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T. M. Mormul, Cand. Sc. (Tech.),
Ye. V. Terekhov, Cand. Sc. (Econ.), Assoc. Prof.

State Higher Education Institution "National Mining University", Dnipro, Ukraine, e-mail: Mormult33@gmail.com; terehoff@t-online.de

ENVIRONMENTAL AND ECONOMIC ESTIMATION OF TECHNOLOGICAL SOLUTIONS IN TERMS OF LAND RESOURCE CONSERVATION IN THE PROCESS OF OPEN-CAST MINING

Т. М. Мормуль, канд. техн. наук,
Є. В. Терехов, канд. екон. наук, доц.

Державний вищий навчальний заклад „Національний гірничий університет", м. Дніпро, Україна, e-mail: Mormult33@gmail.com; terehoff@t-online.de

ЕКОЛОГО-ЕКОНОМІЧНА ОЦІНКА ТЕХНОЛОГІЧНИХ РІШЕНЬ ЗІ ЗБЕРЕЖЕННЯ ЗЕМЕЛЬНИХ РЕСУРСІВ В УМОВАХ ВІДКРИТИХ ГІРНИЧИХ РОБІТ

Purpose. The purpose of the research is substantiation of criteria to estimate land-conservation procedures in terms of open-cast mining which would demonstrate land-restoration level as for the degree of its disturbance and scale as well as for its valuation base.

Methodology. Technical and economic methods as well as method of system analysis have been applied to determine parameters of efficient mode for land resources during open-cast mining; to define current tendencies of sheet ground mining technologies progress as for their relation to the level of land conservation, the method of scientific generalization and systematization has been involved.

Findings. A mode of mining land use has been characterized regarding the development of favourable conditions for conservation of lands used during open-cast mining. The indices of land conservation in terms of the area of its disturbance, their ecological properties and cost estimation have been defined. Methodological approaches as for the selection of technological schemes of open-cast mining in terms of land conservation have been substantiated.

Originality. Dependence of technogenic load on land of mining allocation and the level of ecological and economic efficiency of open-cast final mining as well as further restoration of disturbed lands has been determined. That should become a background to define a direction of post-industrial use of the restored lands.

Practical value. A system of indices has been proposed which is methodological foundation to plan mining objects at the stage of open-cast final mining according to the criterion of minimization of volumes of mining land allocation and development of favourable conditions to restore the lands disturbed by mining.

Keywords: *open-cast mining, dump formation, estimated money value of land, open-cast field, land conservation, mining recultivation*

Introduction. Today mining land use is characterized by further degradation of land resources involved in mining area [1] since currently mining enterprises are not motivated enough to raise the level of land restoration in terms of degree and volumes of its disturbance [2].Thus, in Dnipropetrovsk region, characterized by high level of technogenic load, it is the activity of mining enterprises which is absolutely the most important factor of land damage.

Statement of the problem. Volumes of land restoration after open-cast operations within the region territory are not more than 55 to 60 % of the area of its disturbance; that exerts a detrimental effect on mining land use deepening contradictions between subjects of reclamation. In this context poor attention is paid to estimation of efficiency of process solutions for land conservation from the viewpoint of environmental sustainability and economic attractiveness of technogenic lands. At the same time, scientists emphasize the importance of accurate ecological-and-economic estimation of various operation schedules for reclamation of land disturbed by mining operations to determine how they fit for purposes of land preservation [3]. That would suit the requirements of rational use of land used to be area of mining operation allocation. It should be noted that the progress of mineral mining techniques should rely upon criterion basis which would reflect the effect of mining on the environment taking into consideration its ecodestructive nature [4].

To begin with, efficiency of land use is in compliance with proper rules of its restoration. The rules are a set of controlled variable technical and economic factors of process structure connected with use and restoration of land for the requirements of field development. Conscious control of these factors with the help of criteria to estimate their impact on land use in the region is the instrument for the development of mechanism for targeted land restoration and compliance with the requirements as for optimal type and quality of restored areas planning.

