SUSTAINABLE DEVELOPMENT OF NATURAL AND ECONOMIC SYSTEMS: THEORY, METHODOLOGY, AND PRACTICE

COLLECTIVE MONOGRAPH

Bilostok

2021

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Sustainable development of natural and economic systems: theory, methodology, and practice: collective monograph / under the general edition of Lidiia Horoshkova, Iegen Khlobystov. Poland: Bilostok. 277 p.

ISBN 978-83-953142-4-7

The monograph considers theoretical and practical issues of sustainability modelling of natural and economic systems. Monograph will be useful to scholars, entrepreneurs, experts in the field of economics, management and administration, educators, graduate students, students and all those who wish to improve their command in English.

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1 SUSTAINABLE DEVELOPMENT MANAGEMENT OF NATURAL AND ECONOMIC SYSTEMS

1.1 MODELING OF RESOURCE DISTRIBUTION SYSTEM IN NATURAL-ECONOMIC SYSTEMS

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Current decentralization and reform of the administrative and territorial structure of Ukraine, the issue of overcoming inequalities and disparities of territorial development in Ukraine by building effective system of financial management for united territorial communities as basis for territories` and country`s sustainable development becomes especially relevant.

The study analyzes effectiveness of intergovernmental fiscal relations system and income distribution within united territorial communities in the context of inequalities and imbalances.

Current system of united territorial communities` expenditures. It has been shown that in the current legal framework regarding united territorial communities there are no effective guarantees of optimal, balanced budget allocation between UTCs settlements - members.

To overcome current disparities in expenditures` distribution of a UTC budget, it has been proposed to use economic and mathematical model, which allows to take into account both the dynamics of UTC per capita income and changes in its population.

In September 2015, at the United Nations Summit on Sustainable Development in New York, the Heads of states and governments agreed on Post-2015 Development Agenda defining 17 global Sustainable Development Goals as part of the 70th Anniversary Session of the UN General Assembly. On September 30, 2019, the President of Ukraine signed the Decree «On the Sustainable

Development Goals of Ukraine up to 2030». Achieving these goals, adapted to national situation, ensuring real transition of the country and its regions to the model of sustainable development requires application of all the capacity and resources, increasing efficiency of Ukrainian natural resource and socio-economic potential, overcoming inequalities and disparities in the development of territories as the main objective of public policy.

One of the main tasks of administrative and territorial reform implementation is to remodel relations and powers between administrative territorial units, to set united territorial communities (UTCs) and to grant them master rights to manage their own sustainable development. Decentralization should solve the problem of low standards of local authorities' organization, inefficient management of social development, regional disparities and inequalities. Therefore, the main task of public policy is to build the framework for the most effective use of territories` natural resource and socio-economic potential as the basis for their balanced development. As there is inequality in territories` basic terms of development, i.e. natural resources, demographic situation, socio-economic development potential, the task of the state amid process of reform is not to deepen the inequality, but to negate the disparities. The tasks could be fulfilled in case of communities` financial capability, maximum power transfer to local authorities, and opportunity to put delegated powers into practice as the basis for sustainable, balanced development of both territories and the country.

There is the needed to ensure this type of development, reforms` legal background, development of scientific principles and recommendations for the optimal use of natural resources and socio-economic development capacity in Ukraine in the context of UTCs formation and their sustainable development support when providing subregional stage of reforms.

Wollmann H. (Denmark), Andre C., Garcia C. (Finnland), Baldershrim H., Kulesza M. (Poland), Feltensteina A., Iwata S. (China) and others analyzed international experience of decentralization. Batalov O.A., Datsko O.I., Zhalilo Y.A., Marunyak E.A., Molodozhen Y.B., Murkovich L.L., Oliynyk D.I., Oliynyk

Y.B., Pavlyuk A.P., Romanova V.V., Rudenko L.G., Tobiash E.V., Chykalo I.V., Shevchenko O.V. and other Ukrainian scholars study modern aspects of solving the problems of development of territorial communities and local self-government [2-14]. Close to the topic of research on solving problems of economic security of communal (municipal) property of a territorial community, are the publications of Tobiash E.V.

Issues of social safety amid decentralization are studied by Ezcurra R., Rodriguez-Pose A. The issues of decentralization management are considered in the works of Oates W.E., relationship between centralization and decentralization by Schneider A., relationship between decentralization reforms and corruption by Arican G., Fisman R., Gatti R. Jourmard I., Giomo C., Ruśkowski E., Salachna J. conducted research referring models of local self-government, mechanism of local budgets and models of budget decentralization in European countries.

Analysis of the main publications shows that the studied problem remains completely unsolved, as in most scientific works theoretical concepts concerning management of process of united territorial communities (UTC) development amid reforming of administrative-territorial system are given mainly. There are attempts to solve the problems of resource efficiency management of UTC of a particular region without generalization for the borders of the country. Natural resources have also gone unnoticed by most authors. The results of the analysis of world and European experience of decentralization and further development of UTC do not take into account the specifics of national conditions and therefore cannot be used to build managerial system for local UTC.

The process of decentralization taking place in Ukraine is ambiguous and rather controversial. On the one hand, it is one of the recent positive achievements of Ukrainian authorities; on the other hand, there are numerous problems in its practical implementation.

Therefore, we must say that not all the tasks of the first stage of decentralization (basic reforms) have been successfully completed today. One issue was inequalities and development disparities of territories due to the unresolved or incorrectly resolved problems.

At first glance, due to the amendments to the Budget and Tax Codes, practical steps were taken towards fiscal decentralization, significant changes in intergovernmental budgetary relations and pumping up local budgets due to the redistribution of sources of taxation between different system levels. However, more detailed analysis of the consequences of some mechanisms` implementation indicates that they impede UTCs` development, threaten their financial capacity, retain inequalities and disparities in territorial development and make it impossible to ensure country`s sustainable development.

According to the regulations of the current Budget Code of Ukraine (Articles 97, 99, 100, 102, 103-2, 103-4 and 108), UTCs budgets have direct intergovernmental fiscal relations with the state budget in the form of: basic subsidy; reverse subsidy; training subvention; medical subvention; subsidies for UTC infrastructure building; subsidies for socio-economic development of different territories; other subventions and grants, if granting and appropriate intergovernmental transfers make sense; funds from the State Regional Development Fund (SRDF) (financing for infrastructure projects). Let us provide critical analysis of some of them.

In 2014, the Verkhovna Rada of Ukraine adopted amendments to the Budget Code. The balancing system was replaced by fiscal equalization system, which means horizontal equalization of territorial depending on per capita income achieved due to the introduction of basic and reverse subsidy. According to the Budget Code, a basic subsidy is defined as a transfer provided from the state budget to local budgets for horizontal equalization of territories` taxability. A reverse subsidy is funds transferred to state budget from local budgets for horizontal equalization of territories` taxability (Article 96 of the Budget Code).

Authorities of the Ministry of Regional Development consider that there used to be a balancing system to ensure each level`s budgetary liabilities by their expenditure with the income capacity. That is, balancing of local budgets was carried out based on necessary expenditures to support public sector according to the formulaic approach. Expenditures delegated by the state were calculated, then incomes were defined and if expenditures exceeded incomes, the equalization subsidy covered the difference.

Experts of the Ministry of Regional Development emphasize the advantages of current budgetary relations management model. Firstly, there is expenditure-based equalization but not income-based; secondly, equalization is set only for personal income tax (exception regional budgets); it forms the basis for the taxability index of corresponding budget. It is also stressed that this is national tax and other income sources are not involved in the equalization process.

This approach is not without significant financial and economic managerial disadvantages. Firstly, reverse subsidy depends on UTC budget`s taxability index, which in turn is determined by personal income tax (PIT). PIT is major budget income generating source in local budgets` structure. Its share in all local budgets of Ukraine is 56% of total income excluding transfers, and 55% of UTCs in particular. As the share of PIT accumulated by UTCs is quite significant - 60%, partial funds withdrawal from this source of income may adversely affect UTCs financial position.

Secondly, new equalization mechanism does not solve the main problem – revitalization of the activity providing level playing field for national UTCs financial capacity. Thus, financially capable communities will increase their capacity and transfer some of their incomes to the State budget in the form of a reverse subsidy. At the same time, disadvantaged communities will receive funds from the State budget in the form of a basic subsidy. This mechanism does not support financial sustainability of the vast majority of UTCs, but pose a threat to the financial position of UTCs able to increase their income independently.

According to the information about local budgets` creditworthiness and stability published by the Ministry of Regional Development (based on the analysis of territorial communities` financial indicators), basic subsidy negatively affects UTCs sustainable development if its ratio to own revenues is more than 50% (calculated by division of basic subsidy to total own incomes and basic subsidy). Basic subsidy within 20-30% is considered to be uncritical for a budget. However, according to the analysis, there have been any procedures initiated by the state regarding steadily subsidized UTCs during the reform period.

Moreover, similar standards for the reverse subsidy (at least formal ones) have not been developed. This is a significant failure as the reverse subsidy directly affects stability of local budgets and financial capacity of UTCs. We applied economic and mathematical modelling and proposed a corresponding model.

It was proposed to determine allowable limits of reverse subsidy correlated to UTC per capita income growth rate. It was proved that to describe the dynamics of UTC income it is expedient to use not the exponential law (hard model), but the logistic model (soft model). It was offered to determine safe limits of UTC financial position`s adjustment with the help of the logistic model ensuring sustainable development. Conditions for the external impact on UTC system in the form of reverse subsidy were shaped. Safe limits for its amounts` adjustments were defined as well. It was proved that 50% of UTC income is critical amount of the reverse subsidy. The estimated allowable amount of the reverse subsidy is no more than 25% of UTC income.

The analysis of reverse subsidy`s to UTC income ratio over time was made to prove the conclusions regarding the deterring effect of reverse subsidies and current inequality of UTCs development in Ukraine. It showed that Honcharivska UTC (Chernihiv region); Verbkivska UTC (Dnipropetrovsk region) and Bogdanivska UTC (Dnipropetrovsk region) occupied first places during 2016 – 2018s. Besides, it is noteworthy that reverse subsidies for these communities increased from 2016 to 2018: in Verbkivska UTC (Dnipropetrovsk region) – from 15.92 to 19.9% and 24.9%; in Bogdanivska UTC (Dnipropetrovsk region) – from 13.9% to 19.1% and 23.4%. In Honcharivska UTC (Chernihiv region) – from 25.8% in 2017, form 25.8% to 29.3% in 2018. Honcharivska UTC was set in 2016 so its budget in 2016 had no subsidies.

Average income per capita growth rate analysis for these communities during 2015 – 2017s demonstrated the following results: Verbkivska UTC - 946.22% (2016/2015), 25.98% (2017/2016); Bogdanivska UTC - 632.95% (2016/2015), 24.50% (2017/2016).

Thus, the comparison of own per capita income analysis` results for these communities during 2015 – 2017s showed that the growth rate of community income was distributed as follows: Verbkivska UTC (Dnipropetrovsk region) - 946.22% (2016/2015), 25.98% (2017/2016); Bogdanivska UTC (Dnipropetrovsk region) – 632.95% (2016/2015), 24.50% (2017/2016). That is, exponential income growth was only in the first year (2015). In 2016, income growth rates declined substantially, similar dynamics were observed in the first half of 2018 and came closer to logistical pattern. Meantime, during 2016 – 2017s the reverse subsidy expanded. Reverse subsidies almost reached 25% level calculated as safe for united territorial communities. Their further growth threatens gradual crisis for UTCs.

We also conducted analysis of basic granting and the reverse subsidy withdrawal based on the results of the first half of 2018, by regions of the country (Table 1).

The results indicate that among the regions of Ukraine there are those with a significant part of UTCs receiving a basic subsidy, which has reached or on the threshold. Among them are Lviv, Volyn, Chernivtsi, Ivano-Frankivsk, Ternopil, and Rivno regions. Besides, it was found out that most communities receive a basic subsidy of 30 - 50% in Lviv, Ivano-Frankivsk, Ternopil, and Rivno regions. At the same time, it should be noted that the level of reverse subsidies is quite high - from 18.8% to 29.3% in Poltava, Dnipropetrovsk, Chernihiv, Mykolaiv, Sumy, and Kyiv regions. The level of basic subsidy is quite low here - from 21.8% to 34.7%.

In our opinion, results obtained prove ineffectiveness of the current mechanism of intergovernmental budgetary regulation as it forms the basis for inequalities of UTCs development characteristics, which may threaten territorial and national sustainable development. As we can see, current mechanism forms the framework when some regions of the country make no effort to work without basic subsidies. Meanwhile, regions having stable indicators of their economic development find out that reverse subsidy slows down further development of their potential, as it withdraws part of funds from UTC budget.

Table 1 – Quantitative indices of basic granting and the reverse subsidy withdrawal based on the results of the first half of 2018

Region	Number of UTCs on 01.07. 2018.	Number of UTCs with basic granting	Maximum basic subsidy, %	Number of UTCs withdrawing reverse subsidy	Maximum reverse subsidy, %
Dnipropetrovsk	56	38	34,7	9	24,9
Zhytomyr	45	36	39,8	7	17,5
Volyn	40	33	61,7	7	23,5
Ternopil	40	36	50,1	2	14,7
Poltava	39	17	22,4	14	19,7
Khmelnytskyi	39	34	41,7	4	15,5
Chernihiv	37	21	22,6	8	29,3
Zaporizhzhia	36	32	45,2	2	8,7
Lviv	35	31	55,8	4	6,0
Vinnytsia	34	22	41,0	9	11,4
Mykolaiv	28	22	36,9	5	20,8
Sumy	28	18	26,4	4	18,8
Kherson	26	24	42,7	1	4,5
Cherkasy	26	18	21,8	4	21,2
Chernivtsi	26	25	53,0	1	4,3
Odessa	25	20	37,7	3	4,4
Rivno	25	22	49,3	2	7,8
Ivano-Frankivsk	23	22	59,0	1	9,6
Kirovohrad	13	4	19,8	6	15,6
Kharkiv	12	9	18,0	2	18,7
Donetsk	9	3	48,0	4	8,9
Kyiv	9	4	8,2	4	21,6
Luhansk	8	6	45,7	1	8,1
Zakarpattia	6	3	43,6	3	0,8

Thus, implementation of reverse and basic subsidies creates inequality in UTCs development and their ability to ensure financial capacity and self-sufficiency as one of the main tasks of decentralization reforms.

Other types of subsidies are not without their disadvantages too as they also lead to social inequality in UTCs development.

UTCs have one exclusive subsidy type – for UTC infrastructure building, imposed in 2016 in accordance with the resolution of the Cabinet of Ministers of Ukraine «Some issues of granting a subsidy from the state budget to local budgets for the formation of infrastructure of the united territorial communities» of 16.03.2016, No. 200. It covers 10 main forms funding: a) development of project, urban planning and design documentation; b) quality improvement of administrative services, including setting and modernization of Administrative Service Centres (ASCs), of acquisition of equipment and software; c) formation of modern systems of community management organization, i.e communication networks, databases, public warning systems; d) reconstruction, reorganization and repurposing of budgetary institutions buildings applying obligatory energy efficient technologies; e) new construction, reconstruction and capital improvement of streets, roads, bridges, communal property transfers; f) acquisition of school transport, special purpose vehicles and their accessories for public utilities, fire and special rescue equipment and fire-fighting equipment, specialized medical transport for healthcare institutions; g) new construction, reconstruction and capital improvement of water supply and drainage system facilities, waste management units and remediation of landfills, etc; h) other activities with public utilities to ensure adequate security and civil defence level; i) meeting budgetary accounts payable according to the legal procedure under the program «State budget subsidy to local budgets to build UTCs infrastructure»; j) construction, reconstruction, repair and maintenance of local roads, streets and roads of communal property in settlements, as well as repairs of streets and roads that are constituent roads of national significance (co-financing on contractual basis).

The amount of subsidy to build UTCs infrastructure is specified one, which depends on UTC area and its rural population. Therefore, inequalities may arise from both rural and urban settlements in some UTCs. The last have to seek resources for infrastructure development from their own sources. This situation is unfair, as rural residents cannot be restricted to use infrastructure of cities where they, for example, work. Their development funding is not covered by this subsidy.

Other two subsidies - for the activities, which support socio-economic development of individual territories and funds of the State Fund of Regional Development - depend on the decisions of special Commission of the corresponding ministry, which is the main manager of these funds. This indicates subjectivism of the granting process, which can also lead to inequality in their distribution between UTCs.

Therefore, these shortcomings of state financing mechanisms of UTCs development should be improved because they cause inequalities in UTCs development in Ukraine and prevent sustainable development of the country.

These disadvantages can be attributed to UTCs inequalities within districts and country as a whole. There are also some unresolved issues regarding allocation of resources between settlements within one UTC.

Resource management is the basis for complex systems performance. To analyze and evaluate the quality of management, they use the category of production and resource capacity, which characterizes the maximum capacity of the accumulated and prepared for processing natural, material, technical, labour, financial and information resources to meet the needs of society and individual citizens. .

However, there is the law of scarce resources. According to this law, available resources do not always fully satisfy all the needs and desires of people.

At the state level, society must choose products for manufacturing, taking into account opportunities and available resources to balance supply and demand. Besides, there are vital goods and services that are of social importance and the state must ensure their supply all citizens without exception.

There is similar issue of resource supply at the mezolevel. Each territory is characterized by its specific production and resource potential, and thus by its industrial specialization. At the administrative-territorial level, as well as at the state level, there is a need to supply population with vital goods and services, regardless of abundancy or scarcity of certain resources.

Resource potential (ownership right and right of disposition of resources) and the level of rational, effective management are the main determinants of building capable UTCs amid current decentralization.

The ability to manage a community depends essentially on rational and efficient managerial processes impact tangible and intangible benefits making.

It was emphasized in «The methodology of capable communities formation» (Methodology, 2015) that: capable territorial community is a territorial community of villages (settlements, cities), which, as a result of voluntary association, are able to provide, on their own or through appropriate local governments, can maintain adequate level of service supply, in particular in the fields of education, culture, health, social protection, utilities, taking into account human resources, financial support and infrastructure development of corresponding administrative-territorial unit.

Our analysis prove that there is no effective guarantee of optimal, balanced distribution of resources among UTCs settlements - members in the legal framework for united territorial communities. This problem arises first of all in UTCs, which consist of settlements with different population and different per capita income.

Thus there are some shortcoming.

The first corresponds to the fact that as single council of UTCs is formed by equal and direct elections, the number of representatives of each settlement depends on its population. That is, settlements as UTC centres may have decision-making advantages by the population size.

The second problem is that per capita income does not always depend on population size for settlements; more priority is given to natural resources abundancy, valuable land or big profitable business. It can also lead to uneven use of funds, in particular for the development of settlements.

The third problem is that fair, balanced expenditures and subsidies distribution is possible if there is reliable information on the number of UTCs residents. The information is practically absent, since UTC formation is preceded by the elections announced by the Central Election Commission (CEC), based on information about residents official registration in settlements. Practice shows that the place of registration does not always coincide with the place of residence. In addition, there is a pendulum labour migration in the process of job search between settlements. That is, there are those who work in another locality leaving every morning and returning in the evening. There are those who work during a week, there are also seasonal jobs. Thus, the number of settlements` residents fluctuates. In this case, the traditional approach is that the distribution of necessary expenditures between settlements will not be effective, since it is based on the place of registration without taking into account temporary migration. In turn, settlements accumulating additional workforce every morning must be provided with appropriate infrastructure (transport, catering, etc.). Transport infrastructure between settlements of such communities also needs additional attention.

To plan UTCs and their settlements development (provision of public goods, capital expenditure, level of income, provision of resources and goods, etc.), it is necessary to take into account the population size and potential changes over a period of time.

To simulate the described situation we apply the system of linear homogeneous difference equations. Let us assume that UTC comprises $n \geq 2$ settlements $D_1, D_2, ..., D_n$ and there is the following migration between them: for all $i \neq j$ is the same part a_{ij} of residents of a settlement D_j goes to settlement D_i, and part a_{ji} of residents of a settlement D_j migrates to D_i, but part a_{ji} stays in it. Let $x_i(t)$ be residents of settlement D_i in t –period. Then,

$$x_1(t+1) = a_{i1}x_1(t) + a_{i2}x_2(t) + ... + a_{in}x_n(t),$$

since for vector $x(t)=(x_1(t);x_2(t);....;x_n(t))$ we obtain the system of discretized equations:

$$x(t+1)=Ax(t) \tag{1}$$

is an integral matrix A which elements obey these conditions:

$$0\le a_{ij}\le 1,\ a_{1j}+a_{2j}+.....+a_{nj}=1,\quad j=\overline{1,n}.$$

Let us study n equation solutions (1) $x^1(t), x^2(t),...., x^n(t),$ determined by the next initial conditions:

$$\begin{aligned} x^1(t_0)&=x_0^1=(x_{11}^0;x_{21}^0;...;x_{n1}^0),\\ x^2(t_0)&=x_0^2=(x_{12}^0;x_{22}^0;...;x_{n2}^0),\\ x^n(t_0)&=x_0^n=(x_{1n}^0;x_{2n}^0;...;x_{nn}^0). \end{aligned} \tag{2}$$

The sum of solutions $x^1(t), x^2(t),...., x^n(t)$ of equation (1), which obey conditions (2), are called fundamental system of solutions if the determinant does not equal zero:

$$|X(t_0)|=\begin{vmatrix} x_{11}^0 & x_{12}^0 & \cdots & x_{1n}^0\\ x_{21}^0 & x_{22}^0 & \cdots & x_{2n}^0\\ \cdots & \cdots & \cdots & \cdots\\ x_{n1}^0 & x_{n2}^0 & \cdots & x_{nn}^0 \end{vmatrix}\ne 0.$$

If $x^1(t), x^2(t),...., x^n(t)$ is a fundamental system of solutions of equation (1), then any solution $\bar{x}(t)$ of rhis equation can be presented as:

$\bar{x}(t)=C_1x^1(t)+C_2x^2(t)+...+C_nx^n(t),$

where $C_1, C_2,...., C_n$ - constants.

Let us apply the system of linear homogeneous difference equations with fixed factors:

$$\begin{cases} x_1(t+1)=a_{11}x_1(t)+a_{12}x_2(t)+.....+a_{1n}x_n(t),\\ x_2(t+1)=a_{21}x_1(t)+a_{22}x_2(t)+.....+a_{2n}x_n(t),\\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\\ x_n(t+1)=a_{n1}x_1(t)+a_{n2}x_2(t)+.....+a_{nn}x_n(t), \end{cases} \tag{3}$$

where $a_{ji}, i, j=1,n,$ - real constants.

System solution (3) will be obtained in the form:

$$x_1 = \gamma_1 \lambda^t, x_2 = \gamma_2 \lambda^t, ..., x_n = \gamma_n \lambda^t, \lambda \neq 0, \quad (4)$$

where $\gamma_1, \gamma_2, ..., \gamma_n$ and γ - numbers, which have to be determined.

Let us substitute expression (4) into system (3) after reduction of λ^t and obtain:

$$\begin{cases} (a_{11} - \lambda)\gamma_1 + a_{12}\gamma_2 + ... + a_{1n}\gamma_n = 0 \\ (a_{21} - \lambda)\gamma_1 + a_{22}\gamma_2 + ... + a_{2n}\gamma_n = 0 \\ .... \\ (a_{n1} - \lambda)\gamma_1 + a_{n2}\gamma_2 + ... + a_{nn}\gamma_n = 0 \end{cases} \quad (5)$$

System (5) has zero solution if its determinant equals zero, which is necessary and sufficient:

$$\begin{vmatrix} a_{11} - \lambda & a_{12} & ... & a_{12} \\ a_{21} & a_{22} - \lambda & ... & a_{2n} \\ .... \\ a_{n1} & a_{n2} & ... & a_{nn} - \lambda \end{vmatrix} = 0. \quad (6)$$

Equation (6) is called characteristical for system (3).

To plan UTC future development based on its residents distribution between settlements it is necessary to study vector behavior $x(t)$ when $t \to \infty$. To do this, we need to look for a complementary solution to the system (1).

Let us consider the case when UTC comprises three settlements, that is n = 3.

We assume that $a_{21} = \alpha_1, \quad a_{31} = \alpha_2, \quad a_{12} = \beta_1, \quad a_{32} = \beta_2, \quad a_{13} = \beta_1, \quad a_{23} = \beta_3.$

Then matrix A will be:

$$A = \begin{pmatrix} 1 - \alpha_1 - \alpha_2 & \beta_1 & \beta_1 \\ \alpha_1 & 1 - \beta - \beta_2 & \beta_3 \\ \alpha_2 & \beta_2 & 1 - \beta_1 - \beta_3 \end{pmatrix}.$$

We obtain for system (1) with the matrix A complementary solution.

Characteristical numbers of matrix A are found from the equation

$$\begin{vmatrix} 1-\alpha_1-\alpha_2-\lambda & \beta_1 & \beta_1 \\ \alpha_1 & 1-\beta_1-\beta_2-\lambda & \beta_3 \\ \alpha_2 & \beta_2 & 1-\beta_1-\beta_3-\lambda \end{vmatrix} = 0,$$

or

$$(1-\lambda-\alpha_1-\alpha_2)(1-\lambda-\beta_1-\beta_2)(1-\lambda-\beta_1-\beta_3)+$$
$$+\alpha_1\beta_2\beta_1+\beta_1\beta_3\alpha_2-(1-\lambda-\beta_1-\beta_2)\alpha_2\beta_1-$$
$$-(1-\lambda-\alpha_1-\alpha_2)\beta_2\beta_3-(1-\lambda-\beta_1-\beta_3)\alpha_1\beta_1=0.$$

The last equation can be written as

$$(1-\lambda)^3-(1-\lambda)^2-(\alpha_1+\alpha_2+2\beta_1+\beta_2+\beta_3)+$$
$$+(1-\lambda)((\alpha_1+\alpha_2)(\beta_1+\beta_2)+(\alpha_1+\alpha_2)(\beta_1+\beta_3)+)$$
$$+(\beta_1+\beta_2)(\beta_1+\beta_3)-\alpha_2\beta_1-\beta_2\beta_3-\alpha_1\beta_1=0.$$

The we obtain $\lambda_1=1$, a the other two roots are from equation $(\lambda-1)^2+(\lambda-1)(\alpha_1+\alpha_2+2\beta_1+\beta_2+\beta_3)+(\alpha_1+\alpha_2+\beta_1)(\beta_1+\beta_2+\beta_3)=0$

These roots are $\lambda=1-\alpha_1-\alpha_2-\beta_1$ i $\lambda_3=1-\beta_1-\beta_2-\beta_3$. We build system for each root (5). When $\lambda_1=1$ it is

$$\begin{cases} (-\alpha_1-\alpha_2)\gamma_1+\beta_1\gamma_2+\beta_1\gamma_3=0, \\ \alpha_1\gamma_1-(\beta_1+\beta_2)\gamma_2+\beta_3\gamma_3=0, \\ \{\alpha_2\gamma_1+\beta_2\gamma_2-(\beta_1+\beta_3)\gamma_3=0. \end{cases}$$

Subtracting from the second equation of the system multiplied by α_2, third equation, multiplied by α_1, we obtain:

$$(-\alpha_2\beta_1-\alpha_2\beta_2-\alpha_1\beta_2)\gamma_2+(\alpha_2\beta_3+\alpha_1\beta_3+\alpha_1\beta_1)\gamma_3=0.$$

We think that $\gamma_3=\alpha_2\beta_1+\alpha_2\beta_2+\alpha_1\beta_2$,we have: $\gamma_2=\alpha_2\beta_3+\alpha_1\beta_3+\alpha_1\beta_1$. We substitute these values γ_2 and γ_3 to the first equation of the system and obtain: $\gamma_1=\beta_1\beta_2+\beta_1^2+\beta_1\beta_3$.

Substituting system (5) $\lambda_2=1-\alpha_1-\alpha_2-\beta_1$, we have:

$$\begin{cases} \beta_1\gamma_1+\beta_1\gamma_2+\beta_1\gamma_3=0, \\ \alpha_1\gamma_1+(\alpha_1+\alpha_2-\beta_2)\gamma_2+\beta_3\gamma_3=0, \\ \alpha_2\gamma_1+\beta_2\gamma_2+(\alpha_1+\alpha_2-\beta_3)\gamma_3=0. \end{cases}$$

Multiplying the second equation of the system by α_2, and the third by α_1 and subtracting the obtained equation, we have:

$$\left(-\alpha_1\beta_2+\alpha_1\alpha_2+\alpha_2^2-\beta_2\alpha_2\right)\gamma_2+\left(\beta_3\alpha_1-\alpha_1^2-\alpha_1\alpha_2+\beta_3\alpha_2\right)\lambda_3=0,$$

then if $\gamma_2=\alpha_1^2-\alpha_1\beta_3+\alpha_1\alpha_2-\alpha_2\beta_3,$ we obtain:

$$\gamma_3=\alpha_1\alpha_2-\alpha_1\beta_2+\alpha_2^2-\beta_2\alpha_2.$$

Then

$$\gamma_1=(\alpha_1+\alpha_2)(\beta_3+\beta_2-\alpha_1-\alpha_2).$$

For $\lambda_3=1-\beta_1-\beta_2-\beta_3$ we have:

$$\begin{cases}(-\alpha_1-\alpha_2+\beta_1+\beta_2+\beta_3)\gamma_1+\beta_1\gamma_2+\beta_1\gamma_3=0.\\ \alpha_1\gamma_1+\beta_3\gamma_2+\beta_3\gamma_3=0.\\ \alpha_2\gamma_1+\beta_2\gamma_2+\beta_2\gamma_2=0.\end{cases}$$

After multiplication of the second equation by α_2 , and the third by α_1 and subtracting we obtain: $(\beta_3\alpha_2-\alpha_1\beta_2)\gamma_2+(\alpha_2\beta_3-\alpha_1\beta_2)\gamma_3=0.$

We consider that $\gamma_2=\alpha_2\beta_3-\alpha_1\beta_2,$ then we have:

$$\gamma_3=\alpha_1\beta_2-\beta_3\alpha_2.$$

Obtain from the first equation: $\gamma_1=0$

The fundamental system of solution is presented as: for $\lambda_1=1$

$$\begin{cases}x_{11}=\beta_1\beta_2+\beta_1^2+\beta_1\beta_3,\\ x_{21}=\alpha_2\beta_3+\alpha_1\beta_3+\alpha_1\beta_{1,}\\ x_{31}=\alpha_2\beta_1+\alpha_2\beta_2+\alpha_1\beta_2;\end{cases}$$

for $\lambda_2=1-\alpha_1-\alpha_2-\beta_1$

$$\begin{cases}x_{12}=(\alpha_1+\alpha_2)(\beta_3+\beta_2-\alpha_1-\alpha_2)(1-\alpha_1-\alpha_2-\beta_1)^t,\\ x_{22}=\left(\alpha_1^2-\alpha_1\beta_3+\alpha_1\alpha_2-\alpha_2\beta_3\right)(1-\alpha_1-\alpha_2-\beta_1)^t,\\ x_{32}=\left(\alpha_1\alpha_2-\alpha_1\beta_2+\alpha_2^2-\beta_2\alpha_2\right)(1-\alpha_1-\alpha_2-\beta_1)^t;\end{cases}$$

for $\lambda_3=1-\beta_1-\beta_2-\beta_3$

$$x_{13}=0,$$

$$x_{23}=(\alpha_2\beta_3-\alpha_1\beta_2)(1-\beta_1-\beta_2-\beta_3)^t,$$

$$x_{33} = (\alpha_1\beta_2 - \beta_3\alpha_2)(1 - \beta_1 - \beta_2 - \beta_3)^t.$$

Complementary system solution is:

$$x_1 = C_1(\beta_1\beta_2 + \beta_1^2 + \beta_1\beta_3) + C_2(\alpha_1 + \alpha_2)(\beta_3 + \beta_2 - \alpha_1 - \alpha_2)(1 - \alpha_1 - \alpha_2 - \beta_1)^t,$$

$$x_2 = C_1(\alpha_2\beta_3 + \alpha_1\beta_3 + \alpha_1\beta_1) + C_2(\alpha_1^2 - \alpha_1\beta_3 + \alpha_1\alpha_2 - \alpha_2\beta_3)^t +$$

$$+ C_3(\alpha_2\beta_3 - \alpha_1\beta_2)(1 - \beta_1 - \beta_2 - \beta_3)^t.$$

$$x_3 = C_1(\alpha_2\beta_1 + \alpha_2\beta_2 + \alpha_1\beta_2) + C_2(\alpha_1\alpha_2 - \alpha_1\beta_2 + \alpha_2^2 - \beta_2\alpha_2)(1 - \alpha_1 - \alpha_2 - \beta_1)^t +$$

$$+ C_3(\alpha_1\beta_2 - \beta_3\alpha_2)(1 - \beta_1 - \beta_2 - \beta_3)^t$$

Therefore, based on these equations, it is possible to calculate population size at certain time intervals (the beginning t = 0). Taking into account the expected (planned) changes in each settlement`s population size in UTC territory, it is possible to distribute planned expenditure for providing public goods.

This allows to form the financial revenue distribution models that make up UTCs budgets and to take into account in territorial development strategies and projects such components as: budget revenue dynamics, territorial peculiarities and development determinants, employment rates and migration capacity.

The decentralization process has intensely started since 2015. During the initial stage separate territorial communities were organized, which started the integration process to form UTCs during 2016-2017. Unfortunately, the deceleration of the UTCs formation started in 2017 due to the inefficient regulation of UTCs consolidation. Intensification of decentralization process started only in 2018. It is found impossible to illustrate practical facets of the model in retrospect, which stems from: population size data is out-of-date as the last population census was held in 2001 n Ukraine; official statistics does not take into account circular (short-term) migration inside one country, its regions and certain settlements; population registration in Ukraine includes not the residence but the registration place, which sometimes do not coincide. Total public goods cannot be accurately estimated as actual consumption data is approximate, expert one. As the first stage of reforms is finished by the end of 2019, the purpose of our study was to build economic and mathematical model of financial resource management for public goods provision during the next phase of reforms. By now the decision to improve decentralization reform frame has been made. The accent is transferred from basic to sub-regional level aimed at UTCs and regions consolidation, considerable reduction in their number. The model proposed by us was built just for the second phase of reforms, which have to be intensified in Ukraine by 2020. Thus, the main tasks of UTCs formation in the nearest future are setting of ration measures and sustainability of territories development. To do this we propose economic and mathematical modelling of UTC formation in certain territorial measures.

Assume that in system (1) matrix A is

$$A=\begin{pmatrix} 0,4 & 0,1 & 0,1 \\ 0,4 & 0,8 & 0,3 \\ 0,2 & 0,1 & 0,6 \end{pmatrix}$$

Let us find the law of population distribution in three settlements for this case.

Characteristical equation is

$$\begin{vmatrix} 0,4-\lambda & 0,1 & 0,1 \\ 0,4 & 0,8-\lambda & 0,3 \\ 0,2 & 0,1 & 0,6-\lambda \end{vmatrix}=0$$

or $\lambda^3 - 1{,}8\lambda + 0{,}95\lambda - 0{,}15 = 0.$ Its roots are $\lambda_1 = 1, \lambda_2 = 0{,}3, \lambda_3 = 0{,}5.$

For $\lambda_1 = 1$ we have the system (5):

$$\begin{cases} -0{,}6\gamma_1 + 0{,}1\gamma_2 + 0{,}1\gamma_3 = 0, \\ 0{,}4\gamma_1 - 0{,}2\gamma_2 + 0{,}3\gamma_3 = 0, \\ 0{,}2\gamma_1 + 0{,}1\gamma_2 - 0{,}4\gamma_3 = 0, \end{cases}$$

Then $\gamma_1 = 0{,}5, \quad \gamma_2 = 2{,}2, \quad \gamma_3 = 0{,}8.$

For $\lambda_2 = 0{,}3$ from system

$$\begin{cases} 0{,}1\gamma_1 + 0{,}1\gamma_2 + 0{,}1\gamma_3 = 0 \\ 0{,}4\gamma_1 + 0{,}5\gamma_2 + 0{,}3\gamma_3 = 0 \\ 0{,}2\gamma_1 + 0{,}1\gamma_2 + 0{,}3\gamma_3 = 0 \end{cases}$$

obtain: $\gamma_1 = -2, \quad \gamma_2 = 1, \quad \gamma_3 = 1.$

System

$$\begin{cases} -0{,}1\gamma_1 + 0{,}1\gamma_2 + 0{,}1\gamma_3 = 0, \\ 0{,}4\gamma_1 + 0{,}3\gamma_2 + 0{,}3\gamma_3 = 0, \\ 0{,}2\gamma_1 + 0{,}1\gamma_2 + 0{,}1\gamma_3 = 0, \end{cases}$$

If $\lambda_3 = 0{,}5$, we obtain the following solution: $\gamma_1 = 0$, $\gamma_2 = 1, \gamma_3 = -1$.

Fundamental system of solution is the following:

For $\lambda_1 = 1$

$$\chi_{11} = 0{,}5,\ \chi_{21} = 2{,}2,\ \chi_{31} = 0{,}8;$$

for $\lambda_2 = 0{,}3$

$$\chi_{12} = -2(0{,}3)^t,\ \chi_{22} = (0{,}3)^t,\ \chi_{32} = (0{,}3)^t;$$

for $\lambda_3 = 0{,}5$

$$\chi_{13} = 0,\ \chi_{23} = (0{,}5)^t,\ \chi_{33} = -(0{,}5)^t.$$

Thus, we obtain:

$$\chi_1(t) = 0{,}5C_1 - 2C_2(0{,}3)^t,$$

$$\chi_2(t) = 2{,}2C_1 + C_2(0{,}3)^t + C_3(0{,}5)^t,$$

$$\chi_3(t) = 0{,}8C_1 + C_2(0{,}3)^t - C_3(0{,}5)^t.$$

This is complementary solution of this model.

Thus the obtained equations describe the dynamics of the population size changes in three settlements of UTCs and can be used for UTCs financial resource distribution planning aimed at certain settlements development.

We believe that there is another problem with the inefficiency of allocating both of UTCs budget expenditures to individual settlements and consideration of external migration, above all - labour migration outside the country. In regions with significant external labour migration (emigration), the actual population size does not always coincide with that taken into account by CEC when setting a UTC. It is also not possible to take into account the current system of expenditures and other financial resources (subsidies) distribution from the State budget.

Therefore, there is a need to build a mechanism for fair distribution of UTCs budget.

There is experience in solving this problem. Thus, in the EU, there is a principle of harmonious development, enshrined in the Treaty on the Functioning of the EU. It means distribution of the majority of budget to less developed territories. This approach, in our opinion, poses threat of these settlements affiliation with UTCs or the emergence of communities that would prefer subsidized development instead of creating conditions for their own financial capacity.

Another opposite approach is economic liberalism. It provides dependency of budget expenditures on each participant contribution. The negative experience with this approach is already known in the USA. Due to the threat of social injustice, there are already more and more municipalities separating the rest of the territory, along with the richest districts and, accordingly, their incomes, leaving a gap in the financing of total expenditures. However, this approach will encourage communities to seek new opportunities to earn money.

That is why, it is advisable to use differential approach for the formation of budget expenditures, taking into account their peculiarities based on social justice principles for UTCs` population.

We consider that it is possible to take into account the mentioned shortcomings in distribution of resources between UTCs settlements applying equation of the economic growth model by R. Solow.

We consider that the neoclassical R. Solow model could be used to solve the problem. Set of determinants causes the model`s application as the basis for fair mechanism for income generation and distribution among UTC residents. First, within the Solow model, mechanisms of economic growth flat-rates have been found out, which is the key to UTCs sustainable development. Second, the Solow model was developed for a closed economy in which domestic investment equals domestic savings and there is no international trade. In our opinion, economic conditions for UTC functioning can be considered equal to a closed economy. This conclusion is based on the fact that the main task of decentralization is to create financially viable, self-sufficient communities, so their financial capacity should be formed similarly to the closed economy – mainly from their own sources and available resources. Third, the Solow model reveals the mechanism of savings`, investment`s and population growth`s impact on living standards and the dynamics, which fully meets the task set by us. Fourth, capital accumulation is a key element of neoclassical Solow growth model, which is important for UTCs. Moreover, the neoclassical approach is radically different from the New Keynesian one. The model uses the Cobb–Douglas production function, in which the factors of production are non-substitutable, which is considered as a disadvantage of the model. Taking into account the task to ensure fair income distribution between UTC settlements based on the actual population, the factors of capital and population are not non-substitutable, they must be coherent.

It looks as follows:

$$\dot{k} = lf(k) - (\alpha + \beta)k \qquad (7)$$

Let us find the solution of R. Solow model equation for Cobb-Douglas macroeconomic production function:

$F(K,L) = K^{a} L^{1-a}, 0 < a < 1$

Let $Y = F(K,L)$ be total UTC income, that is own income, infrastructure subsidy and basic / reverse subsidy.

F – homogeneous first-order production function described by equation:

$F(tK, tL) = tF(K, L)$

where K – UTC income;

L – UTC population.

Let us introduce index $k = K/L$, which is equal to UTC own income to UTC total population ratio, so we have index of own income per capita for UTC.

Then capital productivity is:

$$f(k) = \frac{F(K,L)}{L} = F(k,l). \qquad (8)$$

We assume that we have a natural increase in UTC population over period of time:

$$\dot{L} = \alpha L \qquad (9)$$

where α - coefficient (growth rate)of UTC population.

UTC investments (capital expenditures) are used to increase own resources (income) and depreciation of fixed capital, i.e

$I = \dot{K} + \beta K$, where β - depreciation rate (share of capital expenditures).

Then if *l* – rate of investment, then

$I = lY = \dot{K} + \beta K$,

or

$$\dot{K} = lF(K, L) - \beta K \qquad (10)$$

According to the own income per capita definition *k*, we have *lnk = lnK – lnL*. We differentiate this equation by *t*, and obtain:

$\frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{L}}{L}$.

We substitute into the last ratio equations (9) and (10) and obtain the equation of unknown function *k* having the form (8), where function *f(k)* is defined by formula (7). This first-order nonlinear differential equation to own income per capita has simple economic interpretation: net own income increment is the difference between gross own income and steady-state own income.

Equations of R. Solow model for Cobb-Douglas production function take into account

$F(K, L) = \frac{K^a L^{1-a}}{L} = (\frac{K}{L})^a = k$,

are as follows:

$$\dot{k} = l\,k^a - (\alpha + \beta)k, 0 < a < 1 \qquad (11)$$

We integrate the Bernoulli equation by the substitution method.

Let *k = uv*. Then

$\dot{k} = \dot{u}v + \dot{v}u$

equation (11) we set as:

$\dot{u}v + \dot{v}u = l\,(uv)^a - (\alpha + \beta)uv$

or

$$\dot{u}\,v + u(\dot{v} + (\alpha + \beta)v) = l\,u^a\,v^a \qquad (12)$$

Taking into account that one of the unknown functions, such as *v*, can be arbitrarily chosen (because only derivative *uv* must meet original equation), we take any partial equation solutions for *v*

$\dot{v} + (\alpha + \beta)v) = 0$, which turns to zero coefficient of *u* in equation (12).

Obtain:

$$\frac{dv}{dt} = -(\alpha + \beta)v\,.$$

After integration, we get: $\ln|v| = -(\alpha + \beta)v$ or $v = e^{-(\alpha+\beta)t}$ (we do not introduce continuous integration because only a partial solution of the auxiliary equation is required). To calculate u we have equations

$$\dot{u}\,v = l\,u^a\,v^a$$

or

$$\dot{u}\,e^{-(\alpha+\beta)t} = l\,u^a\,e^{-a(\alpha+\beta)t}\,.$$

We divide variables and obtain:

$$\frac{du}{u^a} = l\,e^{(\alpha+\beta)(1-a)t}\,dt\,,$$

then

$$\frac{u^{-a+1}}{1-a} = l\,\frac{1}{(1+a)(\alpha+\beta)}\,e^{(\alpha+\beta)(1-a)t} + \frac{C}{1-a}$$

or

$$u = \left(\frac{l}{(\alpha+\beta)}\,e^{(\alpha+\beta)(1-a)t} + C\right)^{\frac{1}{1-a}}.$$

Then

$$k = \left(\frac{l}{(\alpha+\beta)}\,e^{(\alpha+\beta)(1-a)t} + C\right)^{\frac{1}{1-a}} e^{-(\alpha+\beta)t} =$$

$$= (\frac{l}{(\alpha+\beta)} + C e^{-(1-a)(\alpha+\beta)t})^{\frac{1}{1-a}}.$$

When t→∝, own income per capita is:

$$k \to (\frac{l}{(\alpha+\beta)})^{(1-a)^{-1}}.$$

Thus, we have proposed the model that simultaneously take into account the capital expenditures growth rate and changes in population, if UTC per capita income and gross income rise. If necessary, it is advisable to build this function for average UTC indices, and then to determine the expenditures for each UTC`s settlement taking into account its change in population in case its per capita income meets UTC average.

Similar calculations can be further made within the region to assess the level of financial autonomy of both UTC and region in general. Comparison of regional indicators (in terms of districts) will allow to estimate the level of sustainable development of a territory (region). It will also make it possible to compare these parameters between different regions.

The paper analyzes the effectiveness of intergovernmental relations and income distribution system within united territorial communities in the context of inequalities and imbalances as a threat to sustainable development of territories and the country.

The analysis fiscal equalization system introduced in 2014 instead of income and expenditures balancing system made it possible to conclude that the current system is also not without drawbacks. The main ones are: a reverse subsidy determined by personal income tax negatively affects UTCs financial position, since PIT is the main source of community income. It has been proposed to determine the maximum allowable limits of reverse subsidy correlated to per capita income growth rate of UTCs. A so-called soft model, in the form of a logistic curve, has been proposed to describe the dynamics of UTCs own income. Secure limits of external impact, such as a reverse subsidy, on UTCs financial position have been determined.

It has been proved that current mechanism of intergovernmental budget regulation causes inequality of UTCs development because funds in the form of reverse subsidies are being withdrawn from self-sufficient, financially capable communities. Nevertheless, there are UTCs in Ukraine that have been receiving a basic subsidy for a long time, which does not encourage them to support their self-sufficiency. Implementation of this mechanism creates imbalances in regional development funding.

Current system of united territorial communities` expenditures, which includes financing of education, culture, health care, social protection, utilities, infrastructure development have been analysed in the study. It has been shown that current legal framework regarding united territorial communities there are no efficient guarantees of optimal, balanced budget distribution between UTCs settlements - members.

Distribution issues have been identified, namely: UTCs include settlements with different population size, different per capita income; there is volatility of population caused by migration processes of different duration. Therefore, the need to build mechanism for efficient UTCs budget distribution based on the real needs and capabilities of communities has been proved. Foreign experience does not have effective mechanisms for budgets expenditures distribution, especially when we take into account Ukrainian specifics. Different UTCs can be dramatically different in terms of their capability and potential, even in one administrative region. Therefore, distribution of communities` financial resources should be as efficient as possible and independent of shortsighted decision-making.

To overcome existing disparities in UTCs budget expenditures distribution, it has been proposed to apply economic and mathematical model based on the first-order differential equation, which allows to take into account simultaneously the dynamics of UTC per capita income and its population change.

Application of the proposed models has practical significance as it provides opportunity to increase public policy efficiency to affect inequalities and imbalances as a principle for harmonious development of the country and its territories.

References

1. On approval of the Methodology for the formation of capable territorial communities: Resolution of the Cabinet of Ministers of Ukraine dated April 8, 2015, No. 214. [online] http://zakon2.rada.gov.u. (accessed 04.02.2018).
2. Wollmann H. Reorganizing Local Government: Between Territorial Consolidation and Two-tier Intermunicipality. HKJU-CCPA. 2011. 11(3). P. 681-706.
3. Andre C., Garcia C. local Public Finances and Municipal Reform in Finland. OECD Economics Department Working Papers. 2014. No 1121. OECD Publishing. – Retrieved from: http:dx.doi.org/10.1787/5jz2qt0zj024-en
4. Feltensteina A., Iwata S. Decentralization and macroeconomic performance in China: regional autonomy has its costs. Jornal of Development Economics. 2005. No 76. P. 481-501
5. Ezcurra R., Rodriguez-Pose A. Decentralization of social protection expenditure and economic growth in the OECD, Publius. 2011. No 41(1). P.146-157.
6. Perz S., Barnes G., Shenkin A., Rojas D., Vaca C. Privat and communal lends? International Jornal of the Commons. Vol. 8, No 1. February 2014. P. 179-206.
7. Gerbert J.D., Nahrath S., Csicos P., Knoepfel P. The role of Swiss civic corporation in land use planning. Environment and Planning A43: 2011. P. 185-204 : Electronic resource]. – Retrieved from: http: ://www. enuplan.com / abstract. cgi?id=43293.
8. Oates W.E. On the Theory and Practice of Fiscal Decentralization. IFIR Working Paper Series, 2006. №3. Electronic resource].: http: www.ifigs.org/publication/ifir_working_papers/IFIR-WP-2006-05.pdf.
9. Schneider A. Decentralization: Conceptualization and Measurement. Studies in Comparative International Development. 2003. №38/3. P.32-56.
10. Arikan G. Fiscal decentralization: Aremedy for corruption? Iternational Tax and Public Finanse. 2004. P. 175-195.
11. Fisman R., Gatti R. Decentralization and corruption: Evidence across countries. Journal of Public Economics. 2002. P.325 – 345.
12. Elazar D., Harvey D. Spaces of global capitalism: Towards a theory of uneven geographical development. London; New York: Verso. 2006. 178 p.
13. Perz S. Privat and communal lends? / S.Perz, G.Barnes, A.Shenkin, D.Rojas, C.Vaca // International Jornal of the Commons. Vol. 8, No 1. February 2014. P. 179-206.
14. Yescombe E. R. Public-Private Partnerships: Principles of Policy and Finance / E. R. Yescombe [UK First edition]. London : Yescombe Consulting Ltd, 2007.XVIII+350p.

1.2 KAIZEN TECHNOLOGIES IN NATURAL AND ECONOMIC SYSTEMS MANAGEMENT

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Intergovernmental fiscal relations reforms are the driving force for the local communities' transition to self-sufficiency and more rational planning of their resources, which in future financial periods will make territorial communities economically self-sufficient and financially capable. Decentralization of power relations in the state foregrounds the study the research of complex socio-economic systems, which operate based on collective decision-making and collective action. This requires the study of the preconditions for the effective management of public resources at the local level and the formation of the methodological framework to improve the territorial organization of the state through, first, the formation of self-sufficient territorial communities.

A comprehensive vision of the reforms required by the Ukrainian society is presented in the «Strategy for Sustainable Development of Ukraine-2020» approved by the Decree of the President of Ukraine [1]. Among the priorities of the Strategy are decentralization and reformation of national social and economic system, restructuring of business entities` territorial organization giving maximum geographical considerations. In accordance with the goals of Sustainable Development, adapted for Ukraine (during 2015 – 2030s) [2], the goal 11 concerning sustainable development of cities and communities is directly related to the process of decentralization. Nowadays the problem of strong united territorial communities (UTCs) formation in the context of administrative and territorial reform implementation based on the principles of decentralization becomes especially acute.

Pavliuk Y.P., Oliinyk Д.І., Batalov O.A., Dashko O.I., Murkovych L. L., Molodozhen Y.B. and other scholars studied current aspects of territorial communities` and local self-government's development problems solution [3-6]. Own findings concerning the problem are presented in [7-15].

The new administrative and territorial system should become the basis for constructing a new model of territorial administration, based on the principles of decentralization, subsidiarity, balance of national interests with regional and territorial communities` interests representation, local self-governance widespread, territorial communities` power and autonomy, coherence with natural geographical capacity. That is why the problem of UTCs resource management and their sustainable development conditions deserves special attention. Objective necessity and urgency of building territorial communities self-financing models as the basis of their dynamic development is determined by the fact of current territorial organization management and administrative-territorial structure reforms, which require the formation of new models for territorial communities development management on the principles of decentralization. That is why there is the need to find out new technologies of territorial communities` resources management on the principles of territories self-financing.

According to the Law of Ukraine «On Local Self-Government in Ukraine» (statutory wording of 02.08.2017), «the territorial community is presented by residents permanently residing within a village, settlement, city, which is an autonomous administrative and territorial devision, or a voluntary association of residents of several villages having a single administrative center» [16].

Management of interconnections between internal capabilities and external impact creates conditions for UTCs sustainable development. The main infrastructural components of UTCs sustainable development are economic, environmental and social.

System harmonization and the balance of these three components form enormously complex challenge. Its result is reflected in the «Methodology for the formation of communities capacity» [17]: a powerful territorial community is a territorial community of villages (settlements, cities), which, as a result of a voluntary association, can independently or through appropriate local self-government bodies provide an adequate level of service provision, in particular in the sphere of education, culture, health care, social protection, housing and utilities infrastructure, taking into account human resources, financial support and infrastructure development of the corresponding administrative division.

Thus, at first glance, one may consider that conditions for decentralization of power and territorial community's increased role and significance to ensure the effective functioning of territories and state as a whole at the legislative level have already been created. On the other hand, our studies revealed that there is the need to build a new model of territorial organization of power and administrative-territorial system, since, as we have proved earlier, there is a volatile three-level system of territorial management, therefore, territorial communities` management tools should be improved.

The new model of management should be based on the fact that the main link that ensures the effective functioning of the country's economic system is the territorial community, since it is impossible to provide economic development with only the regulatory influence from the top down. It is necessary to create conditions for the territorial communities dynamic develop. It is quite possible that higher than community levels in the three-level system of territorial management will have to ensure the coordination of the entire system functioning. To solve the problem of the whole country's dynamic development implementation it is necessary to form the conditions of communities stability and efficiency.

In our opinion, to form the effective management system at the stage of territorial community organizing, it is advisable to use a well-known l closed economy model, that is, to model the parameters of the model functioning using only internal capabilities without interaction with the external environment. This model has limitations, as there are no closed economies, as well as territorial communities cannot be socially isolated. However the proposed assumption allows us to assess own, internal capabilities of a territorial community, along with its potential of self-financing and the break-even point. Thus, the autarky of a complex system, i.e. territorial community, enables the assessment of its internal factors and capacities to self-sufficient functioning by means of efficient utilization of own resources and allows to identify the system's possibility to reach dynamic equilibrium.

Evidently, the state of dynamic equilibrium is formed on the basis of the interaction of two opposite trends – the growth of production and consumption. The quantitative measurement of equilibrium is economic efficiency – Pareto-efficiency, which requires optimal resources distribution among market participants for production purposes. We assume the scarcity of resources, limited goods with their unlimited consumption.

Accordingly, we modelled the autarky system conditions, namely the lack of external resources provision (resources limited by the internal territorial community's capabilities) and the need to sustain territory residents (without any consumption restrictions) at current level of well-being.

In our opinion, to describe the case mathematically we may use the input-output model with certain limitations. Clearly, this model is used in economic planning at the regional and national level, if there is the need to determine the volume of output, which provides the residents` demand and production needs for these goods with a well-known technology. This problem with the assumption of linear technology (direct proportionality between the volume of output and the resources cost volume) is mathematically formalized in W. Leontief «Input-Output» model.

In the multi-sectoral model for the territorial community, we will assume that the elements of this complex system are the main factors of production, namely: land, labour, capital, entrepreneurial skills and information. National production is undertaken with the help of these factor inputs in a specific separate territory.

«Land» firstly refers to the land as the type of natural resources. «Labour» refers to active individuals who live in the territory, characterized by permanent residence within the village, settlement, city borders, which are independent administrative-territorial units. «Capital» is a communal property and financial resources of a territorial community. These factors of production use is the basis of territorial community's economic functioning.

Undoubtedly, different nature-resource potential of territories cause the development of different areas of economic activity. This results in specialization of the regional production sphere, i.e. manufacturing, agriculture, services sector, etc. However the study objective is to model the case of self-financing disregarding the territory's specialization. This means the formation of a territorial community's management system, which sustains self-financing and the development by the available resources of indifferent specifics.

Effective management of a territorial community's inner potential provides assessment of the internal economic security level based on the autonomy and self-sufficiency. Of course, this approach is a certain assumption. A territorial community does not function as a «closed system», but the approach allows to measure the inner potential of its functioning and, consequently, to assess the possibilities of self-financing and the break-even point.

In this regard, the input-output model for the territorial community becomes:

$$x\,(t) = A\,x(t) + y(t), \qquad (1)$$

where $x\,(t)$ – gross product, produced inside the territorial community;

A – matrix of direct cost, which does not depend on the time period.

Formula (1), which takes into account investments, may be written as:

$$x\,(t) = A\,x(t) + z(t) + {}^{\wedge}y(t), \qquad (2)$$

So, final products made inside a territorial community includes net final products $^{\wedge}y(t)$ and production costs of fixed assets $z(t)$.

Let $\zeta\,(t)$ be the vector of the spheres of economic activity facilities presented in a territorial community at the point t (beginning of the year). If there is no fixed assets disposal, the investments are absent, the facilities in it are not changed, the construction of new facilities takes place immediately, then the expression of the fixed assets cost function becomes:

$$z(t) = B(\zeta\,(t) - \zeta\,(t-1))\,, \qquad (3)$$

where B – specified matrix (matrix of capital-output ratio growth).

Matrix coefficient $B\ (b_{ij})$ indicates services (products) costs of the i-industry to increase facilities of the j-industry per unit.

If the services output equals the available facilities in the beginning of the year, that is $x\ (t) = \zeta\ (t)$, the correlation (1) is:

$$x\ (t) = A\ x(t) + B(x(t) - x(t\text{-}1)) + \hat{}y(t). \quad (4)$$

With the fixed quantity $t - 1$, the balance illustrates the correlation between net final product $\hat{}y(t)$ and corresponding gross output $x(t)$. To assess the parameters of a territorial communities development in a dynamic perspective on the basis of net final product (services), we examine the dynamics of changes $\hat{}y(t)$, where $t = 1, \dots T$.

Taking into consideration, that the modelling main objective is to find the terms of territorial communities` autonomy and self-sufficiency, we provide the following model limitations:

a) In relation to gross outputs of the territory's economic activities fields, related to the scarcity of fixed assets (there is need in certain quantity of fixed assets to satisfy needs of the limited number of consumers). The number of consumers is measured for different goods or services by the number of territorial community's households, or by the quantity of territorial housing:

$$x\ (t) \leq (\zeta\ (t). \quad (5)$$

b) In relation to labour resources:

$$(d_2,\ x(t)) \leq L(t), \text{ where } t = 1, \dots T. \quad (6)$$

Models (2), (3), (4) and (6) describe the main correlations of the dynamic «Input-Output» model, which unlike in the (1) is controlled, as it enables to trade-off the control actions. They include the volumes of gross outputs in different economic activities fields x(t) and the fixed assets construction $\zeta\ (t+1) - \zeta\ (t)$ in the models (2), (3), (4) and (5).

Hence, it is possible to place limitations on control actions.

c) In relation to control actions:

$$x(t) \geq 0,\ \zeta(t+1) - \zeta(t) \geq 0, \text{ where } t = 1, \ldots T. \quad (7)$$

d) No trade outside a territorial community's boundaries (what is usually regarded as the external trade). This limitation is explained by the initial modelling condition to determine autonomy, i.e. goods and services are manufactured to satisfy needs of territorial community residents. As a result, there is a limitation on the net final product:

$$\hat{y}(t) \geq 0, \text{ where } t = 1, \ldots T. \quad (8)$$

e) A territorial community does not stockpile, so the vector $\hat{y}(t)$ describes final consumption of a territory's residents, which we denote as w(t), so we may specify the limitation (8):

$$w(t) \geq \hat{w}(t), \text{ where } t = 1, \ldots T; \quad (9)$$

$\hat{w}(t)$ – specified time function, which describes the minimum acceptable consumption level (it is determined by physiological needs of a person to ensure normal functioning).

f) We considered models with the simplified idea of capital investment. Taking into account that capital investment is being utilized much longer than others, construction can continue for a long time. Therefore, it is advisable to introduce such a concept as facilities reserve, that is, the facilities, which construction is not completed (construction in progress).

Let in a territorial community (i-community) the volume of facilities reserve which construction was started in year t is $Q(t)$. Let new construction be rhythmical and takes τ^m_i years (construction lag). Then the amount of community's facilities is:

$$\zeta(t+1) = \zeta(t) + Q(t - \tau^m_i), \ t = 1, \ldots T; \ Q(t) \geq 0. \quad (10)$$

Now the formula (3) can be specified including the volume $b_{ij}(\tau)$, which illustrates the amount of resource expenditures in the i- area of economic activity used to form a unit of facilities in j area in τ-th year of construction, and written the following way:

$$z_i(t) = \sum_{j=0}^{n} \sum_{\tau=0}^{\tau_i^m} b_{ij}(\tau) Q_j(t-\tau), \text{ i = 1, ...n; t = 1, …T.} \quad (11)$$

The proposed model can be used to assess the impact, which the key studied parameters including limitations on relation to autarky of economic system have on the overall performance of a territorial community. Thus, this model allows to evaluate the territorial community's capacities considering self-financing and break-even point, that is, to achieve the Pareto-efficiency state.

To ensure the system's economic development, its sustainability has to be kept within certain limitations. The state of maximum sustainability of the dynamic equilibrium is the system's equilibrium state characterized by the maximum efficiency (Pareto-efficiency) [18].

The process of the economic system's efficiency accumulation has its limitations; it is finished with crisis. The dynamic equilibrium state between marginal maximum and minimum values is sustainable.

J. Schumpeter, founder of the economic development theory argued that if economic system moves to disequilibrium, it never comes back [19]. It moves to another stationary equilibrium state at the qualitatively new development level. The new ways of combining efficient methods of available resources application aimed to produce capital and non-capital goods represent the transition mechanism. J. Schumpeter considered crisis period as the environment to implement innovative ideas of entrepreneurs, because it is more difficult to provide them in other business cycle phases. Innovation in a crisis is provoked by the necessity to use scarce resources more efficiently, i.e. factors of production. It is worth paying attention to the fact that during crisis, the importance of people group interaction concerning the use of limited resources is scaled up. This is the synergistic effect manifestation. Its implementation mechanism is self-organization. Hence, self-organization is the tool to overcome crisis. J. Schumpeter paid attention to the fact that the formation of new resources combinations occurs not by command pattern, but due to competition. New resources combinations are more efficient, compete with previous (outdated). In general, this leads to the growth of total resources utilization efficiency in the society.

Consequently, within a complex system, i.e. a territorial community, it is necessary to support constantly the process of self-development and improvement, because in the absence of them the system goes into a state and can be destroyed. In our concern, it makes sense to use the kaizen-strategy to keep the development process, as it provides continuous improvement, because it combines modern tools for managing the constant development of complex economic systems, including the territorial community.

Kaizen is the improvement consumer-biased strategy. The management goal is to strive constantly for the production of better goods (services) at lower prices. Kaizen strategy provides a systematic approach and problem-solving tools to achieve the ultimate goal.

Another important facet of the kaizen strategy is the formation of the way of thinking focused on the process (process thinking), building of the management system which supports the process participants towards excellence and identification of their efforts. This sufficiently distinguishes kaizen from western management practices.

Thus, almost all elements of the kaizen «umbrella» can be used in the process of territorial communities' management reforms, i.e. in the process of setting conditions of their further development based on self-financing.

Taking into account that it is impossible to ensure a territorial community's functioning separate of other communities and external environment, it is reasonable in further research, to remove limitations concerning territorial community's economic system autarky.

The mathematical model of territorial community management using the multi-sectoral model of national economy and the kaizen strategy has been constructed.

It is proved that application of the kaizen strategies will allow to organize, control and manage actions, in the most effective way, of a complex system which is a territorial community amid its dynamic development.

References

1. Decree of the President of Ukraine «On the Strategy of Sustainable Development» Ukraine-2020 «(from January 12, 2015, № 5/2015). URL: http://zakon5.rada.gov.ua/laws/show/5/2015 (date of treatment 04.02.2018). [in Ukr.].

2. Sustainable Development Goals: Ukraine. National report. Ministry of Economic Development and Trade of Ukraine. URL: http://un.org.ua/images/SDGs_NationalReportUA_Web_1.pdf (date of treatment 04.05.2018). [in Ukr.].

3. Batanov O. V. A territorial community - primary subject of municipal authority in Ukraine: concept and attribute. URL: http://www.cvk.gov.ua/visnyk/pdf/2008_2/visnik_st_13.pdf. (date of treatment 04.02.2018). [in Ukr.].

4. Molodozhen Y. B. (2006). Concept and essence of a territorial community in system of local self-management of Ukraine. *University scientific slip: a magazine of Khmelnitskiy university*. № 2. P. 128-136.[in Ukr.].

5. Murkovich L. A. Territorial community as the subject of local self-management in Ukraine: theoretical aspects. URL: http://www.dbuapa.dp.ua/vidavnictvo/2010/2010_02%285%29/10mliuta.pdf. (date of treatment 04.02.2018). [in Ukr.].

6. Territorial community as a base part of the administrative - territorial device of Ukraine: problems and prospects of reforming. The analytical report. Kyiv.: NISI, 2016. 61 p. [in Ukr.].

7. Horoshkova L., Volkov V., Kapranova L., Komelina A. (2018), The Reverse Subsidy`s Impact of United Territorial Community`s Budget Generations. *International Journal of Engineering & Technology*. № 7(4.8). P. 539-543.

8. Volkov V.P., Karbivnychyi I.O, Karbivnychyi R.O., Horbova I.A. (2018). Conditions of the no-loss functioning of territorial formation. Belostok: Belostok. 190 p.

