

METHODIC APPROACH TO IMPROVEMENT OF ORGANIZATION OF LAND UTILIZATION AND PROTECTION IN EROSION-UNSAFE AGROLANDSCAPES

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Abstract

The search of effective methods of agricultural land protection from soil erosion under conditions of land relations' reform in Ukraine is a complex ecological and economic issue requiring a system approach to its solution, adequate organizational and economic support and scientific argumentation. The topicality of the research is based on the importance of the problem of arable land protection from soil erosion, and its solution is related to ecologically safe land utilization keeping to the principles of balanced development of land management. The aim of the research is to develop scientific basis for the recommendations how to improve the system of erosion-safe agricultural land management under conditions of reforming land relations in Ukraine. The article presents scientific fundamentals of organization of erosion-safe land management in the context of the balanced development of nature management, analyzes conditions of utilization and protection of land in erosion-unsafe landscapes, develops scientifically grounded recommendations as to improvement of a system of erosion-safe agricultural land management at a local level. In the process of the investigation a combination of methods were used: monographic, induction and deduction methods, system analysis, cartographic, experimental projecting. A contour organization of the territory is recommended to apply to protect arable land from soil erosion. Reimbursement of money payments and tax privileges can motivate landowners and land users to introduce anti-erosion measures. It is required to consider use value and non-use value of land resources in the process of their estimation for land payments.

Key words: agricultural land use, soil erosion, contour organization of the territory, incentives.

Introduction

In Ukraine, soil erosion is one of the most common degradation processes in land utilization. It covers almost 57% of the country's area (Pro shvalennya Koncepciyi..., 2014). Because of water erosion of soils every year nearly 500 million tons of humus, 1 million tons of nitrogen, 0.7 million tons of phosphorus and more than 10 million tons of potassium are washed out of soil. For the last 20 years in Ukraine the average content of humus has decreased by 0.22%. The loss is estimated in 453.4 billion UAH (Yacuk, Panasenko, 2013). The shortage of reserves of humus and mineral substances causes the decrease of soil fertility. As a result, lowering of biological activity of eroded soils is a reason of getting inadequate yield of agricultural crops (the yield can decrease by 30-80% due to eroded soil depending on a degree of erosion) (Lopiryev, Ryabov, 1989).

In Ukraine, the model of contour-meliorative agriculture was introduced in 1987 to protect arable land from erosion (Tarariko, Mironov, Saiko, 1987). Because of reforming of land relations (since 1991), agricultural lands were divided into land plots, which were given to private ownership. The establishment of new farms on the basis of leasing land plots is often ecologically unreasonable and is carried out without land protective measures (Yacuk, Panasenko, 2013; Solovyanenko, 2013).

The aim of the research is to develop scientific basis for the recommendations how to improve the system of erosion-safe agricultural land management under conditions of reforming land relations in Ukraine. The principal tasks of the research are the following: to determine the main indicators of soil erosion development in Ukraine on the basis of scientific literature analysis on the issue of land degradation; to analyze erosion threat of agricultural land utilization in Ukraine; to develop scientifically grounded recommendations for the improvement of the system of erosion-safe agricultural land management at a local level under conditions of reforming land relations in Ukraine.

Methodology of the research and material

The following research methods were used: monographic, inductive and deductive methods, system analysis, cartographic, experimental projecting.

The object of the research is conditions, process and consequences of the land reform in Ukraine in relation to erosion-safe utilization of agricultural land. The subject of the research is theoretical, methodological and applied aspects in the search of means and mechanisms to improve the system of erosion-safe agricultural land management under conditions of reforming land relations in Ukraine.

Scientific articles on soil erosion and ecologically safe land management, the legislation of Ukraine, data of the land cadastre and documents on land structure have been used in the research. The analysis

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Scientific articles on soil erosion and ecologically safe land management, the legislation of Ukraine, data of the land cadastre and documents on land structure have been used in the research. The analysis

of erosion threat of agricultural land utilization was carried out applying the methodology GOST 17.4.4.03-86 “Method of determination of potential threat of erosion caused by rains” (GOST 17.4.4.03-86, 1986). The potential rain-wash of soil is calculated by the formula:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P, \quad (1)$$

where;

A – is annual soil losses (potential), ton/ha;

R – is a factor of erosion effect of rains (erosion index of rainfalls during the warm period on a map);

K – is a factor of soil capability to fall under the influence of erosion, ton/ha;

L – is a factor of a slope length;

S – is a factor of a slope stiffness;

C – is a factor of vegetation in crop rotation;

P – is a factor of efficiency of anti-erosion measures.

