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MANAGEMENT OF AGRO-RESOURCE POTENTIAL FOR AGRICULTURAL LANDSCAPE STABILITY INCREASE

Evgeny V. Kuznetsov, Anna E. Khadzhidi*, Kharlampiy I. Kilidi and Arsen N. Kurtnezirov

Department of Hydraulics and Agricultural Water Supply, Kuban State Agrarian University named after I.T. Trubilin, 350044, Kalinina str., 13, Russian Federation.

Abstract

They obtained the resource model of the agrolandscape - an averaged natural-anthropogenic environment based on the integral indicator of risks, which determines the meliorative state of the agrolandscape soil. They developed the methodology to manage the agro-resource potential, and the resource model in the form of a dimensionless integrated risk indicator that provides the control over the sustainable development of agro landscapes. Agro-landscapes are represented as a grid of taxa, the agro-resource potential is represented by the monitoring at the key points of taxa on electronic maps in the Google system. The taxon is determined by a vector in a linear rated space. The model is imitational and resource one, because it combines the indicators of the meliorative state of soils of different nature via dimensionless indicators. An integrated risk indicator can be used in the processing of environment monitoring data, it controls the change of resources and manages the risks of resource components using the risk safety scale.

The results of the research are used for the development of technological maps to perform works, for example, to eliminate the flooding of agrolandscapes and to select the reclamation techniques for excess water removal from fields, depending on the type of flooding. The develop standard schemes on computer maps to carry out the works preventing the degradation of agricultural landscapes.

Key words : Model, resource, potential, agrolandscape, fertility.

Introduction

The most valuable property of mankind is natural resources, which are exposed to various influences from the participants of nature management. The most accessible ones are the land resources, fully involved in economic turnover, the state of which can be comprehensively defined by the agroresource potential (ARP). The problem of natural resource rational use is determined by the globalization and the integration of production in environmental management (Golovanov *et al*., 2015). To maintain resources in a sustainable state, it is necessary to develop new technologies to recycle production waste and the approaches to control and manage the environment quality. In agriculture, liquid wastes are the most common ones. The wastes from enterprises in the form of insufficiently purified industrial effluents cause large-scale contamination of agrolandscapes, ground and surface waters, rivers and reservoirs, which are the main source of irrigation and fish farming, but they are not suitable for this purpose because of water pollution.

The agroresource potential is determined by the meliorative state of soils (MSS), which is associated with natural and technogenic processes (NTP) in agrolandscapes. An uncontrolled use of RAT during crop growing affects soil fertility, which ultimately leads to the planned harvest loss. It is necessary that the effect of RAT application is aimed at risk elimination: the occurrence of an adverse event probability - flooding, salinization, the reduction of macroelements, soil humus, etc. The ARP condition can generally be assessed by an integrated risk indicator, including a certain set of private risks.

The management of agro landscape sustainable development can be carried out using the quantitative values of the integrated risk index in the form of meliorative state of soils as a direct link, and resource-

***Author for correspondence :** E-mail : dtn-khanna@yandex.ru

saving adapted technologies as a feedback.

The intensification of agricultural production in the conditions of natural and technogenic factor constant change requires the improvement, the development and the research of new resource-saving and adapted technologies aimed at land resource productivity increase, soil fertility preservation, where one of the main conditions for the sustainable development of agro landscapes with continuous improvement of land resource quality will be the methodology of ARP control and management, ensuring resource preservation and replenishment. The aim of the research is the methodology of agro-resource potential management on the averaged natural and anthropogenic environment, and the development of a resource model in the form of a dimensionless integral risk indicator that provides control over the reclamation state before and after the application of resource-saving and adapted technologies for the sustainable development of agro landscapes.

To manage ARP, it is necessary to develop resource integrated models, using which it is possible to determine the quantitative state of the resource for technological operation selection to restore and protect agro landscapes from degradation. Models should be imitating and resource, modeling the indicators of meliorative state of soils of different nature using the dimensionless indicators that determine a resource state.

During the development of integrated risk indicators, it is necessary to take into account the energy state of agro landscape resources, and control the change in resources during environment monitoring data processing, and to manage resource-saving and adapted technologies (RAT) and resource components by risk safety scale.