9. Horoshkova L.A., Volkov V.P., Khlobistov Ie.V., Kutyk V.V. (2019) Prognostic models of financial regulation of budgets of territorial communities. *University Economic Bulletin of Pereyaslav-Khmelnytsky State Pedagogical University*. No. 42. C. 179-190. [in Ukr.].

10. Horoshkova L.A., Volkov V.P. (2018). Management of financial processes of decentralization and formation of territorial communities. *University Economic Bulletin of Pereyaslav-Khmelnytsky State Pedagogical University*. No. 36/1. C. 285-293. [in Ukr.].

11. Volkov V.P., Horoshkova L.A., Karbivnichy R.O. Property Management of Territorial Communities. Belostok: Belostok, 2018. 144 p. [in Ukr.].

12. Horoshkova L.A., Volkov V.P., Karbivnichy R.O. (2018) Simulation of complex systems of cluster type. Project management and production development. Severodonetsk: SNU them. V.Dala; Kyiv: University «Krok». No. 2 (66). C. 18-27. [in Ukr.].

13. A public ecological policy of Ukraine is in the conditions of decentralization of power / nauk. red. d.e.n., prof. Ye.V. Khlobystova. Kyiv, 2016. 226 p. [in Ukr.].

14. Khlobystov I.V. Features of formation and development of international environmental policy of Ukraine in the conditions of decentralization of governance // Sustainable development - XXI century: management, technology, models. Discussions 2016: Collective Monograph [Anderson VM, Balgi MD, Barkan VI etc.] / NTUU «Kyiv Polytechnic Institute»; Institute of Telecommunications and Global Information Space of the National Academy of Sciences of Ukraine; Higher economics and humanitarian school. / nauk. red. d.e.n., prof. Ye.V. Khlobystova. Cherkasy, 2016. P. 228-234. [in Ukr.].

15. Guseva I. I., Segeda I. V., Khlobistov E. V. Ecologization of power in maintenance of sustainable development of the state / nauk. red. d.e.n., prof. I.V. Khlobystova / NTUU «Kyiv Polytechnic Institute»; Institute of Telecommunications and Global Information Space of the National Academy of Sciences of Ukraine; Higher economics and humanitarian school. Kiev-Bel'sko-Byala: publisher Chabanenko Yu.A.,, 2015. 276 p. . [in Ukr.].

16. Law of Ukraine «About local self-management in Ukraine». URL: http://www.Zakon2.rada.gov.ua/lows/show/280/97-vr. (date of treatment 04.02.2018). [in Ukr.].
17. On approval of the Methodology for the formation of capable territorial communities: Resolution of the Cabinet of Ministers of Ukraine dated April 8, 2015, No. 214.). URL: http://zakon2.rada.gov.u. (date of treatment 04.02.2018). [in Ukr.].
18. Klebanov T.S., Dubrovyna N.A., Poliakova O.Iu., Raevneva E.V., Mylov A.V., Serhyenko E.A. (2004). Modeling of economy dynamic. Kh.: «YNZhEK». 244 s. [in Ukr.].
19. Shumpeter Y. (1982). Theory of economy development. M.: Prohress. 456 s.[in Ukr.].

2 MAGNETIC METHODS APPLICATION FOR THE MONITORING OF THE SUSTAINABLE DEVELOPMENT OF THE ENVIRONMENTAL AND ANTHROPOGENIC SYSTEMS IN UKRAINE

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2.1 Introduction to magnetic methods application in assessment of the environmental and anthropogenic systems

As pointed out by the World Health Organization in a recent report (October 2018) «Every day around 93% of the world's children under the age of 15 years (1.8 billion children) breathe air that is so polluted it puts their health and development at serious risk. Tragically, many of them die: WHO estimates that in 2016, 600,000 children died from acute lower respiratory infections caused by polluted air». In this Chapter, we consider the application of geophysical methods (primarily magnetic methods) for assessment of environmental and anthropogenic systems.

Environmental pollution by heavy metals and other chemicals hazardous to human health is one of the biggest threats and challenges development of scientific methods and strategies for the sustainable functioning of the European capitals. These hazardous substances are mainly the result of anthropogenic activity, power plants, waste incineration, chemical production, and traffic. The pollutants accumulate in the air and soil of the cities and their surroundings. Magnetic method is a cost-efficient semi-quantitative approach for detecting heavy metals and other pollutants as a complementary tool to the traditional geochemical analyses.

Another application of the magnetic methods concerns the study of agriculture and land degradation. Soil mapping and modeling increasingly used in agricultural practices worldwide are beneficial to local and government land managers and could reduce soil degradation, increase soil productivity and support their restoration. Erosion is one of the key factors in soil degradation. Magnetic properties data of soils have been successfully used in a number of studies. Soil magnetism has proved to be a powerful concept for environmental studies.

Moreover, there is a considerable uncertainty as to whether a strong correlation exists between magnetic anomalies of soils and hydrocarbons, which requires a detailed study of local sediments and soils, and their bedrocks. Magnetic methods may provide a fast and cost-effective way to assess hydrocarbon contamination in soils and sediments.

A number of studies have shown that magnetic monitoring is a robust technique for quantifying pollution particles produced by combustion and/or abrasion processes, containing toxic metals [20, 21], and ambient concentrations of PM10 levels [26]. In the recent investigation of Liu et al. (2016) [16], measuring topsoil (0-15 cm) from Kaifeng City (China), realized a significantly positively correlation of magnetic susceptibility with the concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn. During the past ten years magnetic studies have become part of the environmental monitoring technology. Cao et al., (2015) [4] demonstrated the practical and economical value of magnetic techniques for pollution assessment in Linfen city (China). They used soil and leaves as receptors for atmospheric particulate matter to test the efficiency of magnetic approaches for assessing and discriminating past and present pollution.

To give a plausible interpretation of the newly magnetic minerals formation in the presence of hydrocarbons, models of hydrocarbon contamination in the environment might be applied. Porsch et al. (2014) [32] demonstrated that microbial metabolism was an important factor in the transformation of magnetic minerals. Klueglein et al. (2013) [13] showed that the genus Geothrix plays a major role in hydrocarbon-contaminated environments undergoing dynamic oxic-anoxic redox fluctuations. The Fe(III)-reducing metabolic activity of the bacteria was found to affect the magnetic properties of soils, which can be a useful instrument in identifying biogeochemical hotspots. According to Rijal et al. (2012)

[34], hydrocarbon contaminated soils and sediments in the former oil-field area of Hänigsen (northern Germany) have a higher magnetite content, as compared to the non-contaminated soils and sediments. In the course of air migration particulate matter deposits to flat smooth surfaces (*Patent 102735, 12.08.2013*) [25] and in soil.

In our recent magnetic mineralogical analyses [23] of the chernozem soil in the Kharkov region (Ukraine), we identified the presence of strongly magnetic minerals (magnetite and maghemite) as well as weakly magnetic goethite, ferrihydrite, and hematite. Stable pseudo-single-domain (PSD), single-domain (SD), and super-paramagnetic (SP) grains of pedogenic origin dominate the heavy mineral fraction of the studied chernozems. Additionally, there are other destruction processes, which can be detected by magnetic measurements: spring grassland fires which lead to the changes of the soil nutrient properties and crop production [30]. From our soil magnetic studies undertaken in areas of Ukrainian hydrocarbon deposits [24], it was concluded that weakly magnetic clays and soils which are influenced by hydrocarbons evidence enhanced magnetic properties, i.e. 10-30 times higher than those without hydrocarbons. Another study our result deals with magneto-mineralogical analyses of soils, sediments and dust from urbanized Ukrainian areas. Here a magnetite-like phase was identified as the main magnetic mineral causing the magnetic enhancement in polluted soil [22].

Comparing with other methods for pollutant monitoring, the magnetic measurements are rapid, low-cost demanding and highly effective. Hence, such measurements allow a large number of analyses (i.e., up to several hundred in few days depending on the magnetic parameter measured).

2.2 Magnetic properties of the natural soil in the sustainable development of the environmental systems in Ukraine

Soil magnetism is the reliable instrument to solve environmental problems such the soil identification, pollution, organic matter assessment, contributes to the geoforestry and vegetation processes. Soil magnetism investigation demonstrated valuable results in Ukraine, Turkey, and all over the World. The objectives of the present studies are the magnetic description of the forest soil from Ukraine.

Soil erosion is a major factor in soil degradation and environmental damage. However, erosion studies are not limited to environmental aspects. Much attention is paid to the technological side of the problem of agricultural production. Erosion processes changes the agrophysical and agrochemical properties of soils, which implies that certain adjustments are made to agro-technical and soil protection measures. Therefore, one of the tasks of modern erosion is the exact location of soil species with agronomically significant differences in agrophysical and agrochemical properties.

The great challenge is soil erosion and soil potential loss at the forest areas. Such processes are not limited but close to the vegetation, soil layers identification and development of the soil protection measurements.

Magnetic tools are very attractive for the strategic planning of land use and occupation, mapping large areas with detailed scale [31], environmental monitoring and precision agriculture [7].

The issue of indication of the erosion processes is relevant for a number of disciplines: agroforestry, agriculture, soil science, and land management. Determination of the degree of soil loss is required. Crop production at the eroded lands requires differentiation of fertilizer and pesticide regimes. Due to fundamental changes in the land the use structure of the country related to the implementation of land reform. The accuracy of existing large-scale soil survey data is not acceptable.

The relationship between the results of erosion process modelling and magnetic susceptibility is based on the physical determination of the soil factor, or the USLE model [35]. According to the model description, the values of the indicator depend from the type of soil, humus content, particle size distribution and water-physical properties (permeability). This link has been described in detail by

Brazilian researchers, the weighted average for the various relief elements is R^2=0.83 for USLE [3].

In general, many papers are known to describe the close relationship between the magnetic susceptibility of soil and its result of modelling erosion processes. More informative, in our opinion, is the study of the dependencies between the individual constituents on the basis of which the value of K is calculated. The highest relationship between the content of humus and MS were registered in Czech Republic (R^2=0.97) [11], China [46], and Brazil (R^2=0.85) [29]. The effect of granulometry is usually studied on the example of the content of the clay fraction [35]. The relationship with MS is considered quite high, so in the soils of Brazil recorded R^2=0.83 [36].

We use magnetic susceptibility MS (χ) measurements to identify soil types, frequency dependence of MS (χfd) for determining pollution level and several magnetic mineralogy sensitive parameters.

Field sampling is always accompanied by field MS measurements (volume magnetic susceptibility, κ). Field MS measurements of soils normally are conducted with an PIMV-M portable MS meter (Geologorazvedka). The PIMV-M, which is roughly analogous to the conventional Czech KT-5, has a measuring range of 1×10^{-5}…1 SI units. The relative measurement error is: ±10 % in the range 10^{-5}…10^{-4} SI. The device is based on the frequency method and is used for measuring magnetic susceptibility. Being a part of the low-frequency controller, the plane induction coil is the primary device located at the end of the working surface. The oscillator frequency is approximately 5 kHz.

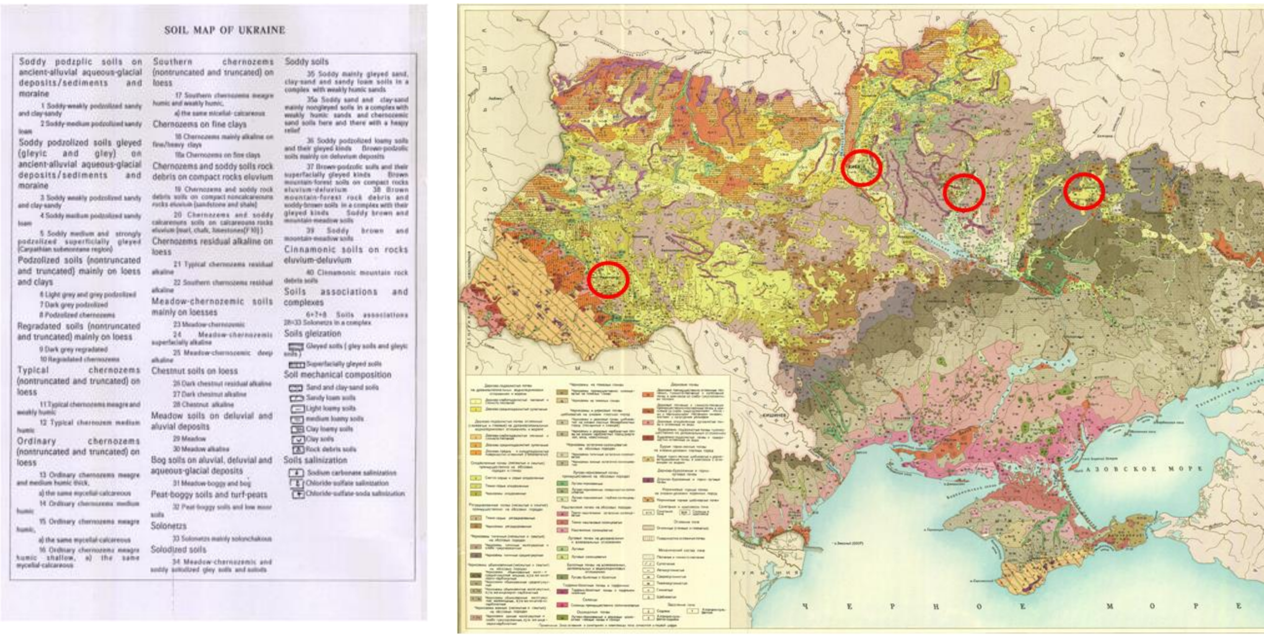
We use the KLY (Agico, Chezh Republic) and MS2 (Bartington) to measure and then calculate mass specific magnetic susceptibility (χ) and its frequency dependence (χfd)

We use an MPMS3 (Quantum Design magnetometer) to measure hysteresis, frequency dependence of MS, and remanent magnetization. The MPMS3 provides accurate measurement results in a temperature range of 1.8-400 K (-271.35 – +126.85 °C), field range ± 7 T, frequency range 0.1 Hz – 1 kHz. In addition, we used a Rotating Magnetometer (Coercivity Meter) to obtain the isothermal magnetization curves (hysteresis, backfield, remanence acquisition) and the KLY-4 – to measure the high-temperature dependence of MS, χ. All of the hysteresis data obtained with the MPMS3 were also corrected for biasing remanences of the superconducting magnet resulting from flux trapping, prior to high-field slope correction.

For studying anhysteretic remanence (ARM) we used the cryogenic magnetometer 2G-760R (www.2genterprises.com), equipped with a degausser system controller 2G-600 and an anhysteretic remanent magnetizer 2G-615. The instrument was used to acquire and measure the anhysteretic remnant magnetization (ARM). Low-field susceptibility versus temperature curves (KT curves) were performed at low and high temperatures with a CS-L cryostat apparatus and a CS-3 furnace under Argon atmosphere coupled to the KLY-3 Kappabridge instrument (Agico, Czech Republic, https://www.agico.com).

The first study area in Ukraine belongs to the central part – Forest-Steppe. The dominated forest soil is Greyic Phaeozems Albic in WRB classification. At the surrounding areas soils are Voronic Chernozems pachic at the watershed and Haplic Gleysols Dystric at the bottom ravine. The second area is situated at the Western part of Ukraine near the Carpathian Foredeep. The forest soil is Greyic Phaeozems Albic and at the surrounding areas they are Haplic Cambisols Eutric at the watershed and Haplic Gleysols Dystric at the bottom ravine. The third area was located at Irpin, Kyiv region. The major soil is Umbric Albeluvisols Abruptic (Sod-podzolic soil). All areas are shown in Fig. 1 with red circuses.

The first case study (Fig. 2) demonstrated results of analazying of magnetic properties of Umbric Albeluvisols Abruptic (Sod-podzolic soil) of Ukraine Forest Area. In Fig. 2a, the study area is Zmiiv, Kharkiv region, and in Fig. 2b the results are from Irpin, Kyiv region. The Umbric Albeluvisols Abruptic from Zmiiv, Kharkiv region were widespread at the local increase in the southeastern outskirts of the city of Zmiiv, Kharkiv region. The primary vegetation is pines 50-60 years old. The study area belongs to the root bank of the river Siverskyi Donets.



a b

Fig. 1. Soil map of Ukraine: a – soil types description, b – soils with areas of observation (red circles)

a b

Fig. 2. Results of studying of magnetic properties of Umbric Albeluvisols Abruptic (Sod-podzolic soil) of Ukraine Forest Area: a – case study at Zmiiv, Kharkiv region, b – case study at Irpin, Kyiv region

The alluvial deposits plays the major role in the lithogenic formation. The Umbric Albeluvisols Abruptic from Irpin, Kyiv region are located at the dune on the right bank of the Dnieper. Eastern outskirts of Irpin River. The vegetation is pines about 80 years old. In Fig. 2a the magnetic susceptibility is two times higher. In both cases with the pedological and magnetic studies four soil horizons were identified and determined by means of MS.

The results of the second case studying are presented in Fig. 3. The transect when moving from the lowland with gleysols predominance to the forest area with phaeozem, predominance was considered.

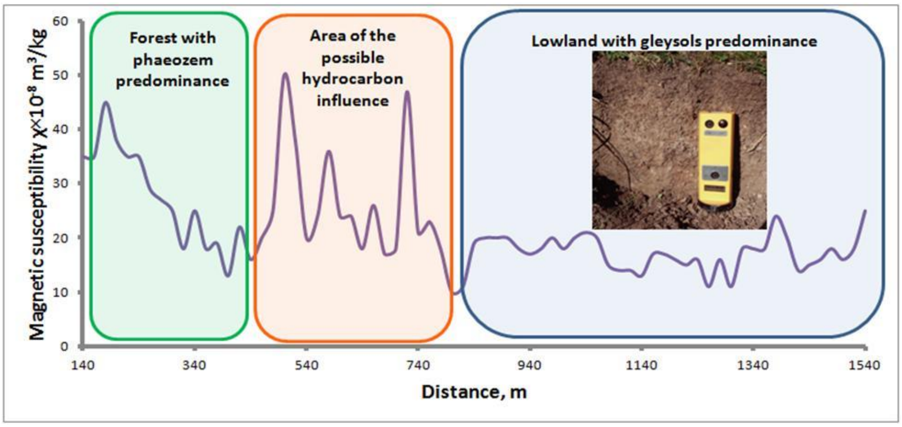
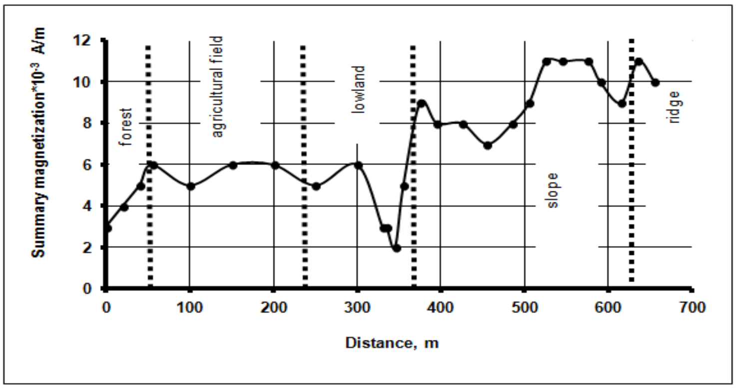


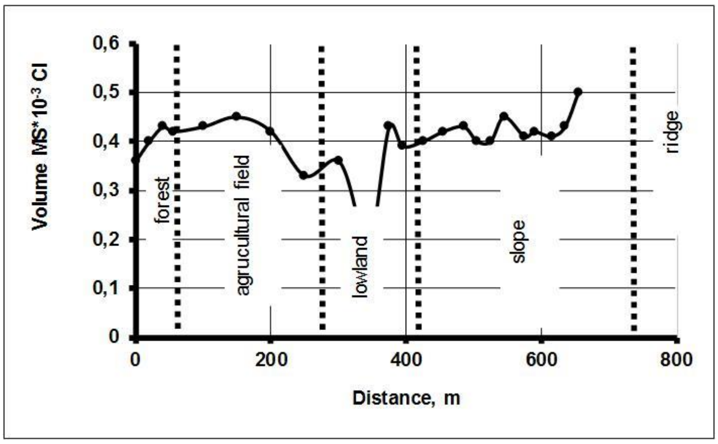
Fig. 3. Results of studying of magnetic properties of Gleysols of hydrocarbon field and Phaeozem of Ukraine Forest Area

The magnetic susceptibility of phaeozems from the forest is 2 times higher and has more visible dispersion comparing with gleysols of lowland area. Three geomorphological patches were identified. One was under strong hydrocarbon deposit influence. The natural soil layers were modified significantly.

In Fig. 4a and 4b the results of studying summary magnetization and field (volume) magnetic susceptibility when crossing catena are presented.



a



b

Fig. 4. Magnetic studies of forest soil (phaeozem) and chernozem of the agricultural area at Forest-Steppe of Ukraine (Poltava Region)

The area of the investigation is located at the Forest-Steppe of Ukraine (Poltava Region). Two major soil types are widespread. The forest soil is phaeozem), and the chernozem was studied at the agricultural area. The magnetic properties are higher at the agriculture lands with chernozems comparing to the phaeozems of forest area.

The map of the soil magnetic susceptibility distribution for phaeozems of the forest area at Polesie of Ukraine (Kyiv) is presented in Fig. 5. The maximums of MS are related to the uphill with predominance of the magnetite as the primary magnetic mineral, which is responsible for magnetic susceptibility increase is soil samples. At the local bottoms of the relief magnetic susceptibility is lower with the predominance of the goethite and hematite which under normal temperature conditions are slightly magnetic minerals.

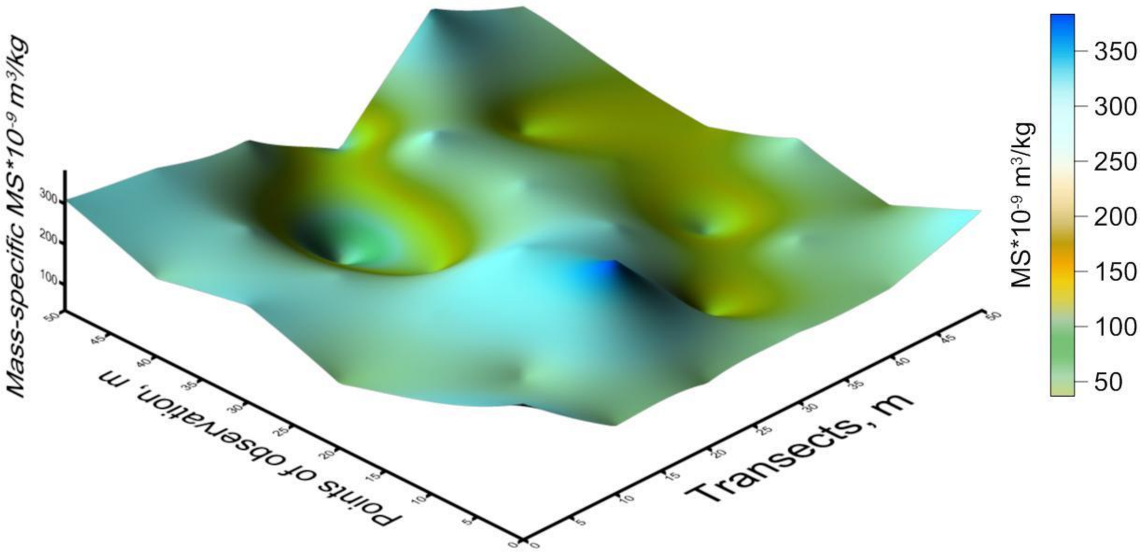


Fig. 5. Map of the soil MS distribution for phaeozems of the forest area at Polesie of Ukraine (Kyiv)

Thus, the sequence from the most to the least magnetic soils of Ukraine is: Voronic Chernozems pachic - Greyic Phaeozems Albic - Cambisols Eutric - Haplic Gleysols Dystric. We compared magnetics which are responsible for the MS enhancement in Ukraine soil with Turkish ones. For the Turkish soil ferromagnetic Nickel (Ni) concentrations plays an important role at the areas where Serpentinite bedrock is located in Ophiolite formations with unique plant species which are very high tolerance to nickel concentrations.

Magnetic parameters are much lower at the lowland with gley processes. In such conditions the iron is in non-magnetic state.

Our results confirmed:

- At the forest areas soil magnetism is related to the geomorphology, soil types, landscape position, and plants vegetation activity.

- The sequence from the most to the least magnetic forest soils in Ukraine is: Voronic Chernozems pachic - Greyic Phaeozems Albic - Cambisols Eutric - Haplic Gleysols Dystric.
- For the Turkish soil ferromagnetic Nickel (Ni) concentrations plays an important role at the areas where Serpentinite bedrock is located in Ophiolite formations with unique plant species which are very high tolerance to nickel concentrations.

2.3 Wind power stations influences to sustainable development of the natural and anthropogenic systems in Ukraine

The wind power stations are an important part green energy development, particularly according to the global exhaustion of natural hydrocarbon resources, and European strategy of transition to the environmental friendly sources of energy. Finally, the European energy independence could be reached attracting mentioned above sources. Taking advantage of offshore wind power appears to be of special significance for the climate protection plans announced by the German Federal Government [28]. The important is to consider the legal provisions governing the assessment of the environmental impacts of wind mills and the planning procedures for mill location [38]. However, the impact of wind power stations on the environment is not sufficiently studied yet. There is practically few experience in constructing and operating wind power stations at the high mountain valleys (1400-1700 m). Of the great importance is the study the Carpathian region of Ukraine to develop new strategy of attracting wind energy to open the way for the exchange of «green» energy between European countries, which are bordered by the Carpathian mountain system (Germany, Poland, Hungary, Slovakia, Romania, Czech Republic). The relevant approach is the attracting of the German experience of operating wind power stations at mountain regions (i.e. Schwäbische Alb, Schwarzwald mountains, etc.).

Wind power generation, which can convert the kinetic energy of wind into electric energy without serious environmental damages, is regarded as one of the most promising distributed energy resources in the world [10]. Wind power stations has been the subject of dramatically increasing interest in recent years [15]. Wind turbine technologies and power electronics converters provide wind power developers and operators with the options necessary to achieve wind power transmission targets. Wind power generation technology is now relatively mature, with annual generation amounting to 640 TWh, accounting for less than 3% of the world's total energy consumption [19]. Given the more stringent requirements on carbon emission control, the share of wind power in energy generation is expected to increase to 30% by around 2050, with annual generation estimated at 22,000 TWh, indicating great potential for growth.

Full-coverage wind data are available in the countries in which wind energy utilization is widespread. A reliable database is provided mainly by the long-term evaluation of the energy supply from existing wind turbines [41]. The location chosen for the projecting wind-power plants needs to be evaluated in consideration of different criteria when determining the potentiality of the wind-power [1]. To understand the possible types of the wind power station influence on surrounding we need a long term data source adopted and analyzed the eleven years (1995-2005) of three-hour period measured mean wind data. Valuable is the information about constructing in different sites. *Lu et al., 2002* [19] discussed the potential for electricity generation on Hong Kong islands through an analysis of the local weather data and typical wind turbine characteristics. Obviously, the attention should be paid to the site terrains in choosing the wind farm sites [47]. Furthermore, the wind energy potential in the eastern Mediterranean region has been investigated using hourly wind data taken from seven stations during 1992-2001 periods by the Turkish Meteorological Service. Turkish researchers suggested, that in the east Mediterranean Sea coast of Turkey, wind energy sources are convenient for electricity generation. Moreover, in Turkey [43] a technical assessment has been made of electricity generation from four wind turbines having capacity of (600 kW, 1000 kW, 1500 kW and 2000 kW). The similar studies have taken place in different other places, for instance, in Taiwan have been thoughtfully analyzed based on a long-term measured data source (1961-1999) [5], etc.

Studying the German experience, the extensive experimental testing was carried out at a wind power plant on a low mountain range in Germany and at a wind farm on the German coast.

The crucial aim of the studies is to investigate the nature and levels of the impact of wind power stations on the elements of the environment. We suppose to develop the model of economic, social, and other risks assessment. In future, the experience of the studying the Germany and Ukraine mountain areas will be widespread to other similar territories, objects and conditions in Europe.

A significant part of the river flows is formed on the Borzhavsky rock massif (Latoritsa, Osa, Borzhava, Rika (Fig. 6), Repinka, Chisty and Great Zv, Yamka Vygrivskaya, streams of Zhdymyr, Lalovsky, Grabovets, Vendrichka, and others).

One of the most important issues, which need to be studied – how the violation of integrity of plants, the constructing of roads, and finally infrastructure can affect the balance of the nearsurface aquifers and surface watercourses. Now, there is under the negotiation the construction of 47 fifty-meter wind turbines with a capacity of 3-4 MW along the ridge of valley Borzhava in Transcarpathia (Fig. 6).

Thus, our crucial aim is to obtain the necessary experience of the consequences of the construction and operation of such type of infrastructure.

The natural and induced fields, impact factors, and environmental influence of the wind power stations and connected infrastructure can be registered, studied and processed by appropriate geophysical and petrophysical measurements, geostatistical and geospatial methods. We assume to attract remote methods, geospatial methods, soil magnetism data. The risks will be calculated according to well-known procedures tested on other objects.

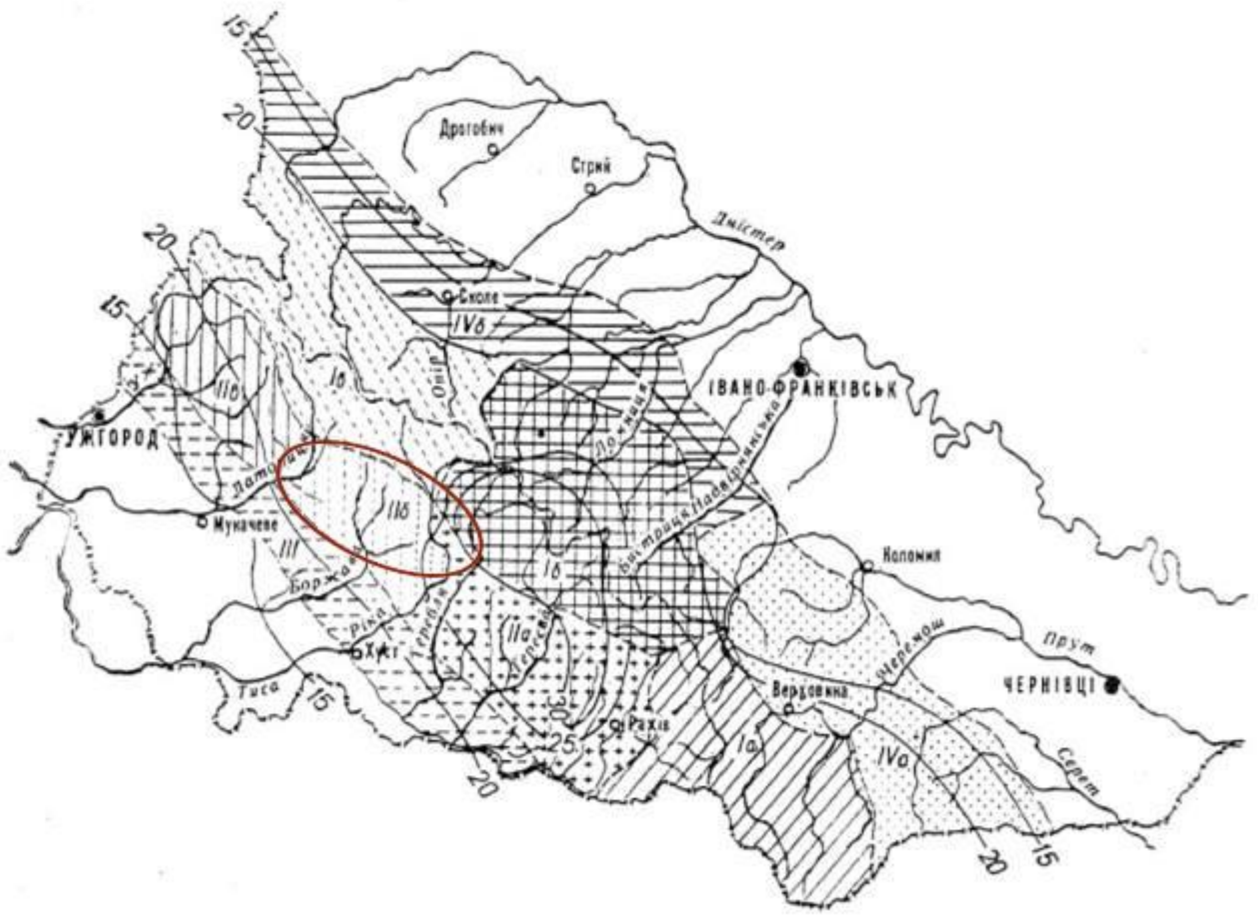


Fig. 6. Schematic map of water protection zones of the forest-mountains areas of Ukrainian Carpathians

At the present state, we need the number of studies, which could to prevent the threat of irreversible processes and distortion of the unique terrain at the areas of the wind power stations construction. To solve this problem, the complex regime observations are essential. Among the most dangerous processes are the modification of the bioenergy exchange between subordinate landscapes, changes of the water balance of rivers, development of harmful engineering geological processes, and landslides. It is necessary to establish all-inclusive observations of the terrain during various hydrometeorological conditions and seasons.

Obviously, the construction of roads with a width of 8 m, creating of infrastructure (canvas, drains and gutters) will be associated with traversing the slopes, removing top soil, and partly the underlying rocks. Furthermore, the removing of the vegetation, including significant areas of bilberries, will take place. The optimistic estimation of the blueberries area destruction is up to 32 ha. The estimated length of the roads is about 32 km along the territory of the Svalyava district and about 30 km at the Volovets district. The underground cable is planned to be laid at a depth of about two meters with a total length of cable about 20 km. For the wind power station, piles are usually clogged in depth of about 20 meters. A construction site must be flat with a square about 50x60 m (Fig. 7). Two substations (area 90x90 m) and three distribution points (area 12x55m) are expected to be built on the ridge. The power lines with the length of about 2.5-3 are planned to be constructed as well. For this purpose, the forest with the area of about 11 ha required to be removed.

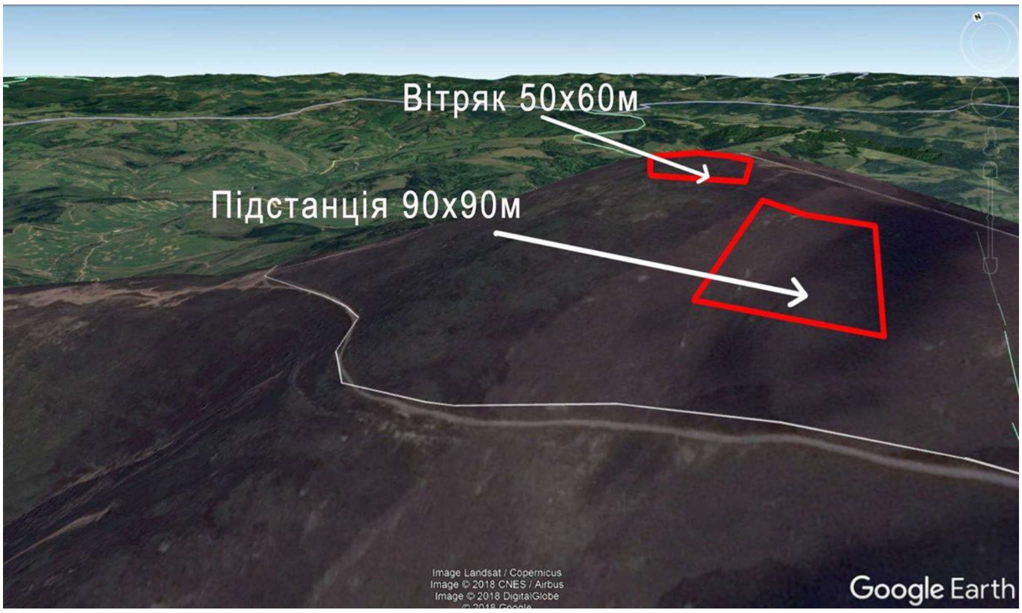


Fig. 7. Scheme of the areas for the construction of a substation of 35-110 kV and one of the wind turbines at the mountain Velikiy Verh

Most of the construction sites are characterized with a height difference of up to 25m (within the site). One of the project sites (planned capacity 35-110 kV) is located on the top of Mountain Veliky Verkh (see Fig. 8).

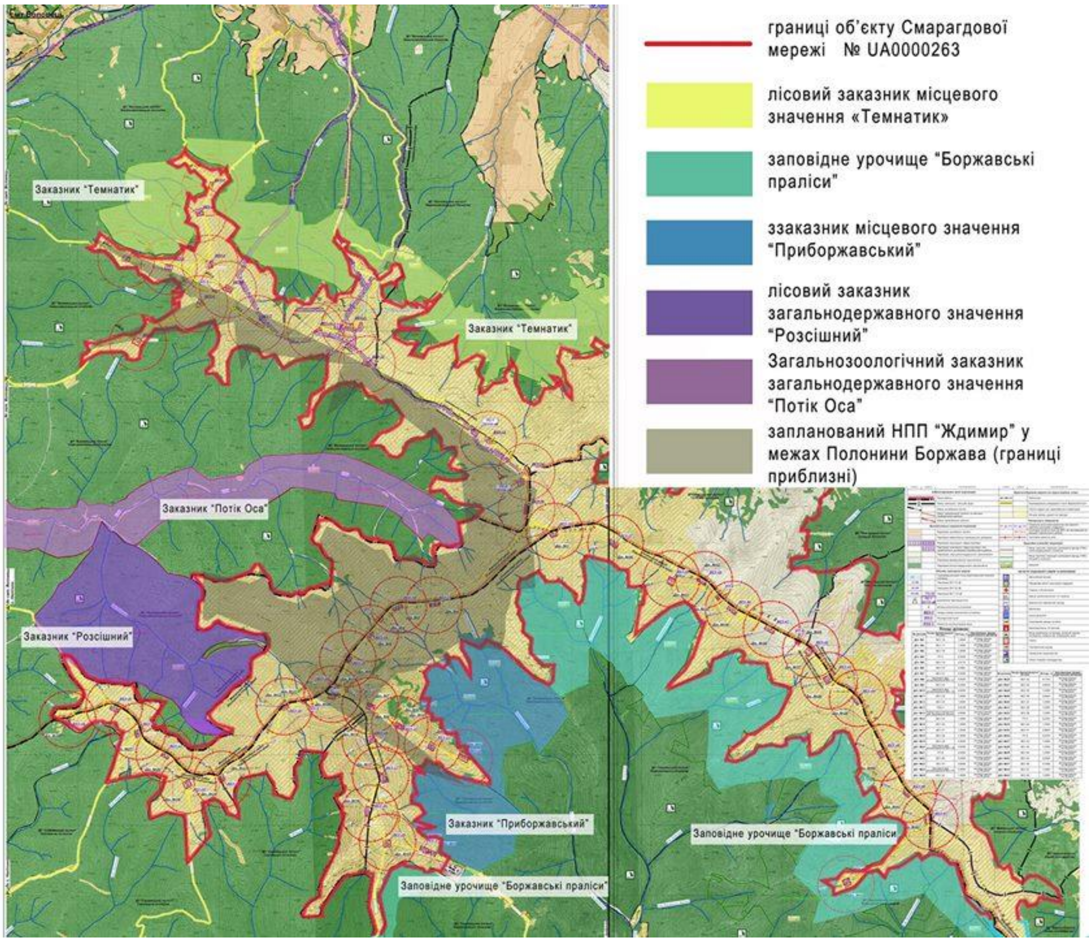


Fig. 8. Scheme of the wind power stations according to the detailed plan of territories of their construction. Distribution of protected areas at the valley Borzhava

Thus, we need to determine two types of the sources of the harmful influence to environment:

- Influence on environmental condition under the period of wind power station construction;
- Influence on environmental condition under wind power station operation.

The natural objects for long-term observations should be selected based on the types of the future impact of the wind turbines and surrounding infrastructure on the environment. By types of influence they are:

- electric fields, including influence of the substations and distribution points;

- electromagnetic fields;

- physical vibration and mechanical impact, including the effect of the sewage drainage facilities;

- acoustic waves;

- soils, soil erosion, loss of fertile agricultural land.

In addition, the stability of the wind energy constructions is required to be determined. It is important especially in conditions of increased seismicity of the Carpathians and the risks of increasing seismicity under the impact of wind turbines. All these factors may lead to a violation of micro-geodynamic processes and an increase in geodynamic stresses.

Expected, that for the environmental protection issues the electric and induced magnetic fields studying during the operation of the wind power station are the most important. The 110 KW air power line projected along the ridge: from the Mountain Veliky Verkh to the Mountain Temnatik. The length of the transmission line with a capacity of 10 kV will be 3,981 km, the length of the transmission line with a capacity of 110 kV will be 12,582 km. The transmission lines, two substations, and three distribution points, located on the slopes, seems to be the most dangerous objects. Internal power distribution networks from wind turbines are carried out by power cable lines with a voltage of 35 kV. Cable lines of 35 kV will be laid at a depth of 1.8 m from the surface in cable channels. Other control cables are supposed to be laid along the roadside of the future road. This road will be built on the territory of the windfall. The electric and magnetic field generated by the wind turbine can affect large areas. Electricity will be transferred from two electric substations to the existing Volovets substation of high voltage.

Hence, the cable network of the wind power station is a source of electrical and magnetic fields. The maximum intensity of the electric field is 1.4 kV/m. At the same time the normative value for the residential building areas is only 1 kV/m. For the magnetic field the values are accordingly: 5.9 μT, and normatively 10 μT.

Another one dangerous impact to the environment stability is the noise, generated by wind power station. The radius of the sanitary protection zone is 400 m around the turbine with a height of 100 m (145 with blades, with a capacity of 2-4 mW). Consequently, the acoustic effect of wind energy in a radius of 400 m can be dangerous to the health. Further aspects of the environmental impact of acoustic waves need to be studied deeply under the project. For now, is known, that the wind is a background noise on Borjava. But the wind is able to block the noise of the turbines only at a speed of 8 m/s or more. The wind of 8 m/s is strong, the temperature feels 5-6 degrees below in this case. From the state of the art we know, that ~13% of all reporting stations experience annual mean wind speeds ≥ 6.9 m/s at 80 m (i.e., wind power class 3 or greater) and can therefore be considered suitable for low-cost wind power generation [2].

Furthermore, the energy mass-exchange processes are important, when considering the natural landscapes and their stability. For studying these mass-exchange processes, we need the information about natural electrical fields (static electric and electromagnetic fields), which play the dominant role in the landscape development. The result of the exchange of electric charges between the atmosphere and the lithosphere is the movement (infiltration) of the pore mixtures (solution) in the geologic environment. These processes have strong influence to the lithology of the top sediments, the supply of groundwater, and finally change chemical composition of groundwater. Hence, such man-made structures will undoubtedly change the existing natural regime. From the results of [27], deep concrete piles, which have a contact with groundwater, can lead to the significant increase of the pH of the water environment, and the migration mobility of heavy metals. In this case, we need to determine the buffer capacity of the groundwater.

All mentioned above objects required to be deeply studied. In fact, the infrastructure completely destroys the unique natural Borjava conditions, which are valuable and attractive for tourism and recreation. Hence, the essential is to obtain quantitative values of geophysical, hydrological, hydrogeological, and soil parameters, which describe the influence of wind power stations to surround environment in relation to the natural background in mountainous conditions.

Recently, we obtained new results devoted to the environmental risk assessment of the wind power station constriction at the Borzhava in Carpathian Mountaions in Ukraine [37]. The dynamic geologic-geophysical model is the most suitable [44]. The statistical simulation algorithm of random fields is important for the wind power station investigation [45]. All studies required to be realised according to the sustainable land use management [31].

Han, 2018 [9] stated that the windpower turbines have positive values for visitors with regard to tourism and learning. On the other hand, it is clear that windpower turbines have negative impact on the landscape, particularly when the level of landscape is high. The estimated results demonstrated a significantly positive viewing value, a significantly negative landscape value, and weakly negative net visit value in average. From the other site the wind power station construction can significantly change the ecosystem condition. *Johnston et al., 2014* [12] distinguished that the potential wind-energy development in the eastern Rocky Mountain foothills of British Columbia, Canada, raises concerns due to its overlap with a golden eagle (Aquila chrysaetos) migration corridor. *Tellería, 2009* [40] concluded that the wind power stations may produce the occupation of many areas important to bird and bat conservation, and therefore preventive measures should be implemented to protect these species and their habitats.

The summary of the environmental issues caused by wind farms were reviewed in the *Dai et al., 2015* [6] by summarizing existing studies. Considering the environmental issues of the wind power stations development in the mountain regions we need to consider the results of *Spiess et al., 2015* [39]**.** In this paper the interdisciplinary research team explored, through socio-economic and technical approaches, the current and future acceptance of wind energy production in the Swiss energy region of Goms, an alpine valley at 1300 m above sea level.

The examples of the magnetic methods application in the mountain ecosystem is considered in *Lizaga et al., 2019* [18]. This work aims to assess how land use changes after generalised land abandonment affect some major soil properties related to soil quality. Bulk density, stoniness, grain size, pH, carbonates, electrical conductivity, soil organic carbon, total nitrogen, water retention capacity and magnetic properties (low frequency magnetic susceptibility and frequency dependence) were analysed in the samples from different land use areas. As well, *Pulley et al., 2018* [33] noted that the environmental factors controlling the magnetic properties of samples within a single field. They examined on a particle size specific basis to continue building on the recent studies of the spatial variability associated with different tracer types. The study area was in the Eastern Cape of South Africa over a Quartzite geology and was covered by rough grassland.

To illustrate the potential of the magnetic measurements [14, 8] for the classification of the mountain soils and the pollution and erosion assessment under the wind power station farms construction consider the case study from the Manyava site. The studies were performed in the upper reaches of the Manyava river near the Manyava waterfall. The soil is Haplic Cambisols by the WRB international classification [22]. The results have shown that the soil of mountainous forest areas of the Carpathian Mountains is generally weakly magnetic. The mass specific magnetic susceptibility (MS, χ) does not exceed 25×10^{-8} m^3/kg. The soils are slightly differentiated by magnetic susceptibility. Similar tendencies are also observed for flishe underlying rocks. The magnetic susceptibility of the upper humus horizons (horizon A according to the international classification) lies within the limits of $15\text{-}25\times10^{-8}$ m^3/kg, underlying rocks have $\chi=5\text{-}15\times10^{-8}$ m^3/kg, for the boulder material at the transition to the river: $\chi=1\times10^{-8}$ m^3/kg. The soil is stony, the thickness of the upper humus horizon A does not exceed 10 cm, with the inclusion of fragmented material. Sometimes, within the distribution of trees, the upper horizon of the soil is covered with a sod-brown pillow. However, most often the soils are grayish, undeveloped, close to the maternal fleece breed.

An example of the distribution of magnetic susceptibility within the cross-section near the Manyava waterfall is given in Fig. 9. The gleyed horizon with signs of the podzolic process is formed within the distribution of mountain forest vegetation in the upper part of the soil profile. The values of the magnetic susceptibility are the highest and reaches 25×10^{-8} m^3/kg. When moving to ponts with the more significant glee process, the magnetic susceptibility drops to 20-15×10^{-8} m^3/kg.

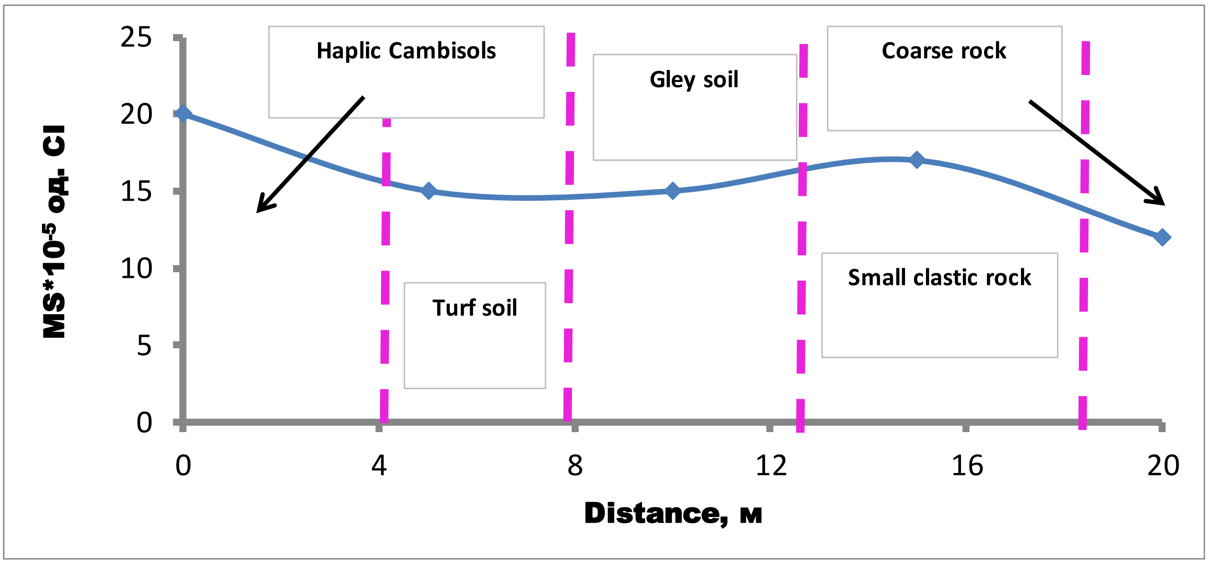


Fig. 9. Cross-section of the soil magnetic susceptibility of reference unpolluted mountain-forest soils near the Manyava Waterfall, Carpathian Mountains of Ukraine

The tectonic conditions play the primary role in the distribution and formation of the qualitative composition of groundwater in the Carpathian region. They are the main factor of accumulation and a search criterion for mineral carbonic underground waters, which are quite widespread in the intermountain part of the western spurs of the Ukrainian Carpathians. Of the great importance is studying of the iinterrelation between neotectonic movements and structural formation [42]. A complex fault system is common for the most deposits of carbon dioxide, siliceous, and thermal waters of Transcarpathia. Deep regional faults are conductors of carbonated cold mineral waters (Golubinskoye field) or thermal waters at the area of occurrence of intrusive bodies and effusive rocks of the Vygorlat-Gutinsky volcanogenic ridge. The tectonic plan of the studied linear faults is complicated by radial faults associated with volcanic-tectonic uplifts (ring structures) and calderas. Complex tectonics is responsible for the significant variability of the chemical composition, mineralization, and temperature of groundwater at short distances (up to 1.2 km) in the same aquifer. Such cases are known at the Derenivskoye deposit of siliceous mineral thermal and subtermal waters, which is 16 km far from Uzhgorod. The deep fracturing stretch zones of in the mountainous part of Transcarpathia are located along rivers that flow along the intermountain valleys. The shallow near-surface cracks extending from elevations are located orthogonal (see Fig. 10).

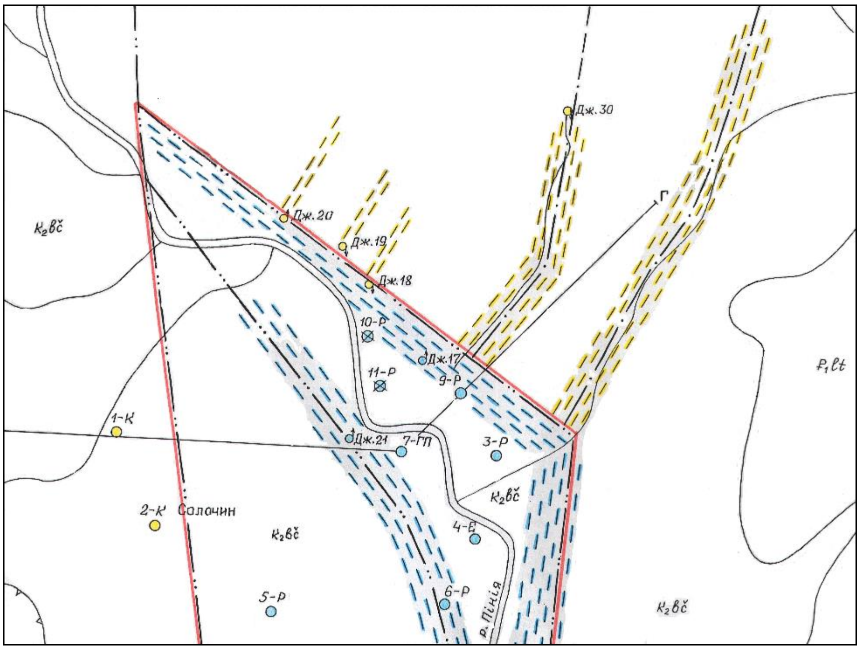


Fig. 10. The location of the open fracture zones at the Golubinsky mineral water deposit on the catchment of the river Pine, tributary of the river Latories. According to B.T. Polonsky data.

Such kind of the fault system was studied at the Golubinsky carbon dioxide mineral water deposit, which lies to the north-western outskirts of the studied territory of the construction of Wind power stations. Near-surface cracks are associated to the outlets of freshwater sources, and finally are in relation with main channels for filtering fresh infiltration waters. Of the great importance is the river nutrition and formation of the final chemical composition and mineralization of carbon dioxide water of the deep origin. Among these types of the mineral waters are well-known in Europe «Luzhanskaya» ## 3,4,7; «Polyana Kupel», «Polyana Kvasova», «Svalyava». These Ukrainian mineral springs are similar for world known waters of Karlovy Vary and Baden-Baden .

The crucial idea of our studies is that the violation of the conditions of entry and mixing of infiltration water with deep water can occur in connection with the construction of wind power stations. As the result the quantitative depletion or qualitative change in valuable medicinal waters is expected under the construction and operating of the wind power stations in mountain ecosystem.

Thus, the development of the wind power station farms at the mountain regions is controversial for now. This kind of the energy have the big potential as the environmental friendly source in terms of the heavy metals and other dangerous chemicals pollution. From the other site there are a number of risks connected with the ecosystems destroying, soil erosion, flooding’s, and loss of mineral water quality.

To assess the mentioned risks promising are combining of the hydrogeological studies and non-destructive geophysical methods, first of all soil magnetism studies.

References

1. Aras, H., Erdoğmuş, Ş., & Koç, E. (2004). Multi-criteria selection for a wind observation station location using analytic hierarchy process. Renewable Energy, 29(8), 1383-1392.
2. Archer, C. L., & Jacobson, M. Z. (2005). Evaluation of global wind power. Journal of Geophysical Research: Atmospheres, 110(D12).
3. Barbosa, R. S., Júnior, J. M., Barrón, V., Martins Filho, M. V., Siqueira, D. S., Peluco, R. G., ... & Silva, L. S. (2019). Prediction and mapping of erodibility factors (USLE and WEPP) by magnetic susceptibility in basalt-derived soils in northeastern São Paulo state, Brazil. Environmental earth sciences, 78(1), 12.
4. Cao L., Appel E., Hu S., Yin G., Lin H., Rösler W., 2015. Magnetic response to air pollution recorded by soil and dust-loaded leaves in a changing industrial environment. Atmospheric Environment, 119, 304-313.
5. Chang, T. J., Wu, Y. T., Hsu, H. Y., Chu, C. R., & Liao, C. M. (2003). Assessment of wind characteristics and wind turbine characteristics in Taiwan. Renewable energy, 28(6), 851-

871.Keyhani, A., Ghasemi-Varnamkhasti, M., Khanali, M., & Abbaszadeh, R. (2010). An assessment of wind energy potential as a power generation source in the capital of Iran, Tehran. Energy, 35(1), 188-201.
6. Dai, K., Bergot, A., Liang, C., Xiang, W. N., & Huang, Z. (2015). Environmental issues associated with wind energy–A review. Renewable Energy, 75, 911-921.
7. de Souza Bahia, A. S. R., Marques, J., La Scala, N., Cerri, P., Eduardo, C., & Camargo, L. A. (2017). Prediction and mapping of soil attributes using diffuse reflectance spectroscopy and magnetic susceptibility. Soil Science Society of America Journal, 81(6), 1450-1462.
8. Gadirov, V. G., Eppelbaum, L. V., Kuderavets, R. S., Menshov, O. I., Gadirov, K. V. (2018). Indicative features of local magnetic anomalies from hydrocarbon deposits: examples from Azerbaijan and Ukraine. Acta Geophysica, 66(6), 1463-1483.
9. Han, T.W. (2018). Estimating the Vewing Value, Landscape Value, and Net Visit Value of Windpower Turbines in Mountain Areas in Korea Using a Choice Experimentation Method. Environmental and Resource Economics Review, 27(3), 421-461.
10. Hara, R. (2016). Prediction of wind power generation output and network operation. Integration of Distributed Energy Resources in Power Systems.
11. Jakšík, O., Kodešová, R., Kapička, A., Klement, A., Fer, M., Nikodem, A. (2016). Using magnetic susceptibility mapping for assessing soil degradation due to water erosion. Soil and Water Research, 11(2), 105-113.
12. Johnston, N. N., Bradley, J. E., & Otter, K. A. (2014). Increased flight altitudes among migrating Golden Eagles suggest turbine avoidance at a Rocky Mountain wind installation. PloS one, 9(3), e93030.
13. Klueglein N., Sekann-Behrens T., Obst M., Behrens S., Appel E., Kappler A., 2013. Magnetite Formation by the Novel Fe(III)-reducing Geothrix fermentans Strain HradG1 Isolated from a Hydrocarbon-Contaminated Sediment with Increased Magnetic Susceptibility. Geomicrobiol. J., 30, 863-873.
14. Kruglov, O., Menshov, O. (2017). To the soil magnetic susceptibility application in modern soil science. In 16th International Conference on Geoinformatics-Theoretical and Applied Aspects.
15. Liang, J., Feng, C.M. (2015). Advanced AC and DC technologies to connect offshore wind farms into electricity transmission and distribution networks. Eco-Friendly Innovation in Electricity Transmission and Distribution Networks.
16. Liu D., Ma J., Sun Y., Li Y., 2016. Spatial distribution of soil magnetic susceptibility and correlation with heavy metal pollution in Kaifeng City, China. Catena, 139, 53-60.
17. Liu, Z. (2015). Innovation in Global Energy Interconnection Technologies. Global Energy Interconnection.
18. Lizaga, I., Quijano, L., Gaspar, L., Ramos, M. C., & Navas, A. (2019). Linking land use changes to variation in soil properties in a Mediterranean mountain agroecosystem. Catena, 172, 516-527.
19. Lu, L., Yang, H., & Burnett, J. (2002). Investigation on wind power potential on Hong Kong islands—an analysis of wind power and wind turbine characteristics. Renewable Energy, 27(1), 1-12.
20. Maher B.A., Moore C., Matzka J., 2008. Spatial variation in vehicle-derived metal pollution identified by magnetic and elemental analysis of roadside tree leaves. Atmospheric environment, 42, 2, 364-373.
21. Matzka J., Maher B.A., 1999. Magnetic biomonitoring of roadside tree leaves: identification of spatial and temporal variations in vehicle-derived particulates, Atmospheric Environment, 33, 4565-4569.
22. Menshov, O., 2017. Magnetic measurements of soil pollution in low urbanized environment. In 16th International Conference on Geoinformatics-Theoretical and Applied Aspects.

23. Menshov, O., Kruglov, O., Vyzhva, S., Nazarok, P., Pereira, P., Pastushenk, T., 2018. Magnetic methods in tracing soil erosion, Kharkov Region, Ukraine, Stud. Geophys. Geod., 62, DOI: 10.1007/s11200-018-0803-1.
24. Menshov, O., Kuderavets, R., Vyzhva, S., Maksymchuk V., Chobotok, I., Pastushenko, T. (2016). Magnetic studies at Starunia paleontological and hydrocarbon bearing site (Carpathians, Ukraine). Studia Geophysica et Geodaetica, 60(4), 731-746.
25. Menshov, O., Sukhorada, A. Method of the atmomagnetic control of the environment. The patent for invention № 102735, published 12.08.2013.
26. Mitchell R., Maher B.A., Kinnersley R., 2010. Rates of particulate pollution deposition onto leaf surfaces: temporal and inter-species magnetic analyses, Environmental Pollution, 158, 1472-1478.
27. Panasyuk, M.I., Matrosov, D.T., Levin, G.V., Lyushna, P.A., Sizov, M.O., Palamar, L.A, Onishchenko, I.P. (2018). Levels of radioactive contamination of groundwater of the ChNPP industrial site and means of limiting its distribution. Safety problems of nuclear power plants and Chernobyl, 30, 87-92. (in Ukrinian).
28. Pehnt, M., Oeser, M., & Swider, D. J. (2008). Consequential environmental system analysis of expected offshore wind electricity production in Germany. Energy, 33(5), 747-759.
29. Peluco, R.G., Marques Junior, J., Siqueira, D.S., Pereira, G.T., Barbosa, R.S., Teixiera, D.B., Adame, C.R., Cortez, L.A. (2013). Suscetibilidade magnetica do solo e estimaro da capacidade de suporte a aplicacao de vinhaia. Pesq Agropec Bras, 48, 661-672.
30. Pereira, P., Brevik, E.C., Oliva, M., Estebaranz, F., Depellegrin, D., Novara, A., Cerdà, A, Menshov, O. (2017). Goal oriented soil mapping: applying modern methods supported by local knowledge. In: Soil Mapping and Process Modeling for Sustainable Land Use Management. Elsevier, 61-83.
31. Pereira, P., Cerda, A., Martin, D., Ubeda, X., Depellegrin, D., Novara, A., ... Menshov, O., Comino, J.R., Miesel, J., 2017. Short-term low-severity spring grassland fire impacts on soil extractable elements and soil ratios in Lithuania. Science of the Total Environment, 578, 469-475.
32. Porsch K., Rijal M., Borch T., Troyer L., Behrens S., Wehland F., Appel E., Kappler A., 2014. Impact of organic carbon and iron bioavailability on the magnetic susceptibility of soils. Geoch. Cosmoch. Acta, 128, 44-57.
33. Pulley, S., Collins, A. L., & Van der Waal, B. (2018). Variability in the mineral magnetic properties of soils and sediments within a single field in the Cape Fold mountains, South Africa: Implications for sediment source tracing. Catena, 163, 172-183.
34. Rijal M., Porsch K., Appel E., Kappler A., 2012. Magnetic signature of hydrocarbon-contaminated soils and sediments at the former oil field Hänigsen, Germany. Stud. Geophys. Geod., 56, 889-908.
35. Royall, D., 2007. A comparison of mineral-magnetic and distributed RUSLE modeling in the assessment of soil loss on a southeastern U.S. cropland. Catena, 69, 170-180.
36. Santos, H. L., Marques Júnior, J., Matias, S. S., Siqueira, D. S., Martins Filho, M. V. (2013). Erosion factors and magnetic susceptibility in differet compartments of a slope in Gilbués-PI, Brazil. Engenharia Agrícola, 33(1), 64-74.
37. Shevchenko, O., Menshov, O. (2019). Wind power stations construction at the mountain ecosystem – risk assessment and monitoring techniques. 18th International Conference on Geoinformatics – Theoretical and Applied Aspects.
38. Söderholm, P., Ek, K., & Pettersson, M. (2007). Wind power development in Sweden: Global policies and local obstacles. Renewable and sustainable energy reviews, 11(3), 365-400.
39. Spiess, H., Lobsiger-Kägi, E., Carabias-Hütter, V., & Marcolla, A. (2015). Future acceptance of wind energy production: Exploring future local acceptance of wind energy production in a Swiss alpine region. Technological Forecasting and Social Change, 101, 263-274.
40. Tellería, J. L. (2009). Wind power plants and the conservation of birds and bats in Spain:

a geographical assessment. Biodiversity and Conservation, 18(7), 1781.
41. The Wind Resource. (2006). In: Wind Turbines. Springer, Berlin, Heidelberg.
42. Tustanovska, L., Ivankevich, G., Yahno, E. (2016). Interrelation between neotectonic movements and structural formation in Kanev area. In 15th EAGE International Conference on Geoinformatics-Theoretical and Applied Aspects.
43. Ucar, A., & Balo, F. (2009). Evaluation of wind energy potential and electricity generation at six locations in Turkey. Applied Energy, 86(10), 1864-1872.
44. Vyzhva, S. A., Deineko, S. I., Demidov, V. K., & Astashkina, O. A. (2010). Dynamic geologic-geophysical model of chalky layer and dispersible soils on territory of the RNPP site. In 9th EAGE International Conference on Geoinformatics-Theoretical and Applied Aspects.
45. Vyzhva, Z., Demidov, V., Vyzhva, A. (2018). The statistical simulation algorithm of random fields on the sphere by the aircraft magnetometry data. In 17th International Conference on Geoinformatics-Theoretical and Applied Aspects.
46. Wang, H., Huo, Y., Zeng, L., Wu, X., & Cai, Y. (2008). A 42-yr soil erosion record inferred from mineral magnetism of reservoir sediments in a small carbonate-rock catchment, Guizhou Plateau, southwest China. Journal of Paleolimnology, 40(3), 897-921.
47. Zhou, W., Yang, H., & Fang, Z. (2006). Wind power potential and characteristic analysis of the Pearl River Delta region, China. Renewable Energy, 31(6), 739-753.

3 MODERN ASPECTS OF SUSTAINABLE DEVELOPMENT MANAGEMENT IN THE CONTEXT OF THE ECONOMY DIGITALIZATION

3.1 MODERN DIGITAL TECHNOLOGIES AS DRIVERS OF INNOVATIVE ENTREPRENEURSHIP DEVELOPMENT

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In the implementation of the model of sustainable economic development of any country in the world, innovative entrepreneurship is seen as a driving force of change and a driver in solving key problems of modern development: ensuring sustainable economic growth, increasing productivity and ensuring full employment; overcoming poverty; strengthening social responsibility and social stability; development of the informal economy as an «airbag»; reduction of the shadow sector of the economy; improving the efficiency of technology transfer and commercialization of knowledge to launch innovations in all areas of economic activity.