Discussion and results

Indicators of soil erosion in Ukraine. Soils erosion is a natural process. Natural conditions are principal factors of erosion, but the main reason of modern development of soil erosion is an exceeded anthropogenic impact on land resources, including those of agriculture (European Environment Agency, 2006, O’Geen A. T., 2006). Formation of soil-protective and melioration equipped agro landscapes, basing on contour-meliorative organization of the whole territory, being the most suitable for the structure of natural landscapes is an effective measure of land protection against soil erosion (Burakov V.Yi., Dubinskiy H.P., 1985). Because a landscape is a complex and multifunctional natural-territorial complex, optimization of mutual relations between natural phenomena and anthropogenic factors can be achieved by creation of a “cultural landscape” (Poiker H.Yi., 1987).

Studying a concept of a balanced development of ecosystem, which includes a process of interaction of a society and environment and can result in optimal correlation between economic activity, security of material and spiritual needs of population and protection of quantitative conditions of natural environment (Bulygin S. Yu., 2005, Stoiko N., 2005), one should mention that a contour organization of territory is one of scientifically grounded approaches to achieve a balanced development of land management. Such organization of the territory secures not just protection from soil erosion but it is also of ecological importance for preservation of biological variety, cleaning of water sources, etc. Having analyzed scientific literature on land degradation, one can distinguish three groups of indicators of development of water erosion of soils in modern land management (Table 1).

Table 1

Indicators of development of soil erosion in modern land management¹

Group of indicators	Characteristics	Criterion
Biophysical	Soil cover	Parent rock, depth of humus horizon, mechanical content of soil.
	Relief	Stiffness, length, form, slope exposition, depth of erosion basis.
	Climate	Amount of rainfalls, intensity of heavy rains.
	Vegetation cover	Field cultivated crops, field thick-cover crops, natural herb vegetation, bush or wood vegetation.
Social-economic	Low level of economic development	Lack of money for introduction of land protective and soil protective measures, meliorations, innovative technologies, growth of culture of agriculture, etc.
	Consumption approach	Attempts to get the most of land and give the least for its protection, improvement and reproduction.
	Low ecological culture	Lack of knowledge, norms, stereotypes and “rules of behavior” of a man in his/her environment, which can help consideration of practical needs of a society and “attempts” of nature to support stability of its own normal conditions and thus, preserve conditions for existence and development of humanity.

¹ Compiled by authors on the basis of (Evaluation and Selection, 2013; Compilation of selected, 2009; European Environment Agency, 2006; O’geen, 2006).

Table 1 (continued)

Group of indicators	Characteristics	Criterion
Institutional	Lack of institutional support	Undeveloped infrastructure of the sphere of market and lease relations (commercial crediting, leasing, mortgage etc.); absence of consistent state policy as to stimulation of land protection (privileged taxation, grants, insurance etc.); deprivation of local authorities from the issues of land relations.
	Ineffective policy of management of land and natural resources	Absence of a target program of development of land relations for long-term prospective; underestimation of the importance of recording of amount and quality of lands, state registration of nature protective and technological limitations in land utilization; imperfection of norms and standards in the system of estimation of loss reimbursement, because of breaking of nature protective laws; absence of argumentation of estimation of project works and their impact on the environment.

The analysis of the information in Table 1, allows to conclude that intensity of soil erosion development in Ukraine is forced by a considerable impact of anthropogenic activity, ineffective system of management of land resources, lack of institutional support of a balanced land utilization, poverty and low ecological culture.

Analysis of arable land utilization in Ukraine. According to data of the State Agency of Land Resources of Ukraine, 6.8 million citizens have got certificates of the right to land plot in 2014. Among them 4.8 million citizens fulfil the right on land by means of lease relations (Solovyanenko, 2014; Doslidzheniya dogovoriv orendi ..., 2014). Agricultural enterprises and farms use 41.9% of agricultural lands on the basis of land plot lease agreements; 38.1% of agricultural land of the country are utilized and possessed by households. The data prove the existence of large, middle and small agricultural farms.

Peculiarities of land utilization are demonstrated on the example of land management of the farm "Halytskyi shliakh" located in the territory of Ushkovychi village of Peremyshliany district in Lviv region. Land possession of the farm is made by lease of land plots. The area of the lands amounts to 120.2484 ha (92 land plots). Soil cover is made of: dark-grey podzolic cover gleyic and cover gleyic slightly washed light loamy soils (49 g) occupy 59.9251 ha (49.9%); dark-grey podzolic gleyic slightly washed with spots of medium washed 10-30% medium loamy (49) – 27.8277 ha (23.1%); dark-grey podzolic cover gleyic medium washed medium loamy (50) – 19.5318 ha (16.2%); dark-grey podzolic gleyic medium loamy (45) – 9.6256 ha (8.0%); podzolic washed gleyic medium loamy (208) – 2.2641 ha (1.9%); heavy washed soils and rock outcrops (215 g) – 1.0229 ha (0.9%). The relief of the farm is characterized by slopes from 3° to 5° (Fig. 1).