Literature Review and Analysis

Climate change on the planet requires a constant perfection in the development of ARP methodology evaluation, new systems to monitor and manage the processes in agriculture. Over the past 30 years there has been the redistribution of precipitation within a year in the south of Russia, during the autumn-winter period, their amount increased by 10% on the average with a constant average perennial annual precipitation rate (Kuznetsov and Khadzhidi, 2014) and thus, the degradation process increased caused by flooding and waterlogging, soil erosion and agrolandscape contamination. The pollution of territories leads to socio-economic risk increase, which requires the development of land degradation prediction methods (Yiang *et al.*, 2014) and affects the population health (Khan *et al.*, 2017). Bioenergy methods are used to assess the ARP of agrolandscapes. They are used usually to control the land resources of the territories (Kolmykov, 2011). It is proposed to carry out a comprehensive energy assessment of the territories according to 9 technical, economic and environmental indicators. The disadvantage of the methodology is the informational nature of environmental indicators. A positive aspect of this method is the energy approach, which in our opinion reflects the climate resource change, which is important for the development of agroclimatic zoning methods to cultivate different crops both in mountainous conditions (Seperteladze *et al.*, 2015) and also in other areas (Kalmykov, 2012). There are the methods of ARP management for wetlands in a modular way (Yu Tarariko *et al.*, 2017). This method allows to consider the geosystem in the form of separate averaged sections (modules), which simplifies the automation of control over the processes and to computerize the management of the system.

The dynamics of land fertility loss requires a constant increase of energy costs to reduce the deficit of ARP, and this leads to harvest cost increase (Safronova *et al.*, 2015). Conservation of ATM can be addressed by an integrated approach for timely information obtaining on the dynamics of processes using simulation models and integral indicators of resource state change, a justified choice of RAT to eliminate the negative consequences on agricultural landscapes (Khadzhidi *et al.*, 2015). They developed the methods to monitor land protection, which apply the scales in the form of risk environmental assessment (Kuznetsov *et al.*, 2017), which allow to establish the initial state of the agrolandscape. It is convenient to use scales and indices of various indicators to select management methods reducing the negative consequences on resources.

The methodology has been developed for the protection of lands that makes it possible to assess the various levels of agrolandscape meliorative state. There are potential models for soil contamination risk evaluation, based on the Monte Carlo simulation (Zhou, Qing, 2014; Jansons, 2012). They developed the conceptual approaches to protect agricultural lands against the risks of agrotechnology use (Khadzhidi, 2010) and the methods for agrolandscape agro-resource potential management (Safronova *et al.*, 2015).

The analysis of literary sources shows that it is necessary to improve the management of ARP by energy and complex methods for the sustainable development of agrolandscapes. In order to preserve soil fertility under climate change conditions, it is necessary to create more advanced systems for the sustainable development of agro landscapes with a continuous improvement of land resource quality, where the methodology for ARP quantitative indicator management should be an important element, which will ensure the conditions for resource conservation and replenishment.

Research Methodology

Object and tools

The degraded agricultural landscapes (from flooding and waterlogging, water erosion, waste from enterprises, etc.) are considered as the object of the study, where it is necessary to restore the ARP first of all and then the agro-resource potential of agrolandscapes via resource-saving and adapted technologies (RAT). The representation of the agrolandscape in the form of an averaged natural-anthropogenic environment (quasi-agrolandscape) makes it possible to abstract the subject of research in the form of the agrolandscape computer model, as well as the possibility of a real object adequate replacement by different models, to study the relationship between controlled parameters (groundwater level, macroelements, humus, ph, etc.) and managing natural and anthropogenic factors, where the management response is the agro-resource potential in the form of resource estimate according to the integrated risk indicator (IRI).

They distinguish the areas of agrolandscapes with the same morphology of relief, typical vegetation and identical PTP are distinguished within the boundaries of the massif, which can be considered a "quasi model of the agrolandscape with an averaged natural-anthropogenic resource" (model). The violation of the agrolandscape stability occurs under the influence of natural and anthropogenic factors. In order to estimate MSP, a resource method is used, which is based on PTP simulation with the provision of information on IRI at the tops of the taxon on the Google electronic map in the form of GPS coordinate point system.

