Issue of agricultural lands exhaustion and land use planning and methodological approaches as solutions to this problem

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Abstract. The article considers one of the priority issues of global land management and land resources management – agricultural lands exhaustion. It was revealed that agricultural lands exhaustion processes are caused by the absence of a number of organizational and economic mechanism elements in land management, in terms of control over the quality condition and land fertility. In order to improve the agricultural land management system, there was proposed a mechanism composed of a combination of legal, land management and agroecological measures.

The central element of the organizational and economic mechanism for monitoring the processes of agricultural lands exhaustion is the proposed methodological approach of assessing the level of agricultural lands exhaustion and subsequent estimation of monetary value of the economic damage caused by the identified processes of agricultural lands exhaustion. Economic calculations of the cost for soil fertility factors restoration up to their optimal parameters are composed of calculation of differential rent values in terms of fertility and location of the investigated and reference soil being capitalized taking into account the standard period of capitalization in agriculture. The monetary value of the economic damage caused by the identified processes of agricultural lands exhaustion is determined as the difference between the values of capitalized rent for the investigated and reference soil.

1. Introduction

One of the main global problems of modern land management is the issue of agricultural lands exhaustion. Thus according to the report “The State of the World’s Soil Resources” of the Food and Agriculture Organization of the United Nations (FAO) published in 2015, 33% of the world's soil resources degraded to a moderate or high degree, and an expert assessment of the world's soil resources characterizes most of them as being in satisfactory, poor and very poor condition [1].

Among the main factors of negative changes in soil cover experts indicate population growth, together with economic growth, which entails more active urbanization processes and climatological changes. To date more than 35% of land is used as resource land for agricultural production, most of which was brought into use by means of destruction of natural vegetation.

In order to prevent further negative environmental processes in relation to world soil resources and acting in line with the framework of the concept of sustainable land use, participants of the UN meeting on the occasion of World Soil Day drew up a list of framework priority measures. Their implementation requires the development of an effective environmental policy of all countries of the world.
In this regard, the most relevant solution to the identified problem at the level of a certain region or country should be the development and implementation of an organizational and economic mechanism that combines a range of legal, land management and environmental measures, including a methodological approach for determination of the agricultural lands exhaustion level, as well as measures aimed at prevention and minimization of both the phenomenon itself and the consequences of agricultural lands exhaustion.

2. Models and Methods
The object of research when studying the issues of agricultural lands exhaustion is soil as an element of the landscape that is most actively used in agricultural production.

The study of agricultural lands exhaustion issues is currently of an interdisciplinary nature. However for the purpose of this phenomenon study the main aspects are: the environmental, economic and social.

2.1. Prerequisites of the economic aspect of the problem study
Currently, the main task of each of the national economies is food security ensuring. In the context of exhaustion of the main means of production in agriculture, the attempts to find solution of this problem are accompanied by great risks.

2.2. Prerequisites of the ecological aspect of the problem study
As agricultural lands exhaustion phenomenon is distributed over vast areas it leads to destabilization and degradation of once sustainable natural ecosystems.

2.3. Prerequisites of the social aspect of the problem study
The synergistic effect of the economic and environmental consequences of agricultural lands exhaustion contributes to the appearance of negative social aspects: lowering of living standards, deterioration of the sanitary-epidemiological situation, appearance of social tension.

Within the framework of this study, combining the prerequisites of the main aspects of studying the issue of agricultural lands exhaustion, the subject of the study was managerial relations in the system of agricultural lands management, as well as studying the issues of measuring the degree of agricultural lands exhaustion using mathematical modelling of their fertility (development of a methodological approach).

2.4. Basic research methods
The basic methods for this study were: observation and description, modelling.

Observation and description. Analysing the available modern research papers in the field of agricultural lands exhaustion, this work provides an analytical review of the agricultural exhaustion concept and the causes of its occurrence. And as a result it proposes an organizational and economic mechanism aimed at preventing and minimizing the manifestation of agricultural lands exhaustion.

Modelling. The methodological approach for calculation the value of agricultural lands exhaustion, proposed within the framework of this study, is based on an information-logical analysis (modelling) algorithm based on information theory. In contrast to correlation and regression methods, information-logical analysis does not impose on the studied factors such mandatory conditions, as: to comply with one of the normal distributions, to have no dependency on each other, to be metric. All these conditions are difficult to fulfil while studying biological objects.