These important problems acquire certain features in the framework of the digital transformation of the economy, and innovative enterprises become key players in the promotion of new knowledge, become a fundamental factor in launching breakthrough innovations.

At the same time, the key issues of forming the state's innovation policy are to achieve a balance between state support for innovation activity of enterprises (for example, constant diversification and expansion of such instruments by the state, goals of innovative development of the state and other stakeholders, mechanisms of involvement in the innovation policy of entrepreneurship, etc.) and ensuring the development of competitive relations (imperfection of knowledge, information gaps, information asymmetry, «market failures», lack of access to funding for innovation or lack of appropriate support infrastructure, etc.).

The rapid spread of digital technologies leads to a change of business model, creation of new conditions for new high-quality opportunities and sources of income, development of the transition to digital business, which creates new or changes existing activities, changes vectors of economic and social development.

Globalization and modern information and communication technologies create new opportunities for the existence and development of successful innovative enterprises and clusters through inclusion in international value-added chains, even despite the general technological backwardness, low purchasing power of consumers and territorial remoteness. This will have a positive impact on the development of the vast majority of sectors of Ukraine's economy and will provide additional opportunities for innovative domestic small and medium enterprises. Therefore, it is important to identify modern drivers of enhancement of entrepreneurship innovative activity, to study foreign practices of the use of digital technologies, the formation of new business models of entrepreneurship in the digital transformation of the economy.

Professor Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, refers to the era we are living in as «The Fourth Industrial Revolution (…) characterised by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human» [1].

However, Pratik Gauri, the President of the consulting firm «5th Element Group» claims that «The 4th IR has already given birth to 5th Industrial Revolution, where we shall bend the focus back to «humanity» and it is high time we embrace it. AI shall help increase human labour productivity, Blockchain shall help give access to banking to the unbanked, and robots shall help humans align ROI with purpose. There is no reason why we cannot make decent investment returns to shareholders, as we continue to build new technologies, create meaningful jobs, build communities, and preserve the environment. Humans created machines and it will always be humans who shall control the machines, and not vice versa» [10]. Thus, one of the proposed ways is the balanced use of advanced technologies such as artificial intelligence (AI), big data, robotics, the Internet of Things (IoT), blockchain and cryptography, and giving people control over these modern technologies. The Fifth Industrial Revolution will play a vital role in bridging the digital divide for the most marginalized sections of society and will help humanity make a qualitative leap towards purpose and inclusiveness [20].

Therefore, it must be recognized that digital transformation is one of the key challenges facing businesses today [21].

It bears mentioning and distinguishing the terms «digitalization» and «digital transformation» which are often used in the context of businesses changes.

In scientific and analytical works devoted to the study of digitalization processes and their development in modern society, there are a significant number of concepts of understanding the content of digitalization. For instance, Gartner, the global research and advisory firm, states following definition: «Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business» [7]. The Organisation for Economic Co-operation and Development (OECD) defines the term «digitalization» as «Digitalisation is the use of data and digital technologies as well as interconnection that results in new, or changes to existing, activities, while digital transformation refers to the economic and societal effects of digitisation and digitalisation» [Vectors]. The authors T. Saarikko, U. H. Westergren, T. Blomquist shares the idea of Brynjolfsson i McAfee stating that «Digitalization is the sociotechnical process of leveraging digitized products or systems to develop new organizational procedures, business models, or commercial offerings» [21]. They also define digital transformation as the sociocultural process of adapting firms to the new organizational forms and skill sets needed to remain viable and relevant in a digital landscape [21]. We find definition of similar content in the Gartner It Glossary: «Digital business transformation is the process of exploiting digital technologies and supporting capabilities to create a robust new digital business model». It is also said here confusion of notions of «digitalization» and «digital transformation» [8].

The Organisation for Economic Co-operation and Development (OECD) names several key technologies and applications which drive the digital transformation:

The Smartphone: The introduction of the smartphone in 2007 transformed computing by enabling constant mobile connectivity and providing individuals with access to a wide range of new applications and services. It has also enabled the development of the «platform» economy.

The Internet of Things: The Internet of Things (IoT) comprises devices and objects whose state can be altered via the Internet, with or without the active involvement of individuals. It includes objects and sensors that gather data and exchange these with one another and with humans. The networked sensors in the IoT serve to monitor the health, location and activities of people and animals and the state of production processes and the natural environment, among other applications. The number of connected devices in and around people's homes in OECD countries is expected to increase from 1 billion in 2016 to 14 billion by 2022.

Big data analytics: Big data analytics is defined as a set of techniques and tools used to process and interpret large volumes of data that are generated by the increasing digitisation of content, the greater monitoring of human activities and the spread of the IoT. It can be used to infer relationships, establish dependencies, and perform predictions of outcomes and behaviours. Firms, governments and individuals are increasingly able to access unprecedented volumes of data that help inform real- time decision-making by combining a wide range of information from different sources.

Artificial intelligence: Artificial intelligence (AI) is defined as the ability of machines and systems to acquire and apply knowledge and to carry out intelligent behaviour. This means performing a broad variety of cognitive tasks, e.g. sensing, processing oral language, reasoning, learning, making decisions and demonstrating an ability to move and manipulate objects accordingly. Intelligent systems use a combination of big data analytics, cloud computing, machine-to-machine communication and the IoT to operate and learn. AI is making devices and systems smart and empowering new kinds of software and robots that increasingly act as self-governing agents, operating much more independently from the decisions of their human creators and operators than machines have previously done.

Blockchain or distributed ledger technology (DLT): Whereas most software protocols support information exchange, blockchain or DLT enables protocols for value exchange, legal contracts and similar applications. It facilitates a shared understanding of value attached to specific data and thus allows transactions to be carried out. In itself, blockchain is a distributed database that acts as an open, shared and trusted public ledger that cannot be tampered with and that everyone can inspect. The combination of transparency of transactions, strict rules and constant oversight that can characterise a blockchain-based network provides the conditions for its users to trust the transactions conducted on it, without the necessity of a central institution. The technology offers the potential for lower transaction costs by removing the necessity of trustworthy intermediaries to conduct sufficiently secure value, legal or other transfers. It could disrupt markets and public institutions whose business model rests on the provision of trustworthy transactions [11].

Smart technologies have changed computing capabilities and developed the «digital platform economy» (an economic activity based on platforms that means online systems which provide comprehensive standard solutions for interaction between users, including commercial transactions), providing constant mobile communication and giving users access to a wide range of new applications and services [17].

The digital platform is a key digital transformation tool that provides information exchange and transactions between a large number of users. It is a set of technological solutions (technologies) that create the basis for the operation of a specialized system of digital interaction, reducing the cost of transactions and eliminating the role of the intermediary. The participants are independent of each other [23].

Since its inception, digital platforms have been designed to be an easy-to-use (free, simple) basis for posting content of the same type on the Internet. A classic example of such a platform technology is Wiki technology. Today, the platforms have become the organizational basis for the development of e-commerce and the functioning of various online communities [23]. One of their key features is the presence of network effects: the more people use the platform, the more valuable it becomes [9].

According to the classification of digital platforms developed by The Center for Global Enterprise, presented in the document «The Rise of the Platform Enterprise: A Global Survey», the following types of platforms are distinguished:

1) Transaction platforms. It is a technology, product, or service that acts as a conduit (or intermediary) facilitating exchange or transactions between different users, customers, or suppliers. The best examples of this type of platform are e-commerce platforms such as Amazon and eBay. On-demand platforms such as Uber, Zipcar and Airbnb provide the exchange of goods and services between individuals [9, 23];

2) Innovation platforms. It is a technology, product or service that serves as a foundation on top of which other firms (loosely organized into an innovative ecosystem) develop complementary technologies, products or services. Examples of such platforms are iOS from Apple Inc. and Android from Google, which have created very large innovative application developer ecosystems for their mobile devices [9, 23];

3) Integrated platforms. It is a technology, product, or service that is both a transaction platform and an innovation platform. This category includes companies such as Apple, which has both matching platforms like the App Store and a large third-party developer ecosystem that supports content creation on the platform;

4) Investment platforms. They consist of companies that have developed a platform portfolio strategy and act as a holding company, an active platform investor or both. For example, the Priceline Group focuses on online travel and related services, including Priceline, Kayak, and Open Table [9, 23].

A digital platform is a business model based entirely on high technology that generates profits through exchanges between two or more independent groups of participants.

Another technology designed to change the future of modern civilization is the Internet of Things (IoT). The IoT is a vast network of interconnected devices and sensors that interact with each other, collect data, and communicate over the Internet. An integral part of the IoT is the Industrial Internet of Things (IIoT). Industrial Internet is radically different in that the system of integrated computer networks and connected industrial (production) facilities with built-in sensors and software for data collection and exchange, allows remote control and management in an automated mode, without a man participation. The Industrial Internet of Things allows people to create industries that are more economical, flexible and efficient than existing ones. Wireless devices that support IP, including smartphones, tablets and sensors, are already widely used in production. In the years to come the existing wired network sensors will be expanded and supplemented with wireless, which will significantly expand the scope of monitoring and control systems at enterprises. The next stage of optimization of production processes will be characterized by an increasingly dense convergence of the best information and operational technologies [17]. Modern industrial Internet of Things (IoT) systems are a new generation of management systems. Their main feature is another business model, where the manufacturer of machinery, equipment or other physical assets can keep them in their possession, due to total control over the condition of these assets and, accordingly, new management and maintenance capabilities [12]. McKinsey, a consulting company, estimates that by 2025, the IoT market will be $ 6.2 trillion, and most experts agree that the IoT will eventually completely transform the existing IT landscape [13].

Today, Big Data has no national borders, promotes innovation and creates economic value as a resource and asset [17]. According to the Gartner IT Glossary Big Data is high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation [3]. A large amount of data is constantly accumulating in almost every area of human life. This includes social media, medicine, and the banking sector, which means any industry that is related either to human relationships or to computing. Many existing startups are beginning to actively use data analysis not only to track customer behavior and make decisions based on real-time information, but also to ensure maximum quality of customer service. Digital governments can use new technologies and data to stimulate the economy, create social values by opening public data [17]. Automated data management will free the minds and hands of progressive analysts and scientists who work with Big Data and will require new skills to work with advanced information analysis systems and its implementation in key business niches (IIA) [2].

Artificial intelligence (AI) is an integral part of a growing number of industries and a key tool for their digital transformation [17]. The very concept of «artificial intelligence» should be interpreted in a broad and narrow sense. So, in a broad meaning AI are systems that can operate with knowledge, and most importantly – to learn; the ability to learn methods of solving problems for which there are no ways to solve or they are not correct (due to time, memory, etc.); the ability to study methods of solving problems that require human understanding; a number of algorithms and software systems, the distinctive feature of which is that they are able to replace a person in any activity, performing its functions and making optimal decisions based on analysis of external factors based on human life experience, software capable of learning and decision making almost the same as humans [18]. In the narrow sense AI is designed to perform a single task or set of specific tasks. It allows machines, devices, programs, systems and services to function in the light of understanding this task and situation [16, 18]. The prospects for using AI are huge: algorithms that allow to process huge amounts of information every hour will be able to identify cause-and-effect relationships that are beyond human power, and thus make predictions more accurate and solutions more effective.

Today, artificial intelligence is becoming one of the fastest growing technological segments, which offers intelligent solutions in various economic and social spheres [18]. Business owners use it to update business processes. Thus, Cisco Systems uses AI / ML for integrated security and network infrastructure development. One example of a company's use of artificial intelligence is the creation of dialog interfaces and voice assistants, in addition, the AI functionality is used to distribute the load on computer systems. The use of AI / ML in health care will reduce the number of emergency hospitalizations. An example of this is the American medical resource Heal – patients can register with a specialist through a form on the website or a smartphone application, immediately paying for a doctor's visit, and receiving a full range of services at home – from standard examination to rapid blood test. The Indian company Xcode Life Sciences also uses AI in development. Among the created software products: Come Alive is a program of cell rejuvenation at the DNA level and the Gene Health module, which recognizes the genetic markers of diabetes and obesity. Recruitment automation becomes possible with AI. Artificial intelligence will speed up the search for a specialist who meets the criteria of the employer. A similar system has already been introduced by the American company Entelo, which analyzes resumes and selects applicants according to the requests of companies. Another way to use artificial intelligence is personalization, advanced search and product recommendations. Global companies have recently begun to use AI in market processes, using machine algorithms to predict market trends, and this experience is successful, say experts at Thomson Reuters – an information platform that works with the world's leading media providers such as the BBC, USA Today. In today's world, automation affects not only accounting, but the entire financial services industry. For this reason, PayPie financial analysts recommend using artificial intelligence to optimize data entry and reporting. This method of work allows to maintain the stability of financial flows and objectively assess the risks. Many organizations around the world have introduced new billing rules based on machine learning over the past two or three years. They are used to process credit card data for billing. AI also identifies trends in credit card deviations, analyzes cases of fraud that lead to reverse payments. The first to publicly announce this were SEO experts THE HOTH – resellers of SEO services for small businesses [19].

Thus, it becomes clear that artificial intelligence is one of the key drivers of digital transformation. According to a study by the American consulting agency McKinsey & Company, in the next ten years, new technologies will radically change the global labor market, saving about $ 50 trillion. However, these changes will affect hundreds of millions of jobs. On the one hand, people will be able to put some of their work routines on the machines, which will allow them to focus on creative work. On the other hand, less qualified personnel will definitely suffer from mass automation. And now we need to think about how to protect them [4].

According to the definition given in the UN Digital Economy Report 2019, blockchain technologies are a form of distributed ledger technologies that allow multiple parties to engage in secure, trusted transactions without any intermediary [6]. According to the developers, this system eliminates theft, fraud, property rights violations and more. The facts stored in the blockchain cannot be lost. They stay there forever. In addition, the blockchain preserves not only the final state, but also all previous states. Therefore, everyone can check the correctness of the final state, listing the facts from the beginning [5]. It is best known as the technology behind cryptocurrencies, but it is also of relevance for many other domains of importance to developing countries. These include digital identification, property rights and aid disbursement. Open-source platforms, such as Ethereum, allow programmers to develop decentralized applications to run on their blockchain. However, one challenge for blockchains is that, for some applications, they require a substantial, reliable electricity supply for processing. Some blockchain applications are already in use in developing countries, for example in the areas of fintech, land management, transport, health and education in Africa [6].

The literature identifies the following advantages of using a blockchain system:

1) decentralization, i.e. the whole network is used, not one computer (organization, person, etc.). In this case, even if one or more computers (persons) cannot perform any functions (liquidated, arrested, etc.), others store this information, which complicates hacker attacks and forgery of information (although no one is safe from this);

2) provability of each transaction: there is a cryptographic confirmation of each transaction, record, etc. In particular, the keys are private (owned by a specific person) and public (which can be used by all users of this network), i.e. if there is one person or one computer;

3) transparency (public access): anyone can see at any time what operations were carried out;

4) security: information is stored using cryptography;

5) the impossibility of making changes to the «signed» block: the information that got into the blockchain is checked and if the check is passed - put a kind of «seal» and these data are synchronized between all participants, from this moment the information cannot be changed;

6) computational logic: the digital nature of the registry works in such a way that transactions in the blockchain can be tied to computational logic and can actually be programmed, which allows users to configure algorithms and rules for automatic transactions between nodes;

7) saving time (system operation 24 hours a day, 7 days a week);

8) saving resources (in particular, public funds) [5].

According to the forecast of the consulting company Gartner on the value of the blockchain business, after the first stage of several high-profile successes in 2018-2021, the world will have much larger targeted investments and much more successful models in 2022-2026. It is expected that in 2030, they will grow to more than 3 trillion US dollars in the world. Today, China alone accounts for almost 50 percent of all patent applications for blockchain technology families, and together with the United States, they account for more than 75 percent of all such patent applications. As we can see, the world is changing rapidly due to the processes of digitization and digital transformation. DT is an exceptional phenomenon in terms of its speed and scale, which calls into question traditional thinking about the most effective way of organizing economic and social activities [17].

According to the Dell Technologies Digital Transformation Index, digitalization helps forecast, manage resources, track supply and blockchain. 77% of surveyed top managers believe that in the next five years they will use new technologies to forecast consumer demand; 68% intend to use the latest technologies to improve supply chain transparency, tracking and efficiency; 47% believe that they will carry out operations using the blockchain.

McKinsey experts claim that firms that resort to digitalization achieve revenue growth of more than 7% compared to others in the industry, and almost 6% higher EBITDA (Earnings before Interest, Taxes, Depreciation and Amortization) [13].

In Ukraine, digitalization in the potential of opportunities can become a basis for stimulating economic growth, the basis of a new path of development in terms of depletion of traditional raw materials for the domestic economy [15]. In 2018, the Government of Ukraine approved the «Concept for the Development of the Digital Economy and Society of Ukraine for 2018-2020» and approved an action plan for its implementation, and in November 2020 approved the document «Vectors of Economic Development 2030». Despite the still low indicators, in particular according to the Networked Readiness Index as of 2019, the country ranks 64th place, there are positive changes in the field of attracting digital technologies for the development of innovative entrepreneurship. For example, in 2018, the Ukrainian e-commerce market increased by 30%, showing the second result in Europe in terms of growth. Non-cash payments in Ukraine are becoming more popular, in particular in May 2020 the volume of non-cash transactions with payment cards was 56% [26].

Thus, the digital transformation of the economy and business leads to significant changes in the nature of work, property relations, social structure of society, intensifies the development and implementation of new strategies and business models, new solutions in the field of business management.

It is digital transformations that make profound changes and achieve development goals faster, cheaper, with new quality - in business, education, medicine, public administration, ecology, tourism, transport, urban management and many other areas.

References

1. Andersson L., L. Van der Heyden. Directing Digitalisation: Guidelines for Boards and Executives. 2017. URL: http://www.thisfluidworld.com/wp-content/uploads/2017/02/Corporate-governance-February-2017.pdf
2. Big Data Analytics: на ринку праці з високими вимогами до знань аналітики в області технологій користуються найвищим попитом // Платформа «Штучний інтелект». URL: https://www.everest.ua/aiplatform/analytics/statystyka-zrostannya-aiu-2019-rotsi-yaku-v2am-potribno-znaty
3. Big Data / Gartner IT Glossary. URL: https://www.gartner.com/en/information-technology/glossary/big-data
4. Chubatiuk Y. Artificial Intelligence for Ukraine: the risk or the opportunity. Everest. URL: https://www.everest.ua/analytics/shtuchnyj-intelekt-dlya-ukrayiny-ryzyk-chy-mozhlyvist/
5. Davydova I. V. Technology Blockchain: the Prospects of Development in Ukraine. *Chasopys tsyvilistykyю*. 2017. Iss. 26. P. 38-41. URL: http://nbuv.gov.ua/UJRN/Chac_2017_26_10
6. Digital Economy Report 2019. Value Creation and Capture: Implications for Developing Countries. UNCTAD. URL: https://unctad.org/webflyer/digital-economy-report-2019
7. Digitalization // Gartner IT Glossary. URL: https://www.gartner.com/en/information-technology/glossary/digitalization
8. Digital Transformation // Gartner IT Glossary. – URL: https://www.gartner.com/en/information-technology/glossary/digital-business-transformation, https://www.gartner.com/en/information-technology/glossary/digital-transformation
9. Evans P. C., Gawer A. The Rise of the Platform Enterprise. A Global Survey The Center for Global Enterprise. 2016. URL: https://www.bearingpoint.com/files/Global_Platform_Survey_Jan_2016.pdf?download=0&itemId=290632
10. Gauri P. How the 5th Industrial Revolution Brings the Focus Back to Humanity. *Thrive Global*. 2019. June 6. URL: https://thriveglobal.in/stories/how-the-5th-industrial-revolution-brings-the-focus-back-to-humanity/
11. Going Digital: Making the Transformation Work for Growth and Well-Being. URL: https://www.oecd.org/mcm/documents/C-MIN-2017-4%20EN.pdf
12. Ianenkova I. G., Rudenko N. O. Conceptual Grounds of Economy's Digital Transformation: URL: https://journals.indexcopernicus.com/api/file/viewByFileId/538348.
13. IoT: All You Need to Know about Internet of Things and about the Future of Modern Civilization. *Everest*. URL: https://www.everest.ua/iot-vse-shho-potribno-znaty-pro-internet-rechej-i-pro-majbutnye-suchasnoyi-czyvilizacziyi/
14. Kenney M. Zysman J. The rise of the platform economy / M. Kenney, // Issues in Science and Technology. 2016. Vol. 32, Is. 3. URL: http://issues.org/32-3/therise-of-the-platform-economy
15. Lazebnyk L. L., Voitenko V. O. The Essence, Features and Parameters of the Digital Economy. *Economics Bulletin of Dnipro Polytechnics*. 2020. Iss. 1. P. 22-29. Retrieved from: https://ev.nmu.org.ua/docs/2020/1/EV20201_022-029.pdf

16. Our Shared Digital Future Responsible Digital Transformation – Board Briefing. World Economic Forum. URL: http://www3.weforum.org/docs/WEF_Responsible_Digital_Transformation.pdf
17. Pizhuk O. I. The Key Drivers of Digital Transformation of the Economy. // Bulletin of KNUTD. Series: Economic Sciences. 2019. Iss. 3. P. 38-47. URL: http://nbuv.gov.ua/UJRN/vknutden_2019_3_6
18. Pizhuk O. I. The Artificial Intelligence as One of the Key Drivers of Digital Transformation of Economy. URL: https://www.researchgate.net/publication /337751419 _Stucnij_intelekt_ak_odin_iz_klucovih_drajveriv_cifrovoi_transformacii_ekonomiki
19. Rational Use of Resources: AI as an Instrument of Business Development // Everest. URL: https://www.everest.ua/raczionalne-vykorystannya-resursiv-ai-yak-instrument-rozvytku-biznesu/
20. Richter F.-J. Once Again Humans Become Central in the Fifth Industrial Revolution. *Horasis*. URL: https://horasis.org/once-again-humans-become-central-in-the-fifth-industrial-revolution/
21. Saarikko T., Westergren U. H., Blomquist T. Digital Transformation: Five Recommendations for the Digitally Conscious firm. *Business Horizons*. 2020. No. 63. P. 825 – 839. URL: https://www.sciencedirect.com/science/article/pii/S0007681320300975
22. Schallmo D., Williams Ch. A. , Boardman L. Digital Transformation of Business Models - Best Practice, Enablers, and Roadmap. *International Journal of Innovation Management.* 2017. Vol. 21. No. 8. 17 p. URL: https://www.worldscientific.com/doi/epdf/10.1142/S136391961740014X
23. Sichkarenko K. O. Digital Platforms: Classification Approaching and the Role of Economic Development Defining. *Prychornomorski Ekonomichni Studii*. 2018. – Iss. 35. P. 28-32. URL: http://nbuv.gov.ua/UJRN/bses_2018_35%282%29__7
24. Spagnoletti P., Resca A., Lee G. A Design Theory For Digital Platforms Supporting Online Communities: a Multiple Case Study. Journal of Information Technology. 2015. No. 30 (4). P. 364–380. URL: https://www.researchgate.net/publication/272318551_A_Design_Theory_for_Digital_Platforms _Supporting_Online_Communities_A_Multiple_Case_Study
25. Vectors of Digital Transformation // OECD Digital Economy Papers. – 2019. – No. 273. URL: https://www.oecd-ilibrary.org/science-and-technology/vectors-of-digital-transformation_5ade2bba-en
26. Vectors of Economic Development 2030 // Cabinet of Ministers of Ukraine. – 2020. URL: https://nes2030.org.ua/

3.2 MODERN PREREQUISITES FOR THE FORMATION OF THE INNOVATIVE ECOSYSTEM OF THE ENERGY SECTOR OF UKRAINE

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Over the past two decades, the intensification of global societal challenges in the world has brought to the fore the problem of implementing the sustainable development model and its goals (UN), forcing governments to reconsider the concepts of sustainable development and innovation and investment mechanisms. The effectiveness and dynamism of the innovation sphere determine the competitiveness of the national economy, its individual industries, territories, businesses, but under modern conditions, the perception of the social effectiveness of innovation has changed significantly. One of the most difficult goals of sustainable development is to provide humanity with clean energy.

In the energy sector of Ukraine, as well as in the global energy sector as a whole, there are serious changes in the energy consumption dynamics, as well as in the structure of their consumption under various factors influence. In particular, according to the forecast of the international report «Global Energy Perspectives 2019» (Global Energy Perspective - 2019) after 2035 there will be a significant change in the structure of consumer demand for primary energy, electricity consumption will almost double, renewable energy will provide more than 50% of electricity; global demand for natural gas will grow and, together with demand for oil, will reach its peak in the early 2030s. This is due to the changing role of various energy resources in the economic development of countries, including the expansion of renewable energy sources, globalization of natural gas markets, changing the scale of oil production, methods of its further use, etc., which will inevitably affect the state of the environment and the climate change dynamics.

Such situation forces all countries of the world to move to the search for alternative scenarios for the energy system development in the future, taking into account the new requirements for sustainable development of countries and their energy security.

The problems of improving approaches to the innovation activities study of the energy sector are also relevant in foreign works, but such research is usually associated with the theory of Open Innovation and the construction of innovation ecosystems. This theoretical approach is rapidly developing over the past two decades and focuses primarily on the study of the effectiveness of creation and implementation of knowledge flow among enterprises and the environment within the established cooperation of many stakeholders, ensuring the practical implementation of innovation ecosystem model of the country and its territories.

In this context, innovation problems of further development of economy energy sector become especially urgent: creation of innovation ecosystems and ensuring their sustainable energy development; development of new innovation and investment mechanisms to ensure its competitiveness; efficiency of inclusion of external stakeholders in these mechanisms and the effectiveness of their interaction in the innovation activities development to influence its innovation dynamics. As researches show, within the innovative ecosystem the choice of optimum stakeholders on creation of new knowledge becomes a crucial stage of its development, as well as wide interaction with external firms on providing their needs in innovative workings out [12 - 18].

Proceeding from fundamental research of innovations, innovative development, the essence and content, the principles of building innovation systems in the twentieth century, we should state their further evolution. Over the past 20 years of the 21st century, an understanding of the innovation ecosystem concept was formed and the stages of evolution of its models were identified: 2003 – «Innovation 2.0» («Open Innovation»), which was based on a three-sector model of interaction among the main stakeholders (government - universities - business) 2010 - the model «Innovation 3.0» («Embedded Innovation») («Embedded Innovation») model, accompanied by the inclusion of civil society in the traditional list of stakeholders and acceleration of the processes of digital economy transformation; 2011 - Model «Open Innovation 4.0» as an Enhancer of Sustainable Innovation Ecosystems, which is considered as an important mechanism to ensure sustainable development, based on the combined knowledge as a source of survival and growth, it is necessary to create a global business model value chain, based on the different scales innovation ecosystem development, uniting different stakeholders, provides an accelerated innovation cycle, takes into account rapidly changing consumer expectations, the implementation speed of automation, digitization and digital security.

The modern energy sector of Ukraine, including industrial enterprises, which provide the extraction of primary fuel, fuel and energy production and transformation processes, operates in a system of global changes and transformations, as well as quickly enough transformed under the influence of risks and threats in the country energy sector in terms of its integration into European energy space.

Innovativeness of functioning of Ukrainian economy energy sector is determined by factors of different nature (economic, technological, organizational, legal, political, scientific and technical, etc.). Nevertheless, given the systemic and rapid changes in the global environment, it seems necessary to investigate the innovation activity state of this sector of the economy in dynamics, to assess the energy sector ability to respond quickly to the technological challenges of world energy sector development, to identify opportunities and threats to the innovative development of the energy sector at this stage. It is first of all about the provisions observance of the world concept on sustainable development till 2030 and the European green course by 2050 in the activity of the enterprises of such sector [20, 21].

Indicators showing the enterprises innovative activity in the extractive industry of the energy sector of Ukraine are shown in Table 1.

The decrease in the values of most indicators in 2015 is explained by the loss of Ukraine's control over the temporarily occupied territories of Luhansk and Donetsk regions, where a significant part of industrial enterprises of the energy sector of Ukraine was located. The share of innovatively active enterprises of the extractive industry to the total number of enterprises of the industry in 2019 was 11.5%, and the positive dynamics of this indicator indicates an increase in innovation activity in the energy sector of Ukraine. At the same time, this indicator is lower compared to the world leading countries.

The largest share (more than 50%) in the innovation activity structure of mining enterprises is occupied by the purchase of machinery, equipment and software (Fig. 1).

Table 1 - Dynamics of changes in the innovative activity of extractive industries of Ukraine, 2013 – 2019

Indexes	Years						
	2013.	2014.	2015.	2016	2017	2018.	2019.
1	2	3	4	5	6	7	8
Number of innovatively active enterprises, units	38	32	21	20	23	11	28
Expenditures on innovations of enterprises in the purchase of machinery, equipment and software, UAH million	609	197,2	89,5	1127,6	296	507	1412
Expenditures on innovations of enterprises at the expense of own sources of financing, UAH million	618,9	363	281	1356	1187	860	2606
Number of enterprises that implemented innovations (products and / or technological processes), units	21	16	12	17	19	10	22
Number of new technological processes introduced into production by enterprises, units	25	18	6	1541	1541	776	884
Number of enterprises that sold innovative products (goods, services), units	5	5	8	9	10	9	10
Volume of sold innovative industrial products (goods, services), UAH million	49	11,5	53,7	42,8	479,9	306,7	703,2

Note. Compiled according to the State Statistics Service of Ukraine.

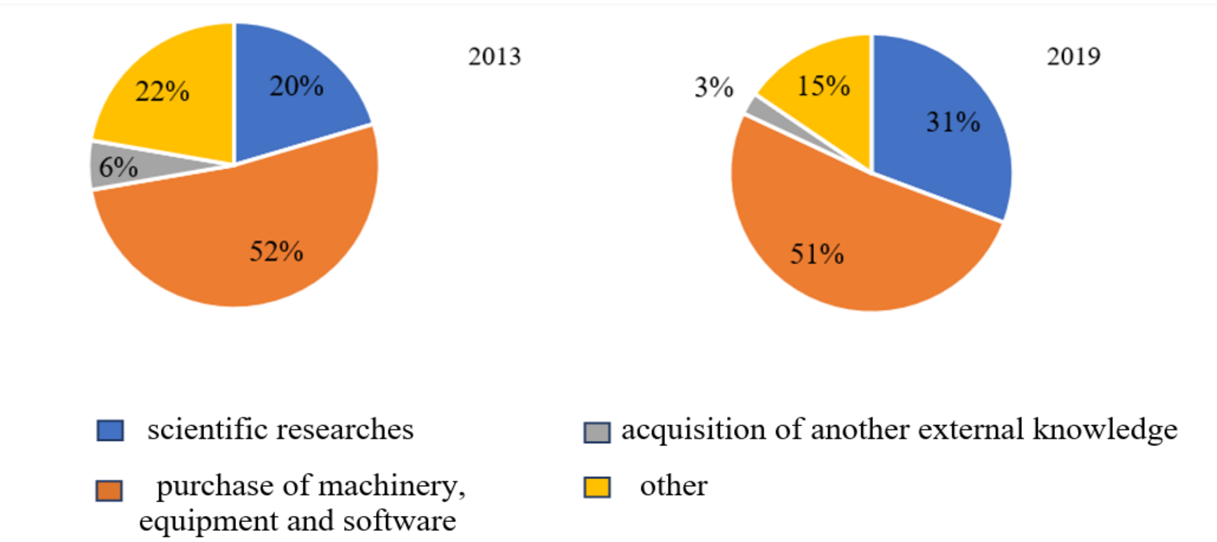

Fig. 1 Structural changes in the innovative activity of extractive industry enterprises of Ukraine, 2013 and 2019

The share of expenditures of extractive companies on the purchase of machinery, equipment and software in 2019 compared to 2018, it has almost tripled. The main source of financing of innovative activities of extractive enterprises in 2019. Enterprises' own funds remained - 26066 million UAH (100% of total financing of their innovation activity). During the studied period there was a rapid growth of the number of implemented new technological processes by extractive industry enterprises, at the same time the number of implemented innovative types of products in this industry remains insignificant. So, in 2019 extractive industry enterprises, engaged in innovative activity, demonstrated positive dynamics in all indicators selected to assess the effectiveness of innovative activity of the energy sector of Ukraine.

There are other dynamics of enterprises innovative activity in the sphere of supply of electricity, gas and conditioned air (Table 2).

Table 2 - Dynamics of enterprises innovation activities in the supply of electricity, gas and air conditioning energy sector of Ukraine, 2013-2019.

Indicator	Years						
	2013	2014	2015	2016	2017	2018	2019
1	2	3	4	5	6	7	8
Number of innovatively active enterprises, units	81	75	31	35	28	16	33
Expenditures on enterprises innovations in the purchase of machinery, equipment and software, UAH million	384,2	506,3	303,3	157,0	288,7	158,3	377,9
Expenditures on enterprises innovations at the expense of own sources of financing, million UAH	301,1	504,6	304,5	422,2	250,6	23,7	243,8
Number of enterprises that implemented innovations (products and / or technological processes), units	39	36	22	25	25	15	26
Number of new technological processes, units introduced into production	51	196	63	42	42	21	55
Number of enterprises that sold innovative products (goods, services), units	6	8	3	10	1	7	4

Note. Compiled according to the data of the State Statistics Service of Ukraine.

As the analysis of the given data shows, in the sphere of electricity, gas and conditioned air supply in comparison with the enterprises of extractive industry of Ukraine there is a recession of innovation activity, the basis of which is political and economic situation in the country (Fig. 2).

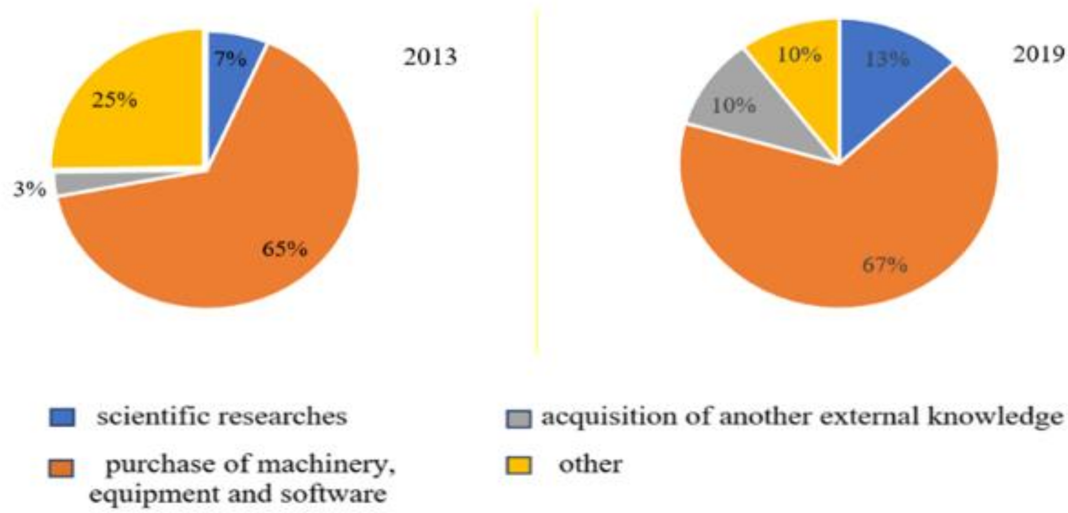

Fig. 2 Structural changes in the innovative activity of enterprises in the field of electricity, gas, steam and air conditioning supply in Ukraine, 2013 and 2019

In the structure of enterprises innovative activity in the sphere of supply of electricity, gas and air conditioning the main share is occupied by purchase of machinery, equipment and software (more than 65%). Financing of innovative activity of these enterprises is carried out from various sources, but the volume of attraction of enterprises own funds has decreased by 51.7% since 2014. Until 2019 a small share of innovation is financed by state (up to 2%) and local (up to 9%) budgets during the study period. Funding also comes from foreign investors, loans and other sources.

Electricity, gas, and air conditioning supply companies are more active in introducing new technological processes than in innovating products, although the number is insignificant compared to companies in the extractive industry, Fig. 3.

So, according to the results of the analysis of industrial enterprises innovative activity of the energy sector of Ukraine, despite the positive dynamics of indicators in 2019, low enterprises innovative activity of extractive industry and enterprises of supply of electricity, gas and air conditioning was revealed.

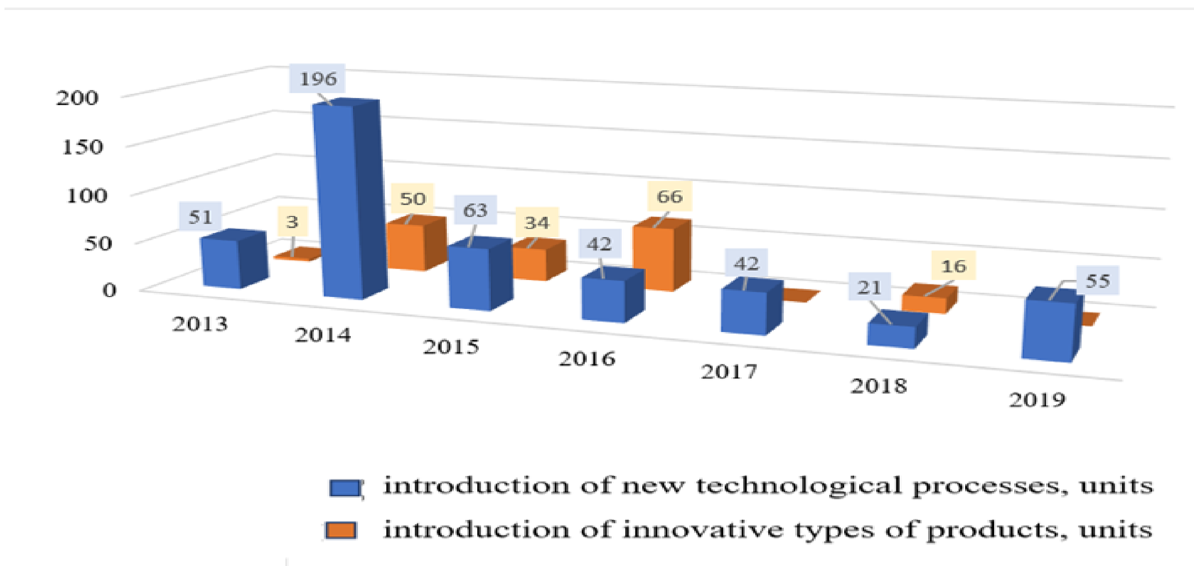

Fig. 3. Number dynamics of new technological processes and innovative products introduced by enterprises supplying electricity, gas and air conditioning in Ukraine, 2013 – 2019

The spring base of enterprises innovative activity financing is formed mainly at the expense of own funds of enterprises, which indicates the limited mechanisms to attract investment in innovation in this area, as well as the stimulation of innovation and implementation of innovative products in the energy sector.

According to the methodology of economic activity types division into technological sectors depending on the scientific expenditures intensity, presented by the Organization for Economic Cooperation and Development (2016), the extractive industry belongs to the medium-technological sector with expenditures on science ranging from 0.5 to 1.8% of the gross value added (GVA) in this sector, and the enterprises supplying electricity, gas and air conditioning refer to the low-tech sector with expenditures on science less than 0.5% of GVA of this sector. However, the lack of implementation in industrial production of new technologies is characterized by increasing energy, production resource consumption, reducing the level of economy competitiveness, the transformation of national enterprises into world outsiders, which together reduce the energy sector potential as a whole in the implementation of sustainable development model.

Thus, the analysis of the economy energy sector development of Ukraine indicates its insufficient ability to respond quickly to the technological challenges of global development in the energy sector, narrowing its opportunities and increasing the likelihood of threats in the energy sector at this stage. The systematic characteristic of functioning of energy sector of Ukraine indicates the low level of formation of its eco innovation system.

The obtained analytical data are used to conduct an integral assessment of eco innovation system functioning of the economy studied sector of Ukraine on the basis of the presented statistical data, which will also make it possible to assess the effectiveness of interaction among its main stakeholders.

The results of the energy sector innovation ecosystem study indicate its low functional capacity to ensure Ukraine's transition to sustainable development, structural changes in the existing model of innovation ecosystem are not yet targeted at the target user, the speed of the innovation process is slowed by unstable dynamics. The transition to the innovation ecosystem model 3.0 «Built-in innovation» should be accompanied by increased innovation activity of both large and small and medium-sized businesses in the energy sector, as well as accelerating the digital transformation of internal and external environment, based on combined knowledge. is important for survival and growth [31, 22]. Equally important is the introduction of mechanisms to ensure interdependence, networking and cooperation among stakeholders in the implementation of value priorities for the energy sector development.

In this context, innovation problems of further development of economy energy sector become especially urgent: creation of innovation ecosystems and ensuring their sustainable energy development; development of new innovation and investment mechanisms to ensure its competitiveness; efficiency of inclusion of external stakeholders in these mechanisms and the effectiveness of their interaction in the innovation activities development to influence its innovation dynamics. As researches show, within the innovative ecosystem the choice of optimum stakeholders on creation of new knowledge becomes a crucial stage of its development, as well as wide interaction with external firms on providing their needs in innovative workings out.

References

1. Onyshchenko V., Komelina O., Shchurov I. Contribution Ukraine's Sustainable Energy Development (Modelling and Forecasting) / Assessment of the Regional Energy Efficiency Potential of the Housing Sector of Ukraine/ Proceedings of the 3rd International Conference on Building Innovations. ICBI 2020. Lecture Notes in Civil Engineering, vol. 181. Springer, Cham. Pp.739-748.
2. João Matias, Joana Costa. Open Innovation 4.0 as an Enhancer of Sustainable Innovation Ecosystems Article in Sustainability October 2020. https://www.researchgate.net/publication/344542375
3. Granstrand, O.; Holgersson, M. Innovation ecosystems: A conceptual review and a new definition. Technovation 2020,90, 102098.
4. Oksanen, K.; Hautamäki, A. Sustainable innovation: A competitive advantage for innovation ecosystems. Technol. Innov. Manag. Rev. 2015,5, 24–30. [CrossRef]
5. Song, J. Innovation ecosystem: Impact of interactive patterns, member location and member heterogeneity on cooperative innovation performance. Innovation 2016, 18, 13–29.
6. Chesbrough, H.; Schwartz, K. Innovating business models with co-development partnerships. Res. Technol. Manag. 2007, 50, 55–59.
7. Liu, Z.; Stephens, V. Exploring innovation ecosystem from the perspective of sustainability: Towards a conceptual framework. J. Open Innov. Technol. Market Complex. 2019, 5, 48.
8. Goals of sustainable development of Ukraine for the period up to 2030.URL: https://zakon.rada.gov.ua/laws/show/722/2019#Text
9. The European Commission's priorities. URL: https://ec.europa.eu/info/strategy/priorities-2019-2024_en
10. Strategy of economic security of Ukraine for the period up to 2025. URL: https://www.president.gov.ua/documents/3472021-39613
11. National Economic Strategy for the period up to 2030. URL: https://www.kmu.gov.ua/npas/pro-zatverdzhennya-nacionalnoyi-eko-a179

3.3 PROBLEMS AND PROSPECTS OF LOGISTICS INNOVATION MANAGEMENT: THEORY AND PRACTICE

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Effective functioning of logistics systems in the face of intensified competition between producers in global and domestic markets leads to the intensification of production and implementation of innovations in logistics systems. However, theoretical and methodological aspects of logistics innovations formation are not fully disclosed by researchers, which necessitate depth research in this direction.

Analysis of enterprises logistics activities in Ukraine shows certain problems in the development of logistics approaches, presence of unused reserves in the implementation of logistics innovations.

Scientists give different definitions of the concept of «logistics system». According to the vision of scientists' logistics system is a relatively stable set of structural (functional) units of the company, as well as suppliers, consumers, and logistics intermediaries, interconnected by the main and (or) concomitant flow and management to implement a strategic logistics plan [1].

The logistics system is a set of actions of the participants in the logistics chain: manufacturers, transport, trade organizations, shops, etc. [2].

Logistics system is a system that integrates logistics elements (links, subsystems), related to organizational relations (internal and / or external) and have orderly connections to achieve strategic goals [3].

Types of logistics systems are given in table. 1.

The issue of innovation in logistics is in the field of researchers view that dealing with logistics issues. Thus, some of them point out that there is one of the few areas of the economy in each country that requires innovative development – transport and communications, another infrastructure that provides unimpeded movement of goods, capital, information, people, services. Another reason for the actualization of innovative development in this area is the growth of megatrends, which characterize rapid growth of material, information, financial and human flows parameters. These same megatrends initiated accelerated diffusion of knowledge in logistics, a new branch of economics.

Table 1 – Types of logistics systems

Type	Essence
Logistics system of resource concentration	A system of concentration channels that provide management of resource flows in order to increase their quantitative parameters in accordance with the requirements of the external environment.
Logistics system of resource allocation	Distribution channel system that provides management of resource flows in order to reduce their quantitative parameters in accordance with the requirements of the external environment.
Logistic concentration and distribution system	A system of concentration / distribution channels that provides management of resource flows in order to change their quantitative parameters in accordance with the requirements of the external environment.

Source: compiled according to [4]

The subject of innovations in logistics is optimization of the trajectory of economic flows circulating in the chain (network), in order to reduce time of the logistics cycle, rationalize overall costs of trade, increase efficiency of the logistics chain.

According to the existing classification of innovations, logistics innovation belongs to the category of process (technological) innovations and is correlated with the use of an innovative approach to the implementation of system (information technology) and management functions of logistics within developed business schemes.

It is obvious that innovative approaches in the logistics of domestic enterprises are appropriate provided by implementation of such approaches as: development of knowledge accumulated by world science and their introduction into scientific circulation and teaching process; adaptation of borrowed knowledge to the economic realities of the state.

Given the methodological approaches, it is established that:

$$R_l > T_l > P_l, \tag{1}$$

R_l – pace of research on the development of new logistics technologies and technical means used in logistics processes;

T_l – pace of creation of new logistics technologies and technical means used in logistics processes;

P_l – rate of development production of new logistics technologies and technical means used in logistics processes.

Dependence (1) indicates the need to ensure a higher pace of research (research and development work) in this direction compared to the pace of innovation by industry; the latter should accordingly exceed pace of their practical implementation in the logistics activities of enterprises.

Inequality (1) can be represented in the form of formula (2) processed by us:

$$R_l = K_{1log}\, T_l = K_2\, P_l, \tag{2}$$

$$K_{1log} = \frac{T_l}{R_l}; \tag{3}$$

$$K_{2log} = \frac{P_l}{T_l}. \tag{4}$$

In this case, in our opinion, the following condition should be met:

$$K_1 > K_2 > 1. \tag{5}$$

Various classifications of innovations are given in the scientific literature. The following types of innovations are distinguished in the economic encyclopaedia [5]:

1) product – creation of new goods or services that focus on emerging demand;

2) technological – improvement of production methods for existing goods (services);

3) market – development of new methods of activity in the market;

4) organizational – improving organizational structures of enterprise management.

By areas of application, innovations are classified as follows: technical and technological, economic, organizational, managerial, legal and social. In particular, economic include innovations in planning, motivation and evaluation of activity result, organizational – study of new forms and methods of organization, regulation and production, management – those that manifest themselves in changing the content of functions, technologies and organization of management, methods of operation of the management staff.

However, in our opinion, from the point of modern management areas of activity outlined above concern to management (as management of the enterprises in market conditions). The management process consists of four interrelated functions: planning, organization, motivation and control. Therefore, these approaches allow us to identify this type of logistics innovations as management, which, in our opinion, include innovations in the planning of logistics activities, its organization, motivation of logistics staff and control of logistics processes.

The effective functioning of logistics systems in the face of intensified competition between manufacturers in global and domestic markets leads to the intensification of production and implementation of innovations in logistics systems.

Logistics innovations are innovations in the logistics system. Taking into account these approaches, in our opinion, logistics innovations can be classified as follows (Fig. 1).

However, a number of domestic and foreign researchers are narrowing the list of forecasting methods. There are following methods of forecasting demand: method of qualitative estimates generalization, method of forecasting on the basis of time series; method of normative forecasting, method of factor forecasting, method of model forecasting.

There are two groups of forecasting methods:

1) heuristic methods, including individual (models such as interviews, generation of ideas), collective (simple ranking method, weighting method,

sequential comparison method, pairwise comparison method), combined (Delphi method and its modifications), expert assessments;

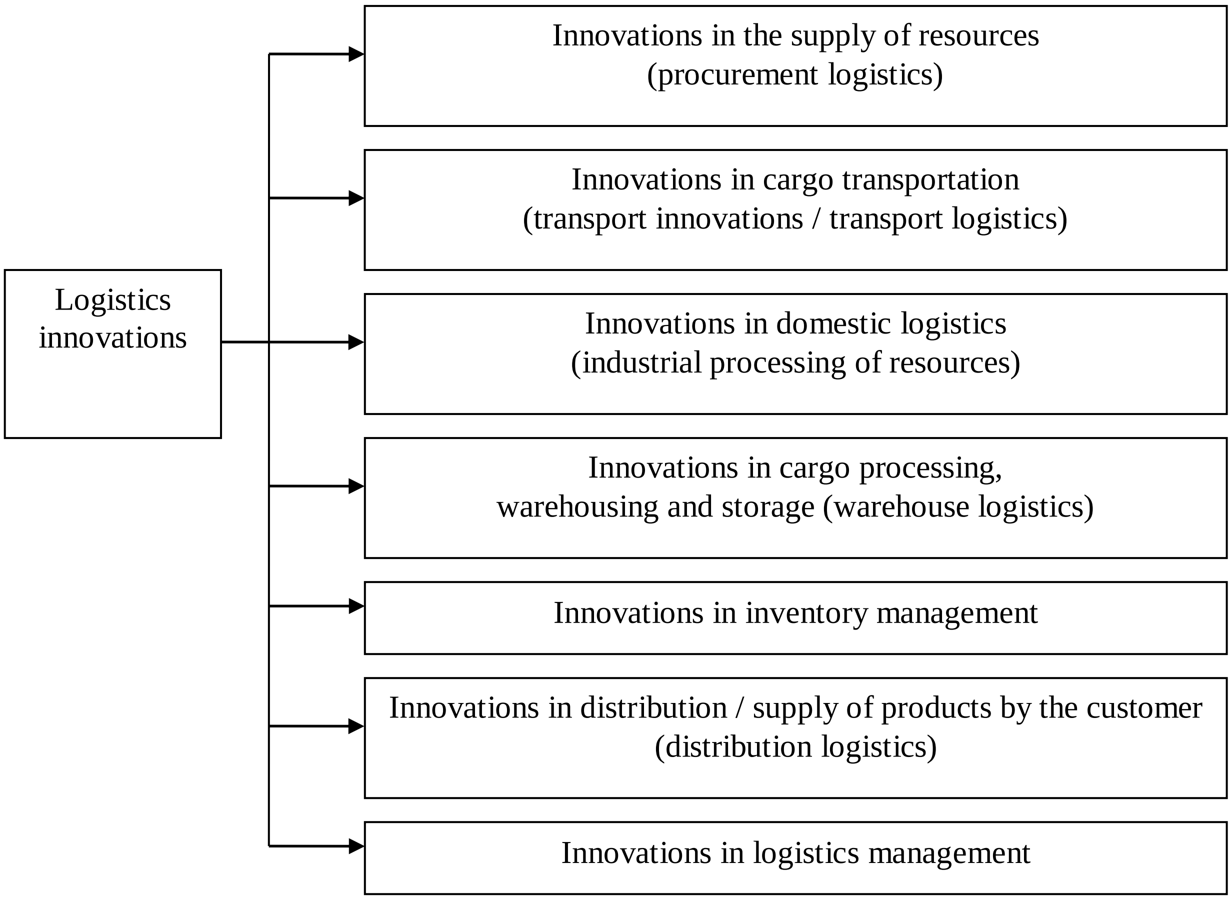

Fig. 1. Classification of logistics innovations

2) mathematical methods, including simplex (simple) methods of extrapolation by time series (least squares method, exponential smoothing, etc.), statistical methods (correlation and regression analysis, factor analysis, etc.), combined methods, which are a synthesis different forecast options.

Jeremy Shapiro [6] notes that the main forecasting models are:

time series models used in short-term forecasting (with a planning horizon of one week to three months) or in medium-term forecasting (with a planning horizon of three months to one year);

causal models used for long-term forecasting from one year and more; new product models that are used to analyze supply chain strategy of a new product;

evaluation models used to predict demand for new products and based on expert estimates.

Today, there are at least 40 software packages for forecasting with a wide range of features and different costs.

Logistics communications are an important link in logistics systems. Because logistics is one of the strategic ways to increase competitiveness of domestic business organizations and efficiency of the economy as a whole. Therefore, it is necessary to analyze experience of foreign enterprises in the field of logistics and take it into account in solving a number of problems that arise during the conduct of organizational and economic activities of domestic enterprises.

Information technologies are widely used in warehousing and storage. In particular, Porsche (Germany) [7] uses software for warehouse management systems (WMS), which allows distribution center to obtain more accurate information about spare parts stored in warehouses, reduce number of paper media and time to keep records. The company has also installed a Radio Frequency Identification (RFDC) system that provides real-time inventory control. The combination of WMS and RFDC systems has speeded up the processing of information about incoming parts. As a result, the capacity of warehouses increased by 17%.

The practice of using the WMS system shows that payback period does not exceed 1.5-2 years. At application of this system: time for acceptance, a complete set and shipment of the order in 1,5-2 times is reduced; accuracy of orders execution increases to 99%; number of staff is reduced by 2-2.5 times; losses related to shelf life or storage conditions are significantly reduced; range of goods increases due to increase of work accuracy; possibility of warehouse management for 4,000-10,000 pallet places by one or two operators is achieved; downtime costs are significantly reduced; reduced time for training warehouse personnel.

Recently, attention has been drawn to the logistics of reverse flows, which deals with the processing of returned goods, as well as waste disposal. Thus, the NKL cooperative (Norway) [7], which produces food, uses 1.5 million reusable fruit and vegetable containers to reduce costs and speed up orders and delivers 14,000 tons (70% of all Norwegian fruit and vegetables). At the same time, cooperative has achieved an increase in the level of loading of its railway transport from 50% to 60%, as a result of which it has reduced the cost of transportation, energy costs, and environmental pollution.

Considering logistics innovations, we cannot avoid the latest (at that time in developed countries, and today – for many Ukrainian companies) logistics technologies. In particular, foreign firms make extensive use of the MRP (Resource Requirement Planning) system [8], a computerized product-oriented approach designed to minimize inventory and adhere to a delivery schedule. American Production and Inventory Control Society defines resource planning as «a system formed around resource planning, as well as one that includes additional planning functions: production planning, basic production scheduling, and capacity planning».

The advanced version (MRP II) [8] has a wider application than MRP, as it can be used not only for planning material resources, but also for planning labour and financial resources, production equipment. The next step in development (after MRP and MRP II) is the ERP system (enterprise resource planning), which is defined as «a business management system that, with the support of multimodular application software, integrates all departments of individual functional areas of the enterprise». Application of the ERP system allows to provide: faster rotation of stocks and reduction by 10-40% of expenses for stocks; quality customer service, increasing the level of order fulfilment to 80-90%; higher accuracy of inventory accounting (up to 90%) with the reduction of physical checks of inventories; less system debugging time (by 25-80%); higher quality of operations; timely receipt of income and increase cash flows.

When considering implementation of a resource planning system (ERP), Mark West and Lee Sparks [9] draw attention to the following dangers: underestimation of the importance of change management; choice of software product to define the business process; promises to provide an ERP package «specifically designed for your business»; insufficient funding for training; choice of «big bang» technique (covering the whole company); limited term of supplier selection; attempt to preserve existing systems; fragmented development at the level of a separate unit; apathy (or attitude «this is not my job») on the part of top managers; use of the new ERP system while maintaining the previous forms of management reporting; belief in the prospect of «open systems» of ERP-interfaces; assumption that enterprise resource planning is a project of limited validity.

DRP (distribution requirements planning) system [8] is inventory control and management techniques in which MRP principles are applied to inventory distribution, a method of inventory replenishment in a multi-tier business environment.

A further development of ERP / MRP II approaches was the CSRP system (resource planning, synchronized with the consumer), which is also called an integrated system for maintaining functional life cycle of the product, proposed by Symix.

«Just in Time» System (JIT) developed in Japan [8] is seen as a philosophy of inventory control, which aims to maintain a sufficient amount of materials in the right place and at the right time to produce the right amount of product.

One of the first attempts to put the JIT concept into practice was the KANBAN system developed by Toyota Motors, which is a «traction logistics system». This system was introduced by the corporation at Takhama plant (Nagoya, Japan). The essence of the KANBAN system is that all production units of the plant are supplied with material resources only in the amount and for such time as is necessary to fulfil order of the consumer unit.

Created in Israel [8], optimized production technology (OPT) as well as JIT is aimed at minimizing inventories of materials and work in progress, reducing production component of the order execution time, especially with flow and serial production methods.

At the end of the twentieth century, logistics technology Lean production («slender/flat production») beginning to be used, the essence of which is a creative combination of high quality, small production batches, low inventory, highly qualified personnel, flexible equipment.

At this time, various variants of the DOL system (demand-oriented logistics), including ECR, QR and VMI, have become widespread among logistics technologies in distribution. The ECR (Effective Consumer Reaction) system is some extent equivalent of a JIT system adapted to meet consumer needs. The ECR system is connected to the QR (Quick Response) system, which is based on the use by computer and retail companies of computerized technologies for automatic identification of goods for everyday business operations related to the movement of goods.

If the ESR and QR systems are used in trade in groceries and other consumer goods, the CRP (Continuous Replenishment Planning) system is used in the service. Thus, Kendall Healthcare Products [10] successfully uses this system to supply hospitals.

VMI (vendor-managed inventory) [8] is a type of JIT in which decision of replenish inventory is made centrally by manufacturers or distributors at the top of the chain.

In our opinion, it is expedient to include such managerial innovations used in logistics as outsourcing, benchmarking, suppliers' associations, and shippers' cooperatives. Outsourcing is the strategic use of external resources to solve problems that have traditionally been provided by the company's internal resources [8]. This is a management strategy according to which performance of non-key functions of the company is entrusted to an external (third party) company, which is a specialized professional service provider.

In particular, Lucent Technologies, which owned most of its manufacturing plants, outsourced its operations after being defeated in the market. This innovation, as well as a strategic partnership with suppliers, has provided a nearly 20 percent reduction in production costs.

In the field of logistics outsourcing, can also be used for traffic management, use of information technology. In developed countries, outsourcing of warehousing services is increasingly used. In some cases, firms even hand over management of their European centers to logistics operators (for example, Rank Xerox) [11]. In recent years, there has also been outsourcing of production services that increase cost of the final product. In such cases, contractor is responsible for the packaging, labeling and configuration of the product in its warehouse, and sometimes even on vehicles.

According to [12], the largest European market for logistics services is in Germany (28% of the European), followed by France (20%) and the United Kingdom (17%). Thus, in the UK, almost 40% of logistics operations are used under contracts.

In Ukraine, outsourcing of logistics services is not developing so actively, which is explained by the following reasons: non-compliance with commitments regarding the level of service; lack of strategic vision of management staff; difficulty in reducing costs; price increase after cooperation; reducing ability to influence and control functions that delegated to the service provider; lack of knowledge-based consulting opportunities, etc.

According to the definition given in the International Dictionary of Marketing Terms [13], benchmarking is a standard of efficiency, quality or advantage, in relation to which all simple activities are evaluated, measured and positioned. In this case, in particular, logistics activities are considered relatively the best in the field of competitors and relatively the best companies in other industries.

Supplier Associations [8] is «a group of the most important subcontractors for the company, whose relations are mutually beneficial, operating on a regular basis for coordination and cooperation, as well as mutual assistance to benefit from cooperation based on Japanese principles such as Kaizen, JIT (just-in-time), U-cell-production. This definition was later expanded: a group of companies operating on a regular basis, created for the open and productive exchange of knowledge and experience. Large Japanese manufacturers, such as Toyota, with the help of a supplier association, promoted development of contractors, coordinated their work to disseminate best practices, provide technical assistance, and use training as needed.

Shippers' cooperatives perform functions of freight forwarding companies, remaining non-profit operations. In this case, all the savings are distributed among members of the cooperative. Thus, the Washington and Oregon Shippers Cooperative Association [10] has 1,200 members, 43 permanent staff and an annual turnover of about $ 25 million. The association has seven terminals in major cities across the country.

Thus, analysis indicates the need to ensure a higher pace of research (scientific and development work) to create new logistics technologies and logistics technical means compared to the pace of innovation by industry; latter must accordingly exceed pace of their practical implementation in the production and commercial activities of enterprises.

Generalization of the advanced foreign experience in the field of logistics allows to allocate the following directions of logistic innovations development:

1) improvement of logistics services to consumers through the use of modern methods of forecasting food demand;

2) effective management of raw materials and products stocks, for which can be used: Internet protocol for replenishment of CFAR stocks; EDI electronic data exchange system; combination of EDI system and bar coding; planned CTP order notification system; radio frequency identification systems; MRPII, CSRR, JIT, KANBAN, OPT and ERP, DRP, VMI planning systems;

3) improvement of cargo processing (movement of raw materials, stocks, work in progress or finished products) through the use of automated transport and warehousing systems AS/RS («automated warehouse»); WMS (warehouse management systems);

4) use of packaging systems: taking into account communicative role of packaging; use of containers, which allows to reduce volume of packaging, etc.;

5) minimization of transport costs by optimizing located distribution centers and warehouses;

6) use of the supply chain management concept, in particular, transport logistics;

7) creation of enterprises with producers of material and technical resources that use FMEA reliability system;

8) use of logistics of return flows, dealing with waste disposal, other reusable containers;

9) use such methods of logistics management as: outsourcing of logistics services, benchmarking in logistics, supplier associations, corporate shipment.

Reference

1. Dybskaya V.V. Logistics: full MBA course / [V. Dybskaya, E. Zaitsev, V. Sergeev, A. Sterligova]. M.: EKSMO, 2008. 944 p.
2. Yevtushenko N.O. Effective management of industrial enterprises on the basis of marketing and logistics. Problems and prospects of market-oriented management of innovative development: monograph. / ed. S.M. Ilyashenko. Sumy: Papyrus Trading House LLC, 2011. P. 466-476.
3. Turchak V.V. Organization of logistics system management at the enterprise / Abstract.. Ph.D.… 08.00.04. Turchak Victoria Vyacheslavovna. Khmelnytsky, 2012. 20 p.
4. Anikin B.A., Tyapukhin A.P. Commercial Logistics. M.: Prospect, 2009. 432 p.
5. Economic Encyclopedia: in three volumes. Vol.1 / S.V. Mocherny (responsible editor) and others. Kyiv: Academy, 2000. 864 p.
6. Shapiro J. Supply Modelling / from English ed. V.S. Lukinsky. St. Petersburg: Peter, 2006. 720 p.
7. Stoke J., Lambert Douglas M. Strategic management of logistics. M.: INFRA-M, 2005, 797 p.
8. Lysons K., Gillingham M. Procurement and supply chain management. M.: INFRA-M, 2005. 798 p.
9. Logistics and retail sales management: leading experts on modern practice and trends / Ed. John Ferney, Mark West, Lee Sparks. N.: Publishing house, 2006. 263 p.
10. Johnson James, Wood Donald F., Wardlow Daniel L., Murphy-Jr. Paul R. Modern logistics [trans. from English]. M.: Publishing House «Williams», 2005. 624 p.
11. Skovronek Czeslaw, Sariusz-Wolski Zdzislav. Logistics at the enterprise: study guide [trans. from Polish.] M. Finance and statistics, 2004. 400 p.
12. Waters D. Logistics. Supply chain management [trans. from English] M.: UNITY-DANA, 2003. 503 p.
13. Yadin Daniel. International Dictionary of Marketing Terms / [trans. from English] ed. V.M. Savchenko, E.E. Kozlov. Dnepropetrovsk: Balance Business Books. 2007. 608 p.

3.4 SCIENTIFIC AND TECHNICAL DEVELOPMENT AS A COMPONENT OF INNOVATIVE ENTREPRENEURSHIP IN UKRAINE

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Scientific and technical development as a component of innovative entrepreneurship is the unique expedient way for our state in relation to providing of the proper level of domestic economy competitiveness, opportunities to involve it in global integration processes as an equal subject. In addition, this direction will be instrumental in also growth of rates of the economy growing, that and will create economic pre-conditions for the substantial upgrading of citizens life. Scientific and technical development allows to decide the task of innovative enterprise, prepares countries to the new calls, offers new, more effective methods of their decision, provides formation of competitive edges during an economic competition. Commercialization of competitive edges generates additional financial possibilities in interests of economy of the state, additionally providing a multiplicative effect. As international experience of the economy growing shows, an innovative enterprise is developed one of basic indexes of competitiveness for every country of the world. The improvement of this index is straight related to introduction of the special public policy and realization of the various programs of innovative activity of businessmen. As an example, USA, Singapore and Germany is the leaders of world economy in obedience to rating of the World economic forum. One of advantages of their leadership is an effective management of innovative processes.

An innovative enterprise is determining description of modern scientific and technical, production, socio-economic and all public processes. The capture of development of enterprise innovative mechanisms depends the future of economy of Ukraine - or it will move in direction of including to the number of developed countries, whether it will remain an economic backward country on the side of a road of scientific, technical and social progress. In the modern understanding an innovative enterprise is determined as a process and as end-point of activity of enterprises. This result is incarnated as the newest or improved product, new services which have market demand or socio-economic meaningfulness for society, and also as the newest or improved technological process which is used in practical activity.