Research Methodology

Monitoring establishes the boundaries of the study area - the model that requires MSP improvement. The monitoring can be represented by the following: the groundwater level (GWL); the content of macroelements, humus, etc. in the horizon A, MSP indices of the agrarian landscape, depending on a research task formulation.

The model of a site is divided into taxa - the discrete objects of the agrolandscape. The number of taxa depends on the size of the agrolandscape studied area and cell size. The information is collected at the node points of the taxon - the vertices - and fixed by the coordinate system to create a resource model of the agrolandscape - an averaged natural-anthropogenic environment.

They study the energy status of land resources at the tops of the taxon according to MSP, which is used to identify common properties and the signs of the agrolandscape and an adequate comparison between each other. The boundaries of the averaged resource environments of the agrolandscape are established according to the energy status of the "taxa".

Substantiation of the resource model and the integral risk indicator

In order to develop the resource model and IRI the scientific developments of scientists were applied (Golovanova A.I., Kuznetsova E.V. and Khadzhidi A.E.).

The model represents the computer program that includes private management risks for MSP to obtain the information on agro landscape resource state according to IRI.

The development of a resource risk model is carried out in 4 stages.

The first one is the identification of risks during the cultivation of crops. The main risks of technology use aimed at ARP preservation are the following ones:

- the irrigation of agricultural crops with mineralized waters, causing the salinization of the arable soil horizon;
- the irrigation of agricultural crops with sewage, which does not provide a positive ecological effect during their disposal;
- the elevation of GWL during the impact of anthropogenic factors on the natural environment (an excessive irrigation norm, the choice of irrigation technology);
- the decrease of soil fertility due to secondary salinization of the root layer, flooding and overmoistening and agrolandscape drying out;
- the decrease of agrolandscape soil fertility during the contamination by toxic salts coming in with irrigation water;
- the decrease of soil fertility due to the removal of nutrients by crops;
- the deterioration of the general agro-landscape MSP, which can lead the system to an ecological disaster;
- the contamination of lands with heavy metals.

The second stage is the substantiation and the choice of the safety risk scale (SRS) with the characteristics of natural processes within the accuracy of observations -

the model check for adequacy.

The third stage is the study of the formulated problem. The main thing here is the direct problem solution - the obtaining of process indices for their further comparison with the results of the studied phenomenon observations.

The fourth stage is the analysis and the modernization of the model due to the accumulation of studied phenomenon data.

When they study the ARP of the agrolandscape, the energy approach is used to maintain the balance of matter in the soil.

Study Results

Theoretical justification of matter energy change

Let's assume that ARP control is possible by the intensity of the substance energy flux, *i.e.* by substance energy change due to the dynamics of macro and microelement, humus and other chemical element content in soil, and in particular at the node points of a taxon. Therefore, it can be assumed that the energy resource state of the agrolandscape is determined by MSP. We assume that the substance energy acts perpendicular to the taxon surface. When the energy of the substance is exposed to the taxon, the risks of the agro-landscape MSP change appear. The change in the energy state of a taxon is determined by the energy flow intensity. The greater the energy flow intensity change per agrolandscape unit (taxon), the greater the risks arising from the use of RAT.

With the normal energy direction to a taxon surface, we obtain the following equations:

$$e = f(S,T) = \frac{\partial^2 E}{\partial T . \partial S}, \quad (1)$$

or for any point of the taxon in a geographical position relative to the energy flow:

$$e = f(S,T) = \frac{\partial E}{\partial S} . \frac{\partial E}{\partial T} cos\,\alpha \quad (2)$$

where, e is the intensity (the density) of the matter energy flow within the taxon;

S is the unit area of the taxon;

T - the interval (the period) of the time the energy acts on taxon;

E - the energy component of the matter flow;

δE/δS is the derivative of the specific energy at the point (taxon node);

δE/δT is the derivative of the flow instantaneous energy;

a - the angle of energy flow deflection from the taxon normal.