To compare characteristics of erosion threat in utilization of arable lands we calculated losses of soil because of erosion according to two variants of area organization: Variant 1 – according to a scheme of division into land plots (Fig. 1); Variant 2 – according to requirements of a contour-meliorative organization of the territory proposed as one of the variants of land protection from negative erosion effects (Fig. 2).

Annual soil losses (A) are classified according to a scale: insufficient – up to 0.5 ton/ha; weak – 0.5- 1 ton/ha; medium – 1-1.5 ton/ha; heavy – 5-10 ton/ha; very large – more than 10 ton/ha.

According to the data of GOST 17.4.4.03-86 for Ushkovychi village of Peremyshliany district, erosion index of rainfalls during the warm period is $R = 12.9$.

The factor determining soil capability to fall under influence of erosion (K) characterizes quantitative wash of soil from a sample land plot because of rain, erosion index $K = 1$ (Zaslavskiy N.M., 1983). In the farm area, slightly washed light and medium loamy soils prevail according to their mechanical content. The factor determining an influence of erosion on soil (K) is determined according to nomogram of GOST 17.4.4.03-86 as a weighted average indicator $K = 2.6$ ton/ha.

Factors of length and stiffness of slopes of arable lands under conditions of Peremyshliany district are important. Mutual impact of the length and stiffness of a slope is revealed by the only topographic factor. The topographic factor (LS) is determined on the basis of results of morphometric analysis of relief and in the process of route examination. According to the examination data, an increase of slope

stiffness causes the increase of a value of the factor of a slope length (L) in geometric progression. A rapid increase of a value of slope stiffness factor, starting from stiffness 3° and higher, transforms land plots of such surface into potentially dangerous ones in relation of intensification of erosion processes.