An agreement about an association between Ukraine and the EU foresees overcoming of present break between the newest scientific and technical progress of the European countries trends and lag in innovative development of our country. It needs introduction of new innovative policy which must include the effective mechanisms of scientific and technical potential stimulation, as well as innovative principles of structural changes in the national economy of country. The important task of the state is determination of innovative development priorities and forming patterns for economic growth of national economy, transition from declaration of such priorities to creation of system support of their realization based on the European experience.

The necessary attribute of the modern economy growing strategy of country become scientific and technical development as constituent of innovative enterprise. For a national economy the characteristic aimed is realization of positive technological transformations of national economy. But due to inconsistent implementation and low efficiency of the state policy of innovative entrepreneurship, our country lags behind developed countries in technological development, number of innovatively active enterprises decreases, development of high-tech industries is slowed down. This leads to a decrease in the level of competitiveness of the national economy. To solve these problems, it is necessary to adapt the innovation system of Ukraine to the conditions of European integration, reorient production system to an innovative path of development, stimulate investment in innovative development of the national economy.

In the modern world a level of scientific and technical development is one of major indexes of not only socio-economic development of country but also basic resource of the economy growing and location of the state in a world economy.

Despite the importance of these strategic processes over the years of transformations in the economy of Ukraine and failed to reach the level of developed countries in terms of innovative development, especially in knowledge-intensive economic activities. The main factors which reduce level of scientific and technical development there are a high degree of wear of the fixed assets, negative expectations of enterprises in relation to the prospects of development of them business activity, low level of innovative activity of enterprises next to the unsatisfactory level of financing due to money of the state budget.

Fruitful scientific and technical development is a priority nowadays, as it provides economic entities with the achievement of the best economic indicators, improvement of product quality and fuller satisfaction of the whole range of consumer needs. On this period of time the economy of Ukraine can not be acknowledged by innovative orientated, that is explained by modest specific gravity of innovative enterprises in its composition. After rating of innovations-2019 of agency of Bloomberg, which is published, when world elites going on the World economic forum in Davos, Ukraine left from TOP-50 of the most innovative countries of the world. Ten of criteria, among which charges on research-and-development, is plugged in this rating, production capacities and concentration of highly technological public companies. This ranking includes dozens of criteria, including research and development costs, production capacity and concentration of high-tech public companies. Despite the fact that at the beginning of 2018 Ukraine still ranked 46th among 60 countries, rose to seven positions in the Global Innovation Ranking and took 43rd place with 126 countries. The latest Bloomberg rating indicates regulatory problems in Ukraine that negatively affect the activity of patent registration when it comes to the quality of research institutions and their connection with production. For Ukraine, the components of political stability and security, rule of law, labor market efficiency, productivity, quality of research institutions and their connection with production, the number of applications for intellectual property rights, etc. are negatively significant [1].

According to the Doing Business rating, the technological component of innovative development in Ukraine has deteriorated and cannot enter the trend of positive changes. This is due to the fact that innovation is associated with qualitative changes aimed at creating a new product, technology or process. Thus, innovative development is a complex indicator that concerns not only the presence of purely technological or competitive industries in a country. Certain subjective factors and components, issues that are covered in the innovation index, affect the basic conditions and prerequisites for the existence of both the state and society. This applies to education, science, appropriate funding for innovation development. In these areas, Ukraine lags far behind the economically developed countries of the world. In our opinion, the changes should start with education in Ukraine, because until now young professionals with new education have difficulty entering the modern market environment. This is a traditional problem associated with the absence or minimal links between educational institutions and industry. Science is removed from the demands of production, and such demands are not always there. Thus, we have insufficient contact of science with business. Manufacturers and businesses know little about the potential of Ukrainian science, there is no practice of cooperation for the development of innovative ideas. This is due to the fact that manufacturers do not always know where to look for innovations in Ukraine, and therefore look for them abroad [2].

In Ukraine, the trend of decreasing innovation activity continues. The number of innovatively active enterprises has almost halved compared to 2010: in 2010 this number was 1462 enterprises, and in 2018 - 777 enterprises. Of these, 737 are in the manufacturing industry and only 40 are in other industries. Expenditures on innovations also decreased almost twice: in 2010 they amounted to 0.9% of total sales, and in 2018 only 0.4%. The same trend occurs in the volume of sold innovative products: in 2010 this figure amounted to UAH 33,697.6 million, while in 2018 - UAH 24,861.1 million. Statistical analysis shows that in Ukraine there is a direct relationship between the size of enterprises and their level of innovative development. This is due to the fact that for the development and implementation of innovations in the enterprise you need to have the appropriate staff and production capacity. According to the State Statistics Service of Ukraine, in 2012–2014, the smallest share of innovative enterprises among the surveyed enterprises was among small enterprises - 11.33%, in 2014–2016, respectively - 14.8%. At the same time, the largest share is observed among large enterprises: 38.87% in 2012–2014 and 39.64% in 2014–2016. Industrial enterprises often face such problems as the impossibility of sufficiently increasing the level of innovation potential and the difficulty of making an informed management decision to obtain the desired economic effect from the introduction of innovations. The most promising industries in terms of scientific and technological development are metallurgy, where the cost of innovation in 2018 amounted to 4.4 million UAH, mechanical engineering - respectively 1.6 million UAH, food production - respectively 1.3 million UAH. In these industries there is a stabilization of profitability, enterprises in these industries are focused on exporting their own products and are able to introduce new, more advanced technological processes and the development of new products. The woodworking, pulp and paper and chemical-pharmaceutical industries are operating at almost constant profitability, and the introduction of innovative technologies is increasing [3].

The problem of financing innovative projects is to find an answer to the question of who should pay for research. Enterprises and business companies are almost unprepared to fund such research, and the state funds the institutes of the National Academy of Sciences and universities, but virtually does not fund purely innovative programs and projects in these institutions. World practice shows that business itself has to pay, because it is primarily interested in innovation. But at the same time innovations are long-term plans and developments and today it is not economically profitable for Ukrainian business. Large corporations in Ukraine have their own research departments, but the research that is performed is somehow related to short-term operating profit. As for the expenditures on innovations, the largest share in 2018 was carried out at the expense of own funds - 88.2%, and only 5.2% at the expense of the state budget. The latter creates certain obstacles for the adaptation of these enterprises to the realities of activity in conditions of market competition. In addition, the real sector of the country's economy is not interested in long-term research due to the better quality of imported goods and due to reduced purchasing power of the population [4].

The state must show its own interest, stimulate a certain direction of innovation. In the absence of a proper strategy for innovative development of the country as a whole and individual industries, it is unlikely that there will be an active expansion of research funding. It is necessary to single out those branches of science in which Ukraine has the largest practical scientific schools, where there are already innovative developments and it is these that need to be paid attention to and supported. In the developed countries of the world, innovations are a key factor in socio-economic development, it is at their expense that they get 50-95% growth in gross domestic product. At the same time, up to a quarter of the working population is engaged in innovative business. In Ukraine, a similar figure is less than one percent. The experience of foreign countries shows that if the share of innovative products in the gross domestic product is less than 20%, then national products lose competitiveness. At the same time, this figure for the member states of the European Community ranges from 25 to 35%, and in China it reached 40%. The constantly growing needs of scientific and technological development can be met only through the materialization of the results of scientific and technological achievements. The results of scientific research and the number of innovative developments is directly dependent on the financial support of this process from the economic system of the state. In the leading countries of the world there is an increase in the knowledge intensity of gross domestic product. The level of spending on research and development in such countries varies between 2-4% of gross domestic product, which indicates the recognition of the importance of science for economic growth [5].

The Strategy of Innovative Development of Ukraine for 2010-2020 envisages a science intensity indicator at the level of 2.5-3.0%, however, starting from 2005, the opposite phenomenon has been observed - reduction of state expenditures for the needs of scientific activity. Absolute spending on these needs has also been significantly reduced, while most other countries have increased their spending, and China has doubled it in the last 10 years. Underfunding of scientific and technical research has a negative impact on their effectiveness and reduces the market relevance of the inventions. At the same time, due to the lack of funding for science, conditions have been created for the outflow of scientists from Ukraine abroad, while the number of researchers in the European Community has more than tripled in the last decade [6].

Having identified the scientific and technical component as the basis for innovative development of the national economy, the need for rational use of natural resources of Ukraine is acute. The available natural resource potential while creating appropriate conditions for investment support of innovation is able to reliably attract the interest of investors for further investment in innovation projects. This is hindered by the fact that the parameters of scientific and technological development in Ukraine remain outside the world limits. This does not provide an opportunity to build an innovation and investment model of its socio-economic development on the basis of advanced technologies and high-tech industries. At present, there is an unequal foreign economic exchange with neighboring countries, when Ukraine acts as a supplier of natural resources and labor to European and post-Soviet countries. Thus, the task of building a competitive national economy, achieving sustainable development and improving the welfare of society remained unfulfilled.

It should be emphasized importance of the competitiveness of the country's economy increasing through innovative incentives for the efficiency of the financial market. This market has the opportunity to generate the desired research and production results, support their commercialization and generate an increase in their own condition in this direction. Almost all indicators of Ukraine's financial market development have deteriorated. The deterioration of the financial climate can be explained by the increase in macroeconomic risks, which have complicated the functioning of this sector. This indicates the need to strengthen state regulation in the implementation of innovation and investment model of development of the Ukrainian economy.

For more than half of the period of implementation of the announced Strategy of Innovative Development in Ukraine, confident economic growth based on the results of scientific and technological development has not been achieved, no effective financial mechanism has been provided for productive innovation and successful adaptation of the national economy to the challenges of the XXI century. Elimination of Ukraine's technological backwardness from developed European countries is possible due to the resumption of independent scientific and technical activities within the framework of financially secured national strategy for the creation of new knowledge and more advanced technologies. State support, including grant support for the efforts of entrepreneurship in the industrial sphere, is needed. An important role will be played by the reliable interest of effective investors, provision of state guarantees to ensure their financial interests.

Activation of the scientific and technical potential of the country should be considered as a component of the innovation and investment path of its development. The formation of competitive advantages in technologically should be the main task of leading industries in this direction. This requires a significant restructuring in the system of scientific research organization, revision of its staffing, stimulating the consolidation of valuable researchers in domestic structures, increasing the prestige of scientific and technical workers. The priority in the development and appropriate financing of scientific and technical activities should be strategically correct definition of efforts directions in the scientific sphere. To ensure adequate funding for scientific and technical activities, it is necessary to conduct a comprehensive search for the necessary resources, use various sources and incentives, and create a favorable investment climate through the efforts of public administration.

Reference

1. Bloomberg Innovation Index 2018. [Electronic resource]. URL: https://www.bloomberg.com/news/articles/2018-01-22/southkorea-tops-global-innovation-ranking-again-as-u-s-falls

2. The Global Competitiveness Report 2017-2018. [Electronic resource]. URL: http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017–2018.pdf
3. Scientific and innovative activity of Ukraine 2018: Statistics. Kyiv: Government service of statistics of Ukraine, 2019.
4. State committee of Ukraine statistics [Electronic resource]. URL: www.ukrstat. gov.ua
5. Global R&D funding forecast // of Battelle. The Business of of Innovation (2016). URL: http://iriweb.org/sites/default/files/2016GlobalRDFundingForecast.pdf.
6. Strategy of economic development of Ukraine to 2020 year: strategy of national modernization // Ministry of economy of Ukraine. URL: http: // me.kmu.gov.ua.

3.5 PROCEDURES AND TOOLS OF PROJECT MARKETING IN THE CREATION OF INNOVATIONS AND SYSTEMS OF THEIR HIGH-TECH PRODUCTION

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The existing progress of the world’s leading countries and companies shows that their success is based on the use of an innovative model of sustainable development and implementation of strategic plans and programs for continuous progress of products and systems of their high-tech production. At the same time, in addition to modern standards of strategic and project management of these processes, to ensure their competitiveness in the global market environment, leading companies use effective procedures and tools of project marketing.

Given the unsatisfactory state of Ukraine’s economy and enterprises, their transition to world standards of management, development and competitive advantage is a real necessity today. Therefore, the topic of research and this article is relevant, has scientific novelty and practical value for the growth of domestic producers.

Modern problems and issues of marketing management of innovation processes were considered in the works of such scientists as S.S. Garkavenko [1], S.M. Ilyashenko [2,3], F. Kotler [4], R. Cooper [5], Y.S. Shipulin [2] and others. But for the complex economic conditions of Ukraine, a detailed study of the mechanisms of market management practical application in unique innovative projects and enterprise development programs there is a few one and the need for additional research in this area of development management to ensure necessary success is an objective reality.

The purpose of the work is to develop scientific and methodological bases and practical recommendations for the formation and application of modern procedures and tools of project marketing in creating innovations and systems of their high-tech production to ensure continuous progress and competitiveness of domestic products and producers.

As we know, any innovation process is risky. This is especially true of unique (complex) innovations and systems of their production, which are developed in modern projects and programs. The risk of innovation is evidenced by the fact that according to world practice, in thousands of new products that appear on the market each year, only 10% are truly innovative (innovative products).

Therefore, innovators need to understand the difficulties and risks of creating a particular type of innovation. F. Kotler [4] identified the following types and features of innovative product-product:

a) world innovations: fundamentally new goods, products, technologies that lead to the formation of a new special market (or its new segment) and other radical changes at the world level;

b) innovative products that create new product lines: products that allow company to enter a new target market, or to expand into those market sectors where the company’s products were previously absent;

c) radically improved goods that meet the needs that were previously met by other similar products, similar in method of application, but which had significantly worse qualitative and quantitative indicators;

d) expansion and distribution (diffusion) of existing product lines: new products, services, which are a supplement to the existing product groups of the company;

e) modified products-goods that are already on the market and come with some improvements that do not radically change their characteristics;

f) goods of market news and repositioning: reorientation of already existing goods (products) for new markets or market segments; reducing prices by simplifying some qualitative indicators of basic innovation. These pseudo-innovations have almost the same properties as their original predecessors, but they are much cheaper.

For the development, organization of production and implementation of a truly innovative product, it is necessary not only to select and develop an appropriate strategy, but also to implement a fairly risky investment. But it is not possible to guarantee absolute success to the innovator himself or to those who are involved in the implementation of innovative product-product on the market.

When planning and implementing innovation and investment projects and development programs of high-tech research and production systems (HTRPS) it is necessary to take into account the following typical causes of possible failures:

a) senior executives seek to «push» the idea they think is right, without paying attention to the negative results of marketing research;

b) the idea itself is good, but the market is overvalued;

c) finished product has design defects;

d) a new product (innovative product) was unsuccessfully placed, its advertising campaign was ineffective, or an excessively high price was set;

e) actual costs of developing an innovative product are higher than expected and they are not offset by revenues from the sale of the novelty;

e) response of competitors is stronger than expected.

According to leading scientists and marketing practitioners, it is possible to minimize the negative results of innovation and risks of creating and implementing an innovative product if the developers and implementers of the innovation program:

a) have a good understanding of consumer needs;

b) characterized by a high ratio of results and costs in all types of research and production and commercial activities;

c) significantly ahead of competitors in time to implement innovations;

d) plan a high margin of expected gross income;

e) allocate significant funds for advertising and product launch;

f) have the leadership of HTRPS, which understands and supports innovation, and its structural elements (economic entities) actively cooperate with each other;

g) continuously implement innovative projects and programs of their development.

Therefore, in the process of research, a set of procedures for marketing project management was developed, which must be performed throughout the life cycle of innovative projects and development programs to ensure the competitiveness of their results. Their essence is as follows.

Constant focus on consumer requirements and demands, trends and changes in the market, need to take into account the actions of competitors, require modern manufacturers to apply project marketing in their innovative projects and development programs. The use of project marketing should promote creation and production of new products at the level of world standards, as well as ensure its competitiveness. The practical implementation of this strategic task in innovative projects and development programs is achieved through the following proposals, procedures and tools:

1. To initiate the program of producers' innovative development, its concept and software and design solutions development as well, it is necessary to carry out the following stages of marketing research and planning of innovative transformations:

a) analysis of the external environment to predict its development;

b) analysis of the internal environment and condition of the producer;

c) analysis of existing market opportunities in relation to the external environment and internal environment to identify ways of innovative development;

d) formation of the target market for the implementation of development programs and projects;

e) research and quantification of uncertainty and risk at different stages of innovation development;

g) choice of priorities for innovation and production development;

g) formation of the organizational structure of innovation and development management;

h) planning of production, marketing and financial activities;

i) control over the implementation of program activities and development projects;

j) preparation of decisions on the need to change development priorities [1-6].

2. To assess market and other positions of producers, as well as opportunities for their innovative development, it is advisable to use SWOT-analysis, which compares market opportunities and threats to the external environment with the strengths and weaknesses of the producer, forming its internal environment and potential. Regardless of the potential of the manufacturer, its strategic marketing analysis should be conducted in the following stages: first expert-indicative, and then more detailed, taking into account location of the study object in the main areas of the matrix SWOT-analysis.

3. In developing innovative software and project activities in the process of SWOT-analysis for effective assessment and use of the existing potential of the manufacturer we should consider 4 options for marketing strategies of its future market behavior, characteristics of which are given in table 1 and 2.

4. For practical and systematic implementation of the main functions of marketing management of innovative development, it is recommended to use procedures and tools of project marketing management, developed in this study and listed in table 3. They are standardized and mutually agreed on the main phases, subphases (periods), stages of implementation (life cycle) of the program (project) and other standards of project-program approach and management of innovative development, which determines their rational use in practice.

Table 1 – Variants of marketing strategies regarding the use of available market opportunities of the manufacturer in its programs and projects

<table>
<tr><td colspan="2">Options for marketing strategies for future activities of the manufacturer</td></tr>
<tr><td>available market opportunities</td><td>probable market threats</td></tr>
<tr><td>1</td><td>2</td></tr>
<tr><td colspan="2">Strategy 1. Deep market penetration that is developing or has the potential to grow. This is done by: a) reducing prices; b) sales promotion; c) by improving the sales network and ways to promote innovative products; d) through the use of multilevel marketing and the complex «marketing mix»; e) by expanding the range of related services («branded service», «turnkey» system), application of flexible credit policies, transfer of complex innovative products for rent, leasing, etc.</td></tr>
<tr><td>Market opportunities: high prices for competitors' products allow to reduce prices; price elasticity of demand allows to increase sales and revenues while reducing prices; limited information about the products received by the target audience; existence of a good and well-established sales network and reserves for its growth; weak «brand» service from competitors; there are opportunities to provide related goods and services; there are needs in pre-sale preparation of the goods, its service after sale; there is a legal and regulatory framework and mechanisms for lending and leasing; increasing market capacity.</td><td>Market threats: strong competitors; substitute goods; absence or weakness of the trade network; non-perception by the target audience of sales promotion methods; unstable economic and business conditions; lack of market mechanisms or their weak development; falling market capacity; sharp fluctuations in consumer needs and demands; unfavorable political, social and other conditions.</td></tr>
<tr><td colspan="2">Strategy 2. Expanding market boundaries, i.e. finding new consumers and customers, new markets for existing and modernized products. This is achieved by: a) entering new markets; b) coverage of new segments in those regions where the producer and its products operate; c) development of new forms and areas of use of existing goods and products.</td></tr>
<tr><td>Market opportunities: there is an unmet need for products that are similar to the analyzed products of the producer; economic recovery; there are market segments that are left out of the competitors attention or they act on them inactively; there are channels to enter other markets; there is a possibility of multipurpose use of production.</td><td>Market threats: protectionism against local producers; lack of channels to promote products to other regions or market segments; there are specific features and traditions in new markets; availability of substitute products for powerful competitors; non-perception of goods in non-traditional areas of their application; unstable external conditions.</td></tr>
<tr><td colspan="2">Strategy 3. Development and implementation of new (innovative) products in existing markets through: a) improvement (modernization) of existing products; b) creation and implementation of a new innovation group of products that replace the outdated and inefficient product group, c) production of new (innovative) products that meet existing needs, but in a different way than existing (traditional) goods; d) creation, development, production and sale of fundamentally new (innovative-new) goods.</td></tr>
</table>

Market opportunities: economic recovery; acceleration of innovative development; stimulating to improve the quality and competitiveness of economic policy of the state and regions; presence of consumer needs differentiation; consumer dissatisfaction with available goods; possibility of using innovations in practice and life; existence of potential customer needs.	*Market threats:* significant changes in the qualitative and quantitative needs of consumers; emergence of strong competitors; significant change in business conditions; falling market capacity due to adverse external conditions; conservatism of searches for innovative goods.
Strategy 4. Diversification of production and sales of products in new (on various grounds) for this organization markets (their segments and sectors). This strategy is implemented by: a) offering in new markets new products that develop the traditional activities of the manufacturer, as well as products that are innovative (by type of activity) for this production; b) orientation of production and commercial activities of the producer on relatively small market shares with a radically defined specific needs of consumers (the so-called niche market).	
Market opportunities: acceleration of innovation processes; raising living standards; economic growth; stimulating innovation policy; presence of significant differentiation of consumer preferences within one or more regions, market segments, etc.; emergence of new demand for new products; availability of clients with clearly defined needs and preferences.	*Market threats:* jumping consumer needs due to the influence of various factors and changes; conservatism of buyers concerning innovative goods; weakness of trade networks; presence of artificial barriers and barriers.

Table 2 – Characteristics of the internal environment of producers (strengths and weaknesses of their potential and activities)

Strengths (positive) sides	Weaknesses (negative) sides
The positive (strengths) of the manufacturer we can include: high reputation; qualified and effective management that uses non-standard and creative management methods; constant contact with clients, partners and intermediaries; high qualification of the staff; a wide range of products; modern production facilities, technologies and equipment with high flexibility of use; availability of reserve capacities and production areas; competitiveness; high quality; significant innovative potential; experience in applying world quality standards (ISO 9000); reliability of resource provision; high financial independence and stability; experience in world markets.	The negative (weaknesses) of the producer include lack of strategy and development practice; deterioration (fall) of competitive positions; low financial independence and stability; ignorance in the market and in marketing; insufficient production capacity; rigid centralization of power; significant production size and management complexity; outdated technical and technological base and products; not rhythmic and unreliable provision; limited or no reserve production areas and capacity; limited or no reliable channels for product promotion and marketing; inefficient and cumbersome management system; lack of clear marketing and marketing programs; reluctance of management to change anything in activity, stereotypes of thinking.

The following main processes of the program (project) life cycle are considered:

I. Pre-investment phase of the program:

I.1. Clarification of the mission and innovative development strategy.

I.2. Formation of the mission, goals and objectives of the future development program and its innovative projects.

I.3. Strategic pre-project research on the program (project).

I.4. Identify possible solutions to the key ideas of the program (project).

1.5. Formation of general qualitative and quantitative parameters of the program (project).

1.6. Structuring of works and measures of the program (project).

1.7. Risk and uncertainty analysis.

1.8. Strategic project research, feasibility study and business planning of the main parameters of the development program (project).

1.9. Consideration and adoption of strategic decisions on the development and implementation of the program (project), its investment support.

II. Investment phase of program development and implementation.

II. (1). Subphase of basic research, design and planning of the program (project).

II. (2) Subphase of active (investment) implementation of of the commodity producer program development (innovative project)

III. Post-investment phase of the program:

III.1. Commissioning and development of new production.

Table 3 – Marketing activities and management in innovative projects and development programs *(author's development)*

Innovation process and development program		**Measures to assess producer potential in relation to its development program**			**Measures to bring the innovation process in line with the needs of the external environment**		
stages of the program	**marketing activities**	**market potential**	**innovation potential**	**production and commercial potential**	**goals of activities at this stage**	**procedures and tools for goal research**	**results**
I. Pre-investment phase of the program: I.1. Clarification of the mission and innovative development strategy.	Diagnosis of the condition, analysis of conformity of the internal possibilities of development to external conditions.	Existing procedures and tools for assessing producer potential for its development program			Assessment of producers, identify promising areas of development in existing conditions.	Strategic analysis. Strategic marketing research.	Identification of problems, assessment of the state and opportunities for development, its directions.
I.2. Formation of the mission, goals and objectives of the future development program and its innovative projects.	Search for innovative ideas for new products and other changes (improvements) in each area of the development program.	Identify market opportunities and threats.	Identify the necessary innovations to meet the needs of consumers and producers.	Identify and evaluate the strengths and weaknesses of the manufacturer	Search for new ideas, defining the objectives of the development program to improve technology and production system.	Methods and tools of strategic, marketing and project analysis, including project management standards.	The list of ideas concerning innovative production, technologies, order of its production, necessary changes in business processes.
I.3. Strategic pre-project research on the program (project). I.4. Identify possible solutions to the key ideas of the program (project). 1.5. Formation of general qualitative and quantitative parameters of the program (project).	Evaluation and selection of innovative product ideas, related changes in production and business processes. Development of a conceptual vision of program (project) implementation options.	Evaluation and selection of innovative product ideas, related changes in production and business processes. Development of a conceptual vision of program implementation options. Evaluate and select ideas that correspond to	Select ideas that develop the overall and innovative strategy of the manufacturer and contribute to the formation of the development program. Assess the possibility and effectiveness of their implementation.	Select ideas that develop production and marketing strategies, ensure development. Evaluate the production and marketing parameters of the program.	Drawing up a plan for detailed marketing research, their implementation for feasibility studies of the main parameters of innovative changes, as well as setting goals and objectives for the formation of marketing strategies and plans for the program.	Preliminary and detailed marketing research of existing markets, their characteristics to establish key parameters of innovative products, system of its production and marketing, taking into account innovative, technical and technological, organizational, economic opportunities for development and production of new	Selected ideas and their preliminary substantiation. Description of the innovative idea and its conceptual characteristics. Analysis of marketing and other indicative preliminary research, formation of preliminary data on the state and possibilities of development.

		the growth of the producer market potential. Check innovative idea from a commercial standpoint.				products.	
1.6. Structuring of works and measures of the program (project). 1.7. Risk and uncertainty analysis. 1.8. Strategic project research, feasibility study and business planning of the development program main parameters (project).	Comprehensive commercial (marketing) analysis of the market, external opportunities and threats to the state and potential of the manufacturer to develop a marketing strategy and plans for its implementation in the program (project).	Search or formation of the target market, its segments and sectors.	Detailed studies of the state and need to improve the innovation infrastructure and potential of the manufacturer to implement its development and projects.	Detailed studies of production and commercial potential of the manufacturer to establish qualitative and quantitative parameters of technical and technological, production, operational and commercial development.	Assessment of market prospects of innovative transformations, development of a marketing complex for program implementation. Defining goals and objectives of marketing management in the development program and formation of marketing strategy for its implementation.	Standard methods of marketing research of the external environment and the internal state of the manufacturer, analysis of results. Use of market segmentation methods and development of product, price, sales and communication policy for the implementation of program activities.	Marketing plan for implementation of the program, a list of standards for project marketing management, strategic, tactical and current plans for marketing activities for the implementation of program activities.
1.9. Consideration and adoption of strategic decisions on the development and implementation of the program (project), its investment support.	Assessment of implementing a marketing program possibility and plans for innovation and software transformation.	Assessment of market opportunities and conditions for effective implementation of marketing plans.	Evaluation of marketing plans effectiveness to ensure development of scientific, technical and technological potential of the manufacturer.	Evaluation of marketing plans effectiveness to ensure growth of production and commercial potential of the producer and sales opportunities for new products.	Assessment of opportunities and prospects for the creation, production, promotion of innovative products. Assessment of commercial and economic effects from the application of marketing	Procedures and tools of functional-cost analysis (FCA); design, technical and economic analysis; evaluation of different types of effects and effectiveness of innovation and project-planning activities of the development program.	Feasibility study of the development program and other innovative projects. Approval of strategic program and design parameters of producer development.

					management and measures to implement the program.		
II. Investment phase of program development and implementation. II. (1). Subphase of basic research, design and planning of the program (project).	Creation of innovative products, technologies and systems of its modern production: design and research and development works; experimental production and experimental testing of prototypes; preparation and development of production, including trial marketing.	Operational assessment of market threats and real commercial benefits of program activities implementation.	Evaluating effectiveness of innovative ideas implementation in design and software solutions. Diagnosis of quality and efficiency of the investment part development of the development program.	Evaluation of marketing activities implementation in project decisions and implementation plans in development programs. Operational management of marketing activities to implement the program and ensure its effectiveness.	Implementation of marketing activities related to: effective development of working and other project documentation; production of prototypes and their testing; conducting trial marketing to clarify the parameters of innovative products and development programs; implementation of marketing management in the program.	Application of marketing research results in design and research works, including ISO, DSTU, PMBoK, TQM, etc. standards to ensure the quality and competitiveness of innovative products and other results of the development program.	Technical and working documentation; prototypes; test reports and trial marketing; design and estimate and other documentation of the program; ensuring the effectiveness of software solutions and program implementation.
II (2). Subphase of active (investment) implementation of the commodity producer program development (innovative project).	Market tests of new products, new technologies and production systems, other results of the program. Bringing an innovative product to market and increasing its output.	Analysis of the market tests results of new products and changes in the development of the manufacturer and its innovative products.	Adjustment of innovation processes and activities of innovation infrastructure; making changes to operational plans to increase the efficiency and quality of the innovative	Operational management of the program implementation; making changes in the development program, current plans and business processes of new production and	Evaluation of the reaction and attitude of buyers and other consumers to the release of new products, effectiveness of the marketing complex in relation to its promotion. Evaluation of the program	Implementation of the marketing complex measures of the program in relation to the production and promotion of innovative products; monitoring, collection of necessary information and implementation of marketing controlling in program activities; implementation of	Adjustment of the marketing complex and policy for sales management and promotion of innovative products; operational decisions on marketing management and making changes to operational plans for the program;

<table>
<tr><td></td><td></td><td></td><td>potential of the manufacturer.</td><td>commercial activities.</td><td>effectiveness.</td><td>marketing management functions of innovative development of a commodity producer.</td><td>evaluation of the effectiveness of marketing management program.</td></tr>
<tr><td rowspan="3">III. Post-investment phase of the program:
III.1. Commissioning and development of new production.
III.2. Organization of new production precise activities.
III.3. Further modernization and development of the producer and its products.
III.4. Diffusion of innovative products into new markets.
III.5. Evaluation of the obtained results.
III.6. Implementation of the following innovative projects.</td><td>Sales growth and marketing adjustment of innovative products parameters depending on the available demand.</td><td colspan="6" rowspan="3">Marketing management to ensure efficiency of sales and competitiveness of innovative products:
● Extensive and constant informing of potential consumers (buyers) about a new, still unknown innovative product.
● Encouraging consumers to test a new product, ensuring its implementation through the wholesale and retail network.
● Creation and development of branded service.
● Accelerate the return on positive profits by intensifying the use of previous marketing measures (marketing mix), increasing sales and production of innovative products and reducing its cost.
● Improving quality of an innovative product, giving it new properties, consolidating its position in the market.
● To protect the basic model of the product - organization of its modifications release, expansion of the range and properties.
● Entering new market segments, expanding existing (effective) marketing channels and finding new ones.
● Reorient advertising from efforts to increase product information to efforts to promote benefits.
● Reduction of prices for consumers, for whom the price is the dominant factor in purchasing goods.
● Conducting additional market research and consumer opinions on further product improvement and development.
● Modification of markets, as well as market expansion by attracting new customers.
● Modification of the product, as well as the marketing complex to stimulate sales of new products.
F. Kotler [4] at this stage of the product life cycle recommends to carry out:
● Increased investment in the development of high-tech production and new (more innovative) products in order to reach a leading position or strengthen its position in the market.
● Maintaining a certain level of investment in innovative re-equipment and development of modern production while studying the situation in the industry (until it becomes clear).
● Selective reduction of investments by «refusal» to serve some consumers of obsolete products with a simultaneous increase in investment (their reinvestment) in profitable products and niche markets.
● Refusal to invest («harvesting» in order to quickly increase cash flow).
● Diversification (or sale) of production and placement of released assets with greater benefits for the producer.</td></tr>
<tr><td>Product achievement of maturity: stabilization of sales and production as a result of market saturation.</td></tr>
<tr><td>Gradual decline in sales, reduction and withdrawal from the production of obsolete products, transition to the production of new higher quality innovative products.</td></tr>
</table>

III.2. Organization of current activities of new production.

III.3. Further modernization and development of the producer and its products.

III.4. Diffusion of innovative products into new markets.

III.5. Evaluation of the obtained results.

III.6. Implementation of the following innovative projects.

The combined implementation of all these standards should strengthen the overall effect of the implementation of programs for innovative development of high-tech research and production systems and ensure their creation of competitive world-class innovative products.

The authors of the article are convinced that proposed procedures and tools of project management due to their integration with world standards of management, strategic and project management should jointly create a synergistic effect and accelerate innovation and economic progress of products and enterprises of Ukraine. This will ensure not only growth of their competitive position in the world, but also increase the welfare of the entire population.

Reference

1. Garkavenko S.S. Marketing. K.: Libra, 2012. 712 p.
2. Ilyashenko S.M., Shipulina Y.S. Commodity innovation policy. Sumy: VTD «University Book», 2007. 281 p.
3. Marketing innovations and innovations in marketing: [monograph] / Ed. Doctor of Economics, Prof. S.M. Ilyashenko. Sumy: VTD «University Book», 2008. 615 p.
4. Kotler F.A Framework for Marketing Managemant. Prentice Hall, Upper Saddle River, New Jersey, 07458. 2014. 464 p.
5. Cooper R.G. Development of new products: marketing. Minsk: Nauka, 2016. 530 p.
6. Redkin O.V., Tolkachov D.M. Strategic and project management of innovative development of the national economy, its high-tech research and production systems, and enterprises: [monograph]. Poltava: PoltNTU, 2019. 334 p.

3.6 BUSINESS ENTITIES MANAGEMENT INFORMATION AND ANALYTICAL SUPPORT IMPROVEMENT AREAS

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The transformation of Ukraine’s economy into the European space, domestic economy instability functioning, the growth of international competition requires new business intelligence tools usage for the business entities' management. The emergence of new risks (pandemic, etc.) increases the requirements for enterprises and organizations management quality. One of the ways to solve this problem is to use modern computer information technology to obtain the necessary complete and reliable information by all management units to make informed optimal decisions. The implementation of new technologies into practice leads to the modification of approaches to enterprise management.

From the efficiency and accuracy of information analysis results depend on the correctness and adequacy of management decisions that affect the efficiency of financial and enterprise economic activities. The constant accumulation, processing and use of information resources increases analytical work the efficiency. Therefore, it is important to organize information flows at the enterprise rationally. The main information system of the enterprise is the management accounting and analytical system, which forms all the necessary data for enterprise management. That is, at the present stage of domestic economy development, enterprises need to update and improve analytical support. Thus, today the urgent task is to introduce the latest information and analytical support to ensure competitiveness and financial stability for long-term activities of business entities in the face of uncertainty about the new risks of the market environment.

In today's world, the structure of business processes at the enterprise is becoming more complicated, the number of internal and external information flows in various sectors of the economy is increasing. Therefore, to improve the quality of management decisions, information technologies (IT) justification are used more actively. In order to improve competitiveness effectiveness of financial and economic activities and maintain company, owners and managers need to properly organize business processes to improve the quality of management. Management information systems are used to integrate data on the work of all divisions of the company. They, in contrast to accounting and operational accounting programs, provide an opportunity to influence and adjust the process at the development stage, as well as increase business transparency.

Improving the efficiency and quality of company management is closely linked to the development of computer technology, modern management concepts are based on appropriate application software. In the structure of software of management information systems of enterprises every year the means of information-analytical data processing gain weight.

In the 70s of the twentieth century, the concept of material resource management of MRP (Material Resource Planning) was proposed. It was designed to automate the planning of raw material requirements in warehouses according to production plans. The disadvantage of the concept was the lack of capacity planning for production capacity and manpower.

Modification MRP II (Manufactory - production) was created in the 80s of the twentieth century for automated planning of all production resources (raw materials, equipment, labor costs) and control of the entire production cycle from the purchase of raw materials to shipment to customers. Its disadvantage was the lack of financial resources planning at the enterprise.

In the early 90's of the twentieth century, a new concept of management system was developed - ERP (Enterprise) to automate and optimize internal business processes, it combined the planning of material and financial resources into a single system. The disadvantage was the lack of company's external relations management. Therefore, in the late 90's of the twentieth century there was a modification of ERP II, which includes the management of internal resources (ERP) and two new components: the accounting system and management of logistics supply channels (SCM) and customer relationship management and customer interaction (CRM).

Thus, modern full-scale ERP is a comprehensive information environment for automation of planning, accounting, control and analysis of all major business processes of the enterprise (production planning, procurement, inventory and sales management, accounting for various resources, interaction with suppliers and customers, quality and human resources management, etc.), which is implemented based on integrated software.

A large number of developed software requires coordination of development stages and information-analytical systems (IAS) implementation with the existing management information systems at the enterprises. The information component of the IAS is formed based on the following information types: planning, accounting, regulatory and reporting. Information support provides an opportunity to quick assess the indicators status that characterize the effectiveness and efficiency of activities. If the main tasks of the IS are the operational processing of data and ensuring transactions between them, the IAS form a sample of relevant information from different types of data sources, as well as presented in a convenient form for management decisions and control the execution process.

In a market economy, competition between enterprises is intensifying. During digital economy development there is a transition from management technologies to technology management to capitalize data, protect information and increase the efficiency and soundness of management decisions. In such conditions, the relevance of IAS, which provides the ability to collect, process and store a variety of data, taking into account the business processes of the enterprise. Due to the availability of accounting and control modules, planning, operational management, analysis in the IAS integrates information from different areas of activity - production, finance, logistics, personnel, suppliers, customers and others. The obtained data are used at all levels of management: preparation of corporate reports, calculation of financial and economic indicators, strategic planning, etc.

A typical approach to the creation of IAS includes three aspects: technical (capabilities of computers and office equipment), technological (information processing methods and technologies for implementing these methods), organizational (principles of information system organization and algorithm of interaction of individual elements). Such a system consists of a data warehouse and telecommunications facilities. It is able to turn a large amount of disparate information into final reports, which are necessary for management decisions. After data integration, enterprise management moves to a more competitive level. In order to maintain market share and profit from business activities, it is necessary constantly to improve the information and analytical systems used at enterprises. Due to model's usage of economic analysis, the scientific level increases. At different levels, the IAS user who makes management decisions needs different data, both in volume and content. To determine the information needs, it is necessary to compile a nomenclature of enterprise resources, perform an analysis of the market, explore the capabilities of existing competitors, and so on. It is also necessary to develop report forms, determine the deadlines for their submission, make a list of users and a list of data that they will obtain on request.

Based on existing experience it is possible to form an algorithm for construction of IAS of the enterprise. The proposed technique structurally consists of 4 consecutive stages, which can be further divided into separate tasks. The content of the stages is as follows:

1. Development of the concept: the necessity of creation is substantiated; the purpose and criteria of efficiency are defined. After the first stage the purpose of the project should be formed, sources of financing are defined, the estimation of possible risks is made, efficiency from realization of system is estimated.

2. System design: evaluation of existing hardware and software, as well as the development of information databases. At this stage, a logical data model and a single database of the enterprise are built, tools for data manipulation are created.

3. Connecting the system software: first install the standard Business Intelligence tools and configure the functions of generating queries and reports, and then create analytical tools that complement the typical capabilities of the system. During the implementation of the third stage it is necessary to build a set of necessary reports, develop tools to find all the necessary information, as well as create the necessary specific analytical tools for the company.

4. Implementation and operation of the system is the longest stage in time. At this stage, the capabilities of the system are tested by a small group of employees of the enterprise, the efficiency of using individual modules is determined, and then the users desire to configure and add individual modules of the system are taken into account. After a comprehensive setup of the system, the efficiency of implementation

is calculated and development possible ways are determined, taking into account the capabilities of hardware and software in the future.

Therefore, during the construction of IAS it is important to take into account the information base specifics and tasks economic essence. Initial data uncertainty and results dimensionality increasing leads to an increase in the informational and structural complexity of management tasks, significantly increases the mutual influence of factors, as well as the number of relations between the data to be considered. The formed single IAS will provide models high-quality transition and management tools to a higher level.

The dynamics of changes in the business environment in 2020 increased the likelihood of income shortfalls or a decrease in the market value of banks' capital. The pandemic has tested the technological readiness of the world's banking sector. Contactless payments have taken on a new meaning, and the security of non-cash payments has become their key advantage. Most banks in Ukraine continued to create new modern products and improve information and analytical support based on the urgent needs of customers.

The leader of the Ukrainian market, Privatbank, has opened more than 100,000 new accounts for legal entities and entrepreneurs, continued to work on national infrastructure development of non-cash and contactless payments, and implemented remote customer identification together with the Diia project. During the year, Oschadbank increased users quantity of the Oschad 24/7 platform by 49%, and Ukrgasbank increased the volume of lending for sustainable development projects, and now environmental projects account for 35% of the bank's loan portfolio. Raiffeisen Bank Aval switched to remote operation in a week and since then more than 70% of tasks are performed remotely. Last year, UKRSIBBANK made significant efforts to organize fast and convenient remote service and ensured that all financial transactions were carried out remotely. Credit Agricole continues the digital transformation of the bank in 2021 - plans to develop a mobile application CA +, and also intends to issue virtual cards. Alfa-Bank has launched a new mobile application

Sense SuperApp, which can create folders, select a screen saver, change the sound design, communication style and more.

In the financial market, Monobank offered customers a modern version of Privat24 with more attractive and understandable tariffs. Long before the pandemic, it relied on digital in the business model. For example, opening accounts after a few clicks in a mobile app and a five-minute meeting with a courier to sign a contract. The business model of the bank is very simple - a single product with maximum ease of use, so that there is nothing superfluous in the interface, user experience and so on. In 2020, new products continued to be launched, the bank worked on creating automatic payments possibility and on changes in the cashback program.

Thus, the main trends in digital banking in the world are the blurring of the line between banks and payment services, as well as the emergence of many financial services (FinTech) based on modern IT-technologies that organically complement the classic bank accounts and operations. Their advantages are increased availability of some markets for goods and services, reduced transaction costs, increased competitiveness and more.

In 2010, most of Ukraine's leading heavy industry enterprises automated main processes (Industry 3.0) and began to use Industry 4.0 technologies. Digitization helps to carry out horizontal and vertical integration of production management systems, gives the necessary flexibility to quickly carry out a large number of orders with different characteristics through all technological stages. Much of the structured information contained in enterprise databases requires the use of Business Intelligence (BI). Its usage increases the speed and quality of work with information, provides an opportunity to optimize all business processes of the company and quickly obtain the necessary quality data.

BI-technologies enables to focus only on key factors of efficiency, to model various actions options, to trace results of acceptance these or those administrative decisions. They are used to solve the following tasks: increase the efficiency of enterprise management; cost reduction; managerial risks reduction; support for strategic decision making; implementation of operational control.

The main tool of BI is software that can use a large variety of information. Data-Based Knowledge is acquired during the creation and completion of a Data Warehousing. The modern BI system collects information from all sources in the enterprise and provides management with analytical summary data together with targets. At the same time, in case of deviations from the planned results, it is possible to analyze the individual components of the unsatisfactory indicator in order to identify the cause and eliminate undesirable consequences.

The use of BI-technology is especially important in times of crisis, when it is necessary to constantly increase the efficiency of the enterprise - to reduce costs, increase productivity and more. These technologies are relevant for companies that operate in conditions of high competition and dynamic market situation in the world. Thus, BI-systems include four areas: storage, integration, analysis and presentation of data.

To save data, a database (DB) is created based on client-server architecture, relational database and decision support tools. That is, it is a large subject-oriented information corporate database, which is specially designed for the reports preparation, analysis of business processes in order to justify management decisions in the enterprise. BI infrastructure tools use the same security tools and metadata («data»), common query generators and administration tools, and have the same interface. They provide a quick search, use and presentation of all metadata objects.

Information analysis is performed using OLAP (Online Analytical Processing) technology, which enables several indicators simultaneous analysis by flexible viewing of information, arbitrary cutting of data, detailing and consolidation, comparison over time and more. Predictive Modeling and Data Mining are also used. These methods use statistical modeling, neural networks, genetic algorithms to create (select) a model for calculating the probability of an event or to identify patterns in the data.

Reporting tools enable to build formatted interactive reports of various types (financial, operational, etc.) in the form of information panels (Dashboards), which provide a variety of graphics. With the help of unregulated requests generator (Ad hoc query) the user can get answers to questions. The system also has convenient means of navigating available data resources. At the same time, integration with Microsoft Office is important, when the BI platform is an intermediate link in the information analysis chain, and Microsoft Excel is the BI client.

Second-generation BI systems are now in use. The main feature of modern information and analytical systems is the adaptation to the typical scenario of the user. They work through the web, use information panels with advanced visualization tools. The upper level of the system warns the manager about the presence of a critical situation, the middle carries out their analysis and research. The lower level of the analytical system contains operational data and reports. The main classes of BI systems have the following features: the use of portal technologies; interface in the form of a board with devices; multilayer data representation; interactivity: convenient data navigation and movement in different dimensions; manageability and relevance; proactivity: defining goals and constraints for individual indicators; customization: adjusting the panel to the level of user control; flexibility of access enables the user to intuitively select reports and graphs; personalization: selection of objects from the authorized list and location on the board according to their importance; collaboration: the admission of simultaneous work of a group of employees.

Currently, there are no clear leaders in the field of BI platforms, various companies have advantages in certain functional components. Oracle and SAP have their own analytics systems, and Microsoft integrates the OLAP service into MS SQL Server and develops it into an analytics server.

For example, Interpipe introduced an ERP system for financial management in the early 2000s, and digitalization of production began only in 2014. The company has customers from more than 80 countries. Receipt and systematization of orders are performed by the ERP-system, which is able to plan production from the first to the last operations. It can also be used to manage stocks of semi-finished products in the warehouse, so there are no impersonal balances and unnecessary stocks. IT solution enables to fulfill all orders faster and more accurately. It is possible to check quickly at what stage of production is a particular order, as well as take into account the specific requirements of each customer country. Due to the accounting and planning automation, total control of all production stages is introduced and finished products quality is improved. Digitalization is not over with products shipment and delivery accuracy to the customer is controlled.

The introduction of modern IT technologies increases the efficiency and transparency of the company, increases competitiveness in the world due to the speed and management decisions quality. Thus, due to the introduction of digital planning and production management at the enterprise, disruptions in delivery times were reduced by 10 times, inventories of work in progress decreased by 20% and the accuracy of orders exceeded 95%.

Metinvest is the largest mining and metallurgical company (MMC) in Ukraine. It consists of more than 30 companies, in size, geography and content, it is unique to our country. The scale of the business and the complexity of the group's architecture required an appropriate approach, so a separate IT company was created for the digital transformation of the business. This company consists of more than 900 specialists and implements more than 100 IT projects per year. It is fully responsible for the digitalization of MMC and ensures high-quality and continuous operation of digital services and information systems (IS).

Modern technical knowledge of specialists at expertise of IT infrastructure centers, business applications, industrial automation and cybersecurity is used in projects of digital solutions implementation, their support and development. Internal R&D | Co-Innovation Lab. explores the possibilities of introducing innovative technologies in the company, for which there are no ready-made solutions in the world.

The integration of the company's digitalization management process is carried out at three levels: Business Engagement, Solutions Delivery, Operations. At the first level, business needs in digital transformations are formed, and the initial assessment of digital initiatives is carried out. At the second level, there is its own project office for the development and implementation of IT projects, it is responsible for change management according to the ADKAR methodology. At the operational level, the introduction of technologies is supported, namely the development of IT infrastructure, automated workstation (AWP), information and cybersecurity.

Quality control of implementation of IT projects and service is carried out daily, quarterly and annually on key indicators SLA (Service Level Agreement), COS (Conditions of Satisfactions), CSI (Customer Satisfaction Index). The effectiveness of digital transformations depends not only on the introduction of new technologies, but also on the organizational model of managing this process at all stages of production. An integrated approach is important, the digital transformation becomes end-to-end: from production processes to personnel management.

Thus, the analytical support of the performance management system at an industrial enterprise is a system of indicators of the accounting and analytical process of transmitting information about the results of the entity to interested users to make effective management decisions. Thus, the implementation of IAS helps businesses to cope with the current challenges of a changing market environment and globalization of the world economy. BI technologies are now being implemented by banking and insurance companies, large retail chains, and powerful players in the telecommunications market to emphasize business customer focus. The industrial enterprises of large corporations are also implementing modern IT to build business processes of the enterprise to ensure stable operation in the future. But the most technological software will not implement itself. The introduction of innovations is a joint work of the company and the provider, which includes analysis and transformation of business processes, integration and configuration of systems, employee training, analytics and more. A well-chosen project manager is half the battle. He must not only know all the internal business processes, IT system, have good communication skills, but also be very persistent. Every employee must understand why he is involved in the digital transformation of the business and what benefits he will obtain from it. It is desirable to move in short iterations and understand what results should be obtained at each step.

There are already many companies in Ukraine that successfully use modern digital technologies for business. The implementation of individual IAS modules is a time-consuming process that requires significant resources and motivation from the company. Information and analytical support, as a component of the enterprise management system, provides an opportunity to solve functional management tasks, providing management with complete and reliable information about business processes and relations with the external environment. Modern business conditions impose new requirements on information and analytical support, which should take into account the constant changes in the external environment and increase the efficiency of the performance business entities management system, taking into account innovative information technologies. That is, today it is necessary to form and implement a strategy of necessary technological changes. Thus, the introduction of the latest information and analytical support is the future for Ukrainian business.

3.7 MANAGEMENT OF TECHNOLOGICAL INNOVATIONS IN THE FIELD OF LOGISTICS: CHALLENGES OF TODAY

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At this stage of economic development, the main areas of scientific and technological progress are: computerization of production; improvement of technologies that existed before; creation of biotechnologies; development of artificial intelligence, Internet of Things (IoT) technology and management theory and practice.

Logistics is focused on thinking in terms of cost and efficiency in space and time, but at the same time emphasizes the importance of the use of the innovation component.

Therefore, the future of logistics is shaped by both new technologies and new modern business models in the industry. Technological innovations play an increasingly important role in all sectors of the economy. Therefore, new technologies and innovative ways of working are being actively introduced in the field of logistics and in the process of supply chain management.

Significant changes in logistics determine innovation. Thus, since 2019, real-time supply chain management (SCV) has been implemented by many companies. And already in 2020-2021 it became a necessary practice. Real-time data is becoming increasingly popular among customers.

There are already a large number of startups whose solutions ensure the transparency of supply chains, provide technology that facilitates rapid response to change, allowing companies to use real-time data [1]. Such data include traffic patterns, weather conditions in a particular area, the condition of roads or access roads to ports, which allows you to optimize delivery routes [1; 2].

Statistics for 2019 show that logistics companies that use fully integrated supply chains are 20% more efficient than their competitors.

The most advanced innovative technologies in modern logistics are RFID, autonomous vehicles, UAVs, warehouse robotics.

RFID (Radio Frequency Identification) tracking technology is a tracking method that uses radio frequency to transmit information using tags attached to an object. An RFID tag attaches to objects such as paper currency, everyday clothing, and even our physical body.

The issue of confidentiality of personal data is questioned. Despite the risk of invasion of privacy, this technology has great benefits for such participants in the logistics process as supplier, buyer, warehouse, carrier [3].

The advantages of RFID are more complete control and greater transparency of warehouse stocks, which ensures easy inventory and reduced theft. RFID is the implementation of already existing technologies of radio and radar equipment. RFID technology has two components: one stores information, and the other reads information on the barcode, such as price, location of the cell with the goods, stocks of goods in the warehouse. The use of RFID increases the efficiency of the supply chain. For example, distribution centers use this technology to track their inventory or equipment. During the implementation of rail container transportation, labels are installed on the container with the code of the owner of the equipment, place of loading and unloading, origin of goods, name of the transported goods. This increases the transparency and visibility of the entire cargo cycle [4].

Internet of Things (IoT) technology is considered to be the most important asset for supply tracking. Connecting an IoT device in different areas allows you to track the movement of equipment, vehicles and goods through cloud services. At the same time, IoT-based container management is also simplified through real-time monitoring, fuel efficiency, preventive maintenance and intensification of container operations [2].

Often startups create new systems that quickly become popular. With little experience working with logistics assets, startups tend to focus on the «light» parts of supply chains, becoming, for example, digital freight forwarders. Thanks to flexible operations, they offer more attractive prices, while ensuring the transparency of the logistics process. For example, in 2017, Uber launched its Uber Freight function in the United States, and in 2019 it expanded to Europe and Canada, striving for a more efficient global freight market [1; 2].

There is a huge potential in freight forwarding Amazon, which plans to expand its own experience in warehousing and transportation to develop its own delivery capabilities. The company has already made great strides with the development of Prime Air, an unmanned aerial vehicle service it builds to create fully electric drones capable of flying up to 15 miles and delivering parcels weighing less than five pounds to customers in less than 30 minutes.

Amazon has announced the Amazon Flex platform, which uses on-demand contract drivers to accelerate the expansion of Prime One Day. The company has also announced its new robotic products, which are sent to hundreds of service centers around the world. One such product is the Pegasus sorting system, which to date has covered two million miles and has already reduced the number of incorrectly sorted goods by 50%, while maintaining the safety features of the existing drive system [2].

In addition, the e-commerce giant is testing Amazon Scout, which is designed to securely deliver parcels to customers who use small stand-alone delivery vehicles.

In 2020, Amazon invested $ 700 million in Rivian, an electric car startup that could produce 100,000 electric vans to deliver Amazon goods.

Another illustrative example of the company's influence on the industry is Flexport, a specialized cloud software for freight forwarding and a platform for data analysis [1; 2].

In early 2019, the company received $ 1 billion in funding to launch an operating system for global trade, which includes a strategic operating model for global freight forwarding and combines the best of all supply chain technologies.

In recent years, warehousing operations have undergone significant changes - and with the gradual integration of technology in logistics, the need for robotization of warehousing operations is growing. Warehouse robotics is developing very fast.

According to the Global Customer Report, one of the obvious innovations is the testing of robotics in stock.

So, the Boston Dynamics mobile robot called Handle is one of the brightest examples: the company has developed a fully autonomous compact device that can access any hard-to-reach places, and at the same time has an extended viewing area. Thanks to this, the robot can quickly unload trucks, stack pallets and move boxes around the warehouse. Technologies such as driverless vehicles or multifunctional work can also increase the efficiency and speed of warehousing processes. For example, GreyOrange and Locus Robotics already use robots that move around the warehouse on their own. Thanks to machine learning technologies and sensors that provide maximum accuracy and ease of tracking, a large number of autonomous robots will appear in modern warehouses in 2020 [1].

Over the past few years, the logistics industry has begun to integrate artificial intelligence (AI) solutions into its operations, including intelligent transportation, route planning and demand planning, and this is just the beginning.

Along with artificial intelligence, augmented reality and augmented intelligence are used. Advanced intelligence combines human intelligence with automated artificial intelligence processes. For example, in logistics planning, the use of advanced intelligence may even surpass the use of artificial intelligence alone, as it combines human capabilities (experience, responsibility, customer service, flexibility, etc.).

According to Gartner experts, enhanced intelligence will create a level of business value and increase productivity.

One of the most exciting trends in logistics technology is digital duplicates (digital copies of a physical object or process).

Digital duplicate technology combines physical and digital worlds and allows you to interact with a digital model of a physical object or part in the same way as with their physical counterparts.

The potential uses of digital duplicates in logistics are enormous. In the transport sector, digital duplicates can be used to collect product and packaging data and use this information to identify potential shortcomings and recurring trends to improve future operations. Warehouses and businesses can also use this technology to create accurate 3D models of their centers and experiment with layout changes or the introduction of new equipment to see their impact. In addition, logistics centers can create digital duplicates and use them to test different scenarios and increase efficiency. In addition, delivery networks can use this technology to provide real-time information that will improve delivery times and further assist autonomous vehicles on their routes [2].

One of the current topics of innovation in the field of logistics is unmanned vehicles. Thanks to this progress, in a few years it will be possible to transport goods on the roads without the participation of the driver in heavy traffic. The use of unmanned trucks can reduce logistics costs by 47%.

Digitization and automation of logistics processes will reduce costs, but the greatest savings (80%) are possible due to staff reductions. According to the publication «Strategy» by 2030, unmanned trucks will be able to deliver goods almost 2.5 times faster than trucks with drivers. This is due to the fact that there is no need for rest for truckers. Also, the latest logistics algorithms will reduce the mileage of trucks empty [5].

Thus, in many highly developed countries of the world, unmanned trucks are being tested and implemented in the activities of organizations. In Australia, for example, much progress has been made in the introduction of autonomous vehicles in industry and mining. Vehicles move there in factories and quarries. In 2019, trucks driven by artificial intelligence, running on the route Munich - Nuremberg, left for Germany. Two trucks are sent on the flight at the same time. One truck is driven by a driver, and the other is driven by a car saw.

The American company PepsiCo also signed a contract with the manufacturer of electric cars Tesla for the supply of 100 Semi trucks. However, it is difficult to introduce such an innovation in Ukraine due to poorly developed transport infrastructure and often no road markings, which is an important condition for the orientation of an unmanned vehicle while driving. Unmanned aerial vehicles (UAVs), or drones, are devices for unmanned forms of delivery of goods.

The Ukrainian company Nova Poshta is also moving in this direction. One of the owners of the company claims that there is a possibility that an engineering company will appear in the structure of Nova Poshta, which will deal with the issue of fast delivery of goods between cities with the help of drones [9]. The advantages of drones include the delivery of goods to cities and areas with underdeveloped transport infrastructure, often in rural areas, where there is no quality road traffic.

However, there are significant disadvantages, such as safety, the limited number of goods that the drone can deliver, the noise it generates, and low battery life.

Automated and digitized logistics processes can minimize the use of human labor and paper documents, and as a result of the introduction, in particular, of artificial intelligence platforms, you can:

first, get a comprehensive analysis and control of the supply chain;

secondly, to achieve the improvement of the following functional areas of

logistics: information logistics, supply logistics, transport logistics, distribution logistics, marketing logistics, warehousing logistics, inventory management, etc.

Electronic technologies are considered to be very promising and effective: EDI, RFID, e-mobility; e-business; e-logistics, etc.

For example, in agriculture such digital technologies are used as: DroneUA, SmartFarming, MegaDrone, AgroDrone. Among the providers of agricultural software are: Cropio, TVIS, Klever Systems.

For agricultural control - AgriEye, PreAgri, Agroonline, Fieldlook. As digital technologies help to increase efficiency and productivity, create opportunities for successful decisions and minimize risks, so Ukrainian farmers are interested in using comprehensive software solutions for their own business.

The blockchain platform is open source, which allows organizations around the world to implement blockchain technology in their own business processes. Very common are:

the method of equipping containers with a start-sensor device (using the highest frequency RFID-tags and built-in temperature sensors) allows customers of the organization to monitor temperature regimes, and in case of their violation receive warning signals;

connection of vehicles to the Internet allows you to manage traffic and monitor transport; - creation of online platforms for carriers automates the management of electronic document management, transport and warehouses, receiving orders, aggregation of delivery service operations and instant calculation of delivery tariffs;

introduction of 3D-printing in the production of various items: spare parts, architectural models, functional prototypes, camera mounts, used props, lighting fixtures and cables;

Blockchain and Smart Contracts technologies allow to carry out contracts of sale and delivery in general without participation of the person (payment is executed with use of blockchain system);

the introduction of artificial intelligence and Machine Learning as its variety allows: first, to increase the efficiency of the logistics business and bring customer service to a new level; second, to improve the system management of organizations by setting up and synchronizing internal and external business processes.

Thus, as a result of the introduction of the latest smart technologies in business processes, an economic effect can be achieved. Its implementation involves assessing the overall economic effect, the result of which depends on the efficiency of logistics solutions in production, individual logistics operations related to the transformation of material flow, assessment of the functioning of the logistics system and overall efficiency.

The main components of the overall economic effect of the logistics approach are:

effective coordination;

integration of logistics resources;

control of quality and efficiency of service in various spheres;

establishing partnerships with suppliers;

reduction of order processing time, equipment downtime, production cycle and logistics costs;

improving product quality;

optimization of integrated management structures;

increasing the reliability of document flow and the quality of the logistics product;

real-time data update for all parts of the logistics chain;

reduction of logistics risks.

Innovative tools for improving transport management in the EU are smart technologies that promote smart governance, in particular:

car sharing (car exchange services);

smart parking (sensor network allows you to quickly find free parking spaces);

the only integrated intelligent transport system of the city, which includes two automated systems: 1) fare accounting (electronic ticket); 2) dispatching management (monitoring, management and control of passenger traffic, in particular display of traffic on the map on GPS-trackers, information boards at stops with the schedule);

drones (delivery of goods, monitoring, disaster relief (delivery of medicines and essentials, assistance in search and rescue operations), crime control, protection of national borders) are particularly effective in agriculture, energy, transport and logistics, oil and gas industry, military affairs, etc .;

electronic control system of the transport system.

Based on the size of the market and the requirements for mobile devices in the network, telematics service with use-based insurance (UBI) and fleet management, intelligent parking service based on narrowband IoT (NB-IoT) technology, network-based emergency services network (ESN) LongTerm Evolution (LTE) and advanced advanced driver assistance. Systems (ADAS) based on LTE-V or 5G network [7].

The experience of the European Union shows that a strategically effective tool is the introduction of «cyberphysical systems» (CPS), including in transport, including systematization of transport systems through digitalization and the use of innovative environmentally friendly technologies in vehicles. Areas of system development of transport are: electrification of transport; use of new energy sources (primarily hydrogen); use of new types of vehicles and their hybridization; robotics of vehicles, unmanned vehicles; replacement of material movements with information; improvement of transport logistics.

Smart transport involves the use of several technologies, ranging from basic control systems such as car navigation; traffic signal control systems; container management systems; automatic recognition of license plates or speed cameras for monitoring applications such as security video surveillance systems; and to more advanced applications that integrate data and feedback from other sources.

The evolution of intelligent transport systems provides an increasing number of technological solutions for transport managers. Examples of the benefits of implementing intelligent transportation technology can be found in Austria, where Autobahn and Highway Financial Stock Corporation (ASFiNAG) turned to Cisco Connected Roadways to provide the Internet of Things to its roadside sensors. The result is a highway designed to monitor, transmit information to drivers and forecast traffic to ensure traffic lanes without congestion [8].

Thus, the development of transport is possible through cross-border cooperation programs: «Poland - Belarus - Ukraine» and «Ukraine - Romania», funded by the European Union under the European Financial Neighborhood Instrument (ENPI). PUM Netherlands Senior Experts, a non-profit program for the transfer of efficient technologies and business experience, helps to solve problems related to the «greening» of transport. All these programs are aimed at:

first, to ensure efficient mobility, reduce congestion, increase safety, develop smart equipment, infrastructure and services to improve the transport system;

secondly, the introduction of new technologies and improving the efficiency of resource use (in the transport sector - is the «greening» of vehicles).

The current state of transport infrastructure and the level of transportation organization does not meet European standards of quality of transport services and the principles of the concept of sustainable (balanced) development.

Smart technologies in the transport management system are interpreted in Fig. 1.

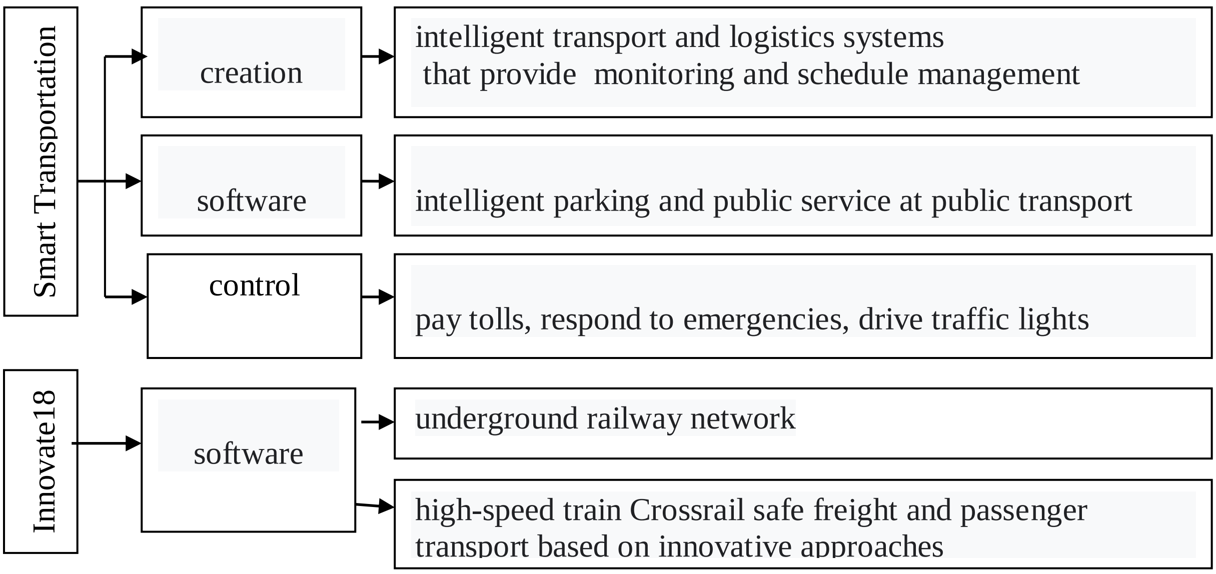

Fig. 1. Smart technologies in the transport management system

The main criteria for assessing smart-technologies in the management system of transport in European countries were:

environmental friendliness (use of eco-transport: electric cars, electric bicycles, electric scooters, trains and trams). For example, the German automotive industry produces about 1.3 million electric cars annually. There is an increase in demand for electric cars among EU countries, in particular in the Norwegian market.