The angle of the energy flux deviation from the taxon normal is closer to the equator of the Earth and makes almost zero. In this case, cos a = 1 in (2).

The function e = f(S, T) is a theoretical description of the resource model serving as an integral evaluation of the IRI during the period of natural and anthropogenic factor impact on the agrolandscape. The weakening or the intensification of the matter energy flux in the agrolandscape leads to MSP change.

Problem solution

According to equations (1) and (2) the energy of matter at the point of the taxon depends on the "weight" of the components and its main elements.

The assumptions are made during the development of the resource model.

1) A taxon is represented by the vector whose energy component is determined by a finite number of parameters (risks) on the averaged natural-anthropogenic environment of the agrolandscape.

2) The instantaneous energy of the substance flow changes in the taxon node, as can be seen from (1) and (2).

3). During the integrated risk assessment, the additivity principle of the substance flow energy on the agrolandscape is taken into account.

Taking into account the assumptions about the effect of the flow intensity on the taxon, let's establish the value of the substance E_n total energy, which determines the SMP for a certain time interval, and which can be estimated from the following expression:

$$E_n = \int \left[\int e(\zeta, t)\, dt \right] d\zeta, \quad (3)$$

Where, e is the intensity of the substance energy flow;

ς is the relative area of the taxon exposed to the energy flux of the substance;

the time of the energy flow action on the taxon.

It follows from (3) that the energy of the substance En integrates the variation of simultaneously arising risk n in space and by the duration of their action on the taxon surface during a certain time period.

Let's establish the basic properties of integral assessments concerning the danger of the agrolandscape taxon degradation under the action of matter energy change.

1) The assessment of a taxon degradation danger is considered as an adequate if all risks are presented in a dimensionless and a relative weight form.

2) The assessment of taxon degradation danger increases linearly with a proportional increase of risk weight in the taxon nodes.

3) A single integral energy flux of matter (3) acts in the taxon node, i.e., the IRI is determined on the taxon node.

4) Taxon are considered equivalent by IRI, if the risks have the same weight values.

Taking into account the additivity of the agrolandscape area, we perform an estimate of the taxon vector under the influence of the total energy of the matter flow of matter in the node. A vector estimate is determined by its norm - the functional set on a vector space, where the vector field with the norm is a normed space.

Taking into account the accepted assumptions, we have the case of a linear normed space, where any pre-Hilbert space can be regarded as normalized, since the scalar product generates a natural norm:

$$\|x\| = \sqrt{\langle x, x \rangle},\ x \in X, \tag{4}$$

Where, $\|x\|$ is the norm of the x vector space element.

The norm of a vector (taxon) can be determined from the Hölder norm of n-dimensional vectors:

$$\|x\|_p = \left(\Sigma |x_i|^p\right)^{\frac{1}{p}} \tag{5}$$

Where, $p \geq 1$ is a natural number.

Consequently, the danger rate for the taxon from (5) at $p = 1$ will be the following one:

$$\|x\|_1 = \Sigma |x_i|, \tag{6}$$

where x_i is the norm of the element of the x vector space.

In this case, the norm corresponds to the energy flux intensity of the substance e_i. Then it follows from (6) at $x_i = I_i$, where I_i is the risk indicator corresponding to the norm e_i and the simultaneous action of n risk indicators:

$$I_{AP\Pi} = \frac{1}{n}\sum_{i=1}^{n} I_i, \tag{7}$$

where, $I_{AP\Pi}$ is the integral indicator of ARP risks; $\sum_{i=1}^{n} I_i = I_1 + I_2 + ... + I_n -$ the sum of individual risk indicators in the vector space of n risks.

The integrated indicator of ARP risks should strive to a minimum. This condition corresponds to the sustainable development of agrolandscapes. Then, obviously, the following follows from the expression (7):

$$I_{AP\Pi} = \frac{1}{n}\sum_{i=1}^{n} I_i \to I_{min}. \tag{8}$$

The equation (8) can be regarded in the first approximation as a resource integral risk model in a formal form, when the risks have fixed dimensionless quantities reduced to a single indicator, in this case, to a numerical dimensionless indicator that reflects a resource state.