Mining operations result in sizeable surface roadways formation; they disturb original wild landscape. Land area allotted for the purpose can be returned to agriculture after specific costly operations. First of all they depend on long-distance delivery of overburden rocks to stow the pits [5]. If overburden thickness is 20 to 100 meters then volume of transport incline is 2 to 182.5 mln cubic meters; volume of residual mine goaf is 0.8 to 135 mln cubic meters, and the area of pit surface is 7 to 225 and 2.1 to 150 ha respectively. It demonstrates significant effect of opencast mining on wild landscape.

Studies by Pivnyak, G. G., Gumennyk, I. L., Prokopenko, V. I., Shapar, A. G. and others deal with reasonable technique of deposit opening involving area of land allocation. They include mining and construction schemes and parameters of main openings in terms of sheet ground. As the researchers consider, area of allotted land experiences its decrease at the expense of construction of temporary internal incline; overburden rocks being a result of its construction are used for crossing track.

Scientists of M. G. Novozhilov scientific school have performed both development and practice of overburden placement techniques within the mine goaf of an open cast. They substantiated technological schedules for deposits where overburden thickness is up to 80 m and ore bed thickness is up to 10 m. Methodological basis to calculate parameters of opening and mining of open-cast fields have been identified involving rational allocation of mine workings.

Currently a technique of initial cut construction within two contiguous open-cast fields becomes more and more important. The initial cut is required to develop both capital and initial cuts perpendicularly to basic mining operations and building rocks are stored in a dump. Dimensions of the initial cut depend on overburden location in it resulting from the first operational entry way and construction of working sites of the open cast being constructed.

V. Prokopenko offered a technique to select dump parameters for further mining of horizontal ore beds which provide minimum consumption of land resources [6]. The research involves the development of mining operation schedules not only to reduce the areas of disturbed land but also to improve conditions of mining recultivation.

A problem of the construction of capital cuts and the initial ones to minimize both goaf and volumes of overburden rock storage is studied in research [7]. Paper [8] emphasizes that the progress of production technologies aimed at reducing of negative effects for other business fields is the important component to control risks arising in the context of interaction of technological system of enterprise and other systems.

Scientific and technical sources as well as design solutions concerning horizontal deposit mining considers a problem of land conservation more simply. As a rule, it is done from the viewpoint of integrated conservation of natural resources affected by mining without substantiation of approaches to mining operations optimization depending upon necessity to minimize land areas disturbed by mineral mining. The managerial problem should be solved by means of substantiation of parameters of land allocation for open-cast facilities in terms of land conservation.

Paper [9] substantiates the fact that estimation of external effects of mining operations including nature disturbance should be reflected by a system of qualitative indices effecting its solutions as for planning directions of own strategic development. Respectively, according to the opinion of Vagonova, O. G., the indices will effect the results of economic substantiation of investment projects of mining enterprises [10].

Land use should be first minimized by means of implementation of technology concepts concerning mineral deposit opening, mining, and updating. On the one hand they provide minimum area of land allocation under open mine workings and external dumps; on the other hand they provide favourable conditions for fuller (in the context of area) reclamation of disturbed land.

However, poor attention is paid today to a problem concerning expediency consideration of open-cast techniques implementation from the viewpoint of land conservation which in turn could become positive tools to determine geometry of open cast with minimum land intensity of mining operations.

Thus, the **study objective** is substantiation and development of estimation criteria for land-conservation operation schedules in the process of open-cast mining which would reflect land rehabilitation level in terms of degree and disturbance scale as well as in terms of their cost estimation. Accordingly, planning procedure for mining objects should be based upon selection of operation procedures for open-cast field opening, mining, and upgrading in relation to land conservation level. In the context of land conservation, field development technique should be aimed at disturbed land area minimization as well as at creation of favourable conditions for its further recultivation.

Results. The reserves of land area reduction should be determined by optimizing the parameters of land allocation for open-cast technological facilities. The key parameters of their location within the whole period of mine development depend on the main open-cast parameters. All the parameters should be set involving each stage of deposit development.