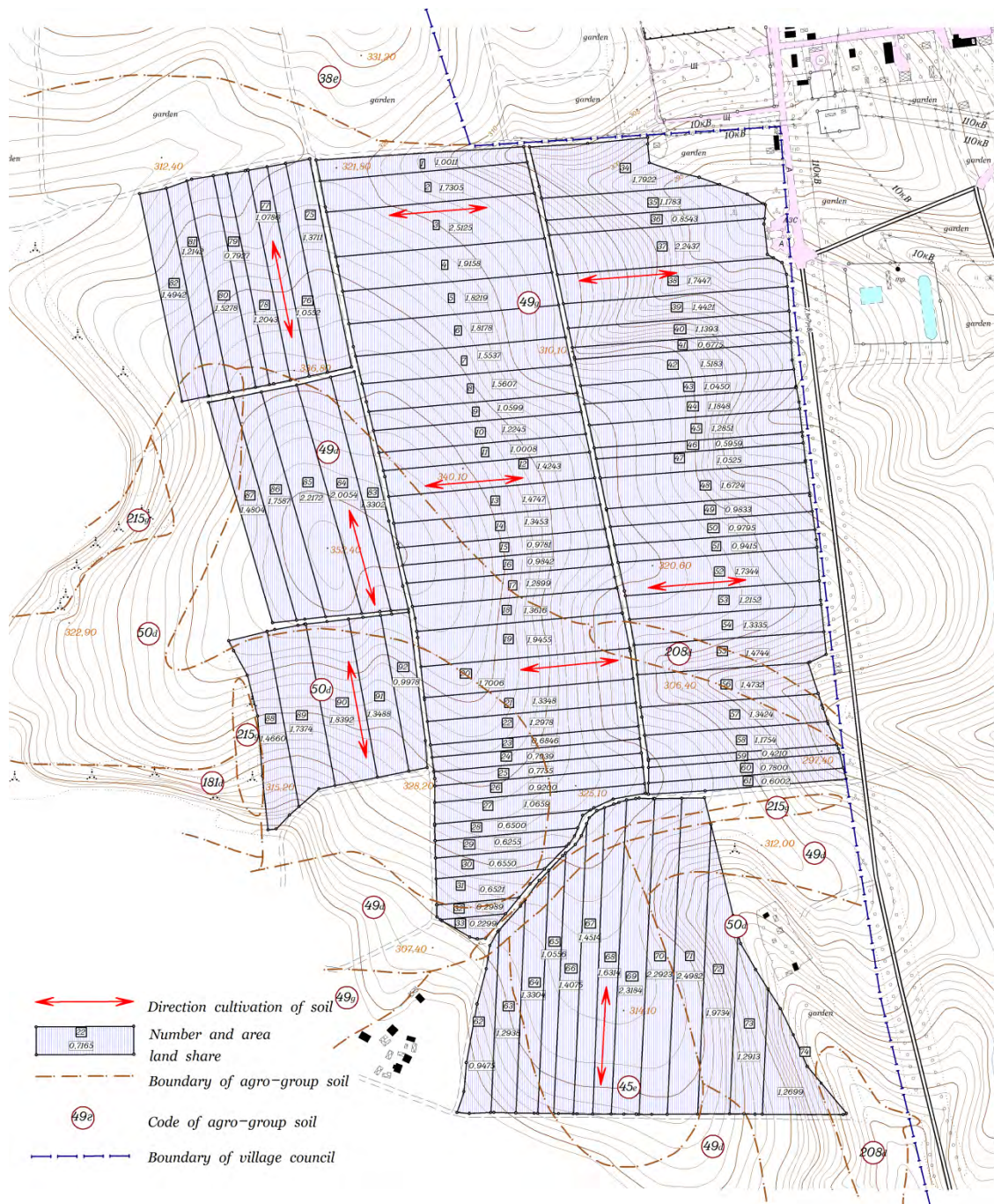


Fig. 1. Scheme of division of a farm's land into land plots.