Consequently, on the right-hand side of the expression (8) the risk indicator corresponds to the critical state of the system, i.e. a critical risk indicator I_{cr}, the exceeding of which impedes the agrolandscape stability.

Taking into account the foregoing, the resource risk model takes the following form:

$$I_{AP\Pi} = \frac{1}{n}\sum_{i=1}^{n} I_i \leq I_{\kappa p}. \tag{9}$$

Where, $I_{AP\Pi}$ - an integral, dimensionless risk indicator (risk model) showing the state of the agro landscape ARP;

$I_{\kappa p}$ – the critical dimensionless risk indicator, the exceeding of which leads to an object unstable position;

I_i – a non-dimensional indicator of an individual (i) risk;

n – the number of risk indicators.

The obtained model (9) is imitational and resource one, because it combines MSP indicators of different nature via dimensionless indicators that determine the critical state of the model.

Interpretation of Research Results

The model defines the energy state of geosystem resources and can be used to process environment monitoring data, controls the change of resources and also allows you to manage the ARP components via RAT.

When you solve a problem, it is necessary to establish the types and the parameters of I_i indicators, their sufficiency and the need to manage ARP. The most convenient tool is the formation of scores in the form of scales, in particular, risk scales (Zhou, Qing, 2014; Kuznetsov *et al.*, 2017; Khan *et al.*, 2017).

Creation of ARP safety scales for agrolandscapes

The meliorative state of agrolandscapes is conditioned by a large number of different indicators. During the study of MSP, it is necessary to establish the key indicators that characterize PTP. They use the indicators characterizing the destructive power of PTP as the measures of danger. These indicators form the basis of the “safety risk scales” (SRS).

Each MSP indicator determines the discrete state of ARP agrolandscape and has the dimension different from the rest indicators. For example, irrigation can result in waterlogging of agricultural landscapes from the rise of mineralized groundwater level (the risk of flooding) and cause secondary salinization of lands (land salinization risk). The irrigation of crops with treated waste water (WW) is the rational use of water resources and fertilizer saving on the one hand, but on the other hand the irrigation with insufficiently purified WW is the risk that can lead to soil contamination and an agricultural landscape degradation.

Consequently, the risks are not unique, have different nature, energy and are expressed by certain physical quantities. Therefore, the MSP indicators should be reduced to a single dimensionless (point) indicator of the risk measure for the integrated assessment of ARP on agro landscapes and in the resource model.

The risk system should be necessary and sufficient to meet the requirements of RAT safe application and the sustainable development of agricultural landscapes. The number of risk indicators for MSP evaluation risk depends on the degree of detail, the purpose of the study and the applied technologies.

It should be noted that the development of score scales requires the psychophysical analysis of indicators, which depends on the number of expert assessments during the study of each indicator. The thesis of indicator “necessity and sufficiency” follows from this conclusion, which is consistent with the set goal for ARP quantitative assessment.

Risk indicators for ARP management

11 basic indicators have been established in order to protect agro landscapes from degradation, for example, in the case of agricultural irrigation, according to the score “risk safety scale”. These include :

1) The mechanical composition of the arable soil horizon - I_1.

2) The availability of mobile potassium - I_2.

3) The availability of mobile phosphorus - I_3.

4) The availability of hydrolyzable nitrogen - I_4.

5) Humus content - I_5.

6) The acid-base balance of soil (*pH*) - I_6.

7) The degree of soil salinity - I_7.

8) The level of groundwater on the agrolandscape area - I_8.

9) The air-water state of soil - I_9.

10) Agrolandscape flooding area - I_{10}.

11) Groundwater mineralization - I_{11}.

The indicators (I_1 to I_8) are used to control and manage the SMP of the arable soil horizon, and the indicators (I_6, I_8 to I_{11}) are used to control the protection parameters from agricultural landscape flooding and waterlogging.

The indicators allow us to assess the impact of irrigation reclamation on agricultural landscapes separately, i.e. to establish control over the agro-resource condition, and also to carry out ARP management integrally according to the resource model (9) via RAT. The increase (the detailing) of indicator number in the system of risks can lead to a systemic study error without answering the basic question about the meliorative state of agrolandscapes.