The feasibility of technological solution is determined by L_c land size coefficient and K_r reclamation coefficient calculated as follows

$$L_c = \sum_{1}^{n} \frac{S_{g.oi}(1 - K_r)}{Q_m};$$

$$K_r = \sum_{1}^{n} \frac{S_{ri}}{S_{g.o}},$$

where $S_{g.oi}$, S_{ri} are areas of allotted (disturbed) and recultivated (returned) lands respectively on the i^{th} open-cast object; n is the number of technological facilities; $S_{g.o}$ is the total area of mining allocation for the deposit development; Q_m is the operating mineral reserves of the deposit.

The importance of the problem solutions is emphasized by the results of author's calculations for land area to be allocated for the facilities of manganese ore deposit development in the context of Ordzhonikidze Mining and Preparation Integrated Works. Thus, depending upon ore bed depth, to locate opening mine workings and a dump, 163 to 228 ha of natural lands (Table 1) are required. Permanent trench takes 3.5 to 4.5 %; transport incline takes 8.6 to 8.4 %; initial cut takes 57.0 to 56.1 %; and construction dump takes 31.0 %. Hence, working trench and construction dump cover the major share of residual mine workings (almost 90 %). Internal dumps are being recultivated and transferred for further use while ore bed mining.

Taking into consideration current economic problems of mining enterprises it is possible to reduce the disturbed land areas, increase areas and quality of restored lands by means of formation of rational technological facilities within open-cast field basing upon the criteria of land conservation. That concerns each development stage. As a rule actual indicators of land use both for individual objects and in general in terms of an open cast cannot mainly meet the requirements of natural land conservation as they are set after substantiation of open-cast contours and productivity, direction and speed of mining advance, opening scheme and deposit development system, general plan etc. at the stage of design without direct optimization in the context of land conservation.

The conditions of land use for technological facilities of mining enterprise (e.g. trenches, basins, dumps, open-cast, roads, industrial sites, tailing pits etc.) should provide maximum reclamation coefficient K_r (unit fraction), minimum land size L_c (ha/t), and as a result, minimum losses of land L_1(ha/t) and land resources L_{1r} (unit fraction) for agriculture. The losses depend on the area of non-recultivated for farming or grazings by the end of mining cancellation. The indicators are in the ratio

$$L_1 = (1 - K_r)L_c;$$

$$L_{1r} = (1 - K_r)B_n/B_r,$$

where B_n, B_r are bonitet (quality) of natural and recultivated land resources respectively.

On the basis of L_1 i L_{1r} indices we conclude that losses of land resources under open-cast objects are the functions of S_{ni}, S_{pi}, S_n, parameters being formed during all the phases of the field exploitation. In general this function can be represented as follows

$$L_1 = f(B, L, F, G, P, T, C, R),$$

where B, L, F are width, length and shape of open-cast field respectively; G is mining and geological conditions of ore bed occurence; P is operational parameters to form functional area of the open cast; T is technological facilities for production; C is opening and mining technique of the deposit; R is surface irregularity of allocation.

As it follows from the latter expression, reserves to decrease land losses are connected directly with the parameters of the technological facilities of a mining enterprise. Therefore, rationality of land use depends on certain ratio of parameters of current objects and their components when minimum land size L_1 and maximum recultivation coefficient K_r are achieved.

Technical and technological solutions as for deposit operation taken on the basis of land size L_1 and recultivation coefficient K_r, may provide following results:

- decrease in the area of natural lands allotted for ore bed open-cast mining;
- increase in the area of recultivated lands returned to the national economy;
- improvement of the quality of lands restored for their original use;
- improvement of the conditions for mining recultivation (decrease in the number of recultivation operations concerning dump crest cutting and filling openings, dump surface leveling, formation of its slope allowable for the use of agriculture machinery, to generate black soil and potentially fertile soil layer in accordance with the requirements of further land use to prevent pollution and erosion of land resources etc.).

Land conservation indicators described above reflect economic efficiency of mining allocation land use. Calculation of these indicators should involve the following. If a certain land area $S_{c.z}$ is not allocated for deposit mining, then land fund of the region retains it. Depending upon B_n bonitet, cost of lands retained for their direct use can be calculated as follows

$$P_{c.m} = G_{c.m}(B_{c.})S_{c.z},$$

where $G_{c.m}(B_c)$ is monetary value of conserved wild lands according to their bonitet.