In EU countries such as the Netherlands, Germany, Belgium, Italy, France and Austria, electric bicycles have become a fast-growing segment of eco-transport;

energy efficiency (reduction of fuel consumption by vehicles per kilometer, in particular expedient (efficient) consumption);

safety (digitalization of transport based on the use of electronic vision and Big Data technologies) (control of each vehicle and significant unloading of traffic flows, as well as increasing the level of traffic safety);

mobility (multimodal model of transportation, constant mobility);

optimization of the transport system (intelligent transport systems, in particular «smart» highways) (transport detectors flexibly regulate the density of traffic flows); - efficiency (saving time and energy).

Thus, the experience of EU countries shows that innovative tools to improve transport management are smart-technologies that promote smart-management (smart governance): car-sharing; smart park; the only integrated intelligent transport system of the city; drones; electronic control system of the transport system. Areas of system development of transport support are: electrification of transport; use of new energy sources (primarily hydrogen); use of new types of vehicles and their hybridization; robotics of vehicles, unmanned vehicles; replacement of material movements with information; improvement of transport logistics.

Thus, the main reasons hindering the development of transport logistics in Ukraine include:

first, the technical and technological backwardness of the domestic transport system in comparison with developed European countries;

secondly, insufficient level of maintenance of transport infrastructure in general;

third, lack of private investment;

fourth, the increase in the cost of transport services.

References

1. Innovations in the field of logistics – SFII. URL: https://sfii.gov.ua/innovacii-v-galuzi-logistiki/.

2. Савчук К. «Top 10 Supply Chain and Logistics Technology Trends in 2020 logistics technology trends URL: https://elnews.com.ua/ru/top-10-ynnovaczyj-kotor%D1%8Be-yzmenyat-logystyku-v-2020-godu/.
3. Kuzyk K. Perspektyvy vykorystannia droniv dlia optymizatsii lohistychnoho protsesu. International Scientific Journal. 2015. S. 3.
4. Bkhuptani M., Morandpur Sh.RFID-tekhnolohyy na sluzhbe vasheho byznesa. Moskva: Alpyna Pablysher, 2007. 288 s.
5. Diakova D. Innovatsiina lohistyka: perspektyvy ta realii. Tovaroznavchi ta marketynhovi doslidzhennia tovarnykh rynkiv: zbirnyk naukovykh prats za materialamy studentskoi naukovo-praktychnoi internet-konferentsii, 20.02. 2014 / holova red. kol. S. Hyrych. Vinnytsia, 2014. S.50–52.
6. Slidamy Amazon: «Nova poshta» testuie dostavku dronamy. URL: Rezhym dostupu do resursu: http://vkurse.ua/ua/business/novaya-pochta-testiruetdostavku-dronami.html.
7. Smart Transportation. Maximize mobile network's value beyond connectivity. 2016. URL: https://www-file.huawei.com/~/media/CORPORATE/ PDF/white%20paper/smart-transportation.pdf.
8. Juan Pedro Tomas What is smart transportation? June 26, 2017. URL: https://enterpriseiotinsights.com/20170626/transportation/20170625transportationwhat-smart-transportation-tag23-tag99.

3.8 DEVELOPMENT OF LOGISTICS MANAGEMENT OF A PRODUCTION ENTERPRISE

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Given the fact that logistics activity takes place in a very dynamic environment the state of the logistics system should be constantly monitored, analyzed and evaluated. The research is devoted to an important and at the same time complicated issue – the process of designing logistics systems as an important component of the operation of the enterprise.

This problem is not fully understood both at the theoretical level and in the field of practical application of design principles. The purpose of scientific research is to determine the essence, tasks and features of the processes of designing logistics systems. The essence of the concepts of «project» and «design» is considered in the article.

The main tasks of designing logistic systems are determined and possible conditions of their implementation are given. The study found the most important factors determining the success of the project on design of logistics systems. A system of branch logistic functions has been proposed. The factors that determine the success of logistics systems implementation are systematized. On the basis of the research, general recommendations for the design of logistics systems at any type of enterprise have been generated.

The list of solutions that are accepted in the process of designing logistics systems has been proposed. Stages and steps in the design of logistics systems have been identified according to the tasks of designing logistic systems. Research results have shown that designing logistics systems should take into account the possible risks of implementing a solution and calculate with the help of mathematical models, possible benefits and losses for the enterprise. In addition recommendations to boost the efficiency of designing logistics systems have been distinguished [1-4] .

A demanding market and growing competition mean that enterprises need to look for new solutions in the manufacturing process, adapting to customer requirements through systematic product improvement and after-sales service. Measures to improve should be characterized by efficiency, that is, achievement of results, not worse than competitors, but with less costs. Exactly because of this reason entrepreneurs seek to achieve new management and information technology solutions, as well as in other interdisciplinary areas such as telecommunications, automation, robotics, flexible manufacturing systems, materials science and microelectronics. The constituent increase in the efficiency of the enterprise is the development of a logistics system that requires careful preparation. Above all, the key to the efficient operation of logistics systems is the high level of their design.

Implementation of logistics systems and their impact on the functioning of enterprises is considered in the works of: Hemamala et al (2017), Ballou (1995), Bostel et al (2005), Kuhn and Schmidt (1988), Multaharju and Hallikas (2015), Göpfert and Wellbrock (2016), Han (2019) and others.

In modern conditions of functioning of enterprises, aspects related to optimization of their activities play an important role. The introduction of logistics systems in a market economy is an important factor in the development of entrepreneurship. When designing and refining logistics systems, it is necessary to have a sufficient level of data, the accounting of which, as well as collection and processing, must be continuous.

In a broad scientific sense, logistics is considered as the implementation of basic and supportive logistics functions through logistics processes and operations that are associated with changing the parameters of space (location), time, form and properties of logistics (material, information, financial, service) flows from optimal cost of resources. In a narrow practical sense, the enterprise logistic activity covers a complex of processes of supplying material resources, supporting production procedures, inventory formation, warehousing, transportation and sale of finished products.

Logistics management of the enterprise is aimed at optimizing the utilization of production capacity, reducing costs and inventories at all stages of the extended reproduction cycle, accelerating working capital turnover, ensuring the reliable fulfillment of contractual obligations for the supply of finished products and complete satisfaction of consumers in the quality of products and services. This type of management is associated with some difficulties, due to the peculiarities of organization and logistics in enterprises:

the diversity, interconnection and interdependence of logistics processes in the enterprise;

implementation of logistics processes by different functional units of the enterprise;

combination of organizational, economic, technological, technical and legal aspects in logistic activity;

significant dependence of the enterprise logistic activity on interaction with the external microenvironment (suppliers, intermediaries, consumers);

lack of a clear system for collecting and analyzing information about the organization, efficiency and bottlenecks of the enterprise logistics system.

Making effective management decisions in these circumstances requires the identification, analysis, evaluation and forecasting of logistics problems of the enterprise, most of which are poorly structured or mixed, containing qualitative and quantitative indicators of logistic activities.

Cost-effective organization and management of material flows in a changing market environment should use the basic logistics principles: unidirectionally; flexibility; synchronization; optimization; integration of process flows.

The organization and operational management of material flows has a leading role in the operational management of the organization, in the timely delivery of products and especially in order to increase production efficiency associated with the use of production resources in time and space [14].

Logistics management of the enterprise must meet a number of requirements shown in table 1.

The logistics capacity planning algorithm is based on an iterative approach - steps 6 and 7 are repeated until a decision is found. This adjustment is performed until the plan receives a significant level of logistics capacity. In the general approach, the process of logistics capacity planning is considered as a set of the following stages: demand is forecasted and other relevant information is investigated on the basis of this the required logistical capacity is determined; the actual logistics capacity is calculated; the difference between the actual and required logistics capacity is determined; alternative plans are offered, which allow to eliminate a certain difference; plan options are compared and the best one is determined; the best plan is implemented and the obtained results are controlled.

One of the key points of logistics management of a production organization is the planning of logistics capacity. The algorithm of such planning is shown in fig. 1.

Adherence to the planning algorithm is an integral part of the successful operation of the production enterprise [5-8].

Strategic approaches to inventory management will be determined, first of all, by the laws of production and final consumption of raw materials and finished products, as well as the processes of replenishment of stocks, their consumption, movement and storage. Inventories are an important element of logistics management as they directly affect: forecasting and planning of production activities of the business entity; organization of the production process and quality assurance of works; support of reliable operation of equipment and its preventive repair [16].

Table 1 - Requirements for logistics management of the enterprise

Requirements	Characteristic
Ensuring rhythmic, coordinated work of all stages of production on a single schedule and uniform output.	Rhythmic work means the optimal (purposeful, in accordance with the laws of the production process) organization in time and space of single, partial and private processes into a single continuous production process, which ensures timely release of each product in the prescribed amounts with minimal production costs.
Ensuring the continuity of production processes.	The continuity of the production process has two contradictory aspects: the continuity of the movement of objects of labor and the continuity of the loading of jobs. The question is which continuity of the production process to prefer in certain conditions.
Ensuring the reliability of planned calculations and the minimum complexity of planned work	It is assumed that within each stage of production, the structure of labor-intensive manufacturing of the product over time does not change. In fact, it changes very significantly. Thus, the preparatory operations are absent at the end of each stage of manufacture of the product, and the final - at the beginning. In the end, the imperfection of the calendar-planned calculations of production at the enterprise leads to known shortcomings: the constant shortage of parts, unforeseen «bottlenecks», the division of labor instead of planning, irregular work, to significant non-production losses of working time.
Ensuring sufficient flexibility and maneuverability in achieving the goal in the event of various force majeure circumstances	In the conditions of imperfect planning at the level of shops and production sites to ensure the implementation of production plans of the organization, all line managers and dispatchers of shops and plant management have to pay much attention to production regulation and redistribution of work to reduce production costs and working time.
Ensuring continuity of planning	Each production unit receives a plan (tasks by volume, nomenclature and deadline), is provided with appropriate resources and aims to achieve the planned end results. To increase the level of planning continuity, management must learn not only to develop monthly plans-schedules of production tasks at each site, but also to be able to keep the production process within the plan-schedule under the influence of various disturbances and restrictions.
Ensuring compliance of the operational production management system (OPM) with the type and nature of specific production	There are developed standard OUV systems. Each of them corresponds to the type and nature of production, but the difficulty of their observance is that the company usually operates different types of production. Even in separate shops it is possible to allocate production with signs of mass, unit and serial production. In market conditions, the need to increase production efficiency necessarily requires an increase in the scientific level of management, automation, its functions, the use of modern mathematical apparatus, computer technology, the creation of integrated enterprise management systems (ISMS).

Source: [1 - 7].

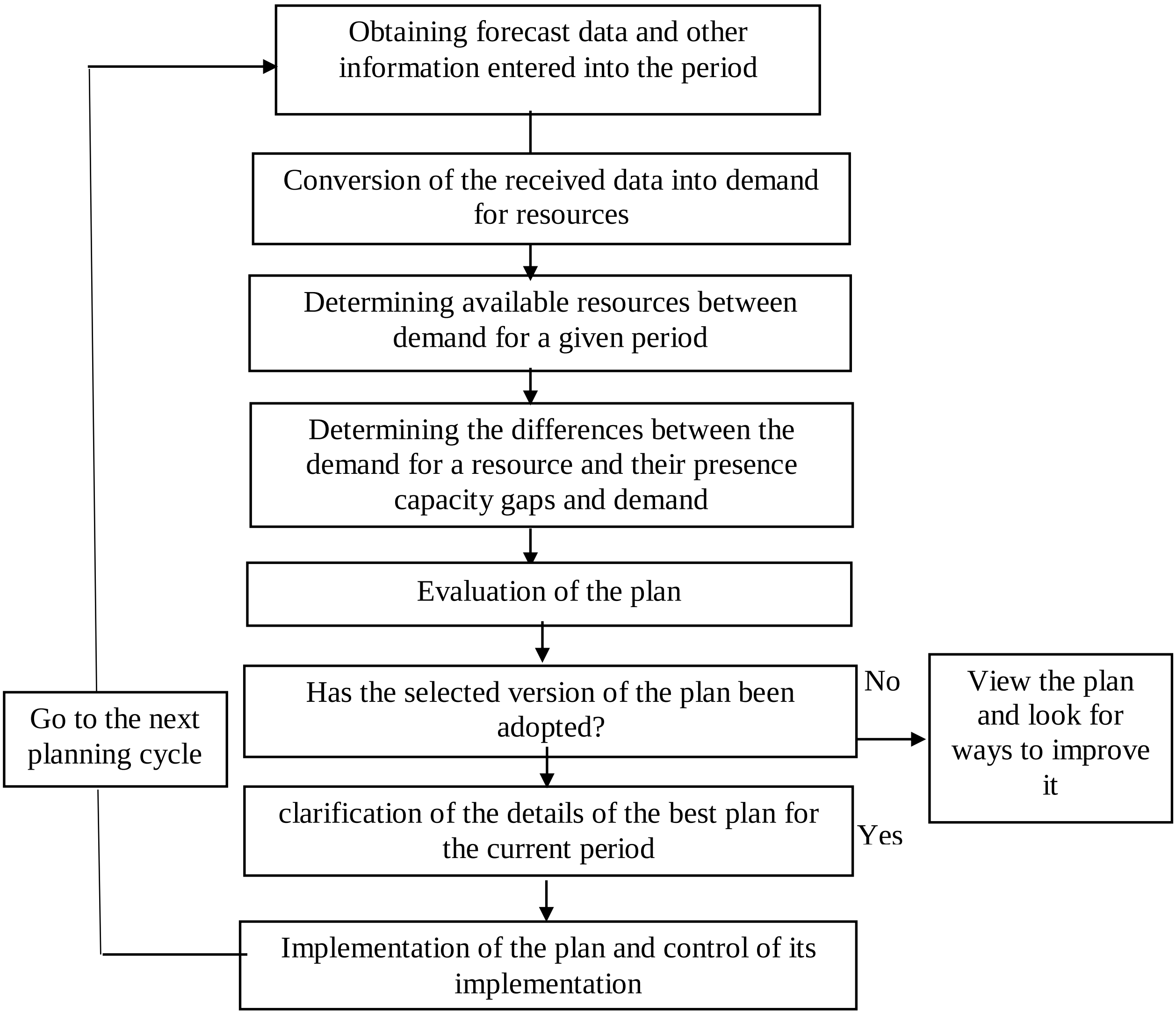

Fig. 1. Logistics capacity planning algorithm
Source: developed by the author.

The next, no less important element of the logistics management of the production enterprise are inventories. The great variety of real types of stocks requires strategic planning and coordination of actions for inventory management of the production enterprise. In fig. 2 shows a schematic diagram of the movement of inventories, which allows to understand the distribution channels and the movement of inventories [19].

Inventories of the enterprise are intended for the following purposes:

formation of a certain independence of the production activity of the business entity from the state of the market of material resources;

accounting for changes in demand for finished products and their smoothing;

protection of the business entity from changes in the period of supply of material resources;

use of advantages of the economic size of the order for purchase of material resources. In fact, the accumulation of stocks at the enterprise should be subject to the principles of logistics: obtaining the necessary material values in the required quantity and quality, in the right place, with minimal costs and the right consumer [23].

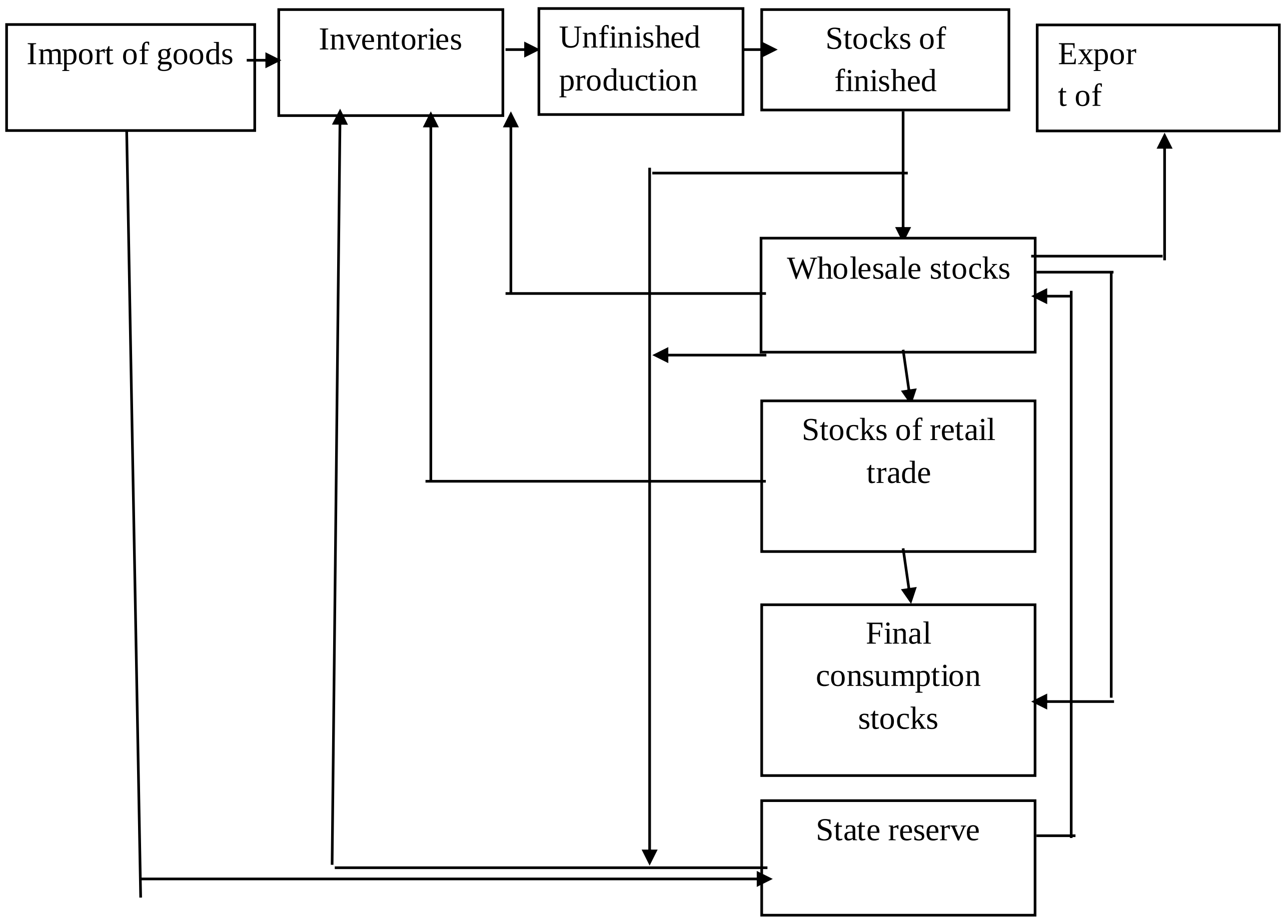

Fig. 2. Schematic diagram of the movement of material resources at the production enterprise.

Source: [19].

If we consider the relationship between enterprise management and logistics management, it is necessary to emphasize the subordinate role of logistics management in relation to the main goal of the organization (accelerated movement of logistics flows).

The main objectives of logistics management of supply, sales and production management are given in table. 2.

Table 2 - The main objectives of logistics management

Functional industries	Purposes
Supply management	supply of materials (parts) in accordance with the agreement and terms
	minimization of transport costs from storage of materials to the first workplace
	reducing the volume of purchased parts
Sales management	warehousing of finished products in intermediate warehouses with the lowest costs
	management of production orders in accordance with production requirements
Production management	order management in accordance with production requirements
	minimization of work in progress
	reducing the depth of manufacture

Source: [1 - 4].

The goals that determine the individual parameters of these industries are subordinated to the goals of functional industries. Logistics management optimizes logistics solutions for options between conflicting goals based on the criterion of minimum integrated costs of the organization [16].

The main approaches to the formation of logistics management of the enterprise as an integrated logistics system are to implement certain stages, shown in Fig. 3. According to different functional branches of logistics management, there are internal, external and integrated micrologistics systems.

External micrologistics systems deal with issues related to the management and optimization of material and related flows from their sources to destinations outside the production cycle. Such systems include logistics systems for sales and supply of industrial enterprises.

Defining the purpose and logistics functions in supply logistics, taking into account the principles of priority of the goals of general business logistics

formulation of logistical principles of supply operation and their implementation in the process of movement of material flows from the manufacturer to the composition of materials

definition of the purpose and logistic functions in the sphere of production on the basis of principles of priority of the purposes of the general enterprise logistics and absence of conflicts

defining the purpose and logistics functions in sales logistics given the principle of priority and unity

formulation of logistical principles of the sales system

identification of divergent economic goals of functional logistics and formulation of principles for eliminating contradictions between them;

identification of divergent economic goals of functional logistics and formulation of principles for eliminating contradictions between them;

implementation of optimization principles and correction of project logistics solutions of general business and functional-sectoral nature

Fig. 3. Stages of formation of the logistics system of a production enterprise

Source: developed by the author.

The links of these systems are divisions that perform various logistics operations for transportation, warehousing, storage, cargo processing, which together with the distribution network of suppliers constitute an external logistics system. The main task of logistics management in such systems is the coordination of logistics functions and coordination of the goals of suppliers, intermediaries and consumers [15].

The purpose of in-house micrologistics systems is to optimize the management of material flows in the production system.

To manage the system means to ensure purposeful development in changing conditions.

The main purpose of the production system is production. Production includes direct technological processes and ancillary operations that are related to the manufacture of products.

In a production system, the planning and control subsystem is a system that provides a subsystem that processes and performs productive work directly related to the conversion of inputs into outputs.

The planning and control subsystem receives information that comes from the subsystem that processes and issues a decision on how this productive system should work [17].

Management should be aimed at solving a wide range of problems, which include:

production capacity planning;

location of enterprises;

planning of the business entity and work areas;

scheduling;

selection of equipment, its operation, current and overhaul replacement;

material resources;

technological process design and control over its implementation;

working methods;

inventory management;

quality control, etc.

In general, the essence of operations management is:

development and implementation of the general strategy and directions of operational activity of the organization;

development and implementation of an operating system that includes the development of the production process, decisions on the location of production facilities, design of the organization;

planning and control of the current functioning of the system [21].

Thus, the production system can be represented as a system of «cost - conversion - output».

It meets the criteria of planning, analysis and control, which ensures consistent management of the enterprise. The main tasks solved by in-house logistics for the production system:

reduction of stocks of material resources and work in progress;

accelerating the turnover of working capital of the firm;

reducing the duration of the production period;

control and management of the level of stocks of material resources;

optimization of technological transport.

All activities of the organization is a complex system consisting of a network of subordinate subsystems.

The structure of the system may include units of the second, third (and so on) levels.

Logistics management by its nature is a set of technical, technological, informational and socio-economic elements.

Direct and feedback between them form a complex system of relationships [16].

Under such conditions, the position of the organization in the market is determined by the presence of its own institution of management, which would ensure compliance with production, economic and commercial activities to market demand and prospects for its development. Today it is possible to achieve by integrating the functions of logistics, production and marketing.

That is, there is a need to form a coordination center that would manage the integration of numerous material, information, labor and financial flows.

Such a center is the logistics department at the enterprise, aimed at identifying, calculating, optimizing and planning flow processes at all levels [17].

By organizing the movement of materials, information, personnel and finances into a single process, the center achieves a reduction in disruptions and costs of production, economic and commercial activities.

The logistics department of the organization, combining in one management complex issues of logistics, sales and transport of goods, acquires significance that is not inferior to production. This allows:

to achieve a significant rIntegrated management of the logistics system of the enterprise in order to streamline flow processes seduction iIntegrated management of the logistics system of the enterprise in order to streamline flow processes total costs for the manufacture and sale of products;

increase the company's ability to quickly adapt to consumer market demands;

to expand and strengthen guarantees of service of products which are at consumers [19].

The logistics structure of the organization must perform the following mandatory functions listed in the table 3.

Table 3 - Functions of the logistics structure of the enterprise

Functions of the logistics structure of the enterprise	Formation and development of the logistics system in accordance with its conceptual principles and provisions
	Development and implementation of logistics strategy in accordance with the market strategy of the enterprise
	Integrated management of the logistics system of the enterprise in order to streamline flow processes
	Coordination of interconnected functions of enterprise management
	Solving problems of specifics of the enterprise

Source: developed by the author.

The issue of principle and management is important in determining the approaches to the organization of logistics in the business entity. Management, in turn, is centralized and decentralized, which depends on the size of the entity, the scale of its activities, the concept of management, the economy, the market situation, the level of intra-system and intersystem integration, and so on.

Centralization of logistics management involves the presence of a logistics service directly subordinate to the top management of the enterprise [14].

The advantages of this approach in logistics management include the ability to attract highly efficient information systems. This radically changes the relationship between the functional units of the entity.

Decentralized logistics management, on the contrary, assumes that all issues related to logistics are resolved at the level of individual units of the enterprise [17].

This approach is more acceptable for large enterprises, where there are some problems with the manageability of its centralized organizational structure. Thus, with a fairly diversified production structure the organization is considered the most rational to leave the distribution function for a certain independent unit that provides operational customer service.

To achieve a high level of coordination of logistics activities within the enterprise use the following management strategies:

optimization of the existing logistics system;

search for new modern methods of coordination in the existing logistics system;

reorganization of logistics management services [17].

Therefore, the goal set by the company in organizing its logistics activities to achieve the greatest coordination of the flow of goods and services should be in the interests of both suppliers and consumers.

Currently, the world's most popular is a mixed, diversified economy. In which government regulation and regulated market mechanisms for private enterprise coexist. Mainly through the tax system and administrative action in the core, basic sectors of the economy, as well as in the social sphere.

For the successful functioning of the economy in regulated market relations, those areas of knowledge that deal with market problems, as well as the problems of product movement from producers to consumers are important. These areas of knowledge include logistics and marketing [16].

The main goal of managing the logistics system of the enterprise is to achieve a high level of its system characteristics: viability, innovation, integration, reliability and adaptability by improving the application characteristics that reflect the quantitative parameters of the components of the logistics system, organization of its functioning and contribution.

The quantitative parameters of the components of the logistics system reflect the capacities and technical characteristics of the logistics assets of the enterprise, which include warehouses, transport, equipment (technological, lifting and transport, equipment for identification and determination of weight of goods), logistic information systems and stocks.

Characteristics of the organization of functioning of the logistics system describe its goals and objectives, logistics strategy, enterprise logistics management system and its organizational structure, characterize the logistics technologies used in the areas of supply, production and distribution, personnel potential of logistics units and their organizational culture.

This can be explained by the fact that in market conditions the leading place belongs to economic management methods, which focus the activities of business entities to meet market demand for goods and services. Moreover, all parts of the logistics chain, from the production of raw materials, including their processing and manufacture of products suitable to meet market demand, and ending with the sale and after-sales service of these products, should focus on the needs of end users. In fig. 4. shows a system for developing methods of logistics management.

The economic methods of logistics management in a saturated market should include marketing, analysis and planning, commercial calculation, market pricing, accounting standards and more. Economic management methods are a set of tools and instruments that purposefully influence the creation of conditions for the functioning and development of entrepreneurship.

The levers of the economic mechanism correspond to the socio-economic nature of the enterprise and are one of the factors in the development of production and exchange on a market basis. Therefore, it is especially important to study the new that is introduced in practice in the context of commercial calculation as an important method of management. According to the definition of Chumachenko NG [19], it synthesizes both management functions and economic levers and tools that are aimed at comparing costs and results and ensuring the profitability of production.

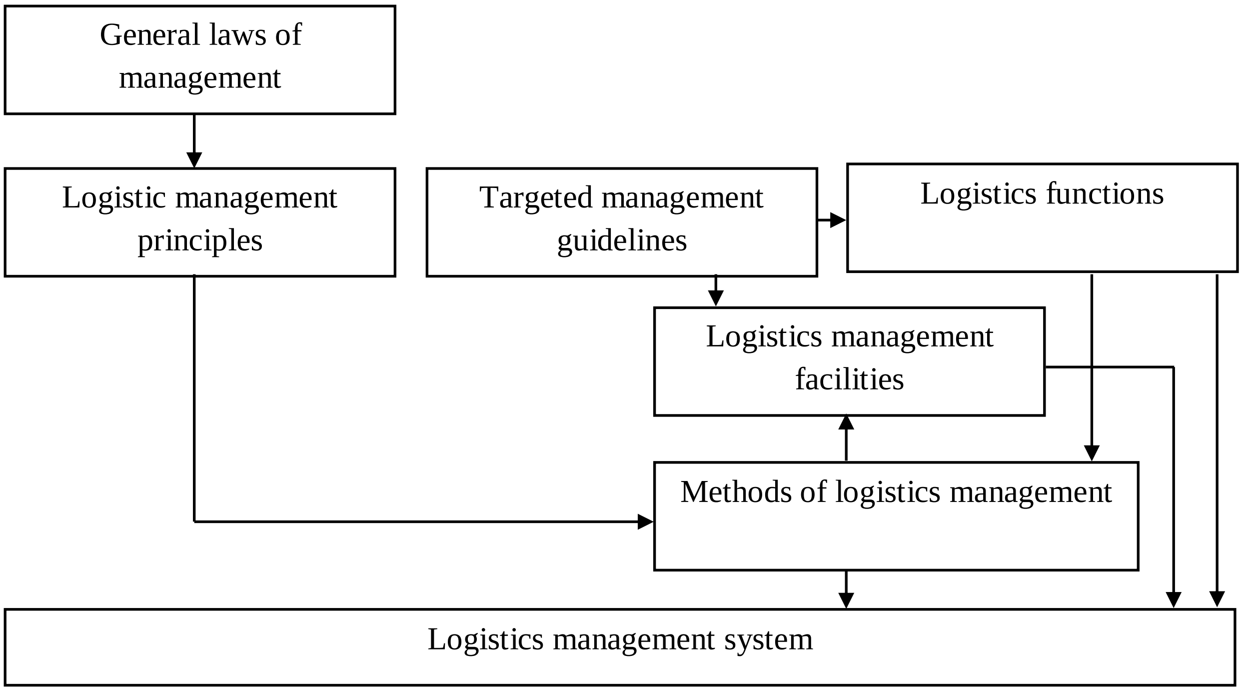

Fig. 4. Logistics management methods development system
Source: developed by the author.

According to the results of scientific research by LV Frolova [21], the greatest attention in logistics management is used by economic methods, because logistics relations are the main component of market relations, because they are based on the needs of consumers. Economic methods of managing logistics processes and flows of enterprises are carried out using special levers of tools used by company owners.

The specific set and essence of economic levers and tools of logistics management is determined by the specifics of the logistics system, which is the company.

Economic methods of logistics management can be grouped according to the following features, which are given in table. 4.

In general, it is expected that on the basis of logistical approaches, economic methods should be embodied in the practice of production structures of producers and industrial consumers. Also in the system of commercial intermediaries and enterprises. These methods ensure the economic interest of economic entities in improving the efficiency of the final results of economic activity through savings and profits from logistics operations and services [18].

Table 4 - Classification of economic methods of logistics management

Signs of logistics management	Economic methods
Compliance with logistics management functions	monitoring; planning; forecasting; analysis; control.
Market mechanisms of management	marketing; market pricing; exchange equivalence; competition; commercial calculation; focus on meeting the effective demand for goods; services and labor resources.
Quantitative estimates	provide economic and statistical methods; economic and mathematical modeling; functional-cost analysis; methods of assessing the level of service; inventory control and management; system analysis; cybernetics; Operations Research; prognosis; qualimetry; risk management, activity optimization.

Source: [6].

Another group of tasks to improve material flows relates to the interaction of commercial intermediaries with each other, with other actors in the commodity market and transport companies, the development and improvement of the efficiency of the warehousing system. The solution of these problems is also greatly facilitated by logistical forms and methods of management.

The economic mechanism of functioning and development of enterprises involves the use of the method of commercial calculation. Based on the global economic policy and goals of the enterprise, in particular in the field of profitability of production and sales, distribution of investments and location of production; financing and crediting; development of technology, personnel policy, policy of acquisition of new enterprises and capital structure, etc. [14].

The adoption of centralized decisions on these issues is combined with a differentiated approach to individual units depending on the nature and content of their activities, the territorial location of enterprises and the degree of participation in the overall production and marketing activities of the enterprise.

In the calculation of commercial use using economic levers and tools such as policies in the field of pricing, production costs, financing and lending. This policy is aimed at obtaining a sustainable profit, which is the ultimate goal of commercial calculation [22].

Identifying the internal relationships of various elements of the economic mechanism of functioning and development of logistics implies the need to consider them in the process of centralized management. This is due to the fact that they are defined and established on the basis of policies developed and implemented at the highest level of enterprise management.

In general, the methodology of logistics management is formed on the basis of integration of scientific approaches and practices of implementation of principles and procedures of production marketing management, delivery logistics and strategy of use of supply objects [14].

The results of the enterprise logistic activity are influenced by a large number of various external and internal factors, which require their constant monitoring and evaluation in order to adjust the goals and objectives, to better adapt to the changing conditions of activity. In the analysis of the environment, more attention should be paid to the factors of the so-called working environment, that is, to those market participants with whom the enterprise directly interacts in the course of its business activities, forming supply chains. There are the following groups of factors influencing the enterprise logistic activity.

To analyze these factors, models of estimating the factor impact of the external and internal environment are formed, during which all factors influencing the enterprise logistic activity are determined, and the degree of their influence due to their quantification, and also the risks of changing their magnitude are evaluated. The results of logistic activities are evaluated using a scorecard that contains key and local indicators with their subordination and differentiation, which provides a comprehensive evaluation of various aspects, types and characteristics of the enterprise logistics system, taking into account their mutual impact and achievement of goals.

Thus, economic methods of logistics management realize the material interests of human participation in production processes through the use of commodity-money relations. These methods have two aspects of implementation, they are shown in Fig. 5.

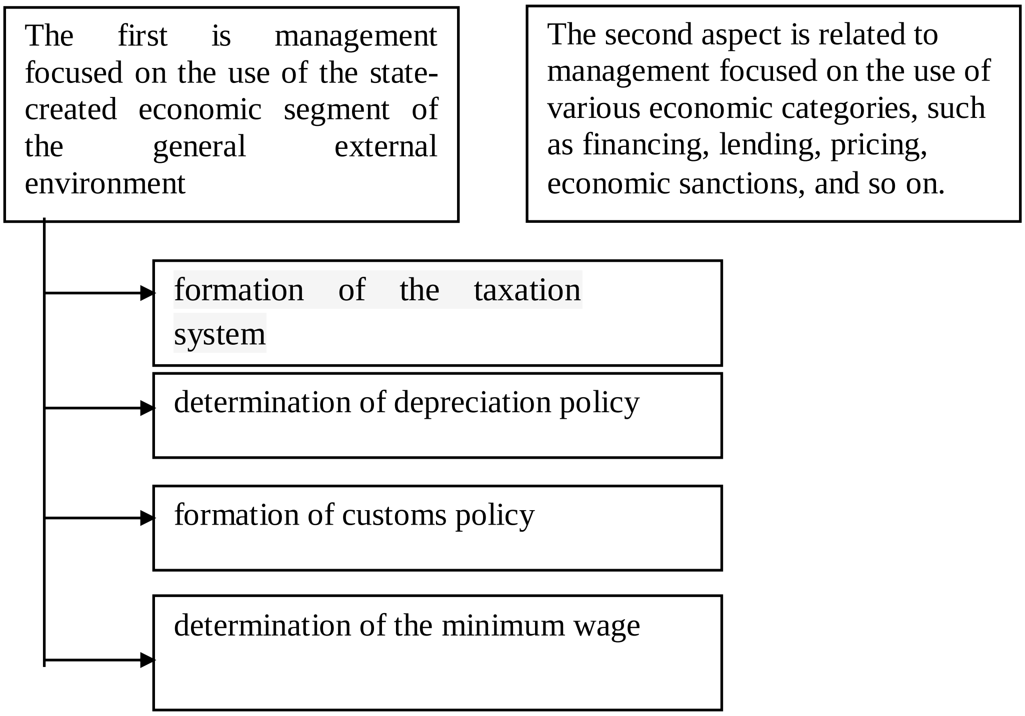

Fig. 5 Aspects of the implementation of economic methods of logistics management
Source: developed by the author.

Realization of separate logistic purposes can be provided by system of branch logistic functions, namely:

planning of the production program;

planning of the production process;

planning of the use of power;

planning of material flow;

internal production transportation;

production control;

operational management of production;

ecology of production processes;

packaging.

Logistics activity takes place in a very dynamic environment, so the state of the logistics system should be constantly monitored, analyzed and evaluated. The goal of improving the logistics system of the company is to increase the efficiency of logistics processes and improve the company's image on the market.

The effect of optimizing a logistics system can be as follows: limiting the number of objects, for example, by consolidating them, changing their location or expanding the system by increasing the number of exploited distribution objects. The main criterion for change is to increase the efficiency of the logistics system and minimize overall logistics costs while maintaining the desired level of customer service.

Logistics specialists seek to ensure the integration of logistics, transport and transmission of information on the movement of goods into a single system, which should increase the efficiency of work in each of these areas separately and intersectoral efficiency in general.

The main cost savings are formed by reducing the volume of inventories of material resources, and time savings - by increasing the speed of delivery [13].

Economic methods must be used to solve important logistical problems or possibly approach this solution.

The list of problems that can be solved using economic methods of logistics management are presented in Fig. 6.

Logistics can solve a number of problems in the field of circulation, the most important of these problems are:

determination of the system of optimal proportions between the volumes of production, warehousing and transportation;

reduction of costs from avalanche-like growth of losses at failures and downtimes;

establishing a rational level of cooperation in the system of actual production, storage and transportation;

formation of a rational structure of management information flows without delay in relation to the production process [19].

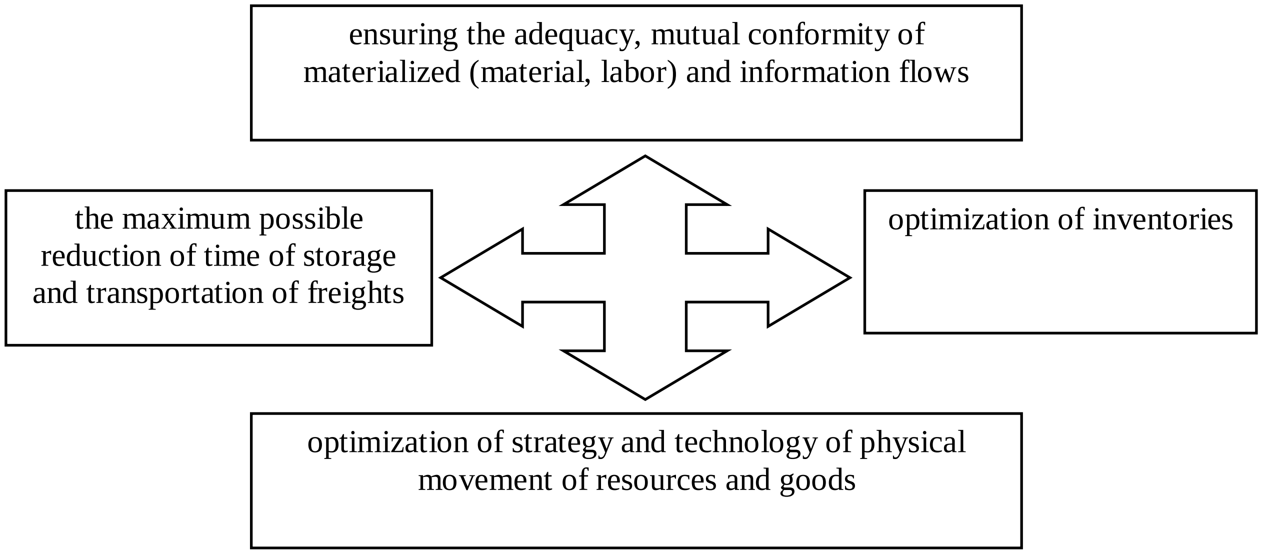

Fig. 6. Tasks that are solved using economic methods of logistics management
Source: developed by the author.

Of particular importance among economic methods is optimization, because the main purpose of logistics management is the formation of cost-effective flow processes and flows based on minimizing total costs and maximizing profits, taking into account the social effect.

The formation of such flow processes, flows and systems requires the development and adoption of logistics decisions aimed at ensuring the efficient operation and development of the logistics system of the enterprise in the macro-logistics environment [14].

Optimization methods of logistics management of a production enterprise are shown in Fig. 7.

Economic methods of logistics management are based on monitoring, marketing, commercial calculation, market conditions, competition for markets, etc.

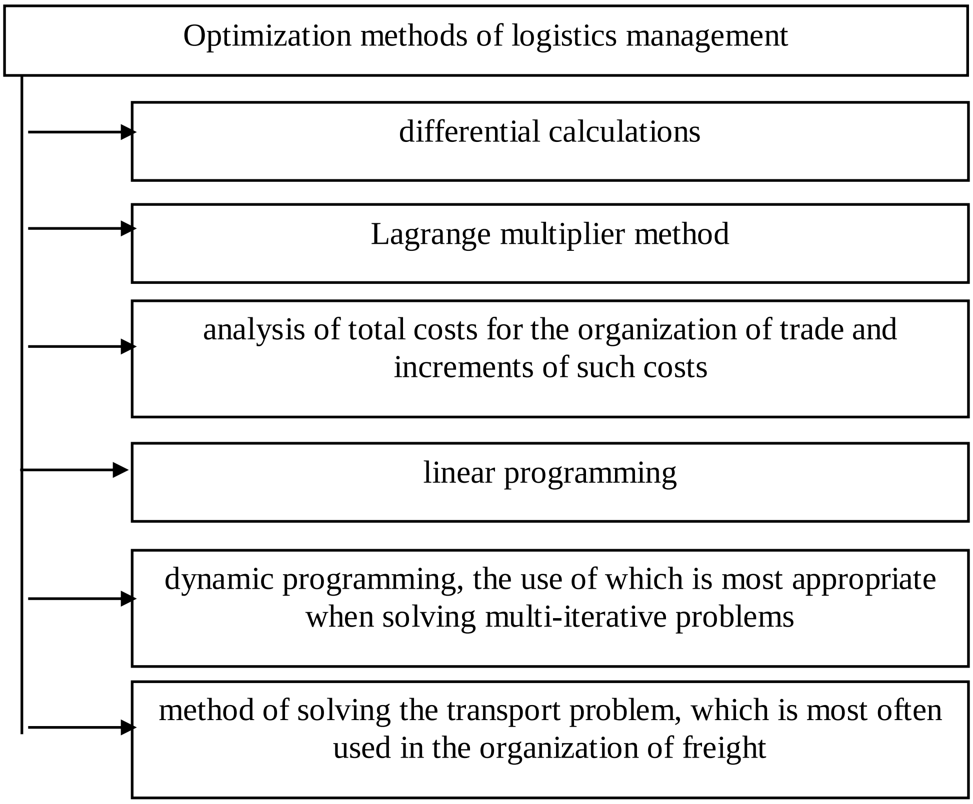

Fig. 7. Optimization methods of logistics management of a production enterprise
Source: developed by the author.

Logistics management is impossible without methods of quality assessment based on the opinions of the jury, experts, consumer expectations, as well as informal approaches that involve the use of the following methods of information: verbal - receiving and transmitting information through negotiations, radio, television, Internet or direct communication with people; written - through newspapers, magazines, reports, etc., obtaining information through economic intelligence [12].

The deep roots of economic competition as a mechanism of market equilibrium has its origins in the material needs and interests of man. Intertwined and colliding, economic interests, and these are the perceived needs of a particular person, highlight the full range of economic relations and the mechanism that balances them - the market. It is in a market-competitive environment that economic interests are formed into a market component of social necessity. Logistics methods are a reliable tool for increasing competitiveness in commodity markets [14].

Industrial and trade enterprises, territorial-industrial complex, set of production and infrastructural elements, as well as connections at different levels (local, regional, state) can act in the system of coordination of interests of economic entities of logistics.

Competition denies irresponsibility and implies a constant desire to be ahead, to succeed. The market, mainly through self-organization and effective feedback, permanently pushes the development of social production through its personified subjects, bringing plans closer to reality [15].

Market mechanisms also ensure that any product (good) will be delivered to the consumer through a system of information and material flow management in the process of movement of goods by professionals who know how to do it best and at the lowest cost.

Competition relations are a general and mandatory condition for the functioning of the logistics mechanism as a way to coordinate and synchronize decisions, needs of consumers and owners.

Established habits and traditions in the field of logistics change only if the minority, which is the bearer of the desire and ability not to stop there, to experiment, to move forward, is able to indicate the prospects and ways to achieve it for most workers, encourages them to follow. Only through the tactics of small, but quite concrete and conscious of other victories, the taste of economic competition is nurtured, its further development is conditioned [14].

Thus, in conditions of fierce competition, the efficiency of the logistics network is not just a requirement, the implementation of which leads to success. It is a necessary condition for the survival of the enterprise. Effective competitive logistics network management solutions help build adaptive logistics networks by providing enterprises with planning and implementation tools that manage enterprise operations and state-of-the-art technologies for organizing and coordinating collaboration to expand these operations beyond the enterprise.

As a result of the implementation of this solution, businesses gain measurable and significant benefits by reducing costs, increasing the level of service and productivity, which ultimately leads to higher profitability of the company, increasing competitiveness.

The modern organization and operational management of production (material flows) must meet certain requirements, namely (Denysenko et al, 2016):

providing rhythmic, coordinated work of all production units on a single schedule and even output;

ensuring maximum continuity of production processes;

ensuring the maximum reliability of planned calculations and the minimal complexity of planned work.

A prerequisite for optimizing the logistics system is the availability of a diagnostic system that would provide the enterprise management apparatus with the necessary data on the state of the subject, which would be the basis for decision making and forecasting for the future. The diagnosis of the operating system will have the effect of detecting its defects. Designing logistics systems should take into account the possible risks of implementing a solution and calculate with the help of mathematical models, possible benefits and losses for the enterprise.

In order to increase the efficiency from the practical results of designing logistics systems, the following recommendations should be distinguished:

1. Intelligent demarcation and correct decomposition of project objectives.

2. When designing a logistics system of an enterprise it is recommended to use information technologies that would allow visualization of the future logistic model for all its participants.

3. Development of an integrated diagnostic system for defects in the functioning of the logistics system.

References

1. Balakrishnan, N., Render, B., Stair, R. and Munson, C. (2017). Chapter 7: Project Management. Managerial Decision Modeling: Business Analytics with Spreadsheets, 4th ed., pp. 383-448. Berlin, Boston: De Gruyter. https://doi.org/10.1515/9781501506208-007

2. Shyshkin V., Nikolayevska A. (2019). Design of logistics systems as a composition of effective functioning of enterprise. Management and entrepreneurship: trends of development issues. pp. 107-115. Zaporizhzhia, Ukraine.
Available at: https://doi.org/10.26661/2522-1566/2019-3/09-08

3. Ballou, R.H. (1995). «Logistics Network Design: Modeling and Informational Considerations», The International Journal of Logistics Management, 6(2), pp.39–54. Available at: http://dx.doi.org/10.1108/09574099510805332.
4. Bostel, N., Dejax, P. and Lu, Z. (2005). «The Design, Planning, and Optimization of Reverse Logistics Networks», Logistics Systems: Design and Optimization, pp.171–212. Available at: http://dx.doi.org/10.1007/0-387-24977-x_6.
5. Burimenko, Yu. I., Halan, L. V., Lebedieva, I. Yu. and Schurovs'ka A. Yu. (2017) Upravlinnya proektami, [Project management]. Odessa: ONAZ im. O.S. Popova (in Ukrainian).
6. Denysenko, M.P., Shmorhun, L.H., Marunych, V.S., Kharuta, V.S. et al. (2016). Orhanizatsiia ta proektuvannia lohistychnykh system, [Organization and design of logistics systems],
7. Milenyum, Kyiv, Ukraine (in Ukrainian). Frame, D.J. (2014). «Reconstructing Project Management», Project Management Journal, 45(1). Available at: http://dx.doi.org/10.1002/pmj.21387.
8. Göpfert, I. and Wellbrock, W. (2016). «Innovation management in logistics: an empirical study», International Journal of Logistics Systems and Management, 25(2), p.227. Available at: http://dx.doi.org/10.1504/ijlsm.2016.078914.
9. Han, H. (2019). «A review and a model for logistics clusters», International Journal of Logistics Systems and Management, 33(1), p.73. Available at: http://dx.doi.org/10.1504/ijlsm.2019.10021193.
10. Hemamala, K., Banerji, S. and Sahay, M. (2017). «A systems approach to mapping logistics systems performance of small and medium manufacturing enterprises», International Journal of Logistics Systems and Management, 27(2), p.164. Available at: http://dx.doi.org/10.1504/ijlsm.2017.083812.
11. Judgev, K. (2010). «Project management: the managerial process», International Journal of Managing Projects in Business, Vol. 3 No. 4, pp. 706-708. Available at: https://doi.org/10.1108/17538371011076145
12. Kuhn, A. and Schmidt, R. (1988). «Simulation of logistic systems», Logistics World, 1(1), pp.47– 52. Available at: http://dx.doi.org/10.1108/eb007416.
13. Larson, D. «Agile Project Management and Data Analytics", Data Analytics in Project Management, pp.171–192. Available at: http://dx.doi.org/10.1201/9780429434891-10.
14. Larson, E.W and Gray, C.F. (2011). Project management: the managerial process, 5th ed., McGraw- Hill, 608 pp. Morris, P.W.G. (2013). «Developing Project Management", Reconstructing Project Management, pp.75–98. Available at: http://dx.doi.org/10.1002/9781118536698.ch5.
15. Multaharju, S. and Hallikas, J. (2015). «Logistics service capabilities of logistics service provider», International Journal of Logistics Systems and Management, 20(1), p.103. Available at:http://dx.doi.org/10.1504/ijlsm.2015.065975.
16. Mykytiuk P.P. (2014). Upravlenija proektami [Project management], Ternopil', Ukraine (in Ukrainian).
17. MANAGEMENT AND ENTREPRENEURSHIP: TRENDS OF DEVELOPMENT ISSUE 3 (09), 2019 114 Schwalbe, K. (2004). «Project Management Techniques», The Internet Encyclopedia. Available at: http://dx.doi.org/10.1002/047148296x.tie145.
18. Söderlund, J. (2004). «Building theories of project management: past research, questions for the future», International Journal of Project Management, 22(3), pp.183–191. Available at: http://dx.doi.org/10.1016/s0263-7863(03)00070-x.
19. Turner, R.J. (1996). Project management: A managerial approach. International Journal of Project Management, 14(3), p.188. Available at: http://dx.doi.org/10.1016/0263-7863(96)88306-2.

20. Posylkina O.V., Khromykh A.H. (2013) Diahnostyka potentsialu vnutrishnolohistychnoi intehratsii protsesiv na vitchyznianykh farmatsevtychnykh pidpryiemstvakh [Diagnostics of the potential of intra-integration processes in domestic pharmaceutical enterprises]. Farmakom - Pharmacom, No 3, 90-98 [in Ukrainian].
21. Zerniuk O.V., Ihnatenko V.O. (2015) Lohistychnyi analiz upravlinnia zbutovoiu diialnistiu promyslovoho pidpryiemstva [Logistic analysis of sales management of an industrial enterprise]. Ekonomika i rehion - Economy and region, Vol. 54, No 5, 60–65 [in Ukrainian].
22. Telishevska O.B. (2016) Otsiniuvannia ta diahnostuvannia vytrat na lohistychno-postachalnytsku diialnist pidpryiemstv za mistsiamy yikh vynyknennia ta protsesamy lohistychno-postachalnytskoho upravlinnia [Assessing and diagnosing the costs of logistics activities of enterprises at their places of origin and processes of logistics management]. Ekonomika: realii chasu - Economics: the realities of time, Vol. 26, No. 4, 176–183. URL: http://economics.opu.ua/files/archive/ 2016/n4.html [in Ukrainian].
23. Kolos I. (2018) Diagnostics in the lean management system of industrial enterprise. Technology audit and production reserves, Vol. 40, No. 2/4 (40), 19–23.

3.9 THEORETICAL FUNDAMENTALS OF INNOVATIVE ACTIVITY MANAGEMENT IN THE BANKING INSTITUTION

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Due to the political and economic instability in the country and at the same time tough competition at the market, banks have to insure themselves with innovative activity. Its implementation will help banks to attract more customers, ensure high competitiveness and financial stability.

Theoretical aspects of innovation management of banks are considered in the works of such scientists as L.P. Bondarenko [1], L.G. Hetman [3], O.B. Zolotareva [6], I.Y. Karcheva [7], Yu.V. Tkachenko [10], Z. Shmigelska [13] etc. Despite the great achievements of the scientists on this issue, the study of banks innovation management features is especially relevant in the current unstable conditions of the whole banking system functioning in Ukraine.

In general, innovations are becoming an integral part of today's business banks. The amount of profit directly depends on its innovative activity. At the same time, the bank's innovative activity is quite risky, that is why it must be well thought out and planned. The innovative activity of the bank must be systematic in order to bring the desired results.

In up-to-date terminology there is no exact interpretation of the concept of «innovation» and «innovation activity». A lot of scientists identify these concepts as similar ones, but this is the wrong way because they are different. First of all, it is important to find out the essence of these two concepts and their differences.

Innovative activity is an activity that is aimed at the commercialization and the use of research to produce new competitive products, changes in the production technology, customer service, etc. Thus, innovations are the direct product of innovation activity, its result. In this context, innovation should be understood as a consistent process of new products, technologies and applications introduction into the activity of new products, technologies as well as marketing methods organization [3].

Innovations have become not just a random thing, but an essence of any organization development, including the bank. Banking innovation have significant difference from the innovations of other organizations. It is worth mentioning that banking innovation is the result of the bank's activities aimed at creating new products and technologies, as well as innovative methods of banking institution management in order to obtain additional income and competitive advantages [7]. The concept of innovation can be applied to all innovations in all functioning areas of the bank, which will allow to achieve a certain positive economic or strategic effect (increase in customer base, increasing market share, reducing the cost of a particular type operations, etc.) [3].

At the same time, banking innovation manifests itself as a new product or service only in the process of its implementation in the financial market or within the bank, and the demand for an innovative banking product or service determines its degree novelties.

Nowadays, there is no single definition of «banking innovation». The main approaches to the interpretation of the concept of «banking innovation» are presented in the table. 1.1.

In our opinion, banking innovation are new or improved banking products and services, as well as innovative methods of banking institution management and other that meet the needs of bank customers, bank own interests and banking legislation requirements, provide stakeholders with additional benefits and the implementation of which provides an opportunity to form new competitive advantages for the bank as a whole.

Analysis of various approaches to the interpretation of «banking innovation» concept makes it possible to discuss the feasibility of considering this concept in the narrow and broad sense. The narrow meaning outlines innovative characteristics of banking products and services as the final result activities of the bank. The importance of distinguishing this category is determined by the fact that these are product innovations that form the basis of current bank innovative activity. At the same time, it should be noted that for the characteristics of banking innovation in the narrow sense, firstly it is important to determine what is understood under the banking product and service. The banking product is clearly defined and structured service designed for a specific client (or group of customers), specific manifestations of the service in practice, taking into account the current market conjuncture. Banking service as a result of a commercial bank is a set of interrelated operations of the bank aimed at meeting a specific customer need.

Banking innovation in the broadest sense should cover all possible aspects of innovative activity of credit and financial institutions.

We consider it appropriate to consider the causes of innovations creation in the banking sector as the next step. Sure, on one hand, the reason for the emergence of banking innovation is the bank's support for sustainable customer relations, which is based on partnership. This means that banks are not only worried about preservation, but also about increasing the capital of its customers. They achieve this by offering innovative products that, in turn, contribute the extension of their activity areas, reducing costs, business activity development and profitability increase.

On the other hand, the prerequisite for the emergence of banking innovation is competition between banking and other financial institutions in conditions of constant financial market development.

Table 1- Approaches to the interpretation of the concept of «banking innovation»

Author, source	The essence of the concept of «banking innovation»
L.P. Bondarenko [1]	Implemented in the form of a new banking product or transaction of the final result of the bank's innovation activity.
V.S. Vikulov [2, p. 206]	Creating a banking product that has more attractive consumers properties compared to the previously proposed, or qualitatively new a product capable of meeting its unmet needs potential buyer, or the use of better technology creating the same banking product.
T. I. Evenko [4]	This is a brand new banking product that first appeared in the Ukrainian financial market, that means it is only in one bank or is new to Ukraine's foreign banking product.
Egoricheva S. B. [5, p. 74]	In the narrow sense: it is the introduction of new or significant advanced banking products and services that meet existing or potential financial needs of clients, own interests of the bank and the requirements of banking legislation, provide additional benefits to stakeholders, are the results banking engineering. In a broad sense: the process of creating added value for customers, employees and owners of the bank by making quality changes in all areas of its activity – products, services, processes, business models and strategies that have resulted from the practical implementation of new ones ideas, knowledge and experience.
J.M. Kryvych [9, p.5]	These are new processes and models used by credit-financial institutions to improve the quality of management personnel and improving positions in the banking services market.
C.N. Yakovenklo [14]	The methods of the institutional organization of banking process and the models of its behavior in nowadays financial world, that are existing in the appearance of new banking technologies, services, products, aimed at the increasing of the efficiency of a commercial bank and its social component.

Thus, the main internal reason for innovation is the need to ensure profitable activities of the bank, and not only in short-term and long-term perspective, which, ultimately, aims at business value rising. Opportunities of making a profit in the market conditions management depend on the intensity of competition in a particular area: monopoly or oligopoly means the possibility of obtaining sufficient amount of profit and from working with traditional familiar products methods. Quite a different situation is in the modern financial market, where reduction of entry barriers due to liberalization, deregulation, change psychology and consumer preferences, the actions of other factors led to a significant increase of participants' number who offers banking products substitutes that very often have even higher consumer value.

In the conditions of intense non-price competition, it becomes a decisive factor the ability of a banking institution to generate new revenue streams through introduction of innovative products, ensuring special quality customer service, which is also a consequence of the implementation of innovative solutions, which distinguish the bank from its competitors. Today there is a fairly large achievement of domestic and foreign scholars on the classification of banking innovation (table 1.2).

Table 2 - Classifications of banking innovation

Criterion	Types of innovation
1	2
Classification of banking innovation, proposed by I.P. Khominich [12, p. 17]	
Causes	reactive; strategic
Targets	operational (current, short-term); promising (long-term)
Functional content	production; intellectual; managerial; financial.
Subject (essence)	product (new product, services); process (technologies, management and customer service schemes, behavior models).
Classification of banking innovation proposed by E.A. Utkin [11, p. 11]	
Causes	reactive; strategic
Subject and scope	productive; market (open new areas and markets for the product); innovation-processes.
The nature of the needs being met	focused on existing needs; focused on the formation of new needs.
Classification of banking innovations, proposed by S.M. Kozmenko, T.A. Vasilieva, S.V. Leonov [8, p. 296-297]	
Causes	reactive; strategic.
Subject and scope	productive; market; innovation processes.
The nature of the needs being met	focused on existing needs; focused on the formation of new needs.
Sphere of origin	internal for the bank; external to the bank.
Subject of application in the context of spheres of origin	financial; technological; administrative; conceptual; communication (marketing, advertising); investment and credit (targeted investment of innovative projects of enterprises).

1	2
Classification of banking innovation, proposed by V.S. Vikulov [2, p. 75-82]	
Causes	reactive; strategic.
Place in the bank's activity	product (basic); market; security.
Innovative potential	radical; combinatorial; modifying.
Extent of influence	point; systemic.
Level of novelty	newly created; built on a new way of using already existing products.
The nature of the needs that are satisfied	focused on existing needs; focused on the formation of new needs.
Place of development	innovations developed by own forces; innovations obtained from a third-party developer.
Time of appearance	innovation-leaders; follower innovations.

It should be noted that in world practice, the following types of banking innovations are usually distinguished:

banking product in new market segments;

innovations as the development of activities in new areas of the financial market;

new methods of cash management and new information technologies use;

modified financial intermediation services aimed at operating costs reducing and more efficient management of assets and liabilities;

new products in the traditional loan capital segments.

From a practical point of view, the typification of innovations allows the bank:

make a reasonable approach to the formation of different types of bank's innovation strategies tied to specific external conditions and the bank's potential;

to develop an appropriate organizational and economic mechanism for innovations implementation to meet the strategic goals of the organization;

more clearly identify each innovation at the beginning of its development, identify opportunities and limitations associated with its use;

provide systematic management of all innovation life cycle stages;

identify possible barriers to the introduction of a particular kind of innovations and develop mechanisms for overcoming them, etc.

It should be noted that in order to increase the efficiency of innovation activity in the banking institution it is necessary to take into account and try to minimize all possible innovation risks.

When considering the sources and factors of banking institutions innovation risk, the highlights are customer satisfaction and protection their interests, which are possible only with the help of simultaneous risk-oriented and customer-oriented approaches.

According to scientists, control should be an integral part of the overall risk management system of the banking institution and take into account the specifics of innovative products and services, operating structure and corporate culture of innovation management, general risk profile, so it is necessary to change approaches to risk management systems constructions which would take into account the peculiarities of innovation activity.

Considering everything mentioned above, it can be stated that the introduction of innovations in the banking institutions activities has its positive and negative aspects. The table 1.3 shows the advantages and disadvantages of innovation in the banking system.

According to everything mentioned above, it can be stated that for banking services user simple mentation of innovations into bank activity usually has positive aspects. For sure, banking operations are aimed at: reducing the time that spent by the client, expanding opportunities for clients, etc.

Thus, the main feature of banking innovation is that they should simultaneously focus both on the internal environment as well as on customers. Innovations should make it easier for banking institutions employees, and also improve the quality of customer service. Every interested party of the banking institution should benefit from the innovations implementation.

Table 3- Advantages and disadvantages of using innovations in the banking system

Positive sides and prospects	Disadvantages and possible negative consequences
1. Improving the convenience of using banking services for bank customers	1. Increasing the risks of theft of funds
2. Lower cost of banking operations	2. Higher costs for banks
3. Increasing the competitiveness of banks and increasing the customer base	3. The need for constant investment in new technologies and as a consequence of declining profits
4. Reduction of time for banking operations	4. Strengthening control over operations
5. Expansion of the line of banking products and services, increasing the efficiency of their provision	5. Dependence on constant updating of technologies and necessity of their renovation
6. Improving the functionality of banking applications and the development of remote service	6. Increasing the bank's spending on research needs and technology implementation
7. Reducing the cost of renting and paying staff for banks	7. Reduction of jobs and as a consequence, possible increase in unemployment
8. Opportunity to implement new interesting ideas that can increase the efficiency of banking	8. Uncertainty of consequences of introduction of technologies and forecasting of their payback, high investment risks of banks

References

1. Bondarenko L.P., Ilchuk P.G. Trends and features of innovative development of banks and the banking system of Ukraine: a collective monograph. Lviv: Novyi Svit – 2000», 2018. 180 p.
2. Vikulov V.S. Typology of banking innovation. *Financial management*. 2006. No. 2. P. 75-82.
3. Hetman L.G. Directions of development of innovative activity in the banking sphere. *International scientific journal «Internauka»*. 2016. № 12 (2). P. 49-54.
4. Evenko T.I. Measures to prevent the financial crisis of banking institutions. *Economy. Management. Innovations*. 2014. № 2. P. 60–72.
5. Egoricheva S.B. Banking innovation: textbook Kyiv: Center for Educational Literature, 2010. 208 p.
6. Zolotareva O.V., Chekal A.A. Innovative banking products and the specifics of their implementation in Ukraine. *Scientific Bulletin of Kherson State University*. *Series: Economic Sciences. 2016. Established*. 16. Ch. 1. P. 112-115.
7. Karcheva I.Ya. Economic efficiency of innovative banks activity: dis. … PhD in Economics. Kyiv, 2016. 210 p.
8. Kozmenko S.M., Vasilieva T.A., Leonov S.V. Marketing of banking innovation. Marketing and innovation management. 2011. № 1. P. 13-28.
9. Krivich Ya.M. Management of the bank's innovation potential: PhD in Economics: 08.00.08. Sumy, 2010. 284 p.
10. Tkachenko M.M., Glushchenko O.V. Current trends in banking innovation. *Financial and credit activities: problems of theory and practice*. 2012. № 1. P. 5-15.

11. Utkin E.A. Innovation management. Moscow: Akalis, 1996.208 p.
12. Khominich I.P. Bank's innovative strategy. Banking services. 1998. No. 3. P. 16-21.
13. Shmigelska Z. Banking innovation: essence, need and development. Bulletin of the *National Bank of Ukraine*. 2014. No. 2. P. 34-41.
14. Yakovenko S.N. Financial innovation in the activities of commercial banks: theoretical and economic aspects. *Modern problems of science and education*. 2013. № 2. P. 66-74.

4 SOLVING THE THREE-CRITERIA PROBLEM OF PHARMACY NETWORK DIVERSIFICATION

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The subject of the article is multicriteria problems that arise when modeling the complex diversification of a centralized pharmacy network. The purpose of the work is to analyze the peculiarities of solving the three-criteria problem of pharmacy network diversification by the method of successive concessions in the MATLAB package. The article solves the following problems: research of the advantages of the proposed three-criteria model of pharmacy network diversification in relation to the classical two-criteria model of portfolio theory; construction of the relation of dominance on a set of criteria; determination of the area of stability in the sphere of the parameters of the concessions method; evaluating the effectiveness of the method for problems of different sizes. The following methods are used: classical portfolio theory, multicriteria optimization, the method of successive concessions, computer modeling of the Pareto set. The results obtained: a study of the processes of complex diversification of the pharmacy network by building portfolio models and solving the relevant multicriteria problems by the method of successive concessions. Admissible sets and sets of pareto-optimal portfolios for the risk management are graphically found, taking into account the activity of the network itself and the client portfolio. Conclusions: The results of computer modeling and numerical analysis of solutions by sequential concessions will be useful for automating the business processes of pharmacy networks, risk management, analysis of market data to improve their efficiency.