Risk safety scale for RAT application

The costs associated with ARP management depend on the MSP of agro-landscapes. More energy costs are required for degraded agrolandscapes, as compared to the ecological norm, so it becomes necessary to establish a norm (ARP critical condition), the exceeding of which leads to the degradation of agricultural landscapes. The degradation rate is assessed by a critical indicator.

Each of the risks is determined by the score indicator Ii according to four-point scale with an appropriate assessment of the considered parameter state. The indicator risk measure is taken to be 1.0 for an “ideal” state. At $1 < Ii \leq 2$, the ARP status corresponds to the “good” estimate. Consequently, when $Ii > 2.0$, the agrolandscape degrades. For a satisfactory condition, the risk measure will be in the range $2 < Ii \leq 3$ and at $3 < Ii \leq 4$- the agrolandscape is characterized by an unsatisfactory state of the I_{ARP} (the agro landscape is in the process of degradation). At $Ii > 4,0$ - degradation (distress).

Taking into account the number of necessary and sufficient indicators to determine the ARP of agrolandscape, a SIS was developed (table 1).

According to SIS, the mathematical expectation of resource damage is determined, which can appear in one or another SIS interval. The solutions for managing PTP on the agricultural landscape are carried out by individual risk analysis that must not exceed the limits of $I_{iкр}$.

Where, $I_{iПТКАП}$ – the studied indicator of risk, determined by SIS in points;

$I_{iкр.}$ – the critical value of the indicator for this risk, at which the system goes into an unstable state, in points.

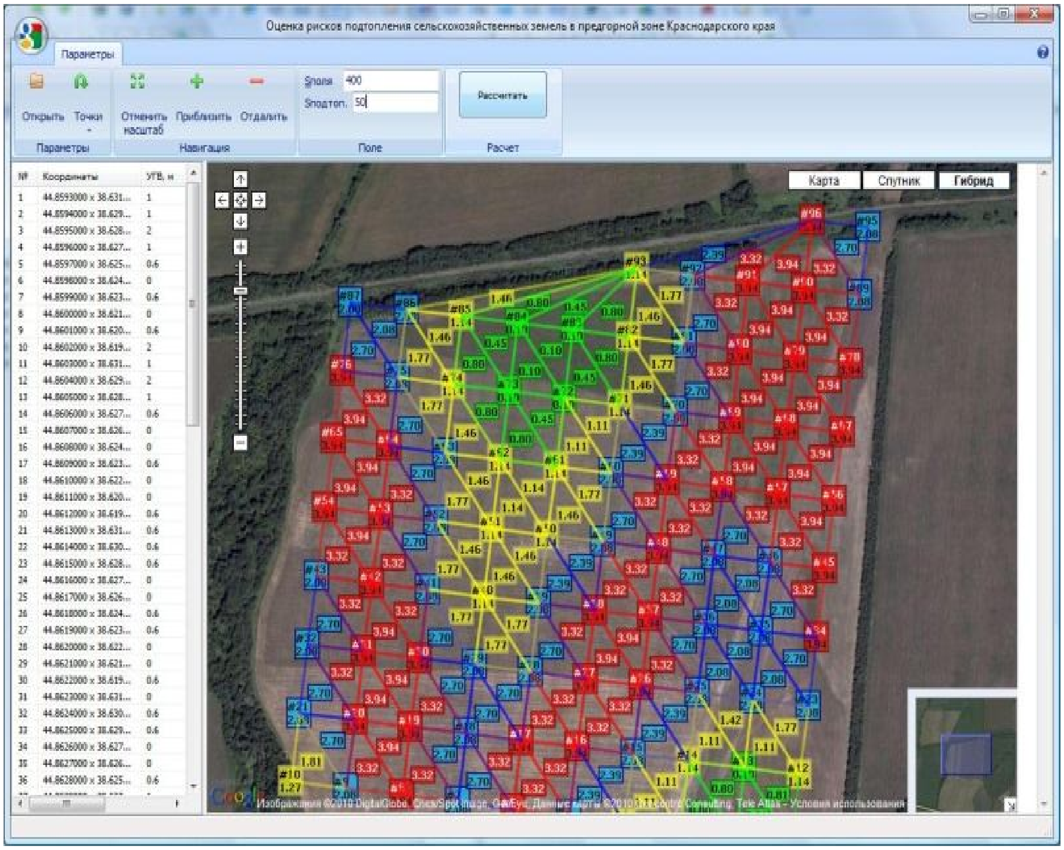

Fig. 1 : MSP model according to SIS.

