Incomplete recovery of soil fertility as a factor of the geoecological content of the food problem: regional aspect

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Abstract. The article considers the incomplete recovery of soil fertility as a geoecological and sociogenic factor of the food problem, requiring not only improving soil properties, increasing its ability to provide plants with the factors necessary for their growth and development in the long-term cycle but also preventing degradation of productive lands. In the chain of safe existence of society, a significant transforming role is assigned to the ecological state of the soil in the process of intensive reproduction of high-quality agricultural products, thereby expanding the consideration of the problem of safe human development in the field of environmental benefits. A prerequisite for the provision of environmentally friendly products of agricultural production is the assessment of the ecological state of the soils of productive land, which is carried out to obtain comprehensive information about the properties of the land as the main means of production in agriculture. This assessment allows identifying primarily problem areas from an environmental point of view as well as determining the amount of financial support in cases of their rehabilitation. For the conditions of the Amur Region, there is a set of measures to prevent the degradation of productive land, which must be interconnected with the tasks of implementing the plan for the production of agricultural products, taking into account zonality and economic efficiency.

1. Introduction
Modern nature of the soil as a means of production has a specific status in the context of food security and it is a predominant source of renewable economic resources. It becomes more obvious and significant in the case of productive lands degradation and a swell in the world’s population [1]. At that, in addition to the problem of maximal economic security of food markets, one of the priorities of national policy is life-supporting natural resource conservation, in particular land, and the maintenance of environmental well-being in the context of growing imbalance between rapidly changing demand and volatile food supply. Concerning food problem from the perspective of secure existence of the society, the significant transformative role of the ecological state of soils in the intensive reproduction process of high-quality agricultural products is taken into account to a greater extent. Thereby, it expands the framework of human development in respect of ecological goods.

2. Models and methods
The methodological framework of the current paper is a systematic approach in conjunction with monographic, structural-functional and business analysis, including the use of landscape-geographical, soil-morphological, cartographic and other general scientific methods. This paper presents the results
of the previous scientific works of the author, devoted to soil erosion in the Amur Region and the Far East [2] as well as conceptual geographic issues of regional food security [3].

3. Result and discussion
One of the most important properties of the land, making it essential, ever-lasting and sustainable means of production is its fertility [4]. It is reflected in integrating system able to fill the needs of plants growing there, synthesizing phytomass, an abundance of nutrients, humus substance, plant-ecological properties of the soil and plants quantitative-qualitative relations, thereby influencing their productivity [5]. According to some scientists, soil fertility recovery can be simple, incomplete and advanced.

3.1. Nature-intensive type of agricultural production
Here, we are concerned with incomplete soil fertility recovery as geoeccological and sociogenic factor of the food problem. It is characterized by the need not only to improve soil properties and increase its ability to provide plants with the factors necessary for their growth and development in the long-term cycle but also to prevent degradation of productive lands.

It is only fair to say that most of the crop produced in modern agriculture runs mainly on mobilizing the incomplete soil fertility recovery without compensating for the nutrients taken by the crop [2, 6, 7] but using high and sometimes uncontrolled doses of mineral fertilizers, pesticides and high water costs for irrigation. Considering the sharp increase in mineral fertilizers introduced into the soil combined with the reduction of organic ones, the cessation of liming, phosphorizing, plastering and other agrochemical measures, the level of degradation and depletion of these soils, their low productivity and the rate of their disposal from circulation become clear and obvious (table 1).

| Activity types                        | 1997  | 2002  | 2007  | 2012  | 2016  |
|--------------------------------------|-------|-------|-------|-------|-------|
| Mineral fertilizers applied, total, tons | 10463 | 6996  | 4937  | 11962 | 5600  |
| Organic fertilizers applied, total, tons | 57848 | 1434  | 7070  | 2035  | 1800  |
| Sour land chalking, hectare           | 11508 | 978   | 2     | -     | -     |
| Sour land phosphorization, hectare    | 2072  | 2854  | -     | -     | -     |

Moreover, land degradation, as a chain reaction that is difficult to stop, leads not only to significant losses in production volumes but also reduces the income of agricultural producers, increases the volatility of food prices, increases the growth of food imports, and can also lead to global hunger and poverty. Thus, land degradation, which took place in a period from 1945 to 1990, led to a 17% decrease in world food production. According to the forecasts of UN Head Ban Ki-moon, land degradation may lead to a reduction in world food production by at least 12% over the next 25 years, which will entail an increase in world food prices by 30%.