3. Results and discussions
Active agricultural production in the context of absence of land surveying obligation for agricultural lands led to a significant deterioration in the ecological condition of not only the main arable lands experiencing a huge anthropogenic impact, but also other agricultural lands occupied by pastures and hayfields.
At the same time, the issue of agricultural lands exhaustion is especially acute in the system of leased land management, when agricultural land is leased to the land user from the redistribution fund for a short period of time. Despite the fact that the land legislation of the Russian Federation spells out quite clear responsibilities for the land user, including: land management without harming the environment, including land as a natural object; implementation of land protection measures, compliance with the requirements of environmental and other rules when using the site; prevention of pollution, exhaustion, degradation, spoilage, destruction of lands and soils, as well as other negative impacts on land and soil [2], at the moment, the issue of agricultural lands exhaustion cannot be efficiently resolved due to the following reasons. Firstly, there are no annual systematic records on the quality state of agricultural lands, including leased land. In addition, there are no criteria for classifying particular land masses by different classes in terms of quality (environmental sustainability). As a consequence of the first reason, and secondly, the mechanism of control over the use of lands of this category is not sufficiently developed at the federal and municipal levels in terms of tracking the dynamics of changes in the real quality state when a land is transferred from one land user to another. In addition, there is no information about the quality of land at the time of the conclusion of a lease agreement, which makes it impossible to trace the dynamics of the agricultural lands exhaustion development, as well as to establish a specific time period of its onset and to identify the persons responsible for its appearance.

In the beginning the concept of agricultural lands exhaustion should be defined, since it is the most controversial in comparison with other negative soil ecological processes. The reason for this is the lack of understanding in the scientific community of what to consider as the initial value of effective soil fertility. As known, effective soil fertility is measured by the yield of crops or natural plant cenoses. Modern agriculture knows more than thirty factors affecting the yield to one degree or another. Undoubtedly, the soil and climatic factors characterizing the environmental conditions of plants are the main ones. However, in various natural zones, they have a wide variety and a different magnitude of the effect on productivity.

In this regard, agricultural lands exhaustion should be understood as a decrease in the parameters of the main factors of soil fertility as a result of biological circulation irregularities. They arise as a result of the excessive removal of nutrients from the soil with the crop as compared with their entry into the soil in the form of fertilizers (organic and mineral) and plant residues, which leads to a constant decrease in the content of humus, a decrease in the amount of nutrients, as well as to shift in the reaction of soil solution media, that is, the Malthus's theory of diminishing fertility is being realized.

Among the reasons for the appearance of agricultural lands exhaustion, there should be noted factors of biological (non-return of organic substances to the soil) and physical (soil destruction under the influence of erosion) nature; the combination of the first two factors together with the use of heavy machinery leads to a significant compaction of soils, reducing its water and air retaining capacity.

The development of agricultural lands exhaustion processes aggravates their use in leased land management due to the lack of proper land surveying control in terms of soil fertility with frequent changes of land users and disordered system of agriculture and sown areas structure.

Due to the reform of the land system and land policy of most developing countries of the world, accordingly, the requirements for monitoring a land use should also be changed. It should be as close as possible to the concept of land as immovable property, market goods, natural resources and means of production. It can be implemented by means of the development and implementation of the following organizational and economic mechanism (figure 1).

An objective condition for the effective functioning of the proposed mechanism is the presence in the region (state) of a system for determining the objective cadastral value and monetary evaluation of the results of the economic use of lands. And a necessary land surveying measure to implement the aforementioned is to introduce the certification of land management, which is confirmed by the experience of foreign countries and by our research [3].

Simplified principle of the proposed mechanism operation can be represented as follows. When acquiring land management rights, the subject of land relations is informed about the fertility parameters
of the lands of his land management. In the case of termination of land relations, the subject transfers the land plot only after a mandatory estimation of land fertility parameters is done. In the case of these parameters values decrease he is obliged to pay compensation for replacement cost. In the case of an increase, he is entitled to receive surplus rent proportional to the amount of land fertility parameters increase [4].

**Figure 1.** Organizational and economic mechanism aimed at preventing and minimizing the manifestation of agricultural lands exhaustion processes.

The main element of the organizational and economic mechanism (figure 1) is the proposed methodological approach to assessing the level of agricultural lands exhaustion and the subsequent monetary value determination of an economic damage from the identified processes of agricultural lands exhaustion.