Table 1 : Risk safety scale.

Risk indicator	**Agrolandscape characteristic**	**MSP evaluation**
$I_i = 1$	Risks are absent	"Ideal"
$1 < I_i \leq 2$	Agrolandscape is not exposed to risks	"Good"
$2 < I_i \leq 3$	Agrolandscape turns into an unstable state	"Satisfactory"
$3 < I_i \leq 4$	Agrolandscape is in critical condition	"Unsatisfactory"
$I_i > 4$	Agrolandscape collapses	"Disaster" (degradation)

Therefore, the assessment of agricultural landscape degradation threat (table 1) should not exceed I_{kr} = 2.0, which determines the "good" (boundary) state of the agrolandscape ARP.

The parameters of the agrolandscape resource model are fixed at each point of an electronic map by the coordinates in GPS system. An integral risk indicator is displayed in point coordinates and compared with a critical integrated indicator. This allows the program to display the initial real situation of agrolandscape ARP.

The program on the loaded map within the studied area simulates the resource boundaries of sites with different amelioration condition of the agro landscape and with the indication of area size according to the relevant estimates of SIS (table 1). The model displays the field sites according to the agro-landscape MSP and the integral indicator $I_{АРП}$ (9):

- green (1-2) - good;
- yellow (2-3) - satisfactory;
- blue (3-4) - unsatisfactory;
- red (>4) - disaster (degradation).

The area under study of 82.39 hectares is heterogeneous according to ARP.

Thus, we obtain the simulation model of the agrolandscape (figure 1).

The result of the study is the simulation model of the agrolandscape (fig. 1) obtained by processing the input parameters of the monitoring according to (9), showing the visual meliorative state of the agrolandscape, the contours and the sizes of the areas where it is necessary to use RAT to increase the ARP. The electronic resource map indicates the tops of the squares where the sampling was conducted. The results of field study processing using the resource risk model and computer program are displayed on the monitor. The ARP status is presented in Google - on an electronic map with the indication of IRI taxa on tops.

These results require further research, because it is necessary to bring them to the logical form of use. This, first of all, the averaging of the contours to the convenient dimensions of geometric shapes, for example, squares or rectangles, and secondly the number of contours should be reduced to the minimum of 2. This will allow to optimize the complexes of machines to process agro landscapes and to develop standard situations, as well as the composition of the technological operations of RAT to manage the ARP of agro-landscapes.

Summary

They obtained the integral indicator of ARP risks responsible for the sustainable development of agro landscapes, which is considered as a resource integrated risk model in a formal form within the first approximation, when risks have fixed dimensionless values reduced to a single indicator, to a numerical dimensionless indicator that reflects the resource state.

The model should be considered as imitating and resource, because it combines the indicators of the meliorative state of different soils with the help of dimensionless indicators that determine the state of the resource according to the critical risk indicator.

The integrated risk indicator allows you to determine the energy status of agro landscape resources and can be used to process environment monitoring data, and controls the change of resources.

The management of ARP agrolandscapes is carried out using the safety risk scale by resource-saving and adapted IRI technologies.

The resource model is represented by IRI in mathematical terms, and in the form of a computer map that displays the ARP state on the agricultural landscape.

The resource model (IRI) is used during the development of technological maps for the production of works, for example, to eliminate the flooding of agrolandscapes and for the selection of reclamation techniques for excess water diversion from fields, depending on the type of flooding. Computer IRI maps allow the development of standard schemes for the implementation of works to prevent the degradation of agricultural landscapes.

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