Table 1

Distribution of land allotment in terms of manganese open-cast technological facilities

Open-cast depth, m	Area of permanent trench along the top, ha	Area of transport incline along the top, ha	Area of working trench along the top, ha	Construction dump			Total area of allotment, ha
				Height, m	Base width, m	Dump area, ha	
50	5.6/3.4*	14.1/8.6	93.0/57.0	73	253	50.6/31.0	163.3
60	7.8/4.0	16.6/8.5	110.5/56.4	88	304	61.0/31.0	195.9
70	10.3/4.5	19.1/8.4	127.9/56.1	101.7	352	70.5/30.9	227.8

Note: numerator is total area of mining allotment, ha; dominator is % of the total area of allotment

When mining enterprise rents certain land area $S_{a.z}$ for ore bed mining, it makes pays for the lands according to bonitet $B_{a.z}$

$$K_{a.z} = P_{a.z}(B_{az})S_{a.z},$$

where $P_{a.z}(B_{a.z})$ is rental payment for land use.

To return lands to their owner (land user), mining enterprise should carry out recultivation operations involving either partial or complete land restoration as well as the recovery of disturbed land areas within mining allocation. Expenditures connected with mining reclultivation Kr are

$$K_r = S_r \cdot C_r/(B_r),$$

where S_r, $C_r/(B_r)$ is the area of recultivated lands and cost price of recultivation activities as their bonitet function respectively.

If land is considered as less valuable farmlands, then mining enterprise compensates (pays) the losses of agricultural production proportionally to the difference between the original land quality and its quality after recultivation. In this context standards of natural agricultural losses are involved [10]. Compensation total of previous production is defined as follows

$$K_p = S_v H_v(B_{r.v}/B_o)K_{int},$$

where S_v is the area of recoverable farmlands; H_v is the standard of agricultural losses; $B_{r.v}$ is the bonitet land index within the disturbed area; B_o is the bonitet index of farmlands over the region; K_{int} is intensity coefficient of farmland use (ratio between estimation of differentiated farmland income of the region where the land is transferred for deposit development and this estimation for the whole region).

As a mining enterprise does not perform complete return of land areas allocated for deposit development to the national economy, it sustains losses determined by the formula

$$U_{nv} = (1 - K_r)G_{g.o}(B_{g.o}) \cdot S_{go},$$

where K_r is the recultivation coefficient; $G_{g.o}(B_{g.o})$ is estimated monetary value of wild lands as a function of their bonitet within mining allocation; $S_{e.o}$ is the area of mining allocation.

It should be noted that each land plot differs in terms of economy being personified as property, thus it is necessary to monitor the nature and outcomes of its damages, but not the land allocation on the whole.

Analysis of the area of scheduled land allocation within the deposit mining plan shows operations as a several-kilometer continuous line. It covers lands of various quality and commercial purpose having different allocation terms. Similarly returned land plots differ both within in terms of their allocation and their previous state; thus, it is required to determine natural correspondence of achieved level of land conservation to original state of disturbed land which is possible to represent in the form of coefficient of land return $K_{n.z}$.

Considering the facts that due to technological reasons rate of land recovery takes certain time lag being 5 to 7 years (in some cases soil formation period takes several decades) and allocation territory can be divided into areas of different fields of economy, and coefficient of land return $K_{n.z}$ is set according to the given volume of land return for several years with the determination of the scope of physical qualitative and quantitative recovery of specific allocation area according to following expression

$$K_{n.z} = \frac{\sum_{j=1}^{T} Sn_j q_{ij} I_{b_{ij}}}{S_{b_i}},$$

where S_{n_j} is the land area returned during j^{th} year; q_{ij} is a share of i^{th} plot of land recovered during j^{th} year; $I_{b_{ij}}$ is the coefficient of ratio between bonitet indices of i^{th} plot of land recovered during j^{th} year and that very undisturbed land area; S_{b_i} is land area of i^{th} year of mining; T is the period plot of land return.