It is well known that the study of biological objects (soils) can be most objectively carried out using their models. Therefore, the basis of the methodology for solving the issue of agricultural lands exhaustion level determining is a comparison of the logical formulas of crop yields, which are formulated from the climatic and soil factors most limiting yields [5].

In this case, the value of the fertility factors parameters of the soil under consideration is compared with the value of optimal fertility factors parameters of this soil under the given natural and climatic conditions, that is, determining the receipt of actual possible crop yield. For example, the results for spring wheat are shown in table 1.

**Table 1.** An example of calculating the agricultural lands exhaustion.

| Condition of factor Order | Condition of factor Order | HTC<sub>a</sub> | HTC<sub>b</sub> | M<sub>A+AB</sub> | pHw<sup>4</sup> | Humus.%<sup>5</sup> | K<sub>2</sub>O<sup>6</sup> | N<sub>8</sub> | NNO<sub>3</sub><sup>b</sup> | P<sub>2</sub>O<sub>5</sub><sup>i</sup> | Result |
|--------------------------|--------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------------|-----------------|-----------------|
| Reference soil           | Reference soil           | 1.4             | 1.3             | 58              | 6.8             | 7.5             | 44              | 0.38            | 18.6               | 18.3             | = 20.0 centner/hectare |
| Reference soil           | Reference soil           | 6               | 6               | 6               | 6               | 6               | 6               | 6               | 6                  |                  |                  |
| Spring wheat             | Spring wheat             | 4.0             | 4.5             | 4               | 6               | 2               | 2               | 4               | 4.5                | 5.0               | = 14.8 centner/hectare |
| Spring wheat             | Spring wheat             | 1.4             | 1.3             | 58              | 6.8             | 7.5             | 44              | 0.38            | 18.6               | 18.3             | = 20.0 centner/hectare |
| Spring wheat             | Spring wheat             | 6               | 6               | 6               | 6               | 6               | 6               | 6               | 6                  |                  |                  |

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**Set of legal measures:**
- legislative consolidation of the mechanism for tracking changes in the real quality condition during the transition of a land plot from one land user to another;
- legislative consolidation of the principle of mandatory inclusion of information on the quality of land at the time of the conclusion of a lease arrangement (purchase and sale);
- legislative consolidation of administrative and economic responsibility for the agricultural lands exhaustion.

**Set of land surveying measures:**
- organization of accounting for the quality of agricultural land and certification of agricultural land management;
- monitoring of compliance with land legislation in terms of tracking the development of agricultural lands exhaustion;
- calculation of the monetary value of economic damage from the identified agricultural lands exhaustion processes.

**Set of agroecological measures:**
- soil fertility monitoring;
- development of a set of agroecological measures on lands with developed degradation processes based on monitoring data of soil fertility.
Obviously, to achieve a truly possible yield in this case, it is necessary to regulate deposits of moisture by means of winter precipitation accumulation (snow retention, regulation of snowmelt increase moisture reserves by 25 – 30%) and regulation of humus and nutrient reserves by adding organic and mineral fertilizers. In addition, a comparison of the fertility factors parameters of the studied soil with the fertility factors parameters of the reference soil makes it possible to determine the degree and qualitative characteristics of agricultural lands exhaustion.

Economic calculations of the cost for soil fertility factors restoration to their optimal parameters show the value of agricultural lands exhaustion, in monetary terms, or the monetary compensation by the land user for the loss of soil fertility:

- the value of differential rent is calculated in terms of fertility from the studied and reference soil;
- the value is adjusted for the rent by the location, as well as capitalized for the established regulatory period of capitalization
- the monetary value of the economic damage from the identified agricultural lands exhaustion processes is determined as the difference between the values of capitalized rent for the studied and reference soil.

4. Conclusion

As a result of the study, the following conclusions were made:

Active agricultural production in the context of no land surveying obligation leads to the development of many degradation processes in the soil, the main of which is agricultural lands exhaustion. The highest activity of these processes is observed on leased lands.

Agricultural lands exhaustion processes are caused by the absence of a number of organizational and economic mechanism elements in land management, in terms of control over the quality condition and land fertility. In this regard, an effective organizational and economic mechanism aimed at preventing and minimizing the manifestation of agricultural lands exhaustion processes has been proposed. The mechanism consists of a set of land surveying measures, environmental measures, as well as legal measures uniting them.

A methodological approach to calculating the monetary value of an economic damage from the identified agricultural lands exhaustion processes, based on a comparative calculation of the rent value by fertility It is proposed.

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