The method of successive concessions is used to solve multicriteria problems, in which all partial criteria are arranged in the order of importance. It is considered that each criterion is much more important than the next that it is possible to be limited to consideration of only pairwise connection of criteria and to choose the admissible concession for the next criterion taking into account behavior of only one following criterion. The disadvantages of the method include the complexity of the appointment and coordination of the size of concessions, the need for a priori ranking of criteria. The complexity increases with the dimension of the problem and the number of criteria. The result does not necessarily belong to a subset of Pareto-efficient solutions. Therefore, the work of the method of concessions is combined with dialogue - by multiple solutions of the optimization problem, graphs of the dependences of the solution at the next stage from the concession of the previous stage obtained. The expert selects the assignments based on the analysis of such diagrams and the assessment of the gains or losses appropriate to the assignment. This paper considers the problem of the effectiveness of the concessions method to solve the problems of portfolio optimization, which are known due to the research of H.M. Markowitz [1] and his modern followers [2]. Such tasks are characterized by multicriteria and prevalence, both in the financial and non-financial spheres.

When applying the methods of multicriteria optimization, traditional definitions of the dominance relation, effective boundary, Pareto set, etc. were used. In particular, in the work of M.Ehrgott [3] the basic definitions, different approaches and methods of multicriteria optimization are systematically stated.

The group of publications of the short literature review devoted to portfolio optimization unites the use of evolutionary methods in research, which is a promising area because the tasks of portfolio optimization belong to the class of complex NP tasks. In [4], a genetic algorithm was constructed to solve the problem of the optimal loan portfolio, where a specific entropy criterion was used as a measure of the degree of portfolio diversification. Article [5] presents several two-criteria formulations for the optimization of the molecules portfolio, taking into account the limited budget and fixed size of the portfolio. The computational diversity of the set associated with the covariance matrix is presented in this paper by the Solow-Polaski measure. The proposed approach is tested in experimental conditions using accurate and evolutionary approaches. The authors [6] consider the problem of optimizing the product range in conditions of uncertainty.

Another group of publications of the literature review consists of works devoted to the study of the peculiarities of the methods of multicriteria optimization, especially the method of successive concessions. [8] considered various issues of solving multicriteria problems of discrete optimization and proposed the method of equivalence sets; investigated the advantages of this method in comparison with other popular methods of solving multicriteria problems, in particular with the method of successive concessions, for the class of discrete optimization problems. In [9] the existing achievements in the application of multicriteria optimization methods are considered to solve problems of evaluating the activities of enterprises, a comparative analysis of modern methods is made, which includes optimization methods both without the participation of decision maker and with the participation of decision maker . In the analysis of the method of successive concessions, a class of tasks was indicated for which this method is recommended - optimization of the values of indicators of the enterprise with the definition of sustainability. The advantages of the method also include the implementation of the concept of restrictions that are imposed on the value of the criteria. The disadvantage of this method is that the solution requires verification of its belonging to the area of compromises. Improving the method of successive concessions in solving problems of multicriteria optimization in logistics is proposed in [10]. The author's approach is based on the introduction of special formats for the task of choosing a city for the warehouse and the form of ownership. The possibility of analytical determination of the order of certain criteria at the request of decision maker is discussed, the influence of different variants of their ordering on the ranking of alternatives is analyzed.

The variety of subject areas in which researchers solved multi-criteria problems by classical and modern methods indicates the relevance of scientific research in this direction. The authors of this article in [11, 12] built multicriteria models of complex diversification of the centralized pharmacy network, where the method of successive concessions was used to solve the corresponding multicriteria problems. Giving the advantages and disadvantages of this method, identified by other authors [8, 9] for their problems, it is necessary to analyze the effectiveness of the method of successive concessions to solve diversification problems. The purpose of the work is to analyze the effectiveness of solving the three-criteria problem of pharmacy network diversification by the method of successive concessions in the MATLAB package [13]. To achieve this goal, the following tasks are solved in the article.

• Research of the advantages of the proposed three-criteria model of pharmacy network diversification over the classical two-criteria model of portfolio theory.

• Construction of the dominance relationship on a set of criteria.

• Determination the area of stability in the space of the parameters of the method of concessions.

• Evaluation the effectiveness of the method for tasks (networks) of different sizes.

The article [11] proposes a mathematical model of diversification in the form of a three-criteria optimization problem. Solving multicriteria optimization problems is not trivial, and requires special methods and definition of decision maker of certain parameters. One of the classic methods is the method of concessions.

We present one of the tasks of complex diversification, which is formalized as a portfolio model for optimizing the distribution of finances between the outlets of the centralized pharmacy network. Optimally distributing goods among outlets, the network gets the maximum profit in time to respond to the circulation of drugs in a certain period, because the demand for drugs in a particular pharmacy is not constant and goods not sold in one outlet can be sold on time in another and bring profit without increasing the length of the composition.

Let, x_i- the share of the i -th pharmacy in the turnover of the pharmacy network, which is equal to the share of distributed financial resources for the i -th pharmacy;

a_i - the expected turnover of the pharmacy (UAH);

n - number of pharmacies in the network.

The model of the optimal portfolio considered in the paper has a composition of the vector objective function, consisting of three criteria. The first two criteria correspond to the classical portfolio theory: risk criterion - *Risk*, which decreases; *Sum* criterion - the profitability on the portfolio, which is desirable to increase.

The third criterion - entropy - *Entropy*, is introduced by us as a value that characterizes the level of diversification of the portfolio and the assessment of the diversity of its components, which the pharmacy network is trying to increase in its activities. In addition, the model has its own specific system of constraints, which is determined by the business process of the pharmacy network in the structure of its activities.

In this model, the *Risk* criterion - structural risk - is the risk of irrational distribution of financial resources of the centralized pharmacy network between outlets. Structural risk is defined as the covariance of the turnover of i -th and j -th pharmacies.

So, we have such multi-criteria problem of quadratic programming.

$$\begin{cases} Risk = \sum_{i=1}^{n} (a_i - \bar{a}) \cdot (a_j - \bar{a}) \cdot x_i \cdot x_j \rightarrow min \\ Sum = \sum_{i=1}^{n} a_i \cdot x_i \rightarrow max \\ Entropy = -\sum_{i=1}^{n\sum} x_i \, ln(x_i) \rightarrow max \\ \sum_{i=1}^{n} x_i = 1; x \in [0..1]. \end{cases} \quad (1)$$

The solution of problem (1) is a vector $\overline{X}^* = (x_1, x_2 .. x_n)$- the optimal plan for the distribution of financial resources of the centralized pharmacy network between outlets.

Solving multicriteria problems of complex diversification will be considered in detail on the example of the method of successive concessions [14, 15].

The method of successive concessions for solving multicriteria problems is applied when partial criteria can be ordered in ecrease of their importance. To choose a diversification strategy, we first choose the following order: *Entropy-Risk-Sum.*

In the first step, we determine the optimal value of the first most important Entropy criterion in the field of admissible solutions.

$$Entropy = -\sum_i x_i \, ln(x_i) \to max$$

$$\begin{cases} \sum_i x_i = 1 \\ 0{,}001 \le x \le 0{,}9 \end{cases} \quad (2)$$

The optimal solution for the first partial criterion is $Entropy$.

In the second stage, we solve the conditional optimization problem by the next most important Risk criterion, adding to the conditions that determine the allowable solutions, the conditions for the deviation of the first Entropy criterion from the found optimal value by $Entropy^*$ no more than the allowable concession $\delta_1 > 0$. So we have the formalization of the second stage:

$$\begin{cases} Risk = \frac{2}{n} \sum_{i=1}^{n\Sigma} \sum_{j=i+1}^{n} (a_i - \bar{a}_i) \cdot (a_j - \bar{a}_j) \cdot x_i \cdot x_j \to min \\ \sum_{i=1}^{n} x_i \, ln(x_i) + \delta_1 Entropy^* \le 0 \\ \sum_i^n x_i = 1 \\ 0{,}001 \le x \le 0{,}9 \end{cases} \quad (3)$$

The optimal solution according to the second criterion $Risk^*$s obtained.

The procedure is repeated for the next most important criterion Sum adding to the conditions that determine the allowable solutions, the conditions for the deviation of the first criterion $Entropy$ and the second criterion $Risk^*$ from the found optimal values $Entropy^*$, $Risk^*$ ot more than the values of the allowable concessions $\delta_1 > 0$ and $\delta_2 > 0$.

$$Sum = \sum_i \bar{a}_i \cdot x_i \rightarrow max$$

$$\begin{cases} \sum_i x_i \, ln(x_i) + \delta_1 \cdot Entropy^* \leq 0 \\ Risk \leq (1 + \delta_2) \cdot Risk^* \\ \sum_i x_i = 1 \\ 0{,}001 \leq x \leq 0{,}9 \end{cases} \quad (4)$$

The solution obtained in the third stage is the solution of the three-criteria conditional optimization problem (1).

Experiments with the models were conducted on real data of one of the pharmacy chains operating in Zaporizhzhia. All calculations were performed in the MATLAB package [13].

Here are some useful definitions for analyzing the effectiveness of solving the three-criteria problem of diversification the pharmacy network by the method of successive concessions in the MATLAB package, which are taken from sources [14, 15].

Definition 1. Stability of the algorithm (stability of the algorithm) - the ability to perform calculations and obtain the final result with a given accuracy when changing the parameters of the algorithm and input data in some area, which is called the area of stability.

Definition 2. Convergence is a property of an algorithm by changing its parameters to perform calculations with an arbitrarily small error for a given class of input data (i.e. when increasing the number of iterations for matching algorithms, the error will tend to zero). Moreover, the increase in accuracy is achieved by changing the internal parameters of the algorithm (for example, the maximum allowable difference between the previous and next approximation).

Definition 3. The correctness of the computational method is a property of the indisputable existence of the solution the problem and ensuring stability of the computational algorithm that implements this method.

Let's consider the parameters that affect the results of solving the three-criteria problem of diversification by the method of successive concessions.

The method of concessions requires the decision maker to determine the relationship of dominance on multiple criteria.

The criteria are: total income of the pharmacy network for a certain period $SUM \rightarrow max$, the risk of income loss, which is defined as covariance on the set of income of pharmacies $SUM \rightarrow max$ and the degree of diversification, which is estimated by the entropy of the investment portfolio of the pharmacy network $ENTROPY \rightarrow max$.

Therefore, the first parameter of the method is the order of solving optimization problems according to one of the three criteria.

The vector of deviation values is the second parameter of the method. After solving the first one-criteria problem, the system of constraints is supplemented by a new criterion, which limits the deviation from the found of the optimal solution at the previous stages.

The number of pharmacies in the network, which determines the size of the problem, is the third parameter of the method.

The fourth parameter concerns the initial approximation and accuracy of the method. In this study, its characteristics are the accuracy of algorithms implemented by standard functions OPTIMIZATION TOOLBOX MATLAB, as the authors [16] have developed a software product for solving research problems in the MATLAB package. Such function is the exitflag, which describes the conditions of the exit. If the value of exitflag is greater than zero, it means that the function matches the desired solution by X. If it is zero, then the maximum value of the function estimate or iteration has been exceeded. But if the value of exitflag is less than zero, then the function does not match to some solution.

Therefore, to analyze the effectiveness of the method of concessions on certain parameters, it is necessary to perform four steps that meet the objectives of this article.

Step 1. Research of advantages of the offered three-criterion model of diversification of a drugstore network concerning classical two-criterion model of the portfolio theory.

The initial approximation of the first stage is fixed as 0.1 from the lower limit of the admissibility interval. For each subsequent stage, we take the optimal value of the previous stage as the initial approximation.

Let's compare the solutions obtained using the classical two-criteria approach and the proposed three-criteria approach.

Consider the five modifications of problem (1), which are formed due to the different sequences of consideration of the criteria of profitability (*SUM*), risk (*Risk*) and the degree of diversification (*Entropy*) by the method of successive concessions.

So we have two two-criteria problems, which we denote according to the sequence of criteria: $SUM - Risk$ and $Risk - Sum$ The results of solving these problems for a small network (the number of pharmacies in the network n = 5) with estimates of the main parameters are given in Table 1.

According to the data in Table 1, we can see that the best result among the two-criteria modifications is achieved for the model RISK_SUM, n = 5.

When adding the third criterion $Entropy$ o the vector objective function, you can get a total of 3! = 6 combinations to consider the sequence of criteria by the method of concessions. But the purpose of the third criterion is to increase the degree of diversification of the portfolio, so we consider it the most important and put in the first place (in addition, a number of experiments have confirmed that such arrangement gives better results than others).

Table 1 - The results of solving two-criteria problems for a small network

Stage of the method	RISK_SUM n=5	SOLUTION	SUM_ RISK n=5	SOLUTION
Stage of the method	1 level	2 level	1 level	2 level
SUM	25.270639	30.037545	141.488922	25.270633
Risk	15.724052	17.296457	641.733543	15.724052
ENTR	1.498915	1.514846	0.094361	1.498911
exitflag	1	5	1	5
X=	0.3944	0.1960	0.0010	0.3944
	0.0010	0.0010	0.0070	0.0010
	0.0010	0.0010	0.9900	0.0010
	0.1644	0.3210	0.0010	0.1644
	0.4392	0.4810	0.00102	0.4392

Therefore, we will consider two three-criteria problems, which we will also denote according to the sequence of consideration of criteria by the method of concessions: $Entr - SUM - Risk$ nd $Entr - Risk - SUM$ The results of solving three-criteria problems (n = 5) with estimates of the main parameters are given in Table 2, where an inefficient modification $Risk - SUM - Entropy$ is also given for comparison.

Table 2 - Results of solving three-criteria problems for a small network

	ENTROPY_RISK_SUM n=5		SOLUTION	ENTROPY_ SUM_ RISK n=5		SOLUTION	RISK_SUM_ENTROPY n=5		SOLUTION
	1 level	2 level	3 level	1 level	2 level	3 level	1 level	2 level	3 level
SUM	60.148	38.320	42.049	60.1488	87.5116	78.7605	25.2706	30.037	28.172
Risk	92.970	31.925	35.118	92.9702	214.1016	154.0467	15.7240	17.296	17.296
ENTR	2.3219	2.0897	2.0897	2.32192	2.08973	2.0897	1.49891	1.5148	1.6907
exitflag	1	5	5	1	4	4	1	1	5
x	0.2000	0.2894	0.2185	0.2000	0.1047	0.0625	0.3944	0.1960	0.3549
	0.2000	0.0921	0.0667	0.2000	0.1979	0.1063	0.0010	0.0010	0.0166
	0.2000	0.0559	0.0859	0.2000	0.4368	0.3766	0.0010	0.0010	0.0049
	0.2000	0.2447	0.2846	0.2000	0.1432	0.2588	0.1644	0.3210	0.2401
	0.2000	0.3180	0.3443	0.2000	0.1175	0.1958	0.4392	0.4810	0.3835

According to the estimates given in Table 2, it can be stated that the ENTROPY_RISK_SUM model n = 5 has the best result. Comparing the results of calculations from tables 1 and 2, we obtain experimental confirmation that the introduction of the entropy criterion allows to increase the income of the pharmacy network, but also increases the risk in different proportions.

Step 2. Construction of the dominance relation on the set of criteria.

The dominance ratio on the set of criteria, based on the significance of a particular criterion for the optimal decision-maker solution and the results of the experiments in step 1, is most successful in the ENTROPY_RISK_SUM model, where the criteria are ranked in descending order of importance. So this is the best result recommended for decision-maker, so Figures 1, 2, and 3 below show the computer simulation results for the the results of computer modeling of the domain of admissible solutions, Pareto set and effective solution (red triangle) ENTROPY_RISK_SUM model.

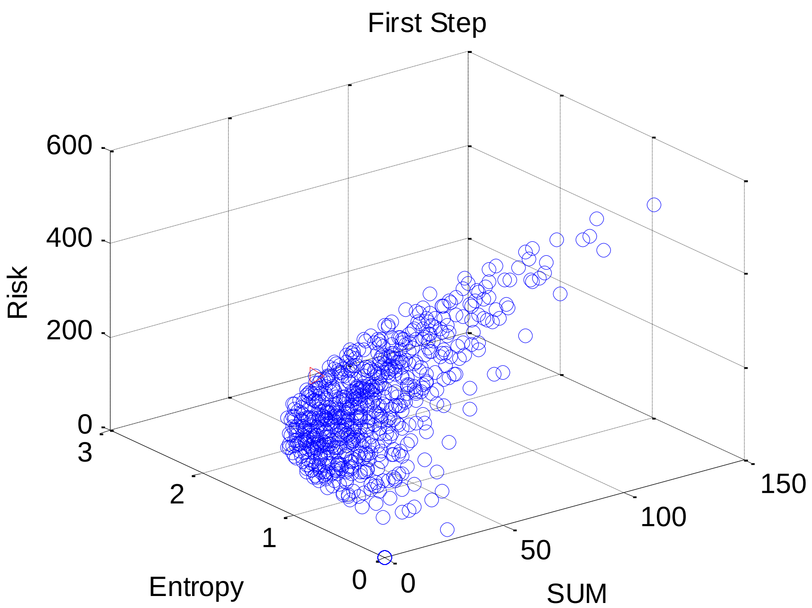

Fig. 1 The result of computer simulation of the first step of the concessions method for the model ENTROPY_RISK_SUM

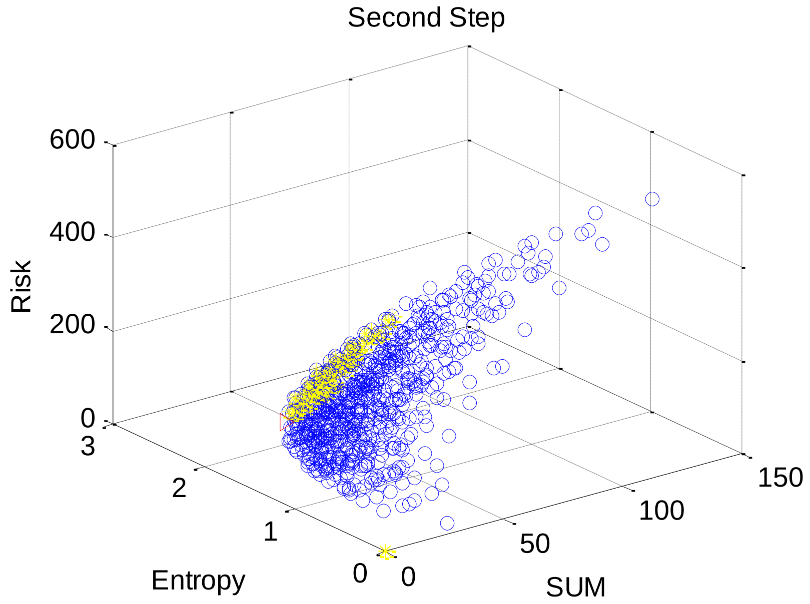

Fig. 2 The result of computer simulation of the second step of the concessions method for the model ENTROPY_RISK_SUM

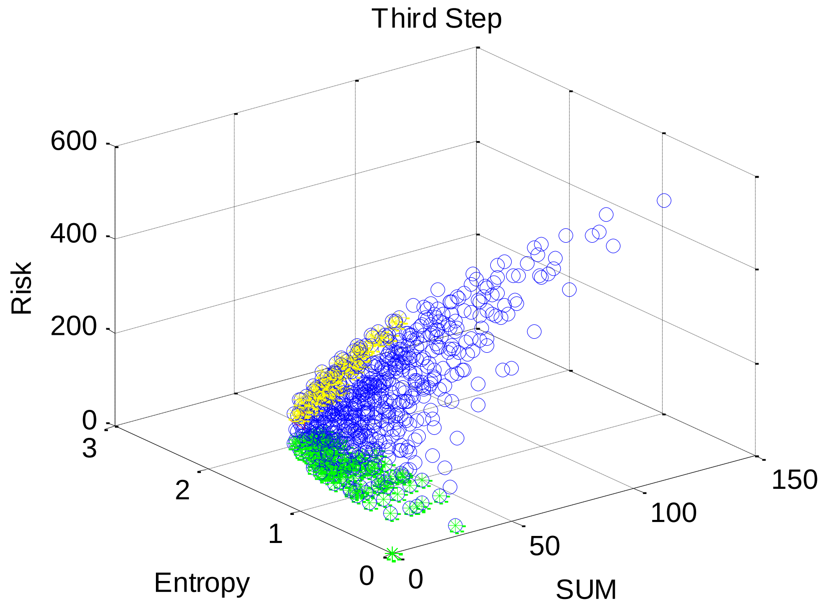

Fig. 3 The result of computer simulation of the third step of the concession method for the model ENTROPY_RISK_SUM

As can be seen from Figures 1, 2 and 3, the visualization of solutions using computer modeling eliminates the previously mentioned disadvantage of the concessions method that the result does not necessarily belong to a subset of Pareto-efficient solutions, and therefore requires verification of its membership compromises. Thanks to the graphical interpretation, the check is performed automatically.

Step 3. Determination the area of stability in the space of the parameters of the concessions method

Construct n area of stability in the sphere of parameters of the concessions method $\delta_1 > 0$ and $\delta_2 > 0$. The color will indicate the end conditions of the algorithm. Red color indicates the successful completion of the algorithm with the value exitflag=1 (First order optimality conditions satisfied). Marked in green Exitflag = 4 (Computed search direction too small). Marked in blue exitflag = 5 (Predicted change in objective function too small).

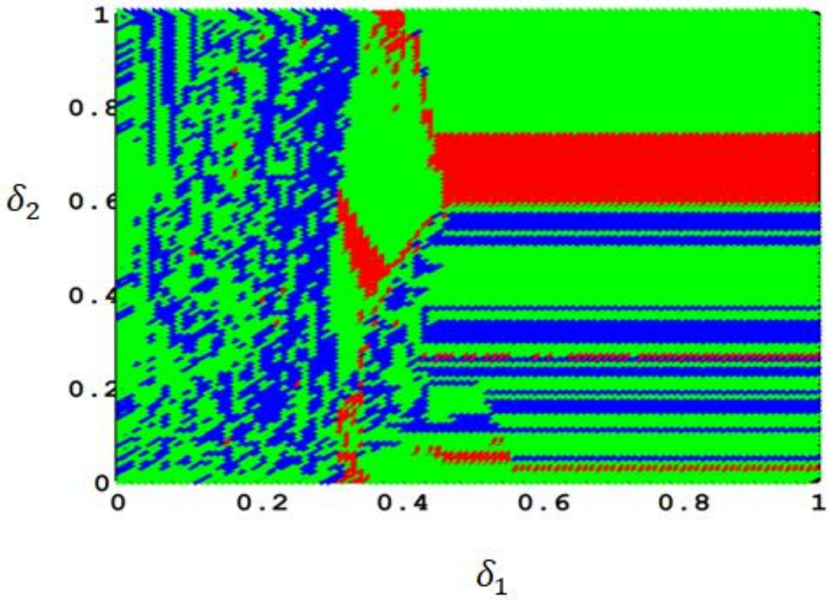

Fig. 4 The area of stability in the sphere of parameters of the method of concessions δ_1та δ_2 for the model ENTROPY_RISK_SUM для n=5

For the ENTROPY_SUM_RISK model, experiments have shown that the concession method is resistant to parameter changes for both small and medium networks (n <33) and large networks with n = 65 objects.

Step 4. Evaluation the effectiveness of the method for tasks (networks) of different sizes.

Let us evaluate the efficiency of the method application for networks of different magnitude n = 5, 33, 65 and problems with different composition of the vector objective function.

Previously, Table 1 and 2 presented the results of solving two-criteria and three-criteria problems for small networks n = 5. Similar experiments were performed with medium networks, the results of which are presented in Table 3 and 4.

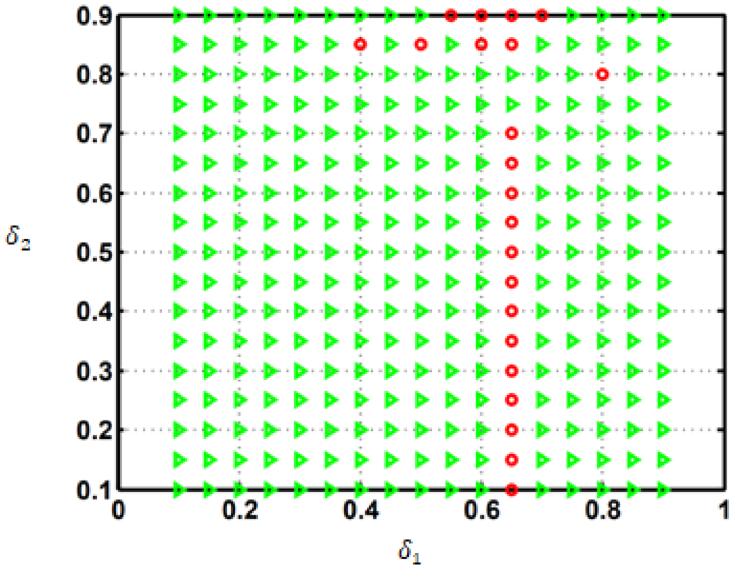

Fig. 5 The area of stability in the sphere of parameters of the method of concessions δ_1та δ_2 for the model ENTROPY_SUM_RISK для n=5

Table 3 - Results of solving two-criteria problems for a medium-sized network n=33

	RISK_SUM n=33	**SOLUTION**	**SUM_RISK n=33**	**SOLUTION**
	1 level	2 level	1 level	2 level
SUM	33.063582	42.227114	146.460480	47.646048
Risk	11.111950	12.223145	866.357922	13.448598
ENTR	2.843013	3.233167	0.364325	3.411142
exitflag	**5**	**5**	**1**	**5**

Table 4 - Results of solving three-criteria problems for a medium-sized network n=33

	ENTROPY_RISK_SUM n=33		SOLUTION	ENTROPY_RISK_SUM n=33		SOLUTION
	1 level	2 level	3 level	1 level	2 level	3 level
SUM	86.534623	60.891761	66.474520	86.534623	127.773763	114.996387
Risk	104.180575	26.346699	28.981416	104.180575	308.114469	123.267737
ENTR	5.044394	4.485830	4.539944	5.044394	3.985071	3.985071
exitflag	**1**	**0**	**0**	**1**	**5**	**5**

The results of experiments with large networks (n = 65) are shown in Table 5 and 6.

Table 5 - The results of solving two-criteria problems for a large network n=65

	RISK_SUM n=65	**SOLUTION**	**SUM_RISK n=65**	**SOLUTION**
	1 level	2 level	1 level	2 level
SUM	40.425748	50.334529	200.644254	85.064425
Risk	10.659792	11.725771	2302.353426	27.226756
ENTR	2.943890	3.208432	0.727123	3.487298
exitflag	**5**	**5**	**1**	**5**

Table 6 The results of solving three-criteria problems for a large network n=65

	ENTROPY_RISK_SUM n=65		SOLUTION	ENTROPY_RISK_SUM n=65		SOLUTION
	1 level	2 level	3 level	1 level	2 level	3 level
SUM	60.598327	66.851087	93.322565	180.035853	162.032267	60.598327
Risk	26.015389	28.969285	124.681982	749.963209	210.482123	26.015389
ENTR	5.245928	5.342298	6.022368	3.312302	3.312302	5.245928
exitflag	**1**	**0**	**0**	**1**	**5**	**4**

Evaluation of the effectiveness of the method of concessions for networks of different sizes is performed by the value of the exitflag function of the MATLAB package, which describes the exit conditions. Therefore, pay attention to the resulting column of each SOLUTION table, which corresponds to the last stage of the method of concessions.

For all problems of dimension n = 5 the value of exitflag is greater than zero, ie this function coincides with the desired solution by X. For the problem with the objective function of the model ENTROPY_RISK_SUM at n = 33 and 65 the value of exitflag is zero. This indicates that the maximum value of the function or iteration estimate was exceeded. But in no case was the exitflag value less than zero when the function did not match some solution.

Therefore, there is always a solution for the considered problems, and its belonging to the admissible area is checked graphically thanks to the developed software in the MATLAB package.

The article finds acceptable sets and sets of pareto-optimal portfolios for risk management of a centralized pharmacy network, taking into account the scale of the network. Thanks to the developed software in the MATLAB package, the relation of dominance on a set of criteria is constructed; determination of the area of stability in the sphere of the parameters of the concessions method; evaluation of the effectiveness of the method for problems of different sizes which are the scientific novelty of this work.

Managing the pharmacy network in the digital transformation of the health care system involves effective management of their own risks, minimizing them by diversifying their own activities, which leads to new challenges and enhances the relevance and practical relevance of research in this area. The results of computer modeling and numerical analysis of solutions by successive concessions will provide investors with an appropriate tool to support decision making, will be useful for automating business processes of pharmacy networks, risk management, market data analysis to improve their efficiency.

Among the areas of further research is a comparative analysis of the effectiveness of other methods of solving diversification problems and taking into account the dynamic factors that affect the magnitude of risk.

The work was carried out as the part of the research work «Mathematical modeling of socio-economic processes and systems», the registration number

DB05038, at the Department of System Analysis and Computational Mathematics of National University «Zaporizhzhia Polytechnic».

References

1. H. M. Markowitz, K. Blay, Risk–Return Analysis: The Theory and Practice of Rational Investing (a four-volume series), McGraw-Hill, 2014.
2. J. B. Guerard (ed.), Handbook of Portfolio Construction. Contemporary Applications of Markowitz Techniques, Springer, New York, Dordrecht, Heidelberg, London, 2010, p.808. URL: http://doi: 10.1007/978-0-387-77439-8.
3. M. Ehrgott, Multicriteria Optimization, Springer, Heidelberg, 2005. doi:10.1007/3-540-27659-9
4. B. Y. Kishakevich, Formuvannia optymalnyh za Pareto kredytnyh portfeliv z dopomohoiu henetychnoho alhorytmu (Formation of Pareto optimal loan portfolios with the help of genetic algorithm), Visnyk KhNU, Khmelnyck, 2010.
5. Alireza Golia, Hasan Khademi Zarea, RezaTavakkoli-Moghaddamb, Ahmad Sadeghieha, Hybrid artificial intelligence and robust optimization for a multi-objective product portfolio problem Case study: The dairy products industry, volume 137 of Computers & Industrial Engineering, November 2019, https://doi.org/10.1016/j.cie.2019.106090.
6. Yevseyeva, E. B. Lenselink, A. de Vries, A. P. IJzerman, A. H. Deutz, and M. T. M. Emmerich, Application of portfolio optimization to drug discovery, volume 475 of Information Sciences,, pp. 29–43, 2019. URL: http://doi.org/10.1016/j.ins.2018.09.049
7. Jian Xiong, Chao Zhang, Gang Kou, Rui Wang, Hisao Ishibuchi and Fawaz E. Alsaadi, Optimizing Long-Term Bank Financial Products Portfolio Problems with a Multiobjective Evolutionary Approach, volume of Hindawi Complexity, 2020, Article ID 3106097. https://doi.org/10.1155/2020/3106097
8. R. V. Khachaturov, Generalized Equivalence Set Method for Solving Multiobjective Optimization Problems, voume 6 of Journal of Computer and Systems Sciences International, 2019
9. G. L. Brodetskiy, D. A. Gusev, O. A Mazunina, A.V. Fel, Possibilities of the Method of Successive Concessions When Selecting for Many Criteria. Magazine, volume 3 (80) of Logistika i upravleniye tsepochkami postavok, June 2017
10. L. M Malyarets'; O. V. Mínênkova, Issledovaniye problem bagatokriterial'noy meditsiny v professional'noy deyatel'nosti na osnove metodov bagatokriterial'noy optimizatsíí, volume 1 of Problemy ekonomiki, 2017. URL: http://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=bth&AN=123664557 &custid=s6224580. Acesso em: 13 mar. 2020.

a. V. Bakurova, H. M. Ropalo, E. V. Tereschenko, Modeling of optimal portfolio of clients of centralized Pharmaceutical network, volume 6 of Technology audit and production reserves, 2019. doi:10.15587/2312-8372.2019.186789

b. V. Bakurova, Modeling of complex diversification for centralized pharmacy network in R. N.: A. V. Bakurova, H. M. Ropalo , E. V. Tereschenko (Eds.), volume 166 of The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020), Kryvyi Rih, Ukraine, 2020 URL: http://doi.org/10.1051/e3sconf/202016609003

11. Mathworks, 2019. MATLAB*-, 2019. URL: https://www.mathworks.com/campaigns/products.
12. R. N. Kvêtniy, I. V. Bogach, O. R. Boyko, O. Y. Sofina, O. M Shushura, Komp'yuterne modelyuvannya sistem ta protsesív. Metodi obchislen' VNTU, Vínnitsya: 2012, p. 193.
13. G. M Gnatíênko, V. E. Snityuk, Yekspertní tekhnologíï priynyattya ríshen', Kiïv, 2008. p. 444.
14. Anna Bakurova, Hanna Ropalo, Elina Tereschenko: Analysis of the Effectiveness of the Successive Concessions Method to Solve the Problem of Diversification. MoMLeT+DS 2021: 231-242 http://ceur-ws.org/Vol-2917/paper21.pdf - P. 231-242.

5 THE INDUSTRIAL ENTERPRISE SUSTAINABILITY FORECASTING MECHANISM DEVELOPMENT

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The successful operation of enterprises and maintaining the sustainability of their development in modern conditions depends on the adaptive model of the enterprise strategic management, which can be implemented, in particular, by means of the traditional econometric approaches. This, in turn, will consider the prerequisites and specifics of the operational activities.

The activities of mining companies, which include mining and processing of minerals, are in interaction with nature and society.

The problem natural resources depletion is characterized not only by their limited physical number, but also environmental (disturbance of resources, soil subsidence, deterioration of groundwater quality, etc.) and socio-economic aspects(competitiveness of products on the world market, social stability, labor potential, etc.) .

The gradual and continuous deterioration of mining conditions around the world is due to changes in the depth of mining operations, which complicates logistics and increases the opening rate for quarries of mining companies. In practice, this means for enterprises the need to take preventive measures of either a technical or economic nature to ensure profitability.

Given the principles of sustainable development, understanding the role of natural resources in the activities of mining companies can improve their transgenerational use (in the interests of present and future generations) [17].

At the state level, long-term use of raw materials has led to the following consequences: the formation of an economy focused on heavy industries, depletion of subsoil, the accumulation of the consequences of negative anthropogenic impact [22].

Due to the limited and impossible replenishment of mineral resources, the subsoil is depleted, which leads to the development of deposits and deterioration of mining and geological conditions of production. In addition, in the early stages of field development, mining companies cause long-term environmental damage to the environment.

The Gray model, the Hotelling model and the rule of El Seraphie [1, 2] are used in order to answer the question of the optimal rate of non-renewable resources extraction.

The use of several methods of modeling and forecasting allows us to assess not only the impact of individual factors on the phenomenon, but also their complex impact [16]. Therefore, it is advisable to combine traditional econometric approaches with the theoretical assumptions of the above models, as they relate to non-renewable resource management.

The econometric approach to ensure the sustainable development of mining companies is based on the concept of efficiency as the main starting point.

Efficiency in this case ,maintaining stochasticity ,is determined by a group of performance indicators of an individual enterprise. It is implied that as a result it is possible to obtain a contingent valuation of efficiency, rather than its exact value [3].

At the same time, forecasting methods for individual phenomena give an accurate result in the short term, and forecasting in modeling complex economic systems using LS (Least Squares) and PLS-PM (Partial Least Squares Path Modeling) methods by estimating variables allows to assess the degree of impact on a phenomenon (in this case - sustainable enterprise development) specific quantitative and implicit qualitative indicators.

Before moving on to modeling, let's define the basic principles of non-renewable resource models.

Gray's model serves as a tool to explain the probable behavior of a mining company. It is based on the following provisions [4, 5]:

perfect competition existence and resource limitation ;

marginal costs of resource extraction are constant;

the price for products (output) corresponds to the price set by the market (price taker).

production in the base time period reduces the allowable production in the next, while profit maximization is planned for the next period.

The consequences of Gray's model [4]: 1) the price of raw materials includes marginal costs of production and lost profits (opportunity cost); 2) there is a flow constraint and a stock constraint.

The first consequence is that the opportunity cost due to the limited period of the mining company operation indicates a decrease in profitability over time due to depletion of resources. It follows that the lost benefit should be equal to the amount of rent received per unit of resource (marginal unit).

The second consequence is that the net present value (NPV) is determined by the amount of discounted rental income, which should be identical to the rent from the resources extraction in the previous period. If such an identity is not observed, it is more profitable for the company to carry out extraction in the current period and not to reinvest in re-extraction, i.e., the entire mineral deposit is extracted at once.

The emergence of rent is due to the relationship between costs and results in different time periods. In this case, the development of deposits should be carried out when the amount of investment resources is greatest. It follows that the company should focus on the profitability of production in each subsequent period.

That is to say, Gray's model is based on the assertion of increasing marginal cost, considering the complexity of further production. If the price of resources increases, the benefit of production in the following periods is provided.

Hotelling' s model (rule) [6, 7] lies in the following - the loss of usefulness of resources can be compensated by increasing their value. This model expands the Gray model by identifying the socially optimal production rate. The model is based on the existence of the need of social welfare increase (SW, the social welfare) in order to establish the optimal resource production rate.

Unlike Gray's model, resource extraction occurs in two or more periods. At the same time, the net present value of public welfare (NPV) should not change during each subsequent period. This means that the product of the additional ton of the resource for the selected period is identical to the social welfare received for any of the periods.

Thus, we can conclude that the total amount of resources to be extracted is limited:

Qr = qx + qx + 1 +… + qy

Under this condition, the maximization of social welfare is as follows:

SW = SW0 + (SW1 / (1 + q) + SW2 / (1 + q) 2 +… + SWy / (1 + q) y-> max)

Given that social welfare (SW) includes consumer welfare (CW) and producer welfare (PW), then, given zero consumer welfare and production costs for the two periods, the percentage change in non-renewable resource prices will be identical to the interest rate on the alternative assets [8]. It follows that prices are growing exponentially.

It is well known that the degree limitation of scarce natural resources can be reduced by substitution. Therefore, there is a critical value of the price at which the resource ceases to be in demand, if there are substitute resources or alternative technologies - blocking price [9].

Accordingly, the purpose of the mining enterprise is to extract resources in such a way as to delay as much as possible in time to reach the blocking price. This requires determining the initial price of the resource.

According to the theory of G. Hotelling [6], mining companies can plan their activities by building their own strategy for the development of mineral resource base in view of the depletion of deposits over time. This is important considering the fluctuating changes in the structure natural resources consumption.

In the Hotelling model, some parameters are taken as constants, including resource demand, resource stock, interest rate on alternative assets, blocking resource price, and marginal cost of production. Changing one or more of these parameters affects the optimal rate of resource extraction.

Gray and Hotelling's models do not reflect the extent of environmental damage and externalities. Also, these models do not imply the redirection of part of net revenue to the creation of basic (natural) assets (replacement capital asset) and the need to maintain the same level of consumption / income in the future (consumption / income stream).

In combination with econometric approaches, eco-destructive factors and the size of environmental taxes will be considered in the modeling.

Ella Serafi's rule is based on the position that a mining company reinvests a portion of the income generated from the sale of non-renewable resources to create an alternative underlying (natural) asset. The main provisions are as follows:

finite series of earnings should be transformed into an infinite series of true income so that their capitalized value is the same.

revenues from the extraction of resources are determined by such components as income (income portion) and compensation (capital portion) parts.

The calculation of income and compensation parts is as follows: TI / R = 1 / (1 + r) n + 1, (11) where TI - real income (true income), R – rent from extractions, r - discount rate, n - number of periods.

The given ratio of real income from production directly depends on two factors - the ratio of «stock-production» and the discount rate, i.e., the rate of increase in rental income exceeds the interest rate on alternative assets. It follows that the mining company increases the initial price of the resource, i.e., the rate of production decreases, the company receives a new (replaced) asset, and limited resources are temporarily stored.

If the prices are calculated considering the rent, the operation of each of the fields will pay off, regardless of the use period , apart from cases of operational costs increase.

Thus, according to the Hotelling model, the interest rate should correspond to the percentage change in prices for non-renewable resources, the rate of depletion of which is inversely proportional to the blocking price. El Seraphie's approach is aimed at reducing the rate of extraction and creating assets to replace non-renewable natural resources through reinvestment.

As practice shows [10], ensuring sustainable development in production areas should be based on previously conducted environmental and economic surveys to assess the process and consequences of changes in the natural environment of the enterprise.

The solution of this problem in the short term is possible if the analysis of the interaction of the mining company with the environment utilizes modeling tools based on forecasting methods using extrapolation and retrospective.

For a long-term analysis, the priority is the implementation of rent assessment of deposits, which improves the efficiency of mineral resources development. Rent valuation is possible by calculating net present value or net discounted income (NPV) [11].

A key economic premise of the Hotelling model is that non-renewable resources serve as financial assets which value tends to increase. That is to say that the Hotelling model is because after reaching the peak of production of limited natural resources, global demand will continue to grow, which will eventually lead to more expensive resources and their shortage. That is why there is a need to ensure production at such a level that the remaining reserves value increases in line with the growth of the real interest rate.

The Hotelling model is based on two mutually balancing trends: the loss of utility from resource extraction (due to reservations or other constraints) is offset by an increase in its value over time. The condition that must be met is that the total amount of limited resources consumption during the operation of the field should not exceed its stock.

With the help of the mathematical modeling, it is possible to determine the approximate limits within which the value of rent is, provided that the resources are interchangeable and the marginal costs for both resources do not differ significantly [12]. For example, mining companies may get a need to estimate the new field. Then calculate the levels of costs for the extraction of alternative resources instead of calculating unexpected future costs for the development of the field. You can replace the resource or indirectly replace it by changing the structure of consumption, considering the natural resources exhaustion.

The Hotelling model does not consider the extraction costs but considers the interdependence of those costs and accumulated production, and cost changes affect the previously established patterns.

In cases where it is possible to produce a substitute for limited natural resources, the initial model is also getting complicated, because such production costs, in contrast to operational costs, are fixed. At the same time, the price growth of the resource is limited, because at a certain point of time it reaches the level of costs to produce substitutes and cannot exceed it, despite the exhaustive natural resources and depletion of fields.

At the same time, in practice, the connection between the extraction costs and cumulative yield (ultimate production) , which determines the emergence of rent, may not be observed, which will be referred below. Accordingly, the Hotelling model in modern conditions can be applied only in conditions of exploitation of certain groups of fields.

The Hotelling model does not anticipate sharp demand fluctuations, when the resource efficiency usage differs significantly at different times. Consequently , the mining company either does not fully use part of the resources due to the modified demand function (limitation is not observed) or loses part of the revenue due to sales at below-optimal prices (efficiency decreases, rent does not arise) [21]. This makes it difficult to forecast the demand for natural resources.

In addition, with the gradual expansion of the resource base due to the use of new mining technologies, it is difficult to determine the available natural resources and predict the time period that will account for the expansion of the mining potential [24].

As noted earlier, the use of rent allows you to regulate the natural resources extraction in order to prevent a rapid depletion of deposits. However, the use of the

Hotelling model may not be possible due to the opposition of such factors as environmental constraints and capacity constraints, as they directly affect the stocks limitations.

In modern conditions, the emphasis on transgenerational effects is shifting away from the problems of depletion of natural resources to the consideration and analysis of sustainable development.

Today there is a gradual loss of the dominant position of the «Hotelling rules» due to changes in the approaches to the mineral resource endowment , ways to obtain them (production) and improvement of the strategic management of natural resources at the macro, meso and micro levels.

In addition, in today's environment there are many risks unforeseen by the approaches of Hotelling, Gray and Seraphim. Many factors hinder uniform and predictable production as a prerequisite for these models. Among them [13, 14, 18, 23]: unpredictability of prices and demand for extracted resources (especially during the technological base structural reorganizations), the inability to calculate the consequences of decisions made, the risk of obtaining a negative value of social welfare, the forecast estimation complexity of the average daily production volumes due to obsolete equipment or technological accidents, costs due to the need to obtain mining-exploration and techno-economic information on production processes, the difficulty of predicting the moment of expansion of raw materials, etc.

In practice, it may turn out that under favorable mining-exploration and economic- geographical conditions, production in a field with small reserves will be more efficient than in the case of production under difficult operating conditions from a field rich in natural resources [15].

There is also a risk of environmental pressure, when the cost of production through environmental taxes increases, which reduces profits, and the company operates on the verge of economic profitability.

Building models for the implementation of computer solutions that provide data collection and forecasting, allows business management to take well-informed managerial decisions at different levels.

In order to determine the required initial data, it is advisable in the factor analysis to solve the problem of reducing the descriptive variables number, estimation of latency indicators , the use of common variables (main components) and further interpretation of the original data.

The main method of factor analysis is the method of principal components (PCA, Principal Components Analysis), the idea of which is to identify latent properties, which can be used to explain the correlation between indicators. That is to say, there is a transition from existing values to a new coordinate system, where the load of factors gradually decreases [5].

The model of structural equations is used in the analysis of indicators of many spheres of economic and production activity. One approach to this model is the Partial Least Squares (PLS) method, which transitions from the original set of features to the set of major components of a smaller dimension while maintaining causation . This approach allows you to move on to some of the most important (resulting) indicators. It is proposed to build a regression model using this method. Factor analysis will be confirmatory, i.e., with hypotheses about the number of factors and their load. This requires using latent variables by means of the method of private least squares, to build a PLS-PM model of sustainable development of the mining enterprise as a complex economic system.

Forecasting allows you to determine the value of a particular indicator in the future based on its values in the past and present. By regression analysis, it is possible to construct a mathematical function between data sets (this is possible given the results of correlation and quantification of the relationship between independent and dependent variables). Then, based on the model, you can calculate and predict future values of latent indicators of sustainable development. The sustainability of development can be assessed by comparing the values of the estimates of the blocks.

The PLS forecasting algorithm allows you to generate forecasts within and outside the sample, which facilitates the evaluation of indicators. Due to the possibility of cross-checking the forecasting errors and statistics of aggregate errors calculate the following indicators: root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE) to estimate the trajectories of the PLS model for explicit variables MV) and latent variables (LV). These criteria allow us to compare the predicted efficiency of alternative models of PLS trajectories.

Excess kurtosis is usually not always zero or close to this value (as in the case of a normal sample distribution). This may indicate the difficulty of forecasting several indicators, including economic (profitability, return on capital and the ratio of capital investment to net income from sales), environmental (revenues from emissions of pollutants into the air and rent for special water use) , social (contributions to social activities) and integrative (coefficient of stability of economic growth and payments in favor of the state).

At the same time, indicators of skewness, which characterize the distribution of probabilities of random variables, indicate a significant slope of the series in the case of such indicators as social contributions, payments to the state and the ratio of capital investment to net income from sales.

From the above we can conclude that the stability index depends on the relative parameters (i.e., the degree of distance of the values of each of the parameters from the critical values).

Since there is a need to introduce into the system of strategic management quantitative information on the parameters of sustainable development [19, 25], resulting in the expected conditions of the enterprise, it is important to forecast indicators of sustainable development as such, the formation of which is influenced by local sustainability.

In doing so, the linear regression model regresses all exogenous indicator variables for each endogenous indicator variable to make predictions. That is, based on a comparison with the results of the PLS model, we obtain data on whether the use of the theoretically established model improves (or at least does not worsen) the predicted effectiveness of indicators. Compared to LM results, PLS prediction results should have less prediction error than LM.

The implementation of PLS-forecasting reveals the following feature: if the indicators are greater than the threshold level, it indicates their instability and requires diagnostics of the enterprise activity. It also means that in the absence of stable trends in the development of the forecast object (mining companies) in the event of a sharp change in development conditions, changes in trends will not be recognized. Accordingly, the extrapolation method is not suitable. Therefore, the chosen approach to building a multidimensional model that reflects the most significant and stable internal and external relationships is correct. At the same time, the assessment and analysis of the sustainable development strategy of the enterprise when changing external and internal parameters requires a study of whether there can be a transition from stable to unstable state.

Therefore, the transition to environmentally balanced economic development through the introduction of innovative technologies and socially oriented initiatives is a necessary condition for strategic management [20]. Moreover, the successful operation and maintenance of the enterprise sustainable development is possible through a combination of traditional econometric approaches, considering the preconditions and specifics of operating activities. When there is a transition from the original set of features to the set of major components of a smaller dimension while maintaining the causal relationship, this allows you to move to some of the most important (resulting) indicators.

Thus, a balanced approach based on the principles of sustainable development differs from traditional ones as it involves the rational use of all types of resources in a gradual transition to more environmentally friendly technologies and waste minimization.

References

1. El Serafy, S. The proper calculation of income from depletable natural resources // Environmental Accounting for Sustainable Development, Ahmad, Y., El Serafy, S., and Lutz, E., Eds. – World Bank, Washington DC, 1989. – P. 10–18.
2. Henseler, J. (2012). Why generalized structured component analysis is not universally preferable to structural equation modeling. Journal of the Academy of Marketing Science, 40(3), 402–413.
3. Pearce, D. & Turner, R. Economics of Natural Resources and the Environment. Harvester Wheatsheaf, London, 1990. – P. 271-287.

4. Diamantopoulos, Adamantios & Siguaw, Judy. (2006). Formative Versus Reflective Indicators in Organizational Measure Development: A Comparison and Empirical Illustration. British Journal of Management. 17. P. 263 - 282.
5. Dijkstra, T. K. and Henseler, J. (2015). Consistent and Asymptotically Normal PLS Estimators for Linear Structural Equations, Computational Statistics & Data Analysis, 81(1): 10-23.
6. Hotelling, H. The economics of exhaustible resources / Journal of Political Economy. – 1931. – Vol. 39. –P. 137-175.
7. Peterson, R. A., & Kim, Y. (2013). On the Relationship between Coefficient Alpha and Composite Reliability. Journal of Applied Psychology,98(1), 194-8. DOI:10.1037/a0030767
8. Chainikov V.V. (2006).Risk treatment in the discount rate when estimating investments in field development / V. V. Chaynikov, D.G. Lapin // Surveying and subsoil use. № 5. p. 29–33.
9. Kryukov V.A. (2014).Raw materials in the new institutional reality // Spatial economy № 4. - p. 26–60.
10. Glazyrina I.P. (2001) Natural capital in the economy of the transition period / I.P. Glazyrina. - M .: NIA-Priroda, REFIA, - p. 204
11. Hicks, J. (1946.)Value and Capital. - Second Edition. - Clarendon, London, - p. 171-188.
12. Golub A.A., Strukova E.B. (1998). Economics of natural resources. - M .: Aspect Press , p.319 .
13. Arbatov A.A. (1991). On the strategy of using mineral raw materials / A. A. Arbatov, EB Strukova // Economics and mathematical methods. T. 27, p. 686–698.
14. Shandova N.V. (2013). Principles of formation of conditions for sustainable development of industry / NV Shandova // Business Inform. № 6. pp. 176–181.
15. Margolin A.M., M.: Nadra (1974). Estimation of mineral reserves - mathematical methods., p. 264.
16. Maslak O., Grishko N., Odintsov M., Yakovenko Y., Buchashvili Kh. (2021).Organizational and economic mechanisms of qualitative modeling of sustainable development of the enterprise. E3S Web Conf., Volume 280. Second International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2021). URL: https://www.e3s-conferences.org/articles/e3sconf/abs/2021/56/e3sconf_icsf2021_02008/e3sconf_icsf2021_02008.html
17. Kasych, A., Rowland, Z., Yakovenko, Y. (3-7 September 2019).Modern management tools for sustainable development of mining enterprises. In Proceedings of the E3S Web of Conferences, Ukrainian School of Mining Engineering, Berdiansk, Ukraine,
18. Grishko N., Maslak O., Sokurenko P., Buriak I., Maslak M. Anti-crisis approach in industrial enterprise management: methodological tools of preventive regulation // SHS Web of Conferences. Innovative Economic Symposium 2019 Milestones and Trends of World Economy (IES2019). 73, 01018 (2020) - https://doi.org/10.1051/shsconf/20207301018/ https://www.shs-conferences.org/ articles / shsconf / pdf / 2020/01 / shsconf_ies_2019_01018.pdf
19. Kasych A., Yakovenko Y., Tarasenko I. (2019). Optimization of business processes with the use of industrial digitalization. Proceedings of the International Conference on Modern Electrical and Energy Systems, MEES 2019, pp. 522-525.
20. Maslak O.I. Approaches to the management of the costs of innovation activity of mining enterprises: aspects of economic security / Maslak O.I., Girshko N.Ye., Hlazunova O. O., Vorobiova K. O. //Scientific Herald of the NMU. – 2017. - № 5. - pp. 137–145.
21. Kasych, A., Vochozka, M., Yakovenko, Y. (2019). Diagnostic of the stability states of enterprises and the limits of their tolerance. Qual. Access Success 20, 3–12.
22. Maslak O.I., Yakovenko Y.Yu., Sokurenko P.I. Theoretical and practical aspects of sustainable development of the enterprise in conditions of uncertainty of the economic environment. Young scientist. № 4 (44). pp. 710–714.
23. Maslak O.I., Korobkova I.V. Information support of the process of managing the strategic stability of the enterprise. Investments: practice and experience. 2015. № 4. ,pp. 23–25.

24. Maslak O., Bezruchko O. Features of assessing the economic potential of the enterprise in conditions of cyclical fluctuations. Bulletin of socio-economic research. 2013. Edition 1, pp. 121–127.

25. Maslak O.I., Grishko N.E., Maslak M.V., Pyrogov D.L. Information analytical provision in the formation of innovative projects portfolio of enterprises in the context of safety-oriented management. Financial and credit activities: problems of theory and practice. 2020. № 2 (33). pp. 205–214.

6 THE SUSTAINABLE DEVELOPMENT MECHANISM FOR THE AGRICULTURAL SECTOR

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The main purpose of sustainable development is to provide the population of the world with food, therefore, the problem of sustainable development for the agricultural sector is utterly relevant and developed at the sectoral level. We believe that it is the agricultural sector that is concerned with environmental and food issues most, since it is a complex system of agricultural production, environment and rural population.

Not only does the sustainable development of the agricultural sector in Ukraine ensure food security, which is a constituent of the state's economic security, but it also provides for the development of the economy as a whole. A necessary condition for sustainable development is positive dynamics of the economic potential of the agricultural sector, which is a set of all available means, opportunities, productive forces, resources, reserves and competencies that can be used in production activities and may utilize market opportunities in order to achieve the goals of society's socio-economic development.

The conceptual change of understanding the priorities of social and economic goals of development, the search for ways to move to the principles of sustainability are urgent for global development. According to modern scientists, it is possible to achieve sustainable development in three scenarios (Hopwood, 2005): 1) reducing the government regulation, increasing the role of informatization and implementation of new technologies will help achieve sustainable development goals without significant changes in government relations (liberal approach); 2) increasing the role of government regulation, technology and science through public administration reform (reformist approach); 3) transforming society's interaction with the environment through radical changes (transformist approach). The sustainable development mechanism for the agricultural sector should be considered through the interconnected structural components: economic, environmental, social, institutional and legal.

The content of sustainable development can be determined through formation of appropriate potentials of its components:

– the economic potential of sustainable development (a system of industrial relations that uses environmentally and socially dangerous means of production, safe resource-saving technologies; organization of production aimed at coordinating the economic, social and environmental outputs);

– the environmental potential («the ability of an ecosystem to continuously restore itself in those qualitative parameters that meet the requirements of social and economic development», whose basis is ensuring the conditions for restoration of natural resources, economical use of non-renewable resources and preservation of biological diversity);

– the social potential of sustainable development (human potential, human and intellectual capital, social consciousness, social infrastructure, social policy). A special role is assigned to accumulation of human capital within the framework of the theory of endogenous growth by improving the levels of education and science, creating and using new technologies and innovations, and developing corporate culture. In modern conditions, it is an effective corporate culture that not only performs the function of favorable social environment formation, but also attracts and maintains talents, develops human capital (Karpenko, 2017). Sustainable economic growth is based on knowledge, creativity (formulation of new ideas and their use to create cultural products and works of art, a capability of creating new technologies and making inventions) and access to information as components of the social potential of sustainable development.

We believe that the determining factor for achieving the goals of the agricultural sector's sustainable development is a system approach, according to which the components of sustainable development should develop in a comprehensive and coordinated manner, ensuring the efficient, secure production functioning, preservation and restoration of natural resources, quantitative and qualitative reproduction of labor potential.

In our opinion, the modern paradigm of the concept of the agricultural sector sustainable development fully corresponds to the new economic paradigm «The Economics of Happiness», which grounds on the state of well-being and environment, ensuring of material and spiritual satisfaction with life, provided that there is an optimal balance between the needs of society and limited resources. The production of high-quality food products within the reasonable use of natural resources is a necessary, but not sufficient, condition for improvement in the quality of life, since non-economic aspects of life determine its duration and quality as well as mental well-being of citizens. A human-centered economics of happiness changes the priorities of social existence and expands the interaction of the sustainable development components. It is the socio-economic model that comes to the fore and determines sustainable economic development: the alternative to the gross domestic product is the Human Development Index, which measures the people's capability of living a long, healthy, creative life. This model further develops the ideas of the Lukas and Romer endogenous growth models, according to which the main factor of economic growth is an increase in investments in human capital that ensures the scientific and technological progress.

Informed management decision-making in the context of sustainable development requires use of modern methodological tools for obtaining the results, which are difficult to obtain by applying traditional methods. We assume that in order to analyze the levers for economic growth of the agricultural sector in the context of sustainable development, the most successful model to be applied is the Robert Solow neoclassical growth model with a stable path of balanced development, according to which it is the efficient use of resources and technological progress that are the imperatives of economic growth.

Sustainable development of the agricultural sector not only guarantees food security as one of the components of general economic security of the state but also provides economic growth, rural development, stimulates the progress of other industries through a multiplier effect. The agricultural sector of Ukraine demonstrates positive dynamics due to the significant natural and human potential, as well as favourable climatic conditions. The objective construct «agricultural sector» is a system of agricultural production, environment and rural population; therefore, the agricultural sector is as close as possible to environ-mental and food challenges. The agricultural sector combines social, production, and environmental functions, sectoral and territorial aspects: the basic agricultural sector which generates the rural environment with the appropriate resource base (spatial, natural, and labour).

Ukrainian agricultural products occupy a significant share in the gross value added, which gives grounds for arguing about the prospects of increasing the volume of exported agricultural products under the optimal combination of production factors (Vasylieva, 2017). The transition to sustainable development principles, a new paradigm of social development, mainstreams the issue of effective interaction of production factors in the process of making a product in the economy. Sustainable economic growth is based on the involvement of endogenous factors that depend on human economic activity; their interaction within the endogenous theory can be described using the apparatus of the production function.

The investigation is aimed at assessing the impact of various factors (forms of capital) on the formation of gross value added and gross output of the agricultural sector of Ukraine's economy under sustainable development using the modified Cobb-Douglas production function.

Scholars consider sustainable development from the standpoint of preserving and increasing all types of capital for future generations (human, natural, and material) (Khvesyk, 2012).

The three-pronged concept of sustainable development originated from the provisions in the Proclamation of Teheran, Final Act of the International Conference on Human Rights in 1968; here, economic and social development was declared as imperatives for sustainable progress, as «ensuring human rights to life, consistent with freedom and dignity, contributing to physical, social and spiritual well-being» (Proclamation of Teheran, 1968). For the first time, development was additionally considered a means to ensure human rights and freedoms, including peaceful and secure existence.

Originating of the modern concept of sustainable development is associated with the Declaration of the UN Conference on the Human Environment (Stockholm, 1972), which emphasizes the relationship of economic and social development with environmental issues, and the famous report to the Club of Rome «The Limits to Growth» (1972) prepared by Dennis Meadows, which addresses the impact of global environmental constraints on resource use and emissions in the 21st century on global development. D. Meadows' study concludes that humanity needs to make a «controlled orderly transition from growth to global equilibrium» (Meadows, 1991). «The Limits to Growth» formulates the ideas of the transition of civilization from quantitative growth to «organic» (qualitative) and «new world economic order» with deep, proactive social innovation through technological, cultural and institutional changes to avoid the growth of negative environmental impact without respecting the Earth's ecological limits (Meadows, 2018).

Accelerated degradation of the natural environment as a result of human activities poses a global threat to humanity. In 1987, the UN World Commission on Environment and Development, in a report by the Chairman of the World Commission on Environment and Development, Prime Minister of Norway Gro Harlem Brundtland «Our Common Future», justified the need to find a new model of civilization development. The model indicated that the needs of modern generations should not jeopardize the interests of future generations in the realization of their needs and opportunities. According to G. H. Brundtland, the history of humankind reached a level at which a change in political priorities was inevitable: savings from arms reduction can be used to finance environmental security measures. G. H. Brundtland introduced the term «sustainable development», which implied a «model of development, where the satisfaction of the vital needs of the present generation was achieved without depriving future generations of such an opportunity» (Koptug, 1997). The Brundtland Commission defined the concept of sustainable development under globalization, technological and social factors from the standpoint of overcoming poverty through respecting ecological limits to meet the needs of present and future generations. Consequently, G. H. Brundtland's anthropocentric approach to sustainable development, in which the environment was a means of human existence, comprised a relationship of needs and constraints (Slavgorodska, 2016).

The participants of the UN Conference on Sustainable Development «Rio+20» (2012) in the Rio de Janeiro Earth Summit recognize that fair and sustainable use of resources is the key factor in choosing a path to a safer, cleaner and more prosperous world for all (United Nations Conference on Sustainable Development, 2012). The Resolution «The Future We Want» adopted by the General Assembly (Resolution adopted by the General Assembly, 2012) emphasizes the following aspects: the recognition of the need to further promote the idea of sustainable development at all levels; integration of its economic, social and environmental components; taking into account the relationship of the latter in order to achieve the goals of sustainable development in all the aspects.

Consequently, sustainable development should not focus exclusively on environmental aspects; it is considered in terms of harmonization of resource use, innovation and investment processes, institutional change with the needs of present and future generations.

The positive dynamics of the economic potential of the agricultural sector as a set of all available means, opportunities, productive forces, resources, stocks, competencies that can be used in production and realize market opportunities to achieve socio-economic development is a necessary condition for sustainable development (Vasylieva, 2019).

The production potential of agricultural production can be determined in terms of a hybrid approach, which includes resource (as a set of production resources) and effective (as the creation of a certain amount of material goods) approaches: the ability to produce a certain amount of material goods through the use of limited interconnected resources (Suvorov, 2020).

At the end of the XX century, the pace of economic development in the leading countries of the world was mainly stipulated by contribution of the intensive factors associated with the emergence of new technologies rather than by the number of people employed and increase in investments. American economists G. Mankiw, D. Romer and D. Weil proposed that the quality of labor force should be taken into account in the model of economic growth, introducing the factor of intellectual capital, which included the cost of education, publication of scientific literature, construction, material and technical resources of educational institutions, etc. (Mankiv, 1992). In the theory of economic growth, P. Romer (Romer, 1996) distinguished two different types of production factors: tangible and intangible. The scientist believed that the emergence of new ideas and technologies (intangible resources) leads to the transformation of material resources into more valuable ones. S. Oliner and D. Sichel, based on the analysis of the reasons for the 1995-1999 acceleration of scientific and technological progress in the United States and on the assessment of the production function parameters, considered information technologies to be a separate significant factor of economic growth (Oliner, 2000). Modification of the production function and consideration of the qualitative parameters of labor potential have resulted from the emergence of the ideas of human capital accumulation at the end of the XX century, which became the basis for models of endogenous scientific and technological progress, according to which technology and knowledge are a public good, and technological progress is the result of knowledge accumulation.

Since human capital is defined as individuals' knowledge, education and competences in the implementation of national goals and objectives (mainly based on intangible resources and hidden opportunities), the model of its assessment should include qualitative and quantitative indicators. At the same time, the development potential is represented by intellectual capital, which is considered a key factor for success (Vasyl'yeva, 2021a).

Not only have the large-scale and multi-vector changes of recent decades transformed a significant part of the world's socio-economic processes, but they have also expanded and deepened the existing risks. The rate of changes has accelerated significantly, and competitiveness has increasingly become determined by the intellectual grounds of capital. It is an economically active person who is the main basis for innovative changes and economic development.

Today, we observe intellectualization of the economy, with an objective process of expanding the conditions for using people's intellectual and creative abilities being underway, with scientific knowledge and specialized unique skills of their possessors becoming the main source and key factor in the development of material and non-material production, in ensuring sustainable economic development. It is determined that the educational, intellectual, and creative potentials of a person are not only a powerful factor of economic growth, but also a source of income at all levels: of a person, of an enterprise and of a state.

The results of studying various approaches to the definition and structuring of human potential allow us to state that the majority of them consider the intellectual component to be the most essential. The due regard for this component and its analysis enables distinguishing intellectual assets, that is, exactly that part of human potential that can be further capitalized and is capable of ensuring creation of added value which will determine the competitiveness level at both micro and macro levels in the future.

In our opinion, intellectual assets can be defined as an economic category that reflects the process of transformation of part of human potential capable of development and changes into other capital of economic units. Intellectual assets represent an integrated category that includes the intellectual capital objects already reflected in accounting (intangible assets), and those that should be included in the accounting system (customer relations, marketing, technology improvement, training and development of personnel, development of new products and services).