The coefficient is appropriate if the original nature of the territory is conserved; changes in the targeted soil use needs adequate monetary representation of the process.

Recovered land should be considered as a combination of several positive qualities and effects that human can use in practice independently; moreover they define rate of potential consumer value of recovered land. It is clear that the range of technogenic soil use is narrower than use of wild lands: purposeful restoration of certain chemical and physical and mechanical soil characteristics is planned. It reduces economic potential of the former as integrity of independent productive possibilities or unused reserves. Thus, the coefficient of changes in cost potential of land is determined as follows

$$K_{z.v} = \frac{\sum_{i=1}^{k} P_{r_i}}{\sum_{i=1}^{n} P_{ni}},$$

where P_{ri}, P_{ni} is market evaluation of recultivated and undisturbed plot of land in accordance with the k, n economic field, respectively; k, n is the number of useful properties of restored and wild lands, respectively.

The latter formula representing calculation of potential productive efficiency potential makes it possible to produce coefficient which includes expenses connected with land recovery in the context of certain operation schedule according to following expression

$$K_v = \frac{K_{b_i} - \sum_{i=1}^{n} P_{ni}}{\sum_{i=1}^{k} P_{r_i}},$$

where K_{b_i} is expenses connected with land recovery cost.

Coefficient K_v makes it possible to demonstrate relative maximum effect of recultivation costs use in the context of full use of plot of land. It can be both positive and negative. Positive value indicates possible decrease of market value of reclaimed land by this value; on the contrary, negative one makes it possible to increase cost estimationg of land for greater compensation of its recovery costs.

If recultivation results in complete changes in disturbed land nature, then its efficiency should involve environmental component of land restoration; in particular it concerns changes in ability of newly formed soil layer to maintain useful properties due to unfavorable natural and technogenic factors of its further exploitation. Agriculture applies coefficients of environmental stability of different types of lands being numerical expression of ecological sustainability of land plot used purposefully in the context of natural ecosystem. The higher level of changes in soil condition after anthropogenic intervention is (being maximum while forming arable land), the lower its ecological sustainability level is. Thus, ecological efficiency of changes in targeted use of technogenic soil may be estimated according to coefficient of soil ecological recovery $K_{e.b}$ which is proposed to determine by the following formula

$$K_{e.v} = \frac{\sum_{i=1}^{m} S_{r_i} E_{s_i}}{\sum_{i=1}^{n} S_{v_i} E_{s_i}},$$

where S_{r_i}, S_{v_i} is area of i^{th} type of land of recultivated and allotted land, respectively; E_{r_i}, E_{s_i} are the coefficient of ecological sustainability of i^{th} type of a land plot after recultivation and before allocation, respectively; *n, m* is the number of different land types located respectively within undisturbed and restored area.

Consideration of land resources in terms of labour conditions of mining enterprise economy to estimate selected land conservation mode should also involve the criteria containing cost changes in land resources as well as expediency of expenses connected with their restoration. They are:

1) economic efficiency of land conservation characterizing level of value (monetary evaluation) conservation of nature lands

$$E_i = \frac{100 \cdot P_r (1 - S_{z.r})}{P_m},$$

where P_r, P_m is monetary value of recultivated and undisturbed lands, respectively; $S_{z.r}$ is loss of land resources according to area.

$$S_{z.r} = (1 - K_r) \frac{B_n}{B_r},$$

where B_n, B_r is bonitet (quality) of wild and recultivated lands, respectively; K_r is recultivation coefficient;

2) economic efficiency of recultivated lands as payback index per recultivation operation

$$E_b = 100 \cdot M_r(B_r) \cdot \frac{K_r}{C_r},$$

where $M_r(B_r)$ is monetary value of recultivated lands according to their bonitet; C_r is cost value of disturbed land recultivation.