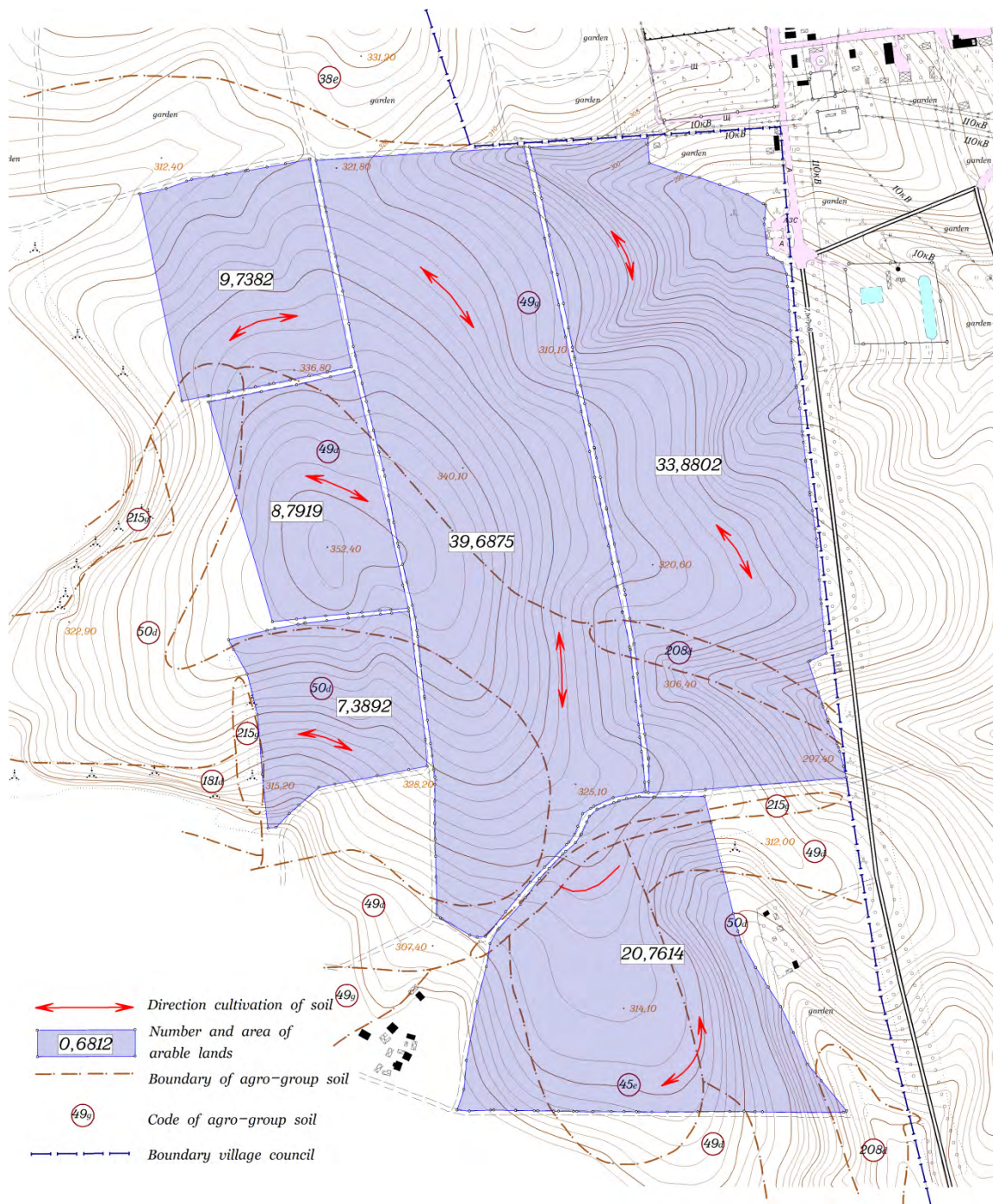


Fig. 2. Scheme of a contour organization of a farms' area.

The length of slopes as a distinguishing factor of potential wash of soil under conditions of farming activity is characterized by a high changeability. Among the peculiarities of the factor value, one should underline its dependency on the slope stiffness. Land plots with high stiffness of slopes, as a rule, are not long and vice versa. An average length of a slope flowing, determined by route examinations, makes 350 m.

Since intensity of erosion is directly proportional to the square root of a slope length, deviation of values of indicator L of the average value makes smaller impact on quantitative estimation of a forecast of soil wash in comparison to other factors.

The analysis of references (Zaslavskiy, 1983), the factor of vegetation cover (C) can change ten and hundred times. The coefficient C can have the value 0.003 on crops of perennial herbs, 0.05 on crops of winter wheat, 0.4 on maize. Considering variety of vegetation cover and different degrees of its deterioration in conditions of the mentioned territory, the average value of the factor $C = 0.01$ in calculation of potential intensity of erosion processes was used.

Coefficient P refers to the decrease of erosion because of contour cultivation of soil, benching of slopes, cropping by strips etc.

The calculation of a potential threat of erosion under the impact of rains according to the two variants is presented in Table 2.

Table 2

Calculation of a potential threat of erosion caused by rains

Indicator	Using lands according to a scheme of land division into plots	According to a contour structuring of the area
Annual soil losses (potential), A , т/ha	5.90	1.49
Factor of erosion effect of rains, R	12.9	12.9
Factor of soil capability to fall under influence of erosion, K , т/ha	2.6	2,6
Topographic factor, LS	2.93	1.78
Factor of vegetation in crop rotation, C	0.1	0.1
Factor of efficiency of anti-erosion measures, P	0.6	0.25

Thus, utilization of arable lands according to a contour organization of territory decreases annual losses of soil.

Recommendations as to security of erosion-safe agricultural land utilization. In Ukraine, an issue of land protection from degradation can be solved by means of land management, aiming to secure rational utilization and protection of land, creation of favorable ecological environment and improvement of natural landscapes (Zemelnyi kodeks Ukrainy, 2015, article 182). However, establishment of a system of erosion-safe utilization of land is complicated due to functional variety of agricultural land utilization (according to forms of ownership, groups of land users, natural characteristics).

Under conditions of market economy, regulation of land relations on the basis of a balanced development with consideration of the interests of the state, landowners and land users, is possible to fulfill by means of effective ecologic and economic instruments. To stimulate landowners and land users to introduce anti-erosion measures (contour soil cultivation, strip cropping, creation of buffer strips, temporary conservation etc.), it is recommended to use:

- lease payments for use of agricultural lands of better quality or location, mentioned in its technological characteristics (slope stiffness, mechanical soil content etc.);
- reimbursements for deterioration of quality of agricultural lands because of economic activity;
- tax privileges for reproduction and protection of land resources.

Interest of land user to make investment in land protection is a considerable condition for an ecologically oriented system of land resource management. Land users should ground a decision as to utilization, protection and reproduction of land resources, seeing potential benefits and expenses. Making estimation of land resources it is necessary to consider their use value (goods, being able to be consumed; functional benefit) and non-use value (value of deferred alternative; value of heritage; cost of existence) (Korgenyev M. M., 2005). Thus, a land resource is considered not just from the position of direct benefits, but also indirect ones, i.e. from the position of protecting the resource for the future generations as an important constituent of ecosystem.

Conclusions

1. To protect arable lands from soil erosion, it is necessary to apply a contour organization of territory, decreasing potential loss of soil.
2. In Ukraine, system of land resource management should be ecologically directed and secured by economic stimulation of erosion-safe utilization of agricultural lands by means of reimbursement and tax privileges.
3. It is required to consider use value and non-use value of land resources in the process of estimation for establishment of land payments.

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