Currently, the fact that 85% of agricultural land in Russia (about 190 million hectares out of 220.6 million hectares in total) is subject to various degradation processes, and the quality of the remaining ones continues to deteriorate, making them more environmentally vulnerable, causes anxiety. At the same time, the main negative processes leading to soil degradation and reducing its fertility are not only erosion and land deflation but also anthropogenic impact on the land. As a result, there is a sharp threat of fertility loss of the degraded lands caused by the following factors: the decrease of humus and organic nitrogen reserves, soil acidification, weakening of microorganisms activity and destruction of the soil structure. Unfortunately, degradation processes presented mainly in the form of water and wind erosion occur to a different extent on agricultural lands in most Russian regions, including agricultural lands in the Amur Region.
3.2. Amur region as an object of study

The study area located in the southeast of the Asian part of the country is characterized by unsustainable agriculture. The unfavorable climatic conditions of the Amur Region and its specific physiographic location lead to low biological productivity of the land. This explains the gradual deterioration of the reclaimative state of soils and requires special, preventive, protective, and land reclamation measures for this zone. The restoration and maintenance of soil fertility in the Amur Region are primarily connected with the fact that the region is nowadays the “granary” of the Far East, and it accounts for almost 60% of all arable land in the Far Eastern Federal District. More than a quarter of all agricultural products in the Far Eastern District are in the Amur Region. Sown areas of the Amur Region have the following structure: soy – 76%, grain crops – 16% and fodder – 5.5%; the remaining area is planted with cucurbits and vegetables, potatoes, and industrial crops.

At the same time, the agricultural area of the Amur zone, in particular, the Amur-Zeya-Bureya interfluve, is characterized by erosion processes in the form of sheet erosion and soil retirement. The depth of the erosion basis of this zone ranges from 40 to 80 m; in near-shore zones of the Amur and the Zeya rivers – from 70 to 140 m. Territory roughness coefficient is 0.5–1.5 km/km², it increases to 1.7–3.5 km/km² towards the Amur and the Zeya rivers. Soils of the Amur Region vulnerable to erosion lose humus quickly, which is up to 12% before the development, lose the fertility and are easily amenable to further erosion, which amounts to 14–45 t/ha or more. In the cultivated land area of 1,514.2 thousand hectares, the intensive sheet erosion which is on average 4.1 t/ha per year leads to the appearance of eroded and erosion-hazardous lands (7.3% and 35.7%, respectively). In the Far Eastern Federal District, the Amur Region is the second after the Primorye Territory in terms of eroded lands (143 thousand ha and 278 thousand ha, respectively) [8, 9].

3.3. Regional system of anti-erosion organization of the territory

Within the conditions of fast-moving degradation processes followed mainly by land erosion, the primary task of state policy in ensuring food security is to provide the efficiency of land management, functioning and protection of land resources. Additionally, there are some economic aspects of anti-erosion land management. According to them, a specific form of territorial covering of economic and environmental factors of soil erosion and the spread of degraded and erosion-hazardous lands is complex territory zoning, which allows classifying the territory both by the forms of erosion and the kind of land protection from degradation.

The system of soil degradation control, in terms of a problem to solve and its constituent elements, is an integral part of a valid agriculture system. According to this, anti-degradation measures should be an integral part of local agricultural systems at the regional level [10].