Land allocation for open-cast deposit mining contains mine workings, internal and external dumps, technological facilities of open cast, and recultivated and disturbed lands. To perform more accurate estimation of land conservation economic efficiency involving various types of soils within certain areas of land allocation, various soil costs and expenditures connected with land reclamation in the context of further use, the authors propose to apply integral coefficient calculated as follows

$$I_k = \frac{(M_r - C_r)S_r + (M_o - C_o)S_o + \ldots + (M_t - C_t)S_t}{M_p \cdot S_p},$$

where M_r, M_o, M_t, M_p is monetary estimation of recultivated (to be returned) lands; those under residual mine workings, technological and subsidiary facilities (e.g. external dumps, other objects not subject to reclamation but being improved in accordance with their further use) as well as wild (undisturbed) lands; C_r, C_o, C_t are expenditures connected with disturbed land improvement for its further use; S_r, S_o, S_t is land area according to its use (recultivated for agriculture; that after liquidation of technological and subsidiary facilities; improvement of external dumps after residual mine working has been closed); S_p is area of wild lands aimed for mining allocation.

In the context of rational land use both location and dimensions of technological facilities of open-cast should provide maximum value of I_k coefficient. The coefficient involves dimensions, degree, and nature of wild land disturbance, its further recovery and use in terms of all the technological facilities. In general, form with consideration of land area, allotted for i^{th} technological facility and restored in j^{th} field of use within total area of land allocation S_p, the coefficient of economic efficiency of land conservation is described by the ratio

$$E_e = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} (M_{rij} - C_{rij}) K_{rij}}{\sum_{j=1}^{m} M_{nj}};$$

$$K_{rij} = \frac{S_{rij}}{S_{rj}},$$

where *n, m* is the number of technological facilities of open cast for which wild lands have been allotted ($i = 1,2,\ldots, n$) and fields of restored land use ($j = 1,2, \ldots m$).

K_{rij} is share of S_{rij} land area of i^{th} technological facility within the total area S_{rj} of lands, restored in accordance with j^{th} use field in total.

Expressions of E_e and K_{rij} indices may help select efficient for land conservation technological schedule of open-cast mining as they involve expenses of a mining enterprise connected with recultivation as well as volume and quality of restored land resources. The indices depend on the conditions of recultivation being mainly determined by the standard schedule of mineral mining. Application of the abovementioned evaluation criteria of land conservation mode helps estimate economic efficiency of sheet ground mining technique. If the developed technique provides more favourable conditions of mining recultivation to compare with standard one, then values of the criteria should grow. Accordingly such a technique for deposit mining should be considered as more economically expedient from the viewpoint of improved land conservation.

To estimate the efficiency of land conservation mode, monetary evaluation should be set as a weighted mean value for all types of soils (arable, pasture, economic area etc.) allotted for technological facilities of open cast. Wild land allotted in 2012 for manganese deposit of Ordzhonikidze Mining and Preparation Integrated Works had following structure: arable – 89.5 %, pasture – 4.3 %, economic areas – 6.2 % (with the weighted mean monetary evaluation of UAH 42.7 thousand per ha). After recultivation 34 ha of lands have been used as follows: agricultural lands (63.7 %), aquicultural lands (5.1 %), forestry (17.1 %), lands for construction needs (13.1 %), lands for recreation needs (1.0 %) (UAH 69.9, 24.7, 45.5, 20.0 and 30.2 thousand per ha were spent for recultivation, respectively with UAH 35.3, 12.0, 25.2, 10.8, 15.0 thousand per ha monetary evaluation of these lands). Thus, restoration of disturbed lands is an unprofitable process for the integrated works which is confirmed by negative value of the determined efficiency. Restored lands are mainly used for water bodies, forest cover, construction and other facilities; return of initially fertile lands with the highest monetary evaluation to the agricultural use is not complete.

Conclusions.

1. The development of the system of efficiency level indices for recultivation operations in terms of open-cast mining is the significant tool to control a mode of mine allocation land use which gives real idea of the scope and outcomes of land allocation. According to the fact, planning of technological mining parameters should estimate prognosticated changes of land areas to be disturbed, volume and quality of land to be restored as well as changes in coast and environmental sustainability of areas which experiences different mining disturbances.