It is determined that intellectual assets are a universal resource with a unique character in terms of increasing the income and value of an enterprise. Intellectual assets act as a form of embodiment of possible future benefits and can make profits. The intellectual assets’ capability of bringing economic benefits is one of the main conditions for their involvement into economic turnover. The possibility of alienating these assets to other entities by transferring different amounts and nature of rights enables their wider use in the process of commercialization through involvement of necessary economic entities. Thus, formation of intellectual assets and their effective use is an important strategic area of a company's development, which should be taken into account when drawing up financial budgets and disseminating information about the company’s activities. Accounting for intellectual assets contributes to capitalization of the company, maximizing its market value. An increase in the company’s value contributes to ensuring sustainability and further development through a greater opportunity to attract investment resources.

Intellectual assets of human potential can be defined both as individual elements of human potential and outcomes of this potential capitalization in activities. These are separate elements of human potential that gradually accumulate and transform starting from the very birth of a person during his/her upbringing, cultural development and involvement in a healthy lifestyle, while obtaining education and professional training, and also these are intellectual outcomes of human activities. Intellectual assets of human potential are considered as competencies (cognitive, emotional, creative), since they have an intangible nature, and as outcomes of intellectual activities (intangible and tangible forms) (Karpenko, 2018).

The intellectual assets of the human potential in Ukraine are estimated by the following indicators:

– the share of employees engaged in professional, scientific and technical activities to the total number of employees, %;

– the share of those employed in education to the total number of employees, %;

– the share of candidates and doctors of sciences in the total number of employees, %;

– the share of employees involved in scientific research and development in the total number of employees, %;

– the number of researchers per 1000 people of the employed population (aged 15-70), persons;

– the ratio of the average number of employees who used a computer with internet access to the average number of employees who used a computer, %);

– the number of people using broadband internet access, per 100 people of the population, persons;

– the specific weight of innovative products sold in the industrial production volume, %;

– the number of patents for inventions received per 1 million people, units;

– the number of utility patents received per 1 million people, units;

– the number of design patents received per 1 million people, units;

– the number of certificates for trademarks and service marks per 1 million people, units;

– the number of patents received in the United States per 1 million people, units.

The measurement of these indicators enabled determination of the integral coefficients for the intellectual assets of Ukraine's human potential (Karpenko, 2018).

For forecasting in macroeconomics, the apparatus of production functions describing complex production processes is used. The production function is a complex model of economic dynamics that characterizes the economic and mathematical dependence of output (quantity of products) on the factors of production used (resources, technology). The classical equation of the production function for agricultural production includes factors of economic growth: production assets K (area of agricultural land, the number of fixed and production assets in value form), total living labour costs L (number of employees in agriculture, working time) and other factors that take into account technical progress N:

$$Y = f\,(K,L,N) \tag{1}$$

In the macroeconomic analysis, CES-function (Yankovyi, 2015) with constant elasticity of substitution of resources is used for economic and mathematical modelling:

$$Y = A[\alpha K^{-\rho} + (1-\alpha)L^{-\rho}]^{-\gamma/\rho}, \tag{2}$$

where Y is the production in monetary terms, K is a cost of capital, L is labour costs, A is a scale factor, α is a weighting coefficient of the production factor, γ is an indicator of the degree of uniformity, ρ is a production function parameter.

At ρ = -1, CES-function has the form of a linear equation (elasticity of substitution is unlimited):

$$Y = a_1 K + a_2 L, \tag{3}$$

where a_1, a_2 are parameters that characterize the qualitative impact of each factor.

At $\rho \to 0$, CES-function becomes the Cobb-Douglas production function (elasticity of substi-tution tends to 1):

$$Y = a_0 K^{a_1} L^{a_2}, \tag{4}$$

where a_0 is a parameter that characterizes the level of technology, a_1 and a_2 are coefficients that characterize the contribution of capital and labour to output growth. a_1, a_2 parameters of the estimation model characterizes the production elasticity by resources, i.e., the quantitative relationship between production volumes in accordance with resources in relative (percentage) terms.

At $\rho \to \infty$, CES-function becomes the Leontief production function with constant proportions of production factors (zero elasticity of substitution):

$$Y = A\, min(\frac{K}{K_0}; \frac{L}{L_0}) \tag{5}$$

For the classical Solow growth model that considers the influence of key production factors on output dynamics, Solow (1961), Barro (2010), and Lyashenko (2013) propose to use the Cobb-Douglas production function with the possibility and limitation of substitution, which is the most adequate model in terms of identifying potential sources of growth. The two-input Cobb-Douglas production function is considered classic; here capital and labour are considered resources (Cobb, 1928). Further research leads to the creation of a modified production function that takes into account the exogenous neutral factor (Solow, 1957; Arrow, 1961), entrepreneurial skills and innovation (Schumpeter, 1934), human capital (Romer, 1986; Lukas, 1988), intellectual and social capital (Kramin, 2016). In the model of economic growth, the American economists Mankiw, Romer and Weil (1992) focuse on the quality of the workforce and introduce a factor of intellectual capital which includes the cost of education and science. Romer (1996) believes that the emergence of new ideas and technologies (intangible resources) leads to the creation of more valuable material resources. Oliner and Sichel (2000) consider information technology an important factor in economic growth and technological progress. Solow (Solow, 1956, 1957) proposes to take into account technological progress, which is the main reason for productivity growth and development of the US economy in the first half of the 20th century by changing the quality characteristics of labour potential and improving labour organization (training, improving production etc.). In this case, the endogenous production function may include three main factors: labour (*L*), physical capital (*K*) and skill level (*H*) (Moreno-Hurtado, 2018, p. 172).

In the economic literature there is a general consensus on innovations that play an important role in increasing the competitiveness of firms, industries, regions, and countries (Asheim et al., 2011, p. 1133–1139; Tödtling & Grillitsch, 2015, p. 1741-1758; Zygmunt, 2019, p. 292), and contribute to sustainable development (Klewitz & Hansen, 2014; Zygmunt, 2020). It is the availability of intellectual assets as important indicators of innovation efficiency that is crucial for economic growth (Zygmunt, 2019). Novakova (2020, p. 11) also concludes on the importance of increasing investment in human development, improving cognitive skills as a prerequisite for sustainable economic development. Marynych (2017) confirms the positive effect of education as a factor of human capital and the untapped potential of the technological factor in ensuring sustainable development of the region. To determine the growth model of the Russian economy Glinskiy et al. (2018) uses the modified Cobb-Douglas production function that includes an innovation factor. For forecasting the economic growth of Ukraine's agricultural sector, Odintsov et al. (2020, p. 153) propose to expand the typical Cobb-Douglas production function due to the «exponential factor of land resources, the cost of innovation and the parameters of state regulation of the tax system (the function includes salary, capital investments, land resources, financing of innovation activities in the agricultural sector of the economy and the tax burden on the industry)».

Sustainable development involves the relationship between economic benefits and environmental impacts. Lyashenko (2012, p. 187) proposes to use the ecological and economic balance taking into account the efficient use of resources and minimization of pollutant emissions. The agricultural sector produces 90% of nitric acid emissions, 70% of methane and 20% of carbon dioxide emissions worldwide (Çetin, 2020). In this case, we believe that to study the factors of sustainable development it is advisable to use environmental and economic production function, including an indicator of environmental pollution as an exogenous factor that negatively affects the results of agricultural production. Yang et al. (2020, p. 166) use both the quantitative and qualitative parameters of labour and environmental impact in the Cobb-Douglas production function to study the sustainable development of China's economy. The authors believe that the main drivers of China's economic growth are physical and human capital, as well as the minimization of environmental pollution to achieve sustainable development. In «The core function of sustainable development» (2015), Tkach proposes a basic function of sustainable development under the information economy, a partial case of which is the modified Cobb-Douglas function, which includes different types of capital: physical, natural, human and information. Dedrick (2003) and Gosinska (2020) use gross value added, which is the main indicator for assessing the performance of the industry and the economy as a whole, as a performance indicator.

To obtain maximum profit in terms of sustainable development we should apply the methodology of construction of the production function, which allows to determine the optimal combination of resources taking into account economic, social and environmental factors. Based on previous studies, we propose to use the four-input Cobb-Douglas production function in terms of sustainable development of agriculture to take into account not only the quantitative parameters of labour potential but also its qualitative indicators (integral coefficient of intellectual assets), as well as environmental impact:

$$Y = a_0 K^{a_1} L^{a_2} I^{a_3} E^{a_4} \quad (6)$$

where Y is the performance indicator (output), K is a fixed capital or fixed assets used (capital investment), L is the living labour costs (number of employees in agriculture), I is an integral coefficient of intellectual assets, E is the pollutant emissions, a_0 is a technological coefficient that characterizes the efficiency of production, takes into account the complex influence of qualitative determinants of labour potential, the influence of factors that cannot be quantified (a technical progress indicator); a_i are the coefficients of elasticity that characterize the contribution of capital, labour, intellectual assets and pollutant emissions to growth of the output Y (i.e., a_i are fractions of factors).

The sum of the elasticity coefficients $a_1 + a_2 +\ldots+ a_n$ characterizes the economies of scale (Kuzmin, 2020, p. 787):

– increasing returns to scale if $a_1 + a_2 +\ldots+ a_n > 1$ (intensive economic growth), the function grows disproportionately, product growth outpaces the growth of factor costs;

– constant returns when changing the scale of production if $a_1 + a_2 +\ldots+ a_n = 1$ (extensive economic growth), the Cobb-Douglas production function is linearly homogeneous, the level of resource efficiency does not depend on the scale of production;

– returns to scale decrease if $a_1 + a_2 +\ldots+ a_n < 1$ (lack of economic growth), the function decreases disproportionately, the increase in the factor costs is accompanied by a slowdown in output growth.

Kuzina (2018, p. 73) defines the main characteristics of the Cobb-Douglas production function: it is increasing, has no extremes, the rate of output slows down with increasing resources, output increases indefinitely with unlimited growth of one of the resources.

The advantages of the Cobb-Douglas production function include the following aspects:

– the form of the Cobb-Douglas production function is relatively simple to use, which allows you to easily determine the indicators of productivity and return on assets, the output elasticity for all parameters, the marginal rates of substitution;

– the Cobb-Douglas production function is able to describe the state of returns to scale, regardless of they increase, are stable or decrease;

– practical universality and adequacy: the Cobb- Douglas production function coefficients directly describe the elasticity of each input factor used;

– macroeconomic orientation: it is based on real economic indicators of official statistical reporting and can be easily parameterized using correlation and regression analysis;

– realism: the functional dependence of the result on costs is nonlinear and does not contain the shortcomings characteristic of linear production functions that describe the processes of an ideal economy.

Despite these advantages, the production function also has a number of disadvantages:

– the production function with the constant economies of scale may inadequately reflect the production process (in conditions of intensive growth of factors, the economies of scale are greater than 1);

– this is based on the assumption of full interchangeability of production resources;

– determining the parameters of the production function is based on marginal prices of factors equal to average prices and calculated on the basis of market prices; this is possible in conditions of perfect competition and market, not in the real economy;

– the principle of complementarity that takes into account the capital structure is ignored.

For conducting an empirical study of the agricultural sector of the economy and the construction of the production function, the relationship between the basic production resources (labour, capital, intellectual assets and emissions of pollutants) and output was used. In a market economy, the main indicator of the degree of development of the industry is gross value added, which reflects the possibility of expanding production. In this case, gross value added and gross output of agriculture are considered performance indicators.

The model considered in the work uses the data of the annual reports of the State Statistics Service of Ukraine (2020): gross value added, gross output of agriculture *Y(T)*, the amount of fixed capital *K(T)*, the number of employees in agriculture *L(T)* and pollutant emissions *E(T)*; indicators of the integral coefficient of intellectual assets *I(T)* given in the paper by Karpenko (2018). The statistics shown in Table 1 were used to calculate the Cobb-Douglas production function with the performance indicator «gross value added».

Correlation and regression analysis is used to determine and verify the parameters of the production function. The approximation of well-known power functions in the Cobb-Douglas production function helps mitigate mistakes and close in on real values.

For the calculation, the logarithm of both parts of the equation of the production function is taken:

$$\ln Y = \ln a_0 + a_1 * \ln K + a_2 * \ln L + a_3 * \ln I + a_4 * \ln E .$$

After appropriate replacements, a linear function is obtained:

$$Y_1 = a_0 + a_1 * X_1 + a_2 * X_2 + a_3 * X_3 + a_4 * X_4 \text{, де } a_0 = \ln a_0 .$$

After calculations using linear regression analysis by the method of least squares, the values of the coefficients of the Cobb-Douglas production function are determined. The production function obtained takes the form:

$$Y = 422388 K^{0,34474} L^{2,63344} I^{1,60806} E^{-2,86638} \tag{7}$$

To assess the calculated production function (7), the parameters of regression analysis are studied. The multiple correlation coefficient is R = 0.983, the standard approximation error is 0.148. Fisher's F-criterion calculated is 46.71 and is greater than Fisher's F-criterion tabular (99% confidence, reliability), which is 8.45 (Table 2). Therefore, the regression equation obtained can be considered significant. This means that with a 99% probability the found Cobb-Douglas production function (3) corresponds to the initial data of the problem.

Table 1 - Statistics for calculations of the production function (*Y(T)* is the gross value added)

T, year	*Y(T)*, mln UAH	*K(T)*, mln UAH	*L(T)*, thous persons	*I(T)*	*E(T)*, thous t	y_1=ln*Y*	x_1=ln*K*	x_2=ln*L*	x_3=ln*I*	x_4=ln*E*
2008	65148	16682	3322,1	0,5	7210,3	11,1	9,7	8,1	-0,6	8,9
2009	65758	9295	3152,2	0,5	6442,9	11,1	9,1	8,1	-0,7	8,8
2010	82948	11311	3115,6	0,6	6678,0	11,3	9,3	8,0	-0,4	8,8
2011	109961	17981	3410,3	0,6	6877,3	11,6	9,8	8,1	-0,6	8,8
2012	113245	18564	3506,7	0,6	6821,1	11,6	9,8	8,2	-0,5	8,8
2013	132354	18175	3389	0,6	6719,8	11,8	9,8	8,1	-0,5	8,8
2014	161145	18388	3091,4	0,6	5346,2	12,0	9,8	8,0	-0,5	8,6
2015	239806	29310	2870,6	0,5	4521,3	12,4	10,3	8,0	-0,7	8,4
2016	279701	49660	2866,5	0,5	4498,1	12,5	10,8	8,0	-0,7	8,4
2017	303949	63401	2860,7	0,5	3879,1	12,6	11,1	8,0	-0,8	8,3
2018	360757	65059	2937,6	0,4	3866,7	12,8	11,1	8,0	-0,8	8,3

Table 2 - Regression analysis parameters for Y(T) (gross value added)

Multiple correlation coefficient *R*	0.983
Coefficient of determination R^2	0.966
Standard approximation error	0.148
Fisher’s F-criterion calculated F_{calc}	46.71
Fisher’s F-criterion tabular F_{tab}	8.45
Number of observations	11

Thus, the constructed production function has reliable statistical characteristics. The value of the multiple correlation coefficient indicates a high close relationship between the performance indicator and the selected factors, the variation of gross value added by 98.3% depends on the fluctuations of the factors included in the equation and only 1.7% depends on factors that are not taken into account. The value of the coefficient of determination R^2 (0.966) is quite close to 1, so the regression model is successful, and the relationship between the resulting indicator of the production function and the input factors is strong. Variance of the output *Y(T)* is due to the regression of the selected levers of influence *(K, L, I, E)* by 96.6 %. This confirms that the model takes into account the most important factors. In addition to the multiple correlation coefficient, the adequacy of the equation is evidenced by the small value of the average approximation error, which characterizes the average relative deviation between the actual and theoretical values based on the equation constructed (Figure 1). Thus, equation (7) meets all the requirements and can be used for economic analysis.

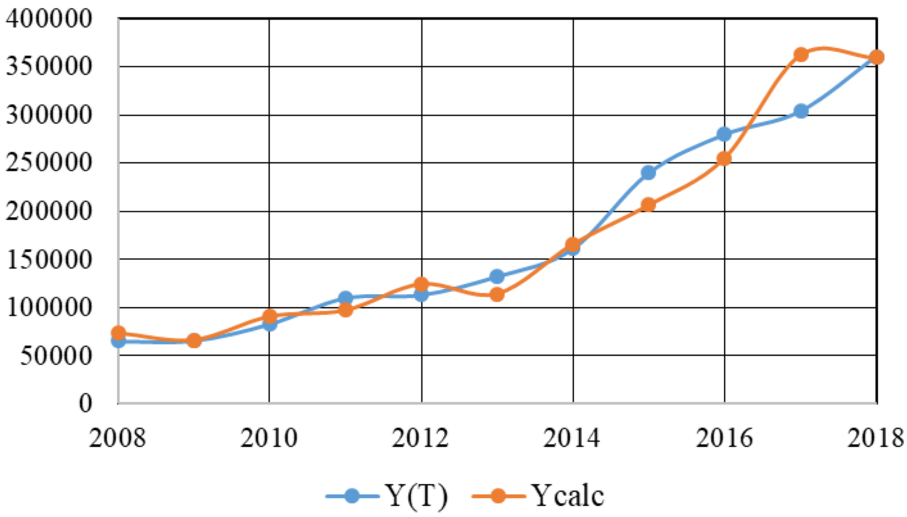

Figure 1. Results of the approximation of the Cobb-Douglas production function for gross value added

The analysis shows that the growth of quantitative and qualitative indicators of labour potential of the agricultural sector has a direct impact on the growth of gross value added of agricultural products, as there is a direct relationship between them.

The economic analysis of the Cobb-Douglas production function can be performed on the basis of elasticity coefficients that reflect the nature of the influence of factors on performance. For example, the elasticity coefficient a_1 = 0.34474 (7) shows the elasticity of agricultural production relative to capital investment with a constant number of employed persons in rural areas, the integral coefficient of intellectual assets and pollutant emissions. If capital investment increases by 1%, the gross value added of agriculture should be expected to grow by 0.34474%. The elasticity coefficient a_2 = 2.63344 (7) indicates the output elasticity relative to the number of employed persons in rural areas with constant capital investment, the integral coefficient of intellectual assets and pollutant emissions, i.e., with an increase in the number of employed persons in rural areas in agriculture by 1% gross value added of agriculture should increase by 2.63344%. The elasticity coefficient a_3 = 1.60806 (7) reflects the elasticity of production relative to the integral coefficient of intellectual assets with a constant amount of capital investment, the number of employed persons in rural areas and the number of pollutant emissions, i.e., if the integral coefficient of intellectual assets increases by 1%, an increase in gross value added by 1.60806% should be expected. The elasticity coefficient a_4 = -2.86638 (7) shows the elasticity of production relative to pollutant emissions with constant capital investment, employed persons in rural areas and the integral coefficient of intellectual assets, i.e., with an increase in pollutant emissions by 1%, reduction of agricultural output by 2.86638% should be expected. The value of the technological coefficient $a0$ obtained (422388) is much more than 1. We can justify a significant impact of technical progress on the growth of gross value added in agriculture.

This means that the increase in gross value added is, firstly, due to an increase in the number of employees ($a_2 > a_1$); secondly, this is possible due to improving the quality characteristics of labour potential ($a_3 > a_1$). This type of economic growth cannot be called labour-saving; according to Solow, the transition to a model of the production function with scientific and technological progress requires qualitative changes in production processes, improving the efficiency of labour resources and productivity.

Thus, the most significant in the economic growth of agricultural production are quantitative and qualitative indicators of labour potential: the number of employed persons (L) and the integral coefficient of intellectual assets (I), while the capital factor is less influential. This reveals the need to update the issue of priority of development of labour potential of the agricultural sector.

Aggregate influence of factors $(a_1 + a_2 + a_3 + a_4)$ exceeds 1: $(a_1 + a_2 + a_3 + a_4) = 1{,}72 > 1$. This indicates the positive strength of their influence; the resulting production function describes the growing economy (Pshenychnykova, 2017) within the endogenous model of growth. The economic development of agriculture mainly has the characteristics of a large-scale economy: at the current level of science and technology, it is advantageous to expand production for increasing output.

Similarly, there is conducted a study of the Cobb- Douglas production function, which considers the gross output of agriculture Ukraine a performance indicator (*Y(T)* is the gross output of agriculture, in constant prices of 2010) (Table 3).

Table 3 Statistics for calculations of the production function (*Y(T)* is the gross output)

T, year	*Y(T)*, mln UAH	*K(T)*, mln UAH	*L(T)*, thous persons	*I(T)*	*E(T)*, thous t	y_1=ln*Y*	x_1=ln*K*	x_2=ln*L*	x_3=ln*I*	x_4=ln*E*
2008	101451	16682	3322,1	0,5399	7210,3	11,5	9,7	8,1	-0,6	8,9
2009	96274	9295	3152,2	0,5120	6442,9	11,5	9,1	8,1	-0,7	8,8
2010	90792	11311	3115,6	0,6479	6678,0	11,4	9,3	8,0	-0,4	8,8
2011	117111	17981	3410,3	0,5566	6877,3	11,7	9,8	8,1	-0,6	8,8
2012	110072	18564	3506,7	0,6072	6821,1	11,6	9,8	8,2	-0,5	8,8
2013	133683	18175	3389	0,5956	6719,8	11,8	9,8	8,1	-0,5	8,8
2014	139058	18388	3091,4	0,5793	5346,2	11,8	9,8	8,0	-0,5	8,6
2015	131919	29310	2870,6	0,5031	4521,3	11,8	10,3	8,0	-0,7	8,4
2016	145119	49660	2866,5	0,5093	4498,1	11,9	10,8	8,0	-0,7	8,4
2017	140535	63401	2860,7	0,4632	3879,1	11,9	11,1	8,0	-0,8	8,3
2018	158307	65059	2937,6	0,4363	3866,7	12,0	11,1	8,0	-0,8	8,3

After performing the calculations using the method of least squares, the desired Cobb-Douglas production function takes the following form:

$$Y = 341K^{0,08353}L^{1,70970}I^{0,32224}E^{-0,98789} \quad (8)$$

The multiple correlation coefficient is *R*=0.892, the standard approximation error is 0.107. Fisher’s F-criterion calculated is 9.26 – this is greater than Fisher’s F-criterion tabular (99% confidence, reliability), which is 8.45. This gives a 99% probability that the found Cobb-Douglas production function (8) corresponds to the initial data of the problem. Therefore, the constructed production function has satisfactory statistical characteristics (Table 4). The value of the multiple correlation coefficient indicates that the variation in the volume of gross output by 89.2% depends on the fluctuations of the factors included in the equation and depends by 10.8% on the factors that are not taken into account. Coefficient of determination R^2 has a satisfactory value (0.796), the variance of the output *Y(T)* is due to the regression of the selected levers of influence (*K*, *L*, *I*, *E*) by 79.6 %.

Based on the actual values of gross output and their calculated values, a graphical model of the results of the Cobb-Douglas production function approximation is obtained (Figure 2). In addition to the multiple correlation coefficient, the high degree of accuracy of the regression equation is evidenced by a slight deviation of the calculated values from the actual ones.

Thus, in equation (8) the elasticity coefficients a_2 = 1.70970 and a_4 = -0.98789 reflect the influence of factors on performance. Because of a_2 far exceeds 1, the main role in the growth of agricultural production is played by the number of the employed persons. In the case of an increase in the number of employees in agriculture by 1%, an increase in gross output of agriculture by 1.70970% should be expected. The elasticity coefficient a_4 is negative; therefore, the quantity and quality of labour are influenced by environmental factors, namely – pollutant emissions deteriorate the quality of life of the rural population and have a negative impact on crop yields. The sum $(a_1 + a_2 + a_3 + a_4) = 1{,}13 > 1$ shows the increasing effect of the economies of scale (value $f(x_i)$ increases more than value x_i), the growth of production outpaces the increase in cost factors, with the expansion of production, the average cost of resources per unit of output decreases.

The significant deviation of the elasticity coefficients (8) from 1 can be explained by the fact that other factors, such as political, social and administrative, can have an impact on the situational variable.

The production functions obtained can be represented by the isoquant curve, which demonstrates different combinations of factors of production function (capital, labour, intellectual assets, environmental factor) in a particular state of technological development, i.e., it illustrates the elasticity of factor substitution, the intensity of various factors in the production process.

Table 4 Regression analysis parameters for Y(T) (gross output)

Multiple correlation coefficient *R*	0.892
Coefficient of determination R^2	0.796
Standard approximation error	0.107
Fisher's F-criterion calculated F_{calc}	9.26
Fisher's F-criterion tabular F_{tab}	8.45
Number of observations	11

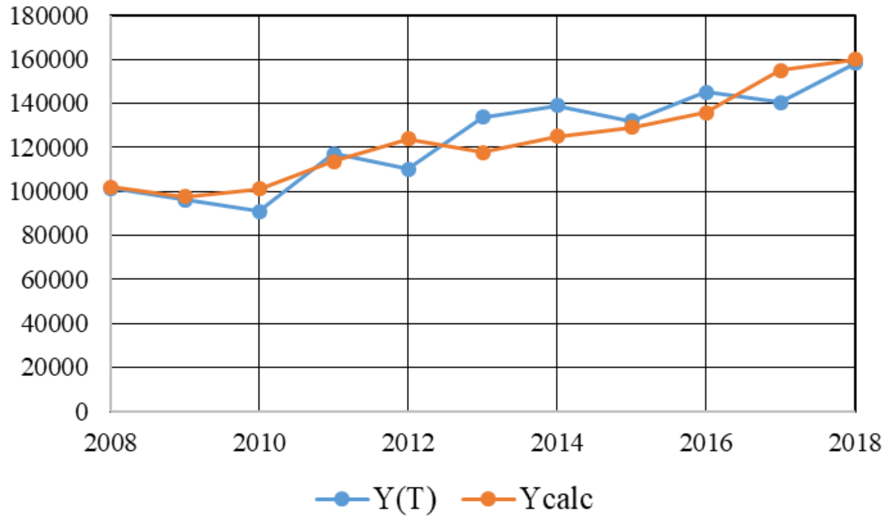

Figure 2. Results of the approximation of the Cobb-Douglas production function for gross output

The resulting output indicator *Y* (gross output of agriculture) and the value of levers of economic growth (*K, L, I, E*), for example, at the level of 2015, are recorded for the analysis of the production function (8). The equation of the balance of fixed capital (*K*) and labour (*L*) at fixed values of other factors (*I, E*) for the production function (8) has the following form::

$$K = \left(\frac{Y}{a_0 + L^{a_2} + I^{a_3} + E^{a_4}}\right)^{\frac{1}{a_1}} \tag{9}$$

The isoquant that meets these conditions is shown in Figure 3. The curve indicates the substitution by capital (*K*) within certain limits of labour (*L*) and vice versa. The slope of the tangent to the isoquant (isocost), plotted at the point of the optimal ratio of capital and labour (Yankovyi, 2018, p. 374), gives evidence of the capital-intensive technical progress – the technological choice is shifted to capital as a more productive factor.

There is the equation of isoquant at fixed values of fixed capital (K) and pollutant emissions (*E*):

$$L = \left(\frac{Y}{a_0 + K^{a_1} + I^{a_3} + E^{a_4}}\right)^{\frac{1}{a_2}} \tag{10}$$

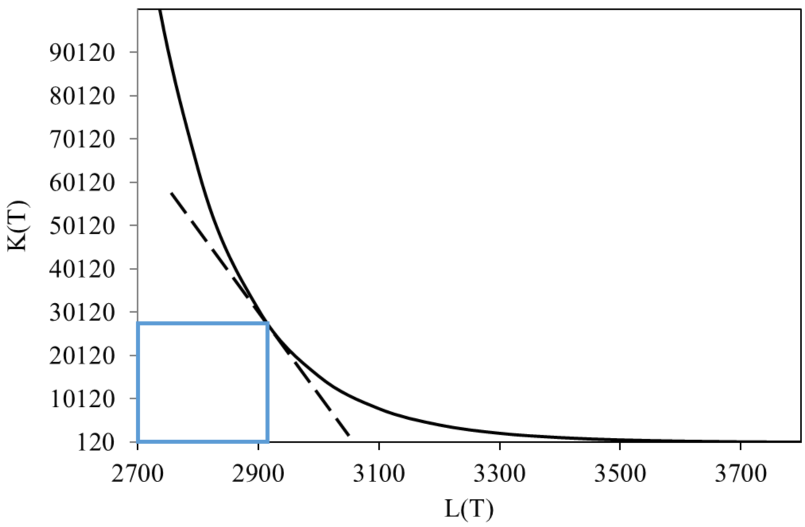

Figure 3. Balance of fixed capital (*K*) and labour (*L*) at fixed values of factors (*I*, *E*)

Figure 4 shows the curve of the balance of labour (*L*) and the integral coefficient of intellectual assets (*I*). The shape of the isoquant indicates a perfect substitution of the production function *L* and *I* (insufficient amount of labour potential can be substituted by higher indicators of education, qualifications, abilities of workers), constructed tangent determines the qualitative indicators of labour potential (*I*) a more productive factor in technical progress. The isoquant described by equation (9) is shown in Figure 5 also confirms the advantage of qualitative characteristics of human capital over material resources: insufficient amount of fixed capital can be partially offset by the growth of intellectual assets. The shapes of the isoquants in Figures 4 and 5 are close to linear isoquants. This demonstrates the perfect substitution of the factors of labour (*L*) and capital (*K*) with the factor *I* and vice versa. This also confirms the importance of intellectual assets in production.

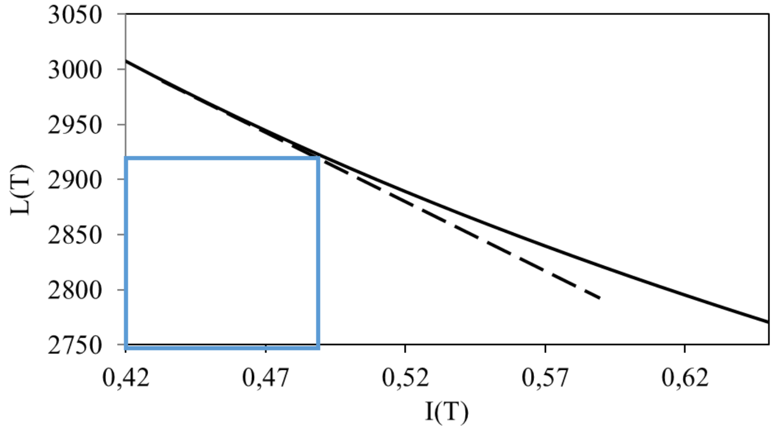

Figure 4. Balance of labour (*L*) and the integral coefficient of intellectual assets (*I*) at fixed values of factors (*K*, *E*)

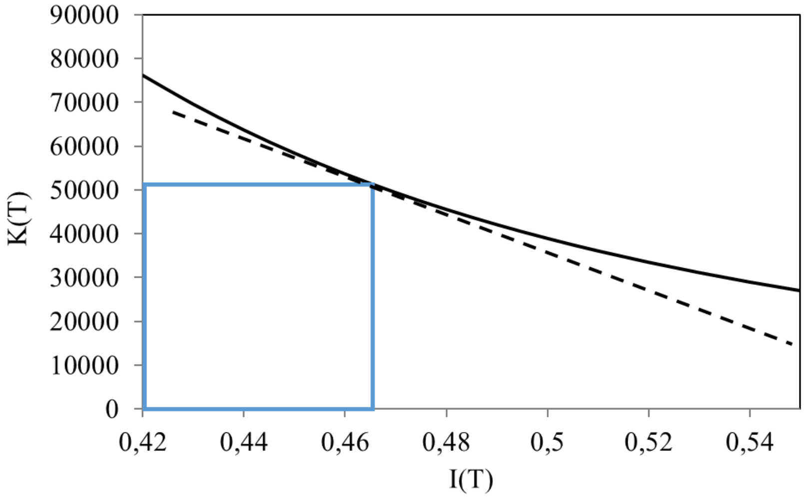

Figure 5. Balance of labour (*K*) and the integral coefficient of intellectual assets (*I*) at fixed values of factors (*L*, *E*)

The equation of isoquant at fixed values of fixed capital (*K*) and the integral coefficient of intellectual assets (*I*) is described by formula (10). Figure 6 shows the curve of the balance of labour (*L*) and pollutant emissions (*E*), which reflects zero probability of substituting these two factors with each other. The shape of the balance curve of the capital (*K*) and pollutant emissions (*E*) built on equation (9) also confirms the impossibility of substitution (Figure 7).

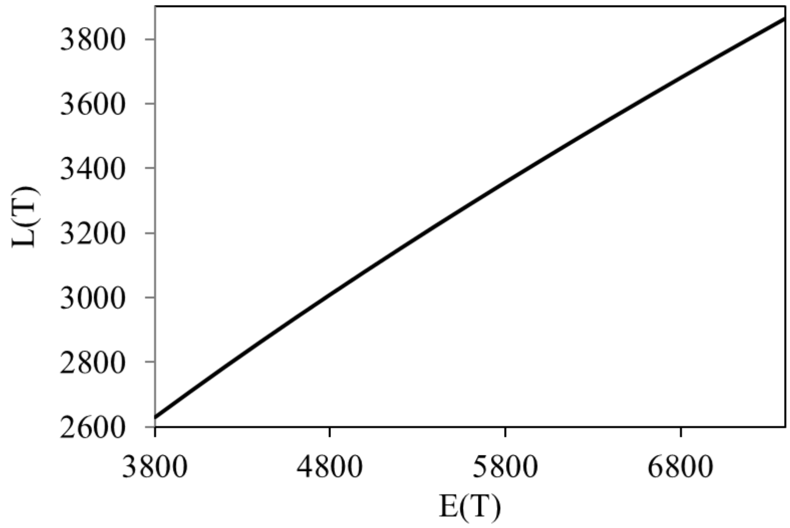

Figure 6. Balance of labour (*L*) and pollutant emissions (*E*) at fixed values of factors (*K*, *I*)

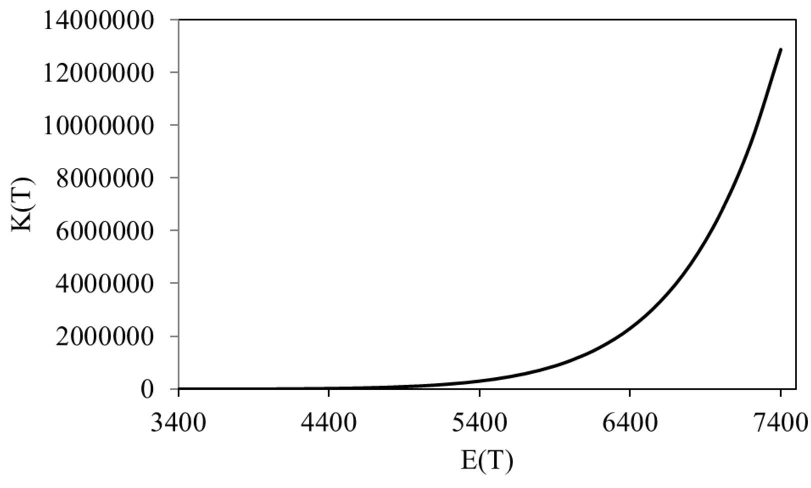

Figure 7. Balance of labour (*K*) and pollutant emissions (*E*) at fixed values of factors (*L*, *I*)

Therefore, the isoquant variations shown in Figures 6 and 7 reflect the impossibility of combining factors of production with the factor «pollutant emission (*E*)», we believe that the environmental factor makes a significant negative contribution and must be taken into account in the model of economic growth described by the production function.

Since the four-factor Cobb-Douglas production function (8) is used for analysis, it is expedient to consider isoquants in the form of 3D surface (balance of three factors with one fixed factor) for a more detailed assessment of its adequacy.

Balance function of fixed assets (*K*), labour (*L*) and the integral coefficient of fixed assets (*I*) at a fixed value of pollutant emissions (*E*) takes the form of the equation (9). The isoquant that meets these conditions is shown in Figure 8. The isoquant surface indicates the importance of the factors *L* and *I*.

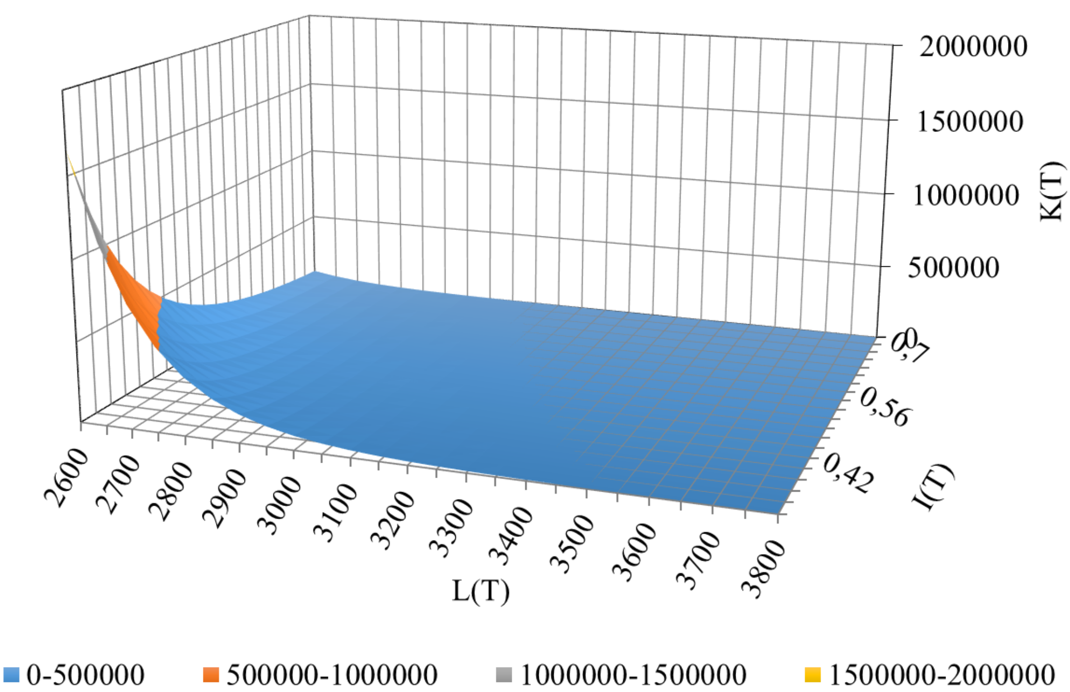

Figure 8. Balance of the fixed assets (*K*), labour (*L*) and the integral coefficient of intellectual assets (*I*) at fixed values of pollutant emissions (*E*)

Equation of the balance of fixed capital (*K*), pollutant emissions (*E*) and the integral coefficient of intellectual assets (*I*) at the fixed value of employees (*L*) is described by formula (9), and is represented in Figure 9 as a surface. The shape of it shows a significant negative impact of increasing pollutant emissions (*E*) and the positive effect of the growth of the integral coefficient of intellectual assets (*I*).

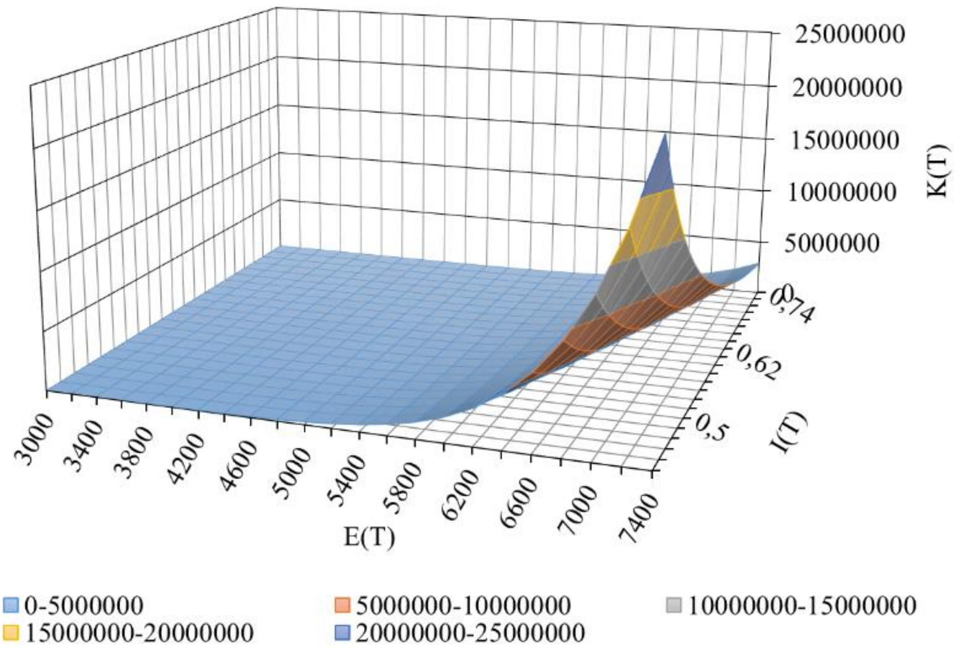

Figure 9. Balance of the fixed assets (*K*), pollutant emissions (*E*) and the integral coefficient of intellectual assets (*I*) at a fixed value of the employees (*L*)

Figure 10 shows the surface of the balance of fixed capital (*K*), labour (*L*) and pollutant emissions (*E*) at fixed values of the integral coefficient of intellectual assets (*I*) described by the equation (9).

Comparative analysis of the parameters of production functions for gross value added (7) and gross output (8) (Table 5) indicates a more efficient use of labour potential for processing agricultural raw materials and the creation of finished products, where technical progress (a_0) and quality indicators of human capital (a_3) have much more influence. Thus, the coefficients of elasticity are functions of factors that include the production function. This is shown in the studies of agricultural economics by Artyukh (2016) and Litvin (2017). We also agree with Shumska's (2007, p. 123) conclusions about the sensitivity of the coefficients of the production function to the political and institutional processes that take place in different periods of time. Ukraine is on the path to an efficiency driven economy that depends on key competitiveness factors: institutions, infrastructure, macroeconomic stability, health care and primary education (Vasylieva, 2018); these factors also affect the values of elasticity of coefficients.

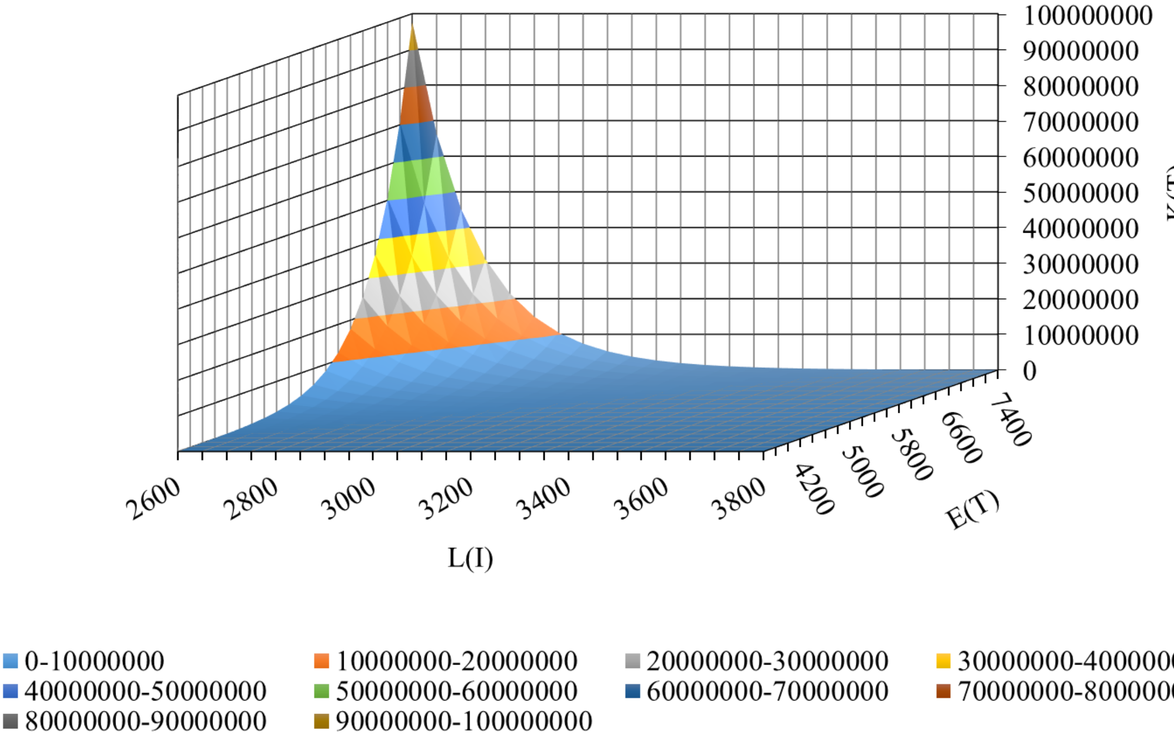

Figure 10. Balance of the fixed assets (*K*), labout (*L*) and pollutant emissions (*E*) at a fixed value of the integral coefficient of intellectual assets (*I*)

Table 5 Results of modelling the production function

parameters	*Y(T)* gross value added	*Y(T)* gross output
a_0	422388	341
a_1	0,34474	0,08353
a_2	2,63344	1,70970
a_3	1,60806	0,32224
a_4	-2,86638	-0,98789
$(a_1 + a_2 + a_3 + a_4)$	1,72	1,13

Using the Cobb-Douglas production function, econometric analysis with eco-socio-economic factors has shown that economic growth in agriculture is associated, firstly, with improved quantitative and qualitative characteristics of labour potential, and secondly, with growing capital investment and reducing pollutant emissions.

Economic growth of agricultural production in Ukraine (gross output) is labour-intensive, not capital-intensive, because ($a_2 > a_1$). This significantly depends on the quantitative indicators of the labour potential of rural areas (a_2), which are gradually declining. This is due to negative demographic trends, which, in turn, has resulted in the degradation of rural areas, reduced employment and income.

The share of labour contribution to output is higher than the share of capital. This is justified by the presence of a significant private sector in agricultural production. Households mainly use manual labour, there are no opportunities to attract investment in technical and technological modernization of production; access to state support is limited due to low production volumes per farm. The prospects for economic growth of agricultural production are not to increase the number of resources, but to improve their quality. It is advisable to implement state support measures aimed at increasing the resource capacity of agricultural producers: subsidies for technical upgrades, investment loans for new capacity, reimbursement of capital expenditures for modernization of production, compensation for investment in land reclamation system, implementation of scientific and technical policy in the agricultural sector. To ensure sustainable growth of agricultural production, it is necessary to introduce innovative developments, resource-saving technologies, increase the use of intellectual capital (Potapov, 2020).

Among the qualitative characteristics of labor potential, special attention should be paid to intellectual assets (cognitive, emotional and creative competencies), which gradually accumulate and transform starting from the very birth of a person during his/her upbringing, cultural development and involvement in a healthy lifestyle, while obtaining education and professional training, and also to the intellectual outcomes of human activities (Vasyl’yeva, 2021a).

Efficient use of labour potential is the basis for economic growth in other sectors of the economy, reducing social tensions, ensuring food independence and security. Modelling how the resource factors act on output using the method of construction and calculation of parameters of the production function allows to predict the sustainable development of agricultural production under quantitative and qualitative changes in the use of labour and capital, as well as environmental factors (Vasyl'yeva, 2021b).

In our opinion, the obtained results on the growing economies of scale give grounds to speak about the optimistic prediction of increasing the resource potential of agricultural production due to the growth of quantitative and qualitative indicators of labour potential, the prospects of which have been widened under decentralization and creation of new economic agents in rural areas.

It would be also beneficial to carry out research to factors of sustainable development of the agricultural sector using other econometric methods.

It would be also beneficial to carry out research to factors of sustainable development of the agricultural sector using other econometric methods.

References

1. Arrow, K., Chenery, H., Minhas, B. & Solow, R. (1961). Capital-Labor Substitution and Economic Efficiency. *The Review of Economics and Statistics, 43*(3), 225-250.
2. Artyukh, M., & Litvin, O. (2016). Zastosuvannya dyvidirialnoho ta multyhralnogo chyslen v doslidzhenni ekonomiky silskoho hospodarstva Ukrayiny [Application of dividirial and multifaceted calculus in the study of agricultural economics of Ukraine]. *Mathematical and computer modeling. Series: Technical Sciences, 13,* 16-26. (in Ukrainian)
3. Asheim, B., Moodysson, J. & Tödtling, F. (2011). Constructing regional advantage: towards state-of-the-art regional innovation system policies in Europe? *European Planning Studies, 19*(7). doi: 10.1080/09654313.2011.573127
4. Barro, R. & Sala-i-Martin, X. (1992). Convergence. *Journal of Political Econom, 100,* 223-251.
5. Çetin, M., Saygın, S. & Demir, H. (2020). Tarım Sektörünün Çevre Kirliliği Üzerindeki Etkisi: Türkiye Ekonomisi İçin Bir Eşbütünleşme ve Nedensellik Analizi [The Impact of Agricultural Sector on Environmental Pollution: A Cointegration and Causality Analysis for Turkish Economy]. *Journal of Tekirdag Agricultural Faculty, 17*(3), 329-345. https://doi.org/10.33462/jotaf.678764 (in Turkish)
6. Cobb, C. W. & Douglas, P. H. (1928). A Theory of Production. *American Economic Review, 18*(1), 139-165.
7. Dedrick, J., Gurbaxani, V. & Kraemer, K. L. (2003). Information technology and economic performance. *ACM Computing Surveys, 35*(1), 1-28. doi:10.1145/641865.641866

8. Glinskiy, V., Serga, L., Alekseev, M., Samotoy, N. & Simonova, E. (2018). The Development of the Food Industry as a Condition for Improving Russia's National Security. *Procedia Manufacturing, 21,* 838-845. doi:10.1016/j.promfg.2018.02.191

9. Gosińska, E. & Ulrichs, M. (2020). Sektorowe funkcje produkcji – wnioski z modeli panelowych dla Polski [Sectoral Production Functions: Results from Panel Models for Poland]. *The Polish Journal of Economics*, *302*(2), 71-94. https://doi.org/10.33119/GN/116617 (in Polish)

10. Hopwood, B., Mellor, M. & O'Brien G. (2005). Sustainable development: mapping different approaches. *Sustainable Development, 13,* 38-52.

11. Karpenko, A., Basenko, K. (2017). Highly Effective Corporate Culture as an Instrument of Talents' Attracting and Retaining. *Balt. J. of Econ.* Stud. **3**(4), 101-106 doi.org/10.30525/2256-0742/2017-3-4-101-106.

12. Karpenko, A. V. (2018). *Rozvytok intelektual'nykh aktyviv lyuds'koho potentsialu: teoriya ta praktyka [The Development of Intellectual Assets of Human Potential: theory and practice]*. Zaporizhzhya: FOP V. V. Mokshanov. (in Ukrainian)

13. Khvesyk, M. A., Bystryakov, I. K. & Levkovska, L. V. (2012). *Stalyy rozvytok: svitohlyadna ideolohiya maybutn'oho [Sustainable development: worldview ideology of the future].* Kyiv: Institute of Economics of Nature Management and Sustainable Development. (in Ukrainian)

14. Klewitz, J. & Hansen, E.G. (2014). Sustainability-oriented innovation of SMEs: A systematic review. *Journal of Cleaner Production, 65,* 57-75. https://doi.org/10.1016/j.jclepro.2013.07.017

15. Koptug, V. (1997). *Itogi konferentsii OON po okruzhayushchey srede i razvitiyu. Nauka spaset chelovechestvo [Outcomes of the UN Conference on Environment and Development. Science will save humanity]*. Novosibirsk: Publishing house of the SB RAS SIC JIGGM. (in Russian)

16. Kramin, T. V., Grigoryev, R. A., Timiryasova, A. V. & Vorontsova L. V. (2016). Vklad intellektual'nogo i sotsial'nogo kapitalov v ekonomicheskiy rost regionov Rossiyskoy Federatsii [The contribution of the intellectual and social capital in economic growth of the Russian Federation regions]. *Actual Problems of Economics and Law, 10(4), 66-76. DOI: 10.21202/1993-047X.10.2016.4.66-76* (in Russian)

17. Kuzina, N. V. (2018). Funktsiya Kobba-Duglasa i yeye graficheskoye predstavleniye [Cobb-Douglas function and its graphical representation]. *Kaluga Economic Bulletin, 2,* 70-73. (in Russian)

18. Kuzmin, P., Kalashnikov, V., Kalashnykova, N. & Watada, J. (2020). The Great Depression: Econometric Analysis and Fuzzy Regression. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 24(6), 785-791. https://doi.org/10.20965/jaciii.2020.p0785

19. Litvin, O. & Artyukh, M. (2017). Uzahalʹnena vyrobnycha funktsiya, shcho yavno zalezhytʹ vid obʺyemnykh pokaznykiv resursiv ta kapitaloozbroyenosti [The generalized production function, which depends explicitly on the volume indicators of resources and capital endowment). *Bulletin of the National Technical University «KhPI». Series: Mathematical modeling in engineering and technology, 6,* 51-56. (in Ukrainian)

20. Lukas, R. (1988). On the mechanism of economics development. *Journal of Monetary Economics, 22,* 3-42.

21. Lyashenko, I. M. & Khrushch, L. Z. (2012). Optymalʹna prohrama pidpryyemstva ta ekoloho-ekonomichna vyrobnycha funktsiya [The optimal program of the enterprise and ecological and economic production function]. *Economic Bulletin of Donbass, 1,* 184-188. (in Ukrainian)

22. Lyashenko, O. (2013). Modelʹ ekonomichnoho zrostannya Solou-Svena z ekzohennym kapitalointensyvnym tekhnolohichnym prohresom [The model of economical growth of Solow-Sven with exogenous capital-intensive technological progress]. *Investments: practice that experience, 15,* 14-16. (in Ukrainian)

23. Mankiv, G., Romer, D. & Weil, D. (1992). Contribution to the Empirics of Economic growth. *Quarterly Journal of economics, 107*(2), 407-437.

24. Marynych, T. (2017). Empirical assessment of long-term aspects of sustainable regional development. *Economic Annals-XXI, 166*(7-8), 86-90. https://doi.org/10.21003/ea.V166-17

25. Meadows, D. H., Meadows, D. L., Randers, J. & Behrens, V. W. (1991). *Predely rosta [Limits of growth]*. M.: Publishing house of Moscow State University. (in Russian)
26. Meadows, D., Randers, J., & Meadows, D. (2018). *Mezhi zrostannya. 30 rokiv potomu [Limits of growth. 30 years later]*. Kyiv: Pabulum. (in Ukrainian)
27. Moreno-Hurtado, C. A., Ochoa-Jiménez, D. A. & Izquierdo-Montoya, G. L. (2018). A simplified endogenous economic growth model with social capital: Evidence for Ecuador. *Business and Economic Horizons, 14*(2), 168-184. http://dx.doi.org/10.15208/beh.2018.14
28. Novakova, L. (2020). The impact of technology development on the future of the labour market in the Slovak Republic. *Technology in Society, 62,* 101256. https://doi.org/10.1016/j.techsoc.2020.101256
29. Odintsov, O., Yevtukhova, T., Vasylkonova, E. & Kunchenko-Kharchenko, V. (2020). Influence of tax burden on economic development of agricultural enterprises in Ukraine. *Journal of Eastern European and Central Asian Research, 7*(1), 150-162. http://dx.doi.org/10.15549/jeecar.v7i1.328
30. Official site of (2020) the State Statistics Service of Ukraine. Retrieved September 28, 2020, from http://www.ukrstat.gov.ua
31. Oliner, D. & Sichel, D. (2000). The Resurgence of growth in the Late 1990s: Is Information technology the Story? *The Jornal of Economic Perspectives, 14,* 3-22.
32. Potapov, A. P. (2020). Modeling the impact of resource factors on agricultural output. *Economic and Social Changes: Facts, Trends, Forecast, 13*(4), 154-168. DOI: 10.15838/esc.2020.4.70.9
33. *Proclamation of Teheran*. (1968) Final Act of the International Conference on Human Rights, Teheran, 22 April to 13 May 1968. U.N. Doc. A/CONF. 32/41 at 3 via University of Minnesota Human Rights Library.
34. Pshenichnikova, S. N. & Romanyuk, I. D. (2017). Analiz proizvodstvennoy funktsii Kobba-Duglasa dlya ekonomik Rossii i ryada stran regiona Tsentral'noy i Vostochnoy Yevropy [Analysis of the Cobb-Douglas production function for the economies of Russia and a number of countries in the Central and Eastern European region]. *Proceedings of Southwestern State University. Economics series. Sociology. Management, V. 7, 3*(24), 148-166. (in Russian)
35. Romer, P. (1986). Increasing returns and long-run growth. *Journal of Political Economy, 94,* 1002-1037.
36. Romer, P. (1996). Why, Indeed, in America? Theory, History, and Origins of Modern Economic Growth. *American Economic Review, 86*(2), 202-206.
37. Schumpeter, J. A. (1934). *Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Cambridge, MA: Harvard University Press.
38. Shumska, S. S. (2007). Instrument vyrobnychoyi funktsiyi v doslidzhenni ukrayins′koyi ekonomiky [The tool of the production function in the study of the Ukrainian economy]. *Economics and forecasting, 4,* 104-123. (in Ukrainian)
39. Slavgorodska, Yu. V. (2016). Stalyy rozvytok v konteksti funktsionuvannya ahropromyslovoho kompleksu Ukrayiny [Sustainable development in the context of the functioning of the agro-industrial complex of Ukraine]. *Taurian Scientific Bulletin. Agricultural sciences, 96,* 255-262. (in Ukrainian)
40. Solow, R. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics, 70*(1), 65-94.
41. Solow, R. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39*(3), 312-320.
42. Solow, R. (1961). Capital Labor Substitution and Economic Efficiency. *Review of Economics and Statistics*. Retrieved October 12, 2020, from https://msuweb.montclair.edu/~lebelp/ACMSCapLabSubREAS1961.pdf
43. Suvorov, N. V., Akhunov, R. R., Gubarev, R. V., Dzyuba, E. I. & Faizullin, F. S. (2020). Primeneniye proizvodstvennoy funktsii Kobba-Duglasa dlya analiza promyshlennogo kompleksa

regiona [Application of the Cobb-Douglas production function for the analysis of the industrial complex of the region]. *Economy of the region, 16*(1), 187-200. (in Russian)
44. *The future we want* (2012). Resolution adopted by the General Assembly on 27 July 2012 (A/RES/66/288). Retrieved November 23, 2020, from http://srsg.violenceagainstchildren.org/sites/default/files/documents/ docs/A_RES_66_288_EN.pdf
45. Tkach, I. I. (2015). The core function of sustainable development. *Actual problems of economy, 1*(163), 59-66.
46. Tödtling, F. & Grillitsch, M. (2015). Does combinatorial knowledge lead to a better innovation performance of firms? *European Planning Studies, 23*(9). doi: http://dx.doi.org/10.1080/09654313.2015.1056773
47. United Nations Conference on Sustainable Development «*Rio +20*» (2012). United Nations. Retrieved October 18, 2020, from http://www.uncsd2012.org/
48. Vasylieva, O. (2017). Factors of Labor Productivity Growth in Agriculture of the Agrarian Region. *Baltic Journal of Economic Studies, 3*(4), 1-6. doi.org/10.30525/2256-0742/2017-3-4-1-6
49. Vasylieva, O. (2019). The economic potential of sustainable development of the agricultural sector of Ukraine. *European Journal of Economics and Management, 5*(3), 14-21.
50. Vasyl'yeva, O., Karpenko, A. (2021). The intellectual component of labor potential as a factor of sustainable development of the agricultural sector. *IV International Scientific Congress*, Ukraine – Uzbekistan – Latvia @ISCSAI April 12-16, 2021. Web of Science. DOI: https://doi.org/10.1051/shsconf/202110005012.
51. Vasyl'yeva, O. (2021). Assessment of factors of sustainable development of the agricultural sector using the Cobb-Douglas production function. *Baltic Journal of Economic Studies*, Vol. 7 (2021) No. 2 March. P. 37-49. Web of Science. DOI: https://doi.org/10.30525/2256-0742/2021-7-2-37-49.
52. Vasylieva, T., Lyeonov, S., Lyulyov, O. & Kyrychenko, K. (2018). Macroeconomic stability and its impact on the economic growth of the country. *Montenegrin Journal of Economics, 14*(1), 159-170. DOI: 10.14254/1800-5845/2018.14-1.12
53. Yang, W. & Zhao, J. (2020). Study on China's economic development from the perspective of strong sustainability. *The Singapore Economic Review, 65*(01), 161-192. https://doi.org/10.1142/S021759081746002X
54. Yankovyi, O., Sotnychenko, L. & Petrashevska, A. (2018). Determination of optimum of capital-labour ratio within two-factor production functions with non-zero substitution by the principle of equal margin. *Baltic Journal of Economic Studies, 4*(3), 372-378. https://doi.org/10.30525/2256-0742/2018-4-3-372-378
55. Yankovyi, V. O. (2015). Vyrobnycha funktsiya z postiynoyu elastychnistyu zamishchennya resursiv [Production function with constant elasticity of substitution resources]. *Socio-economic research bulletin, 3*(58), 228-234. (in Ukrainian)
56. Zygmunt, A. (2019). External linkages and intellectual assets as indicators of firms' innovation activities: results from the Czech Republic and Poland. *Oeconomia Copernicana, 10*(2), 291-308. doi:10.24136/oc.2019.015
57. Zygmunt, A. (2020). Do Human Resources and the Research System Affect Firms' Innovation Activities? Results from Poland and the Czech Republic. *Sustainability, 12*(6), 2519. doi:10.3390/su12062519

7 VIDEOECOLOGICAL ASSESSMENT OF THE CONDITION OF THE URBAN ENVIRONMENT

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Every year more and more people become city dwellers and change the natural landscape into skyscrapers and asphalt. More than half of the world's population lives in cities, and closer to 2050 the figure will reach 70% (according to the UN) [1, 2]. But even now, most cities are unable to cope with rapid population growth. This is manifested in many areas, including an urban environment. Raising the issue of environmental safety of urban geosystems, usually means hydrosphere pollution, air quality, radiation, and noise pollution, but leaves aside no less important environmental factor - the constantly visible environment and its condition.

Everything visible environment that surrounds a person is divided into two components: natural and artificial. Thus, the natural visible environment fully complies with the norms of the psychophysiological state of man, including the physiological norms of vision. In turn, the artificial environment differs from the natural and, as a rule, contradicts the laws of visual perception of man. The processes of urbanization and industrialization distance us from the visual ideal: the artificial environment ceases to bring aesthetic pleasure and leads to several socio-environmental problems.

Significant interest in the study of the visual urban environment emerged in the late 1980s when the problem of pervasive urbanization became apparent. The color scheme and structure of the urbogeosystems in this period differ sharply from the natural one. The architecture of cities is dominated by uniformity, urban buildings are mostly static and have a large number of planes. Thus, the artificial environment has created another problem of human ecology - the problem of the quality of the visual environment, which is studied by the science of videoecology. The search for ways to harmonize and streamline the visual urban space was performed by prof. V. Filin, about which he wrote in his monograph «Videoecology». What is good for the eye and what is bad» [3, 4].

Thus, the research of Prof. V. Filin shows that a constant visual environment, its saturation with visual elements, can in some way affect the psycho-emotional state of man. After all, the eye is the most active of the organs of perception, it never stands still. Rapid eye movements are called saccades (from the French word «sail»). Saccades occur constantly, against our will, with open and closed eyes, while maintaining the average number of saccades per unit time (usually the interval between saccades is 0.2 - 0.6 seconds) - that is, automatically, like breathing, heartbeat, or digestion. In other words, a person can not help but look around and perceive the environment, just as he can not breathe air [3, 4].

In general, the artificial visual environment can be divided into comfortable and uncomfortable. In turn, uncomfortable visual fields are represented by two types: aggressive and homogeneous. It is determined that aggressive visual fields consist of many identical elements, evenly distributed on a surface, and homogeneous are those visible fields in the surrounding space, where either there are no visual details at all, or their number is sharply reduced [3, 4].

The environment significantly affects human behavior. Thus, in an aggressive visible environment, a person is often in a state of unreasonable resentment. Experts have called this disease «big city syndrome», which is defined as «experiencing negative, uncomfortable feelings of physiological and mental nature.» According to psychiatrists [5], 80% of their patients suffer from this syndrome. After all, due to the unnatural visual environment, the amount of stimuli begins to exceed the individual capabilities of man, which threatens the emergence of pathological conditions, which often manifest themselves in human aggression.

Ukrainian scientist Prof. V. Fesyuk, considering aspects of formation and development of large urban systems of north-western Ukraine, proposed an algometric model of constructive-geographical and geo-ecological analysis of the environment of large cities and an algorithm for implementing the process of optimizing the ecological state of cities. The scientist has developed a method that allows you to practically assess the level of video-environmental friendliness of the urban environment. Its essence is reduced to the calculation of the coefficient of videoecological favorability [6, 7].

Engineer and designer, Doctor of Technical Sciences A. Tetior also note that: «... the visible environment of many large cities becomes unnatural, creates psychological discomfort ...». Considering the problem of aesthetic «pollution» Tetior AN gives its main features:

- homogeneous, monochrome, and monotonous architectural environment;
- vagueness of buildings;
- violation of scale and symmetry in the facades of buildings;
- construction of small-scale landscape of buildings;
- lack of compositional and harmonious unity with the natural environment;
- the emergence of large-scale aggressive environments and local fields of visual discomfort [8].

In this regard, the state of the surrounding landscape has a significant impact on the quality of the visual environment of the city, which is closely related to the mental state of man. Roger Ulrich was one of the first to consider the relationship between the human condition and the surrounding landscape. In 1984, a researcher noted that hospital patients who had a room overlooking a small grove recovered faster and needed fewer painkillers than those who could only see brick walls and asphalt [2].