In the practice of anti-erosion territory organization at the regional level, special attention should be paid to the observation of the following factors: climatic conditions, terrain, soil, geological structure, vegetation and human economic activity. One of the permanent factors that determine the course of erosion and has a direct and indirect effect is the terrain. Differentiation of slopes according to soil erosion underlies the division of lands in establishing the categories of erosion hazard. The lands are divided into groups that include different categories, such as cultivability and agricultural feasibility. Since agricultural organizations located in soil erosion areas have one or several watersheds, there can be various categories of land within specific land tenures (figure 1).

The distinguished categories of land enable: 1) to determine the structure, means and methods of erosion protection in accordance with local environmental and economic conditions, and the availability of eroded and erodible lands; 2) to establish the extent and the form of the engagement of the general anti-erosion system elements, taking into account the characteristics of erosion processes and agricultural areas (size, organization and industrial structure, specialization); 3) to place means and methods of anti-erosion protection on all agricultural organizations’ lands with differentiation of anti-erosion measures, taking into account the state of erosion of the territory and the natural and climatic as well as social factors of erosion development in large parts of watersheds.
3.4. The system of anti-erosion measures according to the complexity type (on the example of the Amur region)

Using the indicators of the types and proportions of land, the extent and the patterns of agricultural use, the prevalence of natural forage land, forests and shrubs, we have identified types of anti-erosion measures for the conditions of the Amur Region and its agricultural zone. They are as follows:

Type 1. Forest-field-meadow on high ground involves the growth of the proportion of agricultural soil-protective crops in the eroded areas, using, if necessary, soil-protective crop rotation; grassing and afforestation of the most eroded areas; compliance with the requirements for the design, fields placement and work areas with long sides (in the direction of the main tillage) across the slope; land clearance operations on natural forage lands and livestock grazing on the slopes; minimizing or prohibition of logging on steep river banks and measures aimed at the quick natural renewal of forest vegetation. Similar anti-erosion and preventive requirements should be provided for forest-field-meadow type in the mountains.

Type 2. Field-forest-meadow on high ground involves the erosion control of agricultural territories and accounting for erosion prevention measures by designing and proper placement of soil-protective crop rotations with continuous sowing crops and perennial grasses on eroded arable slopes; designing fields and work areas with long sides across the slopes with the placement, if necessary, of meadow buffer strips along their borders; grassing and afforestation of the most eroded lands, carrying out gully stabilization, forest reclamation and hydraulic engineering anti-erosion measures; improving natural forage land and regulating livestock grazing; restriction of logging and the use of reforestation measures [10-12].

4. Conclusion

In conclusion, it has to be said that due to the growing critical future human needs in food provision, the current agriculture system is focused only on obtaining the maximum amount of products,
regardless of its quality, and the fight against soil degradation is relegated to the background. In our point of view, to prevent the incomplete soil fertility recovery, the agricultural system should have a sufficient soil-protective orientation: eroded lands should be allocated for soil-protective crop rotation; agrotechnical and forest improvement measures should be carried out.

For the conditions of the Amur Region, a set of measures to prevent the degradation of yielding lands must be carried out in conjunction with the tasks of implementing the agricultural production plan, taking into account zonality and cost-effectiveness of the specified protective measures, which can provide:

- the correct field placement, work areas, protective belts, roads and other line elements of territory planning, taking into account climatic features, terrain and soils;
- introduction, justification and development of various types of crop rotation, taking into account soil protection properties and the erosion hazard of crop cultivation;
- designing a system of forest vegetation on agricultural lands, including various types of forest belts and vegetation, as well as ensuring the protection and regulation of the use of forests of groups I and II in the coastal stripes of the Amur and the Zeya rivers and their inflowing streams, along the slopes of beams, and in light soils of pine woods;
- the combination of integrated land reclamation measures and hydraulic engineering anti-erosion techniques with anti-erosion agricultural technology and forest reclamation;
- the measures to restore the fertility of eroded soils, grassing and afforestation of low-yield and agriculturally useless lands;
- the measures preventing soil erosion to improve natural forage land and increase their productivity [9, 10, 12].

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