represents a high level of specific water supply of territories, m^3 per km/year;

– relative comprehensive index of specific water supply of territories and population ($RCISWS_i$): $RCISWS_i = \sqrt{RCMF_i \cdot RSWST_i})$.

One of the tools for *encoding* particular indices of water supply is the so-called desirability function proposed by E. Harrington, expressed as (53):

$$\begin{gathered} DFSI_i = \exp[-exp(-SI_i)]\,; \\ DFWRUF_i = \exp[-exp(-WRUF_i)]; \\ DFRCMF_i = \exp[-exp(-RCMF_i)]; \\ DFRSWST_i = \exp[-exp(-RSWST_i)]; \\ DFRCISWS_i = \exp[-exp(-RCISWS_i)], \end{gathered} \tag{53}$$

where $DFSI_i$ – desirability function for the *sustainability index*; $DFWRUF_i$ – desirability function for the *water resources utilization factor*; $DFRCMF_i$ – desirability function for the specific water supply of population; $DFRSWST_i$ – desirability function for the specific water supply of territories; $DFRCISWS_i$ – desirability function for the comprehensive index of specific water supply of territories and population.

The generalized desirability function for water resources is calculated based on particular desirability functions as follows:

$$GFDWR_i = \sqrt[5]{DFSI_i \cdot DFWRUF_i \cdot DFRCMF_i \cdot DFRSWST_i \cdot DFRCISWS_i}, \tag{54}$$

Based on the generalized desirability functions of climatic resources ($GDFCR_i$), soil resources ($GSRDF_i$), land resources ($GDFLRL_i$), biological resources ($BRAL_i$) and water resources ($GFDWR_i$), the generalized desirability function of the natural resource potential of agricultural landscapes is determined using expression 55:

$$GFDNRPL_i = \sqrt[5]{GDFCR_i \cdot GSRDF_i \cdot GDFLRL_i \cdot BRAL_i \cdot GFDWR_i}, \tag{55}$$

The application of the presented methodology for assessing the natural resource potential of agricultural landscapes using the Harrington's desirability function in the form of an algorithm developed by the authors and based on the calculation of climatic, soil, land, and biological resource indicators of a natural system, makes it possible to eliminate their isolation and provides the following advantages:

– first, the results of the analysis and qualitative assessment are based on generally recognized indices of natural resource potential;

– second, the results of the analysis and assessment of natural resource potential are *determined quantitatively* and can be used for the *territorial organization of agricultural production*;

– third, the obtained results can be used for the *implementation of the algorithm for assessing the natural resource potential of agricultural landscapes* on digital platforms.

4. Conclusions

Thus, the distinctive features of the methodology and algorithm developed by the authors for assessing the natural resource potential of agricultural landscapes using the Harrington's desirability function are as follows:

– a difficult, complex and multiparametric task requiring the consideration of a wide range of diverse factors and the continuous improvement of assessment methods on the basis of a systemic approach based on the materialistic theory of scientific knowledge, within the framework of natural science concepts in the context of the triad of ecology (as the basis of life on Earth), economics (as a resource of economic activity) and society (as an important condition for maintaining public health;

– a new methodological approach to assessing the natural resource potential of agricultural landscapes, which is based on the qualimetric assessment of particular natural resource indicators using the mathematical tools of the Harrington's generalized desirability function, which allows converting actual parameter values to a uniform dimensionless numerical scale with fixed boundaries from 0 to 1, followed by the conversion of *particular quantitative scales* into *generalized quality criteria scales*;

– increase in the accuracy of predictive and retrospective calculations due to the use of multiparametric models of individual natural resource factors, based on the search for modern and innovative mathematical tools, which arises when solving multicriteria problems and is associated with the *multilevel nature of the system of particular criteria*, their *nonequivalence*, and the *need for simultaneous accounting for quality indices specified both quantitatively and qualitatively*;

– the Harrington's desirability function, applied to the assessment of the natural resource potential of agricultural landscapes and based on mathematical models of individual natural resource indicators, serves as a mathematical tool that requires, *first*, the classification of all analyzed natural resource factors by their areas of application, determining their most specific "niches"; *second*, the compilation of the complete set of generalized comparison parameters for each of such niches; *third*, the substantiation of the number and quality of these parameters; and *fourth*, continuous improvement of the methodology for assessing natural resource factors on the basis of the materialistic theory of scientific knowledge;

– the algorithm for assessing the natural resource potential of agricultural landscapes has the following advantages: 1) it is a quantitative value expressed as a single number, that is, it is uniform; 2) it is single-valued, that is, a given set of individual natural resource parameters of natural resource assessment corresponds to a single function value; 3) it provides a simple and universal way of transforming natural resource indicators using the desirability scale for all criteria.

Author Contributions: Conceptualization, Aidos Omarov, Zhumakhan Mustafayev and Gulnar Aldazhanova; methodology, Aidos Omarov, Zhumakhan Mustafayev and Irina Skorintseva; software, Aidos Omarov, Zhumakhan Mustafayev and Irina Skorintseva; validation, Aidos Omarov, Zhumakhan Mustafayev and Gulnar Aldazhanova; formal analysis, Aidos Omarov, Zhumakhan Mustafayev, Irina Skorintseva and Askhat Toletayev; investigation, Aidos Omarov, Zhumakhan Mustafayev, Gulnar Aldazhanova and Askhat Toletayev; resources, Aidos Omarov and Zhumakhan Mustafayev; data curation, Aidos Omarov, Zhumakhan Mustafayev, Amanzhol Kuderin and Askhat Toletayev; writing – original draft preparation, Aidos Omarov and Zhumakhan Mustafayev; writing—review and editing, Aidos Omarov, Zhumakhan Mustafayev, Gulnar Aldazhanova and Amanzhol Kuderin; visualization, Aidos Omarov and Zhumakhan Mustafayev; supervision, Amanzhol Kuderin and Askhat Toletayev; project administration, Askhat Toletayev; funding acquisition, Amanzhol Kuderin.

Funding: This research has been funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP 26194635- "To develop landscape support for the organization of agricultural nature management in the Abay region for the purposes of sustainable development") (2025-2027).

Data Availability Statement: Data will be made available on request. For requesting data, please write to the corresponding author.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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