Since then, more information has been obtained that demonstrates that the appearance of the natural landscape reduces nervous tension in people, normalizes heart and brain activity, and has a positive effect on the results of psychological testing to determine the level of emotions. The positive effect of the type of natural landscapes on the human cognitive system has also been proven. In nature, the movement of our eyes is different from how we look in the city. For example, in the park, the time of fixing the gaze is reduced, and it moves from object to object faster, without lingering on small details, as is usually the case in the city. Studying the differences in the work of the cognitive apparatus in different habitats, psychologists Stephen and Rachel Kaplan developed a theory of restoring attention. In their book «Experiencing Nature: The Psychologist's View», the authors argue that in urban settings, people need to constantly focus on routine matters - from working at a computer to following traffic rules. All everyday processes, scientists say, require effort and severely deplete our cognitive resources during the day. But when a person abstracts from his daily worries and comes into contact with nature (for example, while walking in a park or forest), he ceases to be focused, his attention, fascinated by the picture of the world, becomes involuntary and easily switches. This condition serves us as a kind of «renewal», after which we can return to normal with a better mood, rested nervous system, and increased ability to concentrate [2].

In addition, contact with nature gives us something more. Studies by Francis Cuo and William Sullivan, who studied urban areas with varying degrees of landscaping, show that people who live in a greener environment feel happier and more protected. People living among greenery are more likely to communicate with each other and know their neighbors better. This not only protects them from various types of psychological pathologies but also helps prevent petty crimes [2].

The urban environment cannot be successfully studied and modeled without taking into account the attitude to it that exists in the minds of ordinary inhabitants of this environment. According to G. Kaganov (1990), their subjective opinions, sympathies, assessments are no less important environmental factors than purely objective factors - sanitary, geographical, socio-economic, and others. This interesting socio-ecological phenomenon is explained by the hypothesis of psychologist M. Heidmets, according to which a city dweller pays special attention to the environment mainly when something is wrong in it [9, 10].

In connection with the above, research has been conducted to study the problems of the quality of the visual environment in the city, in other words, the assessment of the video-ecological condition of the urban environment.

The Shevchenkivsky administrative district of the city of Kharkiv was chosen for the research. The choice of this territory is due to social demand because it is one of the central districts of Kharkiv. Shevchenkivskyi administrative district is located in the northern part of the city. It borders with Kyiv, Kholodnohirsk, Osnovyansky districts. It occupies a significant part of the historic (Nagirny) district of Kharkiv 62 km^2 and is the second largest of the 9 districts of the city. The housing stock of communal property includes 869 dwelling houses, in which about 229.2 thousand people live.

The industry of the district is represented by medium and small enterprises of chemical, construction, and food industry, well-represented trade infrastructure. A significant contribution to the volume of industrial production is made by PJSC «Pharmstandard-Biolik», SE «Chemical Reagents Plant STC» Institute of Single Crystals «, TDV» Zhytlobud-2 «, LLC» HADO «, LLC» HASK-Flex «, LLC» Tandem Impex «, PJSC «Aviakontrol», PJSC «Tochprilad».

It should also be noted that in the Shevchenkivskyi district there is a wide network of enterprises of socio-economic infrastructure, which is expanding from year to year. For example, the largest hotels in the city are located in this area: «Kharkiv Palace», «Kharkiv», «National», «World», «Kyiv».

From year to year, Shevchenkivskyi district confirms its status as the greenest district of the city, thanks to the constant planting of large trees, sanitary and rejuvenating tree pruning, and flower decoration of flower beds. That is why it is important to determine the quality of the visual environment of recreational areas and adjacent areas [11].

To provide a preliminary assessment of the visual environment of the district, the research took into account public opinion. For this purpose, a sociological survey was conducted among the residents of the Shevchenkivskyi district of Kharkiv, during which 200 respondents - residents of the district, filled in the appropriate Google form. It turned out that 7.5% of respondents consider the visual environment quite satisfactory, and 12.5% - generally unsatisfactory (Fig. 1).

Further questions were suggested to determine the factors of negative impact on the visual environment. Therefore, it is determined that 30% of respondents often notice an excess of identical architectural details on the buildings of the district.

Regarding the determination of the homogeneity of the visual environment, the following results were obtained: 37.2% of respondents very often notice the monotony and uniformity of the district. It should be noted that in comparison with the results of research in other areas of the city [12], the results are satisfactory.

Landscaping of the district significantly affects the video-ecological situation. Greenery can «mask» aggressive and homogeneous fields, making the environment more visually comfortable for the human eye. During the study, the area of the district occupied by greenery was determined. Thus, it was established that the Shevchenkivskyi district of Kharkiv is landscaped by 39.2%. According to public opinion, 12% of respondents are completely satisfied with the landscaping of the district, and 12.5% are not satisfied at all (Fig. 2).

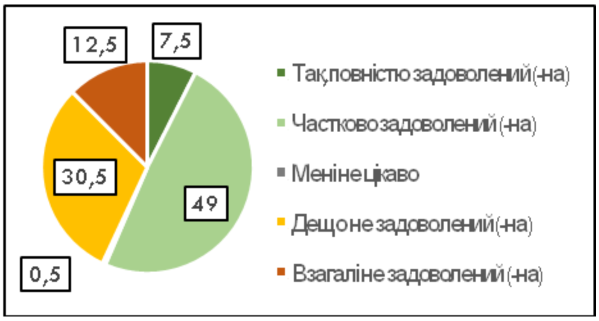

Figure 1 The degree of satisfaction of the residents of Shevchenkivskyi district with the state of the visual environment (according to the results of sociological research)

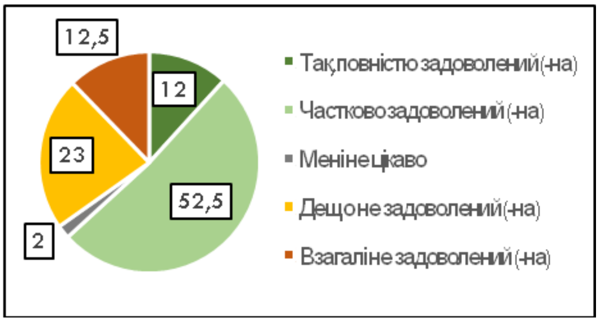

Figure 2 Degree of satisfaction of residents with the landscaping of Shevchenkivskyi district (according to the results of sociological research)

Thus, studying the opinion of citizens about the visual environment of modern cities, it is possible to significantly enrich the aesthetic component, even mitigate the negative effects of anthropogenic pollution, creating a favorable, in terms of video ecology, habitat. However, the methods of the sociological survey are not devoid of subjectivity, which is explained by special individual aesthetic assessments of the perception of the problem by each individual. In this regard, such technologies can be used only in combination with other research methods.

The next stage of videoecological research was to compare the videoecological situation in the territories of two representative test sites in the Shevchenkivskyi district. The following test sites were selected: №1 - the intersection of Science Avenue and O. Yarosha Street, №2 - the intersection of Victory and Ludwig Svobody Avenue (Fig. 3).

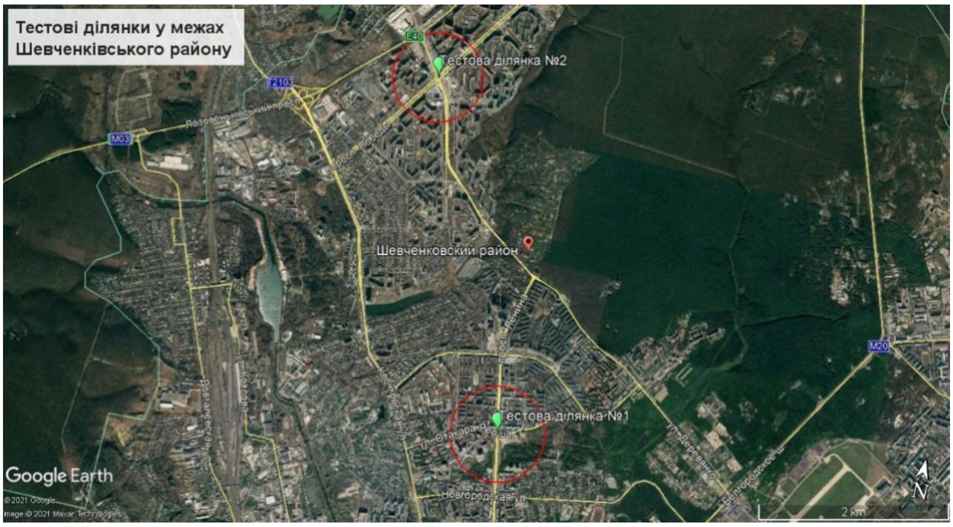

Fig. 3 Representative test sites within Shevchenkivskyi district of Kharkiv

These areas are characterized by significant building density and high traffic and pedestrian traffic. It was also found that the areas have varying degrees of landscaping. Thus, the territory of test site №1 is landscaped by 38%, which is almost 2 times higher than the corresponding figures for test site №2 - 20.7%. This can be explained by the presence of a recreational zone on the territory of the test site (Fig. 6). To more accurately reflect the situation, *the coefficient of optimal landscaping* (*Kopt.land*) was calculated, which shows the optimal provision of the area with greenery per capita.

$$K_{opt.land} = L / 50\ m^2 * D, \text{ where}$$

L - area of green areas

(50 m2, minimum area of greenery for one person) [13];

D - population of the study area

Therefore, for the test plot №1 Kopt.land is - 0.55, and for the test plot №2 - 0.3, the approximation of the coefficient to 1 indicates an increase in the optimality of landscaping.

On the territory of both test sites, there are residential and commercial buildings, which creates aggressive visual fields (Fig. 5.6). However, it should be noted that larger areas of greenery in the test area № 1 «mask» aggressive visual fields, thereby improving the quality of the visual environment.

Fig. 4 Commercial buildings that create aggressive visible fields on the territory of the test site №1

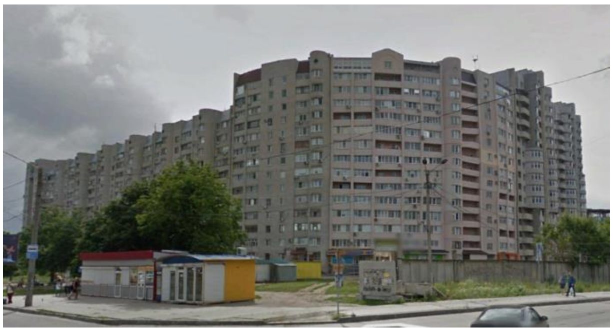

Fig. 5 Residential buildings that create aggressive visible fields in the test area №2

On the territory of the test site № 1 there is a recreational zone - a natural monument of local significance Sarzhin Yar water and landscape park. This is a unique natural formation, which is of great importance in the recreational infrastructure of the Shevchenkivskyi district of Kharkiv. Thus, this area not only improves the quality of the visual environment, acting as a green oasis through landscaping but also performs many social functions, promoting recreation. As a result of videoecological research within the recreational area of Sarzhin Yar, functional zoning was performed, which is reflected in the map diagram (Fig. 6). Thus, the functional zoning of the object is the rational placement of recreation areas for certain activities of the holiday population.

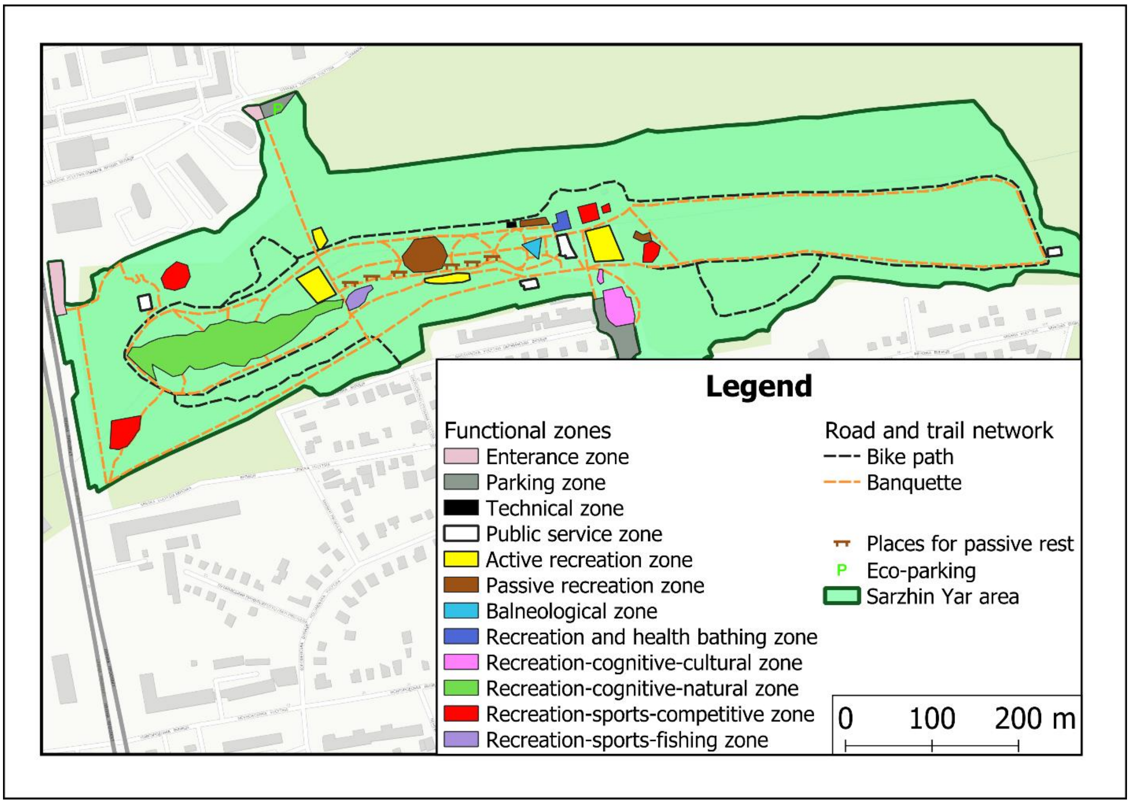

Fig. 6 Functional zoning of Sarzhin ravine

Within the Shevchenkivskyi district, Sarzhin Yar covers an area of 17 hectares and is connected to the Central Park of Culture and Recreation. M. Gorky, Kharkiv Forest Park, and the Botanical Garden of Karazin University, which contribute to the formation of a single network of the green infrastructure of the district. This is also facilitated by the location of such an element of green infrastructure as eco-parking directly near the entrance areas of the ravine.

The main environmental elements of this area are the river Sarzhinka and several small lakes (Fig. 7). It is these elements, surrounded by the natural landscaping, that create a favorable microclimate for relaxation. At the bottom of the ravine from Oleksiyivka flowed Sarzhin stream, a right tributary of the river Sarzhinka. The stream was filled up during the laying of the line of the transmission line to Pyatihatki along the bottom of the ravine in 2006 and is now preserved in fragments.

The Sarzhynka River originates near the village of Zhukovsky, flows under the Belgorod Highway (a metal footbridge is spanned through it), forms Kachyne Lake, then descends to the bottom of the Sarzhin Yar through the Pomirky tract (and then flows exclusively along with it), merges with the Sarzhin Stream. lake.

Fig. 7 The main environmental elements territory of Sarzhin Yar

The diverse and interesting vegetation of the natural monument of local significance of Sarzhin Yar. Here you can find different types of regular and landscape park plantings. Thus, there are tapeworms, or individual trees (Fig. 8), straight alleys with ordinary cladding, and bosquets (Fig. 9). The center of Sarzhin Yar is a group of poplars.

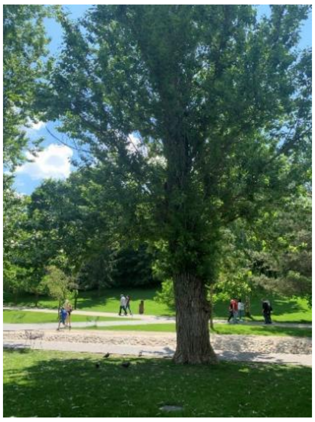

Fig. 8 Solitaires (individual trees)

Fig. 9 Bosquets

The Center for Urban Design and Mental Health, combining the results of research conducted around the world, presented a set of principles for the formation of a healthy visual environment («Mind the GAPS» - an abbreviation of green, active, pro-social, safe places).

The first principle is the landscaping of urban space - one of the most mentioned factors for maintaining mental health in the city. This applies not only to parks and squares but also to the landscaping of streets and avenues (on the way of daily traffic of citizens). It is important to take care of all green spaces in the city so that they do not acquire the status of «dangerous». In the territory of Shevchenkivskyi district, this principle is implemented on the example of the recreational zone of the natural monument of local significance « Sarzhin Yar».

The second principle is the formation of space for active activities. This principle implies both sports grounds for singles and team sports and the creation of conditions for the use of bicycles and hiking in the city. Convenient transport links, reduced speed of road traffic, short pedestrian crossings and wide sidewalks, quality public transport provoke citizens to move more. Among other things, these changes affect mental health: exercise increases serotonin production, improves sleep, increases resistance to stress. Also, such an environment contributes to the emergence of social interaction. On the territory of Sarzhin Yar, this principle is implemented in four functional zones: active recreation, recreational-sports-competitive, recreational-health bathing-beach, and recreational-sports-fishing.

The third principle is called «prosocial space». It shows how important social interaction in the city is for a person's mental health. Communication between people is an integral part of human life, but the aggressive urban environment forces citizens to abstract and not notice other people. Therefore, it is necessary to create a comfortable social environment. Examples of such an environment are: «living» facades of buildings, mixed functional zoning to saturate the streets with people at any time of day: benches, tables for board games, and other public centers. On the territory of Sarzhin Yar, this principle is implemented in three functional zones: passive recreation, recreational-cognitive-cultural and recreational-cognitive-natural.

The last principle is one of the keys - the formation of a safe space. Dangers include «aggression» from cars, environmental pollution, disorientation in space, and the danger that other people can carry. The main measures are taken to ensure safety are good lighting, video surveillance, passive surveillance of passers-by, timely repair and maintenance of order in the urban space, clear planning, and the availability of landmarks. It is important to put a person, his convenience, and his capabilities at the top of the pyramid of priorities [5].

No less important factor influencing the psychophysiological state of man is the quality of the aquatic environment. Shatylivske mineral water source is a business card of Sarzhin Yar. Above the spring in 1960 a concrete pavilion of original futuristic shape (pump room) was built on three pillars designed by architect V. Vasiliev. It is believed that «Kharkivska-1» is the cleanest water in the city, which itself comes to the surface. In any case, that's what Kharkiv residents say. In general, Kharkiv-1 water is a hydrological monument of nature. Volume - 345 thousand liters of mineral water per day! Located between Shatylivka (Nagirny district) and the Botanical Garden of V. N. Karazin Kharkiv National University (Pavlovo Pole). The Botanical Garden metro station is nearby.

From ancient times people bathe in the cold water of the Sarzhin Yar. Previously, they bathed directly in the concrete tray of the canal, which flows spring water. The water temperature in winter here is + 3 ° C - + 5 ° C, and in summer it reaches + 7 ° C - + 9 ° C. Bishop Onuphrius, which led to the cultic features of spring water and attracted even more attention of city dwellers. It is always crowded.

Water samples were taken to determine the qualities of Sarzhin Yar spring water. The regulatory framework for water quality assessment is formed based on general requirements for the composition and properties of water and the values of maximum permissible concentrations of substances in the water of water bodies. The general requirements determine the permissible composition and properties of water, which are evaluated by physical, bacteriological, and generalized chemical parameters. Water quality assessment is based on a system of benchmarks based on the principle of comparison. Single, indirect, and comprehensive assessments of drinking water pollution by hydrochemical parameters are used. It is comprehensive assessments that provide the most accurate and objective information on the quality of drinking water [15].

The place of groundwater outflow from underground horizons is well equipped. The source is located on the territory of recreational purpose with minimal influence of anthropogenic factors. The sampling site is subject to public influence (as it is a recreation area) and the impact of the industry is minimal. The place is characterized by significant demand among the population, mostly students.

According to the Water Code of Ukraine, water quality assessment is carried out based on environmental safety standards for water use and environmental standards for water quality of water bodies [14]. The current standards for assessing the quality of drinking water based on the environmental safety of water use make it possible to assess the quality of water used for communal, drinking, and fishery needs [14].

In the training and research laboratory of analytical ecological research of the Karazin Institute of environmental siences students and employees of the laboratory twice a year for the last 14 years conducted a chemical analysis of the spring water of Sarzhin Yar. Comparison of the studied samples was carried out with the TLV of substances for the water of drinking water and cultural and domestic water use.

According to the test results, no maximum permissible concentrations were detected following the State Sanitary Norms and Rules «Hygienic requirements for drinking water intended for human consumption» (DSanPiN 2.2.4-171-10), Document z0452-10, current, current version from 12/28/2019, basis - z1304-19 [16].

Analysis of the quality of drinking water from a spring in Sarzhin Yar revealed that water from a natural spring has excellent organoleptic and physiological parameters. The absence of indicators exceeding the TLV confirms the drinking properties of this water.

According to DSanPiN 2.2.4-171-10, depending on the production technology, the following types of drinking water are distinguished:

- treated - drinking water made from water obtained from

surface sources of drinking water supply, underground sources

drinking water supply by purification or domination;

- untreated (natural) - water obtained directly from underground sources of drinking water supply, which by all indicators meet the requirements of Sanitary norms without their purification.

Water from a spring in Sarzhin Yar refers to untreated natural water.

№	Name of indicators	Test results by years									Units of measurement	Threshold limit value
		2000	2005	2007	2013	2017	2018	2019	2020	2021		
1.	Scent	0	0	0	0	0	0	0	0	0	mark	≤ 3
2.	Coloring	5	5	5	5	5	5	5	5	5	degrees	≤ 35
3.	Turbidity	1,15	1,26	1,39	1,48	1,40	1,25	1,12	1,08	1,05	FTU	≤ 3,5
4.	Transparency	30	30	30	30	30	30	30	30	30	cm	≥ 30
5.	Hydrogen index, pH	6,84	7,35	7,2	6,51	6,44	7,13	7,21	7,4	7,69	pH	6,5-8,5
6.	General alkalinity	6,0	6,1	5,9	5,8	6,3	6,2	6,4	6,3	6,2	mmol / dm^3	Not specified.
7.	General rigidity	8,2	8,6	7,9	8,0	7,9	8,1	7,88	7,85	8,2	mmol / dm^3	≤ 10,0
8.	Calcium	108,2	111,0	106,7	110,4	104,9	108,8	110,5	112,0	111,5	mg / dm^3	Not specified.
9.	Magnesium	26,8	25,4	23,9	27,0	25,6	26,4	24,9	25,3	26,1	mg / dm^3	Not specified
10.	Chlorides	58,6	62,4	64,8	70,2	60,4	58,4	60,6	62,2	60,2	mg / dm^3	≤350,0
11.	Sulfates	174,2	188,4	190,3	179,2	180,4	187,4	179,1	177,5	175,0	mg / dm^3	≤500,0
12.	Total mineralization	893,4	883,4	864,5	876,2	881,2	899,3	883,1	890,8	895,1	mg / dm^3	≤1500
13.	Iron	0,11	0,21	0,25	0,3	0,22	0,035	0,03	< 0,01	< 0,01	mg / dm^3	≤ 1,0
14.	Aluminum	< 0,01	< 0,01	< 0,01	< 0,01	< 0,001	< 0,001	< 0,001	< 0,001	< 0,01	mg / dm^3	Not specified
15.	Zinc	< 0,01	< 0,01	< 0,01	< 0,01	< 0,001	< 0,001	< 0,001	< 0,001	< 0,01	mg / dm^3	Not specified
16.	Cadmium	< 0,006	< 0,006	< 0,006	< 0,01	< 0,006	< 0,006	< 0,006	< 0,006	< 0,006	mg / dm^3	Not specified
17.	Copper	0,028	0,035	0,023	0,03	0,031	0,026	0,022	0,028	0,03	mg / dm^3	Not specified
18.	Lead	< 0,01	< 0,01	< 0,01	< 0,01	< 0,001	< 0,001	< 0,001	< 0,001	< 0,01	mg / dm^3	Not specified
19.	Chrome	< 0,01	< 0,01	< 0,01	< 0,01	< 0,001	< 0,001	< 0,001	< 0,001	< 0,01	mg / dm^3	Not specified
20.	Nickel	< 0,01	< 0,01	< 0,01	< 0,01	< 0,001	< 0,001	< 0,001	< 0,001	< 0,01	mg / dm^3	Not specified
21.	Arsenic	-	-	-	< 0,01	< 0,001	< 0,001	< 0,001	< 0,001	< 0,01	mg / dm^3	Not specified
22.	Ammonia	0,01	0,02	0,04	0,04	0,08	0,1	0,06	0,06	0,04	mg / dm^3	≤2,6
23.	Nitrites	0,01	0,012	0,008	0,008	0,006	0,01	0,008	0,002	0,001	mg / dm^3	≤3,3
24.	Nitrates	18,8	20,4	22,3	21,9	18,7	20,4	19,4	24,3	28,6	mg / dm^3	≤50,0

Fig. 10 Analysis of drinking water quality from a source in Sarzhin Yar

Drinking water intended for human consumption must meet the following hygienic requirements: be safe in epidemic and radiation terms, have favorable organoleptic properties, and harmless chemical composition.

For drinking water consumed by the population of the city, preference should be given to water from underground sources of drinking water supply, reliably protected from biological, chemical and radiation pollution.

Providing a hygienic assessment of the safety and quality of drinking water, it is examined for epidemic safety indicators (microbiological, parasitological), sanitary-chemical (organoleptic, physicochemical, sanitary-toxicological) and radiation indicators,

The spring water in Sarzhin Yar is recognized as drinking water with an optimal content of minerals, intended for human consumption, with a mineral composition adequate to the physiological needs of the human body.

Water from a spring in Sarzhin Yar, the composition of which according to organoleptic, physicochemical, microbiological, parasitological and radiation indicators meets the requirements of state standards and sanitary legislation.

Hydrogen index (pH) - an indicator that characterizes the property of water due to the presence of free hydrogen ions in the studied samples for 20 years, the pH is 6.44-7.69, which indicates a slightly alkaline environment of water. No exceedances have been identified.

Color - an indicator that characterizes the intensity of watercolor, which is due to the content of colored organic matter. For the tested water, it is 50, which is equal to 1/7 TLV.

Total hardness is an indicator that characterizes the property of water due to the presence of dissolved salts of calcium and magnesium (sulfates, chlorides, carbonates, bicarbonates, etc.).

According to the recommendation of the World Health Organization (WHO), a person receives sufficient amounts of magnesium and calcium, provided that water consumption is approximately 5.0 mmol / l, and the maximum concentration limit for water sources is $\leq$ 10.0. Do not forget that magnesium and calcium are two essential elements that enter the human body from the water. In water from a source in Sarzhin Yar, the hardness does not change for 20 years and is about 8 mmol / l, which is within the TLV.

However, the Recommendations of the World Health Organization for drinking water still define vital indicators: Ca - 60-130 mg / l; Mg - 10-80 mg / l. Water from the studied source has a content of Ca at the level of 108 mg / l and Mg at the level of 27 mg / l, which is within normal limits.

Total alkalinity - an indicator that characterizes the property of water due to the presence of anions of weak acids, mainly carbonic acid (carbonates, hydrocarbons). In the current DSanPiN 2.2.4-171-10 this indicator is not normalized for sources, but for drinking water from other sources its TLV is 6.5 mmol / l, and in the water of the studied source, the alkalinity is 6.2 mmol / l.

The smell is an indicator that characterizes the property of water to irritate the receptors of the mucous membranes of the nose and sinuses, causing the corresponding sensation. No foreign odor has been detected in the water from the spring in Sarzhin Yar for 20 years.

In the studied water, the turbidity does not exceed 1.5 NOC (TLV $\leq$3.5). This indicator characterizes the natural property of water due to the presence in the water of suspended solids of organic and inorganic origin (clay, silt, organic colloids, plankton, etc.).

The predominance of certain salts or gases in mineral waters affects their taste. Thus, the presence of carbon dioxide gives water a sour taste, the presence of table and hydrogen chloride salts - salty. Alkaline salts give the water a salty-bitter taste, sulfuric acid - bitter, ferrous - slightly tart, sulfuric - an unpleasant odor and taste of rotten eggs.

The type of hydrocarbon (carbon dioxide) mineral waters include waters where the content of hydrocarbon and carbonate ions varies depending on the type of water from 1.0 to 8 g / dm^3. The content of hydrocarbon and carbonate ions in the investigated water is 0.450 g / dm^3.

Chloride mineral waters contain chloride ions in the amount of 2.0-6.5 g / dm3. The water in Sarzhin Yar contains chloride ions in the range of 0.065 g / dm3.

Sulfate mineral waters contain from 2.0 to 5.5 g / dm3 of sulfates. Springwater from Sargin Gorge contains 0.175 g / dm^3.

That is, water from a spring in Sarzhin Yar belongs to the category of freshwater, the species is moderate freshwater.

Biologically active are waters of different degrees of mineralization, if in them along with widespread anions and cations dissolved at least one of the following elements: Fe- in the amount of more than 10 mg / dm^3, As- more than 7, Br- more than 25, I- more than 10, Li- more than 5 mg / dm^3 or radioactive elements Ra and Rn are present. In the water from the source in Sarzhin Yar, the minimum content of Fe is less than 0.3 mg / dm^3, As, Br, I, Li, Ra, Rn are absent, ie this water cannot be classified as biologically active.

Using the formula, the IPR for the source for the last 5 years (2017-2021) was calculated.

Table 1 - The value of SAR for water from a source in Sarzhin Yar (2017-2021)

Place of sampling	WPI				
	2017	2018	2019	2020	2021
Sarzhin Yar	0,17	0,18	0,18	0,21	0,19

Table 2 Hazard factors of chemical elements (2020)

Name of the substance	Coefficient
Chlorides	0,17
Iron	0,5
Zinc	0,01
Copper	0,015
Ammonia	0,02
Nitrites	0,002

According to the table, it can be noted that the spring water from Sarzhin Yar is fully fit for consumption.

Analysis of the impact of the quality of the visual environment has shown that any disturbance of the living environment inevitably entails negative consequences, which are often expressed in deteriorating health and deteriorating social factors. To solve such problems, multifunctional recreational areas that meet the requirements for population relaxation are essential. Thus, on the territory of the existing recreational zones it is necessary to carry out functional zoning, which would maximally involve the territory of the park; to equip sites and elements of infrastructure that meet the needs of different groups of the population; to organize economic infrastructure: areas for walking dogs, places for storage of inventory and areas for garbage collection; to control the quality of spring waters used by citizens; take measures to rehabilitate green areas (rejuvenation of plantings) and increase their diversity; organize convenient access to the park: approaches from public transport stops, linear eco-parks.

References

1. Ellard C. (2016). Habitat: How Architecture Affects Our Behavior and Well-Being. 330. (in Russian).

2. Vitmanova O. S., Lagodny E. N. (2020). The influence of the surrounding landscape and videoecology on humans in an urbanized environment. *International Journal of Applied Sciences and Technologies «Integral»*, Moscow. 2-2. 32-37. (in Russian).

3. Filin, V. A. (2001). What is good for the eyes and what is bad. Moskov: Videoecology (in Russian).

4. Filin, V. A. (1990). The color environment of the city as an environmental factor. Proceedings of the International Seminar: Coloring of the city, 1, 55-60 (in Russian).

5. Kirsanov A. N., Kirsanova S. A. (2017). Two arts: progressive and traditional arts from the point of view of videoecology. Part I. Videoecology and constructivism. *Traditional arts and crafts and education.* St. Petersburg. No. 2 (20). 1-24. (in Russian).

6. Lusse, M. K. (1989). Visual qualities of the environment of settlements. Quality problems of the urban environment. Moscow: Nauka. 118–127 (in Russian).

7. Miroshnichenko, V. V. (2012). Environmental comfort of urban geosystems of Kharkiv (videoecological aspect). Man and the environment. Issues of neoecology, (1-2), 92-99. Retrieved from https://periodicals.karazin.ua/humanenviron/article/view/927 (in Russian).

8. Tetior A. N. (2007). Urban ecology. Textbook for students of higher educational institutions. Moscow: Academy. 336. (in Russian).

9. Bokov, A. V. (1999). Landscape-architectural methods for improving the visual perception of the urban environment. Moskow: Madzhenta (in Russian).

10. Kaganov, G. Z. (1990). Problems of perception of the urban environment by the population. Moscow: Nauka, 38–45 (in Russian).

11. Information about Shevchenkivskyi District. Retrieved from: https://www.city.kharkov.ua/

12. Nekos A. N., Gladyr V. S., Sapun A. V. (2020). Assessment of the visual environment of the city (on the example of the Kholodnohirsky district of Kharkiv). Man and the environment. Issues of neoecology, (33). 80-90. Retrieved from https://periodicals.karazin.ua/humanenviron/article/view/15799 (in English).

13. Morar T., Radoslav R., Spiridon L., Păcurar L. (2014): Assessing pedestrian accessibility to green space using GIS. Transylvanian Review of Administrative Sciences, 10. 116–139. (in English).

14. Water Code of Ukraine. (1995). Retrieved from: https://zakon.rada.gov.ua/laws/show/213/95

15. Low of Ukraine about drinking water, drinking water supply and water disposal. (2002). Retrieved from: https://zakon.rada.gov.ua/laws/show/2918-14

16. Hygienic requirements to drinking water intended for human consumption. State Sanitary Rules and Norms 2.2.4. – 171 – 10. (2010). Retrieved from: https://dbn.co.ua/load/normativy/sanpin/dsanpin_2_2_4_171_10_gigienichni_vimogi_do_vodi_pitnoji_priznach enoji_dlja_spozhivannja_ljudinoju/25-1-0-1180

17. State Service of Geology and Subsoil of Ukraine. Groundwater: resources, use, quality.

18. Nekos A. N., Garbuz A. G. (2012). Ecological assessment of environmental objects and food products. Kharkiv: V. N. Karazin KhNU, 104. (in Ukrainian).

19. Drinking water. Retrieved from: https://znaytovar.ru/new53.html

8 ECOLOGICAL CONSEQUENCES OF THE LARGE FORESTS FIRES IN THE NORTHERN HEMISPHERE DURING 2020

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Large-scale forest fires on the globe are one of the challenges facing our civilization. The fact is that during the forest fires significantly affected all the components of ecogeosystems, namely, soil cover, hydrosphere, atmosphere, flora and fauna, and the biosphere as a whole. The problem of large-scale forest fires has significant environmental, economic and social consequences.

The impact of fires on forests has been studying for over 50 years. As early as 1948 studied the effect of fires on forest. Fundamental works were carried out by the authors. Most of the scientific works on this topic were published in the USSR/Russian Federation [1–8]. This is natural, since the surface area of forests in the USSR was 3 billion acre, and in the Russian Federation 1.9 billion acre [6]. At the same time in the Russian Federation annually during forest fires about 24.7 million acre are destroyed, which is 1.3% of the total surface forest area in the country.

An outstanding contribution to the study of forest fires and their ecological consequences was made in the world by authors [9–12], in the Russian Federation by authors [1–6], in Ukraine by authors [13–16] and many others.

The author [3] is the founder of a new scientific direction called a systematic study of environmental issues of forest fires, allowing to assess and predict the risks and hazards caused by fires. The ultimate goal of such researches is to improve the level of protection for people, territories and property. The author [3] used computational-analytical and experimental methods. This allowed her to assess the impact of fires on the environment.

The author of many scientific works [1–2] founded a new scientific direction called physics of forest fires and their mathematical modeling.

The author [13] in many publications substantiated theoretical and methodological assessments of the technogenic risk of pyrogenic origin and the probability of fire damage to ecogeosystems. This author studied the factors, manifestations and consequences of post-pyrogenic relaxation, ecogeosystems, described, using specific examples, post-pyrogenic relaxation, formulated practical recommendations.

The causes of forest fires and their consequences, both theoretically and experimentally, have been studying for a long time. Usually, the focus is on predicting and preventing forest fires. In works [3, 4, 7], mathematical models were developed, the mechanisms of occurrence of the most dangerous forest fires, namely crown fires, were studied.

In papers [14–16], the authors described the ecological consequences of large-scale forest fires in Ukraine in the spring–summer–autumn seasons of 2020. The environmental consequences have been shown to be record-breaking, or rather anti-record. During 2020, large-scale forest fires also occurred in the U.S.A., Spain, Greece, the Russian Federation and other countries. The ecological consequences of large-scale forest fires in the Northern Hemisphere during 2020 are of interest to study.

The relevance of such a study is as follows. Humanity lives in an era of global warming, which is caused by a further increase in the number of people on the planet, an ever-increasing man-made impact. At the same time, emissions of additional heat, harmful substances, gases and, in particular, carbon dioxide into the atmosphere increase. An increase in the mass of this gas leads to an intensification of the greenhouse effect. As a result of this effect, the temperature of the atmospheric surface layer rises, the probability of large-scale forest fires and deterioration of the state of ecological systems increases. Thus, a positive feedback appears in ecogeosystems, which leads to an acceleration of the negative ecological consequences of large-scale forest fires on the planet.

In spring–summer–autumn of 2020, forest fires of record intensity were observed in the Northern Hemisphere. The fires have had serious environmental consequences. At the same time, significant natural resources were destroyed. The process of absorbing carbon dioxide by forests, that enrich the atmosphere with oxygen is well known. The combustion has led to the release of carbon dioxide, which has contributed to the acceleration of global warming. Fires in large areas destroyed ecosystems, reduced biological diversity, caused significant damage to the habitat of animals and vegetation, and killed useful soil microorganisms. After fires, soil fertility is reduced, and the probability of its erosion is increased. Fires have led to a deterioration in the quality of drinking water, groundwater, streams and rivers after fires are less enriched with water. The reservoirs were contaminated with ash and soot, which damaged fauna and flora. The atmosphere is significantly polluted by the combustion products of forest tracts. Powerful acoustic (including harmful infrasonic) radiation was injected into the atmosphere. All of this took place during forest fires during 2020. A quantitative assessment of the environmental consequences of large-scale fires during 2020 is required, which has led to the relevance of this work.

The aim of the work is to analyze and quantify the mass of emissions of combustion products and chemical elements into the Earth's atmosphere, as well as the energy and power of acoustic and thermal radiation caused by the large forests fires in the Northern Hemisphere during 2020.

The geographical location, the area covered by the fires, their duration are borrowed from open data posted on the Internet. When assessing the environmental consequences of large-scale fires, the initial parameters are the area of the fire, the mass per surface area of combustible materials, as well as the transform coefficients of the mass of combustible materials into the mass of combustion products.

To study the ecological consequences of large-scale forest fires in the Northern Hemisphere, the following methods were used: information analysis, theoretical calculations, mathematical modeling and system analysis of the entire complex of effects. The quantitative indicators of the energy and power of fires (thermal energy and power), processes of mass emission of smoke, soot, carbon monoxide, carbon dioxide, nitrogen, heavy chemical elements, energy and power of infrasonic radiation were subject to modeling.

General issues of large-scale fires are discussed in [1–6].

Certain aspects of the methodology for analyzing the ecological consequences of large-scale fires were developed by a number of specialists [17]. The technique is most fully described in [18, 19]. In this paper, we will follow the author [18, 19].

When assessing the environmental consequences of large-scale fires, the initial parameters are the area of the fire *S*, the mass per surface area of combustible materials $\tilde{m}$, as well as the transform coefficients of the mass of combustible materials into the mass of combustion products. As the latter, we choose the mass of smoke, masses of CO_2, CO, C and hydrocarbons (CH_4, C_2H_4, C_2H_2, C_2H_8, C_3H_6, C_3H_8). Let us separately estimate the masses of chemical elements injected into the atmosphere (N, K, Ca, Fe, Zn, Sr, Br, Pb, and Se). In this case, we will proceed from the following ratios: mass of smoke $m_s = 0.04m$, $m_{CO_2} = 2.25m$, $m_{CO} = 0.1m$, $m_C = 3\cdot10^{-3}m$, mass of hydrocarbons $m_h = 0.04m$.

The mass per surface area of chemical elements also discharged during forest fires is given in Table 1 [16].

Under natural conditions, mass per surface area of smoke $\tilde{m}_s \approx 10^{-5}$ kg/m^2, $\tilde{m}_{CO_2} \approx 4.6$ kg/m^2, $\tilde{m}_{CO} \approx 10^{-3}$ kg/m^2, $\tilde{m}_C \approx 10^{-6}$ kg/m^2, mass per surface area of hydrocarbons $\tilde{m}_h \approx 10^{-2}$ kg/m^2.

Table 1 - Mass per surface area of chemical elements discharged during forest fires

Chemical element	Mass per surface area of chemical elements											
	N	K	Ca	Fe	Zn	Cr	Br	Mn	Pb	Rb	Sr	Se
$\tilde{m}$ (kg/m^2)	0.1–1	$(0.2–1.2)\cdot10^{-5}$	$(0.4–0.8)\cdot10^{-5}$	$(0.6–3.7)\cdot10^{-6}$	$(0.7–8.7)\cdot10^{-7}$	$(1.4–6.5)\cdot10^{-7}$	$(0.7–2.3)\cdot10^{-7}$	$(0.1–2.9)\cdot10^{-7}$	$(0.4–0.8)\cdot10^{-7}$	$(0.2–0.5)\cdot10^{-7}$	$(0.1–0.5)\cdot10^{-7}$	$(0.1–0.3)\cdot10^{-7}$

Analysis of the data in Table 1 shows that the highest mass per surface area was observed for atomic nitrogen discharges, much less for potassium and calcium, and even less for other elements.

The mass per surface area of forest combustible materials varies widely. For grass $\tilde{m} \approx 0.1-1$ kg/m^2, for shrubs $\tilde{m} \approx 1-5$ kg/m^2. The lowest value of the mass per surface area is observed in forests in the forest-steppe zone (about 10 kg/m^2), and in the subtropics and tropics, $\tilde{m} \approx 60$ kg/m^2. The values of $\tilde{m}$ used in this work are given in Table 2.

Table 2 - Parameters of forest fires

Parameter	Country			
	U.S.A.	Russian Federation	Spain	Ukraine
Mass per surface area (kg/m^2)	40	20	30	10
Burnout characteristic time (h)	2.8	1.4	2.1	0.7

Fires are accompanied by powerful thermal Π_t and acoustic Π_a radiation fluxes.

The flux densityΠ_t can be calculated from the relationship from [18]:

$$\Pi_t \approx \sigma(T^4 – T_0^4),$$

where $\sigma = 5.67 \cdot 10^{-8}$ W/(K$^4 \cdot$m^2) is the Stefan–Boltzmann constant, T is the flame temperature, T_0 is the air temperature, which is further assumed to be ~300 K.

According to [30], about 0.3% of the energy E released during a fire is converted into the acoustic radiation energy E_a. In this case, the power of acoustic radiation is $P_a \approx 0.003P$, where P is the power released during combustion. Moreover $\Pi_a = P_a/S$. Under normal conditions $\Pi_a \approx 1$ mW/m^2.

Forest fires in the Russian Federation. Large-scale fires began in January 2020. By May 15, 2020, according to Greenpeace, about 33.4 million acre have burned, and according to the Russian Federation data, only 11.6 million acre, of which 4.7 million acre are forests [20, 21].

On June 28, 2020, Greenpeace reported that fires in the Russian Federation had passed 51.9 million acre, and the Russian authorities reported that the fire covered a surface area of 29.7 million acre, of which 16.3 million acre were forests. Fires in the Russian Federation continued in August, September and October 2020. Buryatia, the Trans-Baikal, Krasnoyarsk, Primorsky, and Khabarovsk regiones, as well as the Bryansk, Irkutsk, Smolensk, Kemerovo, and Jewish Autonomous Regions were most affected. During the day, the surface area of fires increased by 12.4 thousand acre. Forests in Yakutia suffered the most, their share exceeded 80% [21]. The strongest forest fires were recorded in May (their duration was at least 30 days) and in July (duration was about 20 days). The surface area of the forest burned down is estimated to be about 29.7 million acre within two months. The damage caused amounted to about US $600 billion.

The photo of a forest fire in the Russian Federation is shown in Fig. 1.

Fig. 1 – The photo of a large-scale forest fire in the Russian Federation in summer of 2020 [Available from https://opozhare.ru/posledstviya/statistika-lesnyh-pozharov]

Forest fires in the U.S.A. Fires during 2020 blazed in 12 states. The largest of them took place in the states of California, Oregon and Washington [22, 23].

California State. Fires in California started on August 2, 2020, but they were relatively weak.

In the middle of August 2020, the air temperature sometimes reached 50°C. The hot and dry climate contributed to the emergence of the so-called dry lightning. On August 16, 2020, 200 lightning strikes were registered in 30 minutes. In total, about 2500 lightning strikes were noted during the day. Dry lightning provoked 585 forest fires. This was followed by megafires (Fig. 2). They lasted from August 18 to September 18, 2020.The total surface area of fires was 6.7 million acre.

Fig. 2 – The photo of a large-scale forest fire in the state of California (U.S.A.) in summer of 2020 [Available from https://iz.ru/1050026/video/v-kalifornii-obiavili-rezhim-chs-iz-za-pozharov]

In early September, as a result of fires over California, pyrocumulus appeared, i.e. pyro-cumulonimbus clouds, which quickly rose upward, up to an altitude of 15 km. Such clouds appear during the eruption of powerful volcanoes. Pyrocumulus form their own meteosystems, affecting the weather far beyond a large-scale fire. The frequency of lightning appearance in the presence of such clouds increases, provoking more fires.

Megafires were accompanied by the appearance of fire tornadoes (fire whirlwinds) (Fig. 3). In these cases, the flame height increased from 50–60 m to 10 km. In this case, combustion products were thrown even into the stratosphere. The aerosols (soot) ejected can remain in the stratosphere for months or even years. Absorbing solar radiation, soot significantly changes the thermal regime of the stratosphere and troposphere. According to measurements on satellites, the temperature of the atmospheric surface layer was 191°C.

Fig. 3 – The photo of a unique phenomenon of the occurrence of a fiery tornado during a forest fire in California (U.S.A.) in summer of 2020 [Available from https://newizv.ru/news/incident/17-08-2020/v-ssha-ob-yavili-evakuatsiyu-v-ozhidanii-ognennogo-tornado]

Due to the emission of a large amount of smoke in the daytime, twilight was observed, the sun was almost not visible, the sky acquired a dark orange color (a «red day» had come) (Fig. 4). Smoke went east, reaching Europe by mid-September.

Fig. 4 – The photo of a unique phenomenon (red day) caused by a large-scale forest fire in California (U.S.A.) in summer of 2020 [Available from https://newdaynews.ru/inworld/702344.html]

As a result of the fires, 29 people died, the city of Paradise was destroyed, more than 4000 buildings burned down, 120 thousand people were evacuated. In California, 172 thousand people were left without electricity. 14 thousand specialists took part in extinguishing the fire.

Economic damage amounted to US $130–150 billion.

Oregon State. The fire covered about 1 million acre. 0,5 million people were evacuated from the total population of the state of 4.2 million people, i.e. about 12%. The fire lasted more than 7 days. More than 20 people died, dozens were missing. Destroyed 5 small towns, hundreds of buildings [23].

Washington State. Fourteen fires were burning over a surface area of more than 0.5 million acre. The element lasted at least 10 days. There were casualties, more than 10 people were missing [24].

Alaska State. More than 107 large fires were observed on the territory of 1.7 million acre [25].

For comparison, let us add that the surface area of forest fires in Canada in August 2020 was about 4.9 thousand acre. 3.8 thousand people out of 4 thousand inhabitants were evacuated [26].

The total surface area of forests tracts burned in the U.S.A. during 2020 was about 6.7 million acre.

Such sad statistics characterize the state of the consequences of forest fires in the Western Hemisphere. The following is the state of the consequences of fires in Europe.

Forest fires in Spain. Fires in the Spanish province of Andalusia began on August 27, 2020 and lasted for at least three weeks (Fig. 5). The surface area covered by the fire was close to 24.7 thousand acre [27]. 3100 people were evacuated. Fires were extinguished by 500 people, 16 helicopters, 8 aircraft and army personnel were involved [27]. The damage caused amounted to about US $500 million.

Forest fires in Greece. The fire in Greece on 19–20 July 2020 began with 47 fire sites. The fire of variable intensity continued until September 5, 2020 (Fig. 6). 87

people died. The fire was extinguished by 391 firefighters, 154 units of equipment, 12 aircraft, 4 helicopters and volunteers [28].

Forest fires in Greece near Athens were recorded in August–September 2020. From 40 to 60 fire sites of forest fires were recorded every day. The surface area covered by the fire was about 2.5 thousand acre. The fire was extinguished by 180 firefighters, 56 units of equipment, including 6 planes and 8 helicopters [28].

Fig. 5 – The photo of a large-scale forest fire in Spain in summer of 2020 [Available from https://earthcentre.earth/climatechange.php]

Fig. 6 – The photo of a large-scale forest fire in Greece in summer of 2020 [Available from https://www.eurointegration.com.ua/rus/news/2021/05/20/7123382/]

A significantly smaller fire (197.7 acre) took place on the territory of the Republic of Athos on June 13, 2020.

Damage caused by fires amounted to about US $50 million.

Forest fires in France. The fire broke out on August 5, 2020 in the south of France (Fig. 7). More than 3700 acre of forest were burnt down. 4 thousand people were evacuated. 2 thousand rescuers took part in extinguishing the fire. 15 firefighters were injured [56].

The damage caused amounted to about US $75 million.

Fig. 7 – The photo of a large-scale forest fire in the south of France in summer of 2020

[Available from https://www.bbc.com/russian/news-40725728]

Forest fires in Ukraine. Fires in the Kiev and Zhytomyr regions took place in April–May 2020. In about a month, the fire covered a surface area of 5.7 thousand acre.

The fire element in the Kharkiv region was observed from 2 to 7 September 2020. The fire damaged about 1235 acre of forest.

The first fires in the Luhansk region also began on September 2, 2020.

The strongest fires were recorded in the Luhansk region from September 20 to October 4, 2020 (Fig. 8). The fires affected 32 settlements, burned down 300 houses, killed 11 people, 19 people asked for medical help with burns. 150 people were resettled. 1154 people, 294 units of equipment, 3 firefighting aircraft, a helicopter and a fire train took part in extinguishing the fire [30].

The damage caused by fires in Ukraine amounted to about US $1 billion.

Large-scale forest fires in Ukraine are described in more detail by the authors in the paper [37].

Fig. 8 – The photo of a large-scale forest fire in Luhansk region (Ukraine) in summer of 2020

[Available from https://donpress.com/news/07-07-2020-vtorye-sutki-polyhaet-masshtabnyy-lesnoy-pozhar-v-luganskoy-oblasti]

The results of the assessment of the main parameters characterizing the ecological consequences are shown in Table 3, from which the mass of burnt forest materials is seen to be about 3.5 Gt, the mass of smoke discharged into the atmosphere was not less than 140 Mt, which was almost 100 thousand times higher than the smoke content over these territories under normal conditions. The mass of discharged CO_2 was about 7.8 Gt, which is more than an order of magnitude higher than its content under normal conditions. The mass of the injected CO gas was about 350 Mt, which is thousands of times higher than its mass under normal conditions. The mass of the ejected soot exceeded 10 Mt, which is almost 100 thousand times more than the mass of C under normal conditions. The mass of injected hydrocarbons was about 140 Mt, which is two orders of magnitude higher than their mass under normal conditions.

Table 3 - Parameters of ecological consequences of forest fires in the Northern Hemisphere during 2020

Parameter	Russian Federation	U.S.A.	Spain	Ukraine	Background values over this area	Relative increase
Surface area of fires (acre)	29.7 million	6.7 million	24.7 thousand	56.8 thousand	–	–
Mass of burned materials (Mt)	2400	1080	3	2.3	–	–
Smoke mass (Mt)	96	43.2	0.12	$9.2\cdot10^{-2}$	$1.5\cdot10^{-3}$	$9.3\cdot10^{4}$
CO_2 mass (Mt)	5400	2430	6.75	5.2	676	11.6
CO mass (Mt)	240	108	0.3	$2\cdot10^{-3}$	0.15	$2.3\cdot10^{3}$
C mass (kt)	7200	3240	9	6.9	0.15	$7\cdot10^{4}$
Hydrocarbons mass (Mt)	96	43.2	0.12	0.1	1.47	95
Energy release (PJ)	$2.4\cdot10^{4}$	$1.1\cdot10^{4}$	30	23	–	–
Mean duration (days)	60	30	30	10	–	–
Mean power (TW)	4	3.6	0.01	$2.3\cdot10^{-2}$	–	–
Acoustic radiation energy (PJ)	72	33	$9\cdot10^{-2}$	$6.9\cdot10^{-2}$	0.117	900
Acoustic radiation power (PW)	12	11.1	0.03	$6.9\cdot10^{-2}$	$3.9\cdot10^{-2}$	590

Table 3 shows that the most significant ecological consequences of forest fires took place in the Russian Federation. In the U.S.A., they were about four times smaller. The ecological consequences of forest fires in Spain and Ukraine were significantly smaller.

The mass of chemical elements, formed by forest fires and injected into the atmosphere, is given in Table 4. The highest emissions were for nitrogen, calcium and potassium.

Table 4 shows that the largest discharges took place during large-scale forest fires in the Russian Federation, and somewhat smaller one in the U.S.A. The discharges in Spain and Ukraine were by a factor of hundreds to thousands of times smaller.

The energy of acoustic radiation was about 100 PJ, which is almost 1000 times higher than its energy under normal conditions. In this case, $\Pi_a \approx 0.1–4$ W/m^2 at the norm of $\Pi_a \approx 10^{-3}$ W/m^2.

The flux density Π_t for different values of the temperature excess $\Delta T = T – T_0$ is given in Table 5. The values of Π_t are seen to change by four orders of magnitude, depending on ΔT. At $\Pi_t \geq (0.1–1) \cdot 10^2$ kW/m^2 forest materials are ignited.

Table 4 - Mass of chemicals injected during forest fires

Chemical element	Country				Total injection
	Russian Federation	U.S.A.	Spain	Ukraine	
N (Mt)	24–240	11–108	0.03–0.3	0.02–0.2	35–348
K (t)	24–144	54–324	0.2–1.2	$(4.6–27.6) \cdot 10^{-2}$	80–470
Ca (t)	48–96	108–216	0.4–0.8	$(9.2–18.4) \cdot 10^{-2}$	160–320
Fe (t)	7.2–44.4	16.2–100	0.06–0.37	$(1.4–8.5) \cdot 10^{-2}$	24–144
Zn (t)	0.8–10.4	1.9–22.4	$(0.7–8.7) \cdot 10^{-2}$	$(1.6–20) \cdot 10^{-3}$	2.7–33.9
Cr (t)	1.6–7.4	3.8–17.6	$(1.4–6.5) \cdot 10^{-2}$	$(3.2–14.9) \cdot 10^{-3}$	5.4–25
Br (t)	0.8–2.8	1.9–6.2	$(0.7–2.3) \cdot 10^{-2}$	$(1.6–5.3) \cdot 10^{-3}$	2.7–8.9
Mn (t)	0.1–2.9	0.27–7.83	$(1.0–29.0) \cdot 10^{-3}$	$(2.3–66.7) \cdot 10^{-4}$	0.4–10.7
Pb (t)	0.4–0.8	1.08–2.16	$(0.4–0.8) \cdot 10^{-2}$	$(9.2–18.4) \cdot 10^{-3}$	1.6–3
Rb (t)	0.2–0.6	0.54–1.35	$(0.2–0.5) \cdot 10^{-2}$	$(4.6–11.5) \cdot 10^{-4}$	0.8–1.95
Sr (t)	0.1–0.6	0.27–1.35	$(0.1–0.5) \cdot 10^{-2}$	$(2.3–11.5) \cdot 10^{-4}$	0.4–2
Se (t)	0.1–0.4	0.27–0.81	$(1.0–3.0) \cdot 10^{-3}$	$(2.3–6.9) \cdot 10^{-4}$	0.4–1.2

Table 5 - Heat flux density from fire

ΔT (K)	Excess of temperature during fire									
	100	200	300	400	500	600	700	800	900	1000
Π_t (kW/m^2)	1	3.1	6.9	13	23	37	56	83	120	160

Catastrophic fires in the Northern Hemisphere during 2020 have caused record ecological consequences. The mass of smoke and soot was 100 thousand times higher than their mass under normal conditions. The emissions of CO, CO_2, hydrocarbons, as well as the energy of thermal and acoustic radiation were very significant. People suffered and died from thermal radiation. The energy of acoustic radiation contains 1–10% of the infrasonic radiation energy. The latter is not perceived by a human ears, but acts on all his organs, causing fear, panic and even mental disorders.

The total surface area covered by fire was about 37 million acre, which is about 3300 times less than the surface area of the Earth. The relative excess of the masses of the discharged combustion products and the radiation power decreased by the same number of times due to the transport processes. Nevertheless, the mass of smoke and soot in the entire Earth's atmosphere has increased by about 30 times, and the mass of CO has approximately doubled compared to the normal state. Of course, the particles of smoke and soot in the troposphere are gradually washed away by rain and other precipitation. Particles thrown into the stratosphere exist there for months or even years.

Sound waves attenuate at relatively small distances, in contrast to them, infrasonic waves propagate on a global scale, having a negative impact on the biosphere and people, in particular.

The large-scale fires that burned in the Northern Hemisphere during 2020 were found to have catastrophic ecological consequences. The greatest contribution was made by the forest fires in Russia and the U.S.A. Ecosystems were affected on a surface area of about 37 million acre. About 3.5 Gt of wood was irretrievably lost. The economic damage amounted to about US $750 billion. Dozens of people died and were injured. Material and moral damage has been caused to many thousands of people.

About 140 Mt of smoke was discharged into the atmosphere, which is almost 100 thousand times higher than its content in the atmosphere above burned forests under normal conditions. More than 10 Mt of soot was discharged into the atmosphere, which is 70 thousand times higher than its content under normal conditions. The mass of the injected CO gas was about 350 Mt, which is 2.3 thousand times higher than its content under normal conditions. The mass of hydrocarbons discharged into the atmosphere was about 140 Mt, which is about 100 times higher than their mass under normal conditions. About 7.8 Gt of CO_2 gas was additionally discharged into the atmosphere, which is an order of magnitude higher than its content under normal conditions.

Hundreds of megatons of atomic nitrogen, hundreds of tons of potassium and calcium, as well as from units to tens of tons of such chemical elements as Fe, Zn, Cr, Br, Mn, Pb, Rb, Sr, and Se have been discharged into the atmosphere.

The energy of acoustic radiation was about 100 PJ, which is almost a thousand times higher than its energy under normal conditions. The energy of weakly damped infrasonic radiation was 1–10 PJ. Infrasound has significantly impacted ecosystems.

The thermal radiation flux density reached 56–160 kW/m^2, which could cause an increase of fires.

Even after the distribution of forest combustion products around the globe, their concentration exceeded the concentration under normal conditions. This primarily applies to smoke, soot, and carbon monoxide.

The ecological consequences of large forests fires during 2020 for the planet have become record, or rather anti-record.

References

1. Grishin A. M. (1994). *Physics of forest fires*. Tomsk: TSU. (In Russian).
2. Grishin A. M. (1996). General mathematical model for forest fires and its applications. *Combust. Explos. Shock Waves 32*, 503–519. https://doi.org/10.1007/BF01998573
3. Isaeva L. K. (2001). *The environmental consequences of fires*. Diss. acad. degr. Doctor of Technical Sciences in form of the scientific report. Moscow: Academia GPS MVD RF. (In Russian).
4. Kondratyeva L. M. (2002). Multifactors of Forest Fire Impact on Biosphere Components. The forest protection from fires in modern conditions. Khabarovsk: KPB Publ (In Russian).
5. Andreev Yu. A. (2003). *Influence of anthropogenic and natural factors on the occurrence of fires in forests and settlements*: the dissertation author’s abstract. Dr. Tech. Sciences. Moscow: FSA VNIIPO EMERCOM of Russia (in Russian)
6. Vorobiev Y., Akimov V., &Sokolov Y. (2004). *Forest fires in Russia*: *Status and Problems.* Moscow: EMERCOM of Russia, DEKS-PRESS (In Russian).
7. Dorrer, G. (2008). Dynamics of forest fires [Electronic resource]: [monograph] / Institute of computational modeling SB RAS, Sib. State Technological University, G. Dorrer. Novosibirsk: SB RAS Publ. (In Russian).

8. Perminov, V. (2010). Mathematical modeling of the emergence of the highest and massive forest fires. Thesis for the degree of doctor physical and mathematical sciences. Tomsk: Tomsk State University (In Russian).
9. Boer M. M., Resco de Dios V., Bradstock R. A. Unprecedented burn area of Australian mega forest fires. Nature Climate Change. 2020. Vol. 10**.** Pp. 171–172. https://doi.org/10.1038/s41558-020-0716-1
10.Khabarov N., Krasovskii A., Obersteiner M., Swart R., Dosio A., San-Miguel-Ayanz J., Durrant T., Camia A., Migliavacca M. Forest fires and adaptation options in Europe. Regional Environmental Change. 2016. Vol. 16. Pp. 21–30. https://doi.org/10.1007/s10113-014-0621-0
11. Silva S., Fearnside P., Graça P., Brown I., Alencar A., Melo A. Dynamics of forest fires in the southwestern Amazon. Forest Ecology and Management. 2018. Vol. 424. Pp. 312–322. https://doi.org/10.1016/j.foreco.2018.04.041
12. Dhall A., Dhasade A., Nalwade A., Raj V. K. M., Kulkarni V. A survey on systematic approaches in managing forest fires. Applied Geography. 2020. Vol. 121. Article No. 102266. https://doi.org/10.1016/j.apgeog.2020.102266
13. Buts Yu. V. Scientific and methodological bases of relaxation of ecogeosystems under the technogenic loading of pyrogenic origin. Dissertation for obtaining a scientific degree of Doctor of Engineering Sciences in specialty 21.06.01 – ecological safety. Sumy: Sumy State University. (In Ukrainian). Retrieved from https://essuir.sumdu.edu.ua/handle/123456789/76266
14. Chornohor, L. L., Chernogor L. F., Titenko, A. V. (2020). Environmental consequences of large-scale forest fires in Ukraine in Spring–Autumn 2020. Environmental protection: Proceedings of Science Articles of the XVI Ukrainian Science Taliev Lections. Kh.: KhNU imeni V. N. Karazin (In Ukrainian).
15. Titenko, A. V., Chornohor, L. L. (2020). Environmental consequences of large-scale forest fires in Ukraine in 2020. Ecology, neoecology, environmental protection and sustainable using of natural resources: materials of the VIII International Scientific Conference of Young Scientists. – Kharkiv: V. N. Karazin Kharkiv National University, 33–35 (In Russian).
16. Chernogor L. F., Nekos A. N., Titenko G. V., Chornohor, L. L. Ecological consequences of large-scale forest fires in Ukraine in Spring – Summer – Autumn 2020. *Visnyk of V.N. Karazin Kharkiv National University Series «Ecology»*. 2021. № 24. 79–90. https://doi.org/10.26565/1992-4259-2021-24-07 (in Ukrainian).
17. Kuznetsov G. V, Baranovskii N. V. Forecast of forest fires appearance and their environmental consequences. Novosibirsk: Publ. SB RAS, 2009. — 301 c.
18. Chernogor, L. F. (2012). Physics and Ecology of Disasters. Kharkiv: V. N. Karazin Kharkiv National University Publ. (in Russian).
19. Chernogor, L. F. (2017). Space, the Earth, Mankind: Contemporary Challenges. Kharkiv: V. N. Karazin Kharkiv National University Publ. (in Russian).
20. Forest fires in the Russian Federation on June 28, 2020. (2021).
URL: http://www.forestforum.ru/viewtopic.php?f=24&t=24615
21. More than 990 thousand hectares of forest burn in the Russian Federation. (2021).
URL: https://www.dw.com/ru/в-россии-горят-более-990-тысяч-гектаров-леса/a-53883974
22. California sky turned orange from forest fires. (2021).
URL: https://www.dw.com/ru/ot-lesnyh-pozharov-nebo-kalifornii-stalo-oranzhevym-a-54889865/a-54889865
23. Americans fleeing from the fire: half a million people evacuated in Oregon. (2021).
URL: https://www.bbc.com/russian/news-54096007
24. Forest fires are raging in U.S.A. (2021).
URL: https://ru.euronews.com/2020/09/12/usa-west-coast-massive-fires
25. Forest fires in Arctic. What is their true scale? (2021).
URL: https://www.bbc.com/russian/features-49241145
26. «People had 15 minutes to get ready.» In Canada, due to unprecedented heat, a village burned down. (2021). URL: https://www.bbc.com/russian/news-57695158

27. Forest fire in Spanish Andalusia captured new territories. (2021).
URL: https://rg.ru/2020/08/31/lesnoj-pozhar-v-ispanskoj-andalusii-zahvatil-novye-territorii.html
28. Forest fires rage in Greece around Athens. (2021).
URL: https://www.eurointegration.com.ua/rus/news/2020/09/9/7114176/
29. Forest fires rage in France: 10 thousand people evacuated. (2021).
URL: https://www.bbc.com/russian/news-40725728
30.A man died in a fire in the Luhansk region: 945 ha are on fire. (2021).
URL: https://www.pravda.com.ua/rus/news/2020/09/3/7265071/

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(in English)

SUSTAINABLE DEVELOPMENT OF NATURAL AND ECONOMIC SYSTEMS: THEORY, METHODOLOGY, AND PRACTICE

COLLECTIVE MONOGRAPH

All materials are given in the monograph in the author's edition

Approved for 20.12.2021
Format. Offset printing
Risograph printing. Typeface Times.
Conventional printed sheets 13,45