2. Depending upon the criteria of land conservation both technical and technological mining means taken at the previous stage of deposit development stipulate land areas used during further operational stages. That is why the proposed criteria of land conservation should be reflected while planning technological events during the whole period of a deposit mining according to the idea of cascade model according to which results of implementation of technological solutions of previous stage of a deposit development create prerequisites to implement land conservation events during following stage.

3. The advantages of the certain technological schedule for mineral deposit mining should be first determined on the criteria of decreased volume of land disturbance and increased level of land restoration in terms of quality and area. Selection of other land-conservation criteria for the needs of spatial planning of mining operations should be performed on the basis of expedient level of changes in technogenic land structure. Prevention of value losses of recultivated land results in positive effects and prerequisite for minimization of unprofitability level of mining enterprise environmental programs.

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Мета. Обґрунтування критеріїв оцінювання землезберігаючих технологічних схем відкритої розробки родовища, що відображають рівень відновлення земельних угідь у залежності від якості та масштабів їх порушень, а також від їх вартісної оцінки.

Методика. Для визначення параметрів ефективності режиму відпрацювання земельних ресурсів в умовах відкритої гірничої розробки використані методи техніко-економічного й системного аналізу, для визначення актуальних тенденцій розвитку технологій розробки горизонтальних родовищ за їх відношенням до рівня землезбереження застосовано метод наукового узагальнення та систематизації.

Результати. Надана характеристика режиму гірничого землекористування по відношенню до створення сприятливих умов для збереження земель гірничого відводу відкритої розробки родовища. Визначені показники збереження земель за площею їх порушень, їх екологічними властивостями та грошовій оцінці. Обґрунтовані методичні підходи щодо вибору технологічних схем відкритих гірничих робіт у режимі землезбереження.

Наукова новизна. Встановлена залежність між рівнем техногенного навантаження на земельні ресурси гірничого відводу й рівнем еколого-економічної ефективності доопрацювання кар’єрного поля та подальшого відтворення порушених земельних угідь, що має бути основою для визначення напряму післяпромислового використання відновлених земель.

Практична значимість. Запропонована система показників, що є методичним підґрунтям для планування об’єктів гірничої розробки на етапі доопрацювання кар’єрного поля за критерієм мінімізації обсягів гірничопромислового відчуження земель і створення сприятливих умов для відтворення земель, що зазнали руйнування внаслідок гірничодобувної діяльності.

Ключові слова: *відкриті гірничі роботи, відвалоутворення, грошова оцінка земель, кар’єрне поле, землезбереження, гірничотехнічна рекультивація*

Цель. Обоснование критериев оценивания землесберегающих технологических схем открытой разработки месторождений, которые отображают уровень восстановления земельных угодий в зависимости от качества и масштабов их нарушений, а также от их стоимостной оценки.

Методика. Для определения параметров эффективности режима отработки земельных ресурсов в условиях открытой горной разработки использованы методы технико-экономического и системного анализа, для определения актуальных тенденций развития технологий разработки горизонтальных месторождений по их отношениям к уровню землесбережения применен метод научного обобщения и систематизации.

Результаты. Дана характеристика режима горного землепользования по отношению к созданию благоприятных условий для сбережения земель горного отвода открытой разработки месторождения. Определены показатели сбережения земель по площади их нарушения, их экологическим свойствам и денежной оценке. Обоснованы методические подходы к выбору технологических схем открытых горных работ в режиме землесбережения.

Научная новизна. Установлены зависимости между уровнем техногенной нагрузки на земельные ресурсы горного отвода, уровнем эколого-экономической эффективности доработки карьерного поля и дальнейшего восстановления нарушенных земельных угодий, которые должны быть основой для определения последующего направления послепромышленного использования восстановленных земель.

Практическая значимость. Предложенная система показателей является методической основой для планирования объектов горной разработки на этапе доработки карьерного поля по критерию минимизации объёмов горнопромышленного отвода земель и создания благоприятных условий для восстановления земель, которые были нарушены в результате горнодобывающей деятельности.

Ключевые слова: *открытые горные работы, отвалообразование, денежная оценка земель, карьерное поле, землесбережение, горнотехническая рекультивация*

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