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THE MECHANISM TO IMPLEMENT ENVIRONMENTAL INVESTMENT PROJECTS ON THE BASIS OF EQUITY FINANCING

The article deals with the problem of fair co-financing of socio-ecological and economic projects of a region, which is topical for the northern regions of Russia. At the same time, we solve the task of forming an optimal set of projects based on the fair sharing depending on the interest of business, state and society in the project implementation. In the process of analysing the attractiveness of socio-environmental and economic development projects in a region, we have developed a scheme for solving this task. At the first stage, we recommend an expert assessment using the fuzzy scales developed by the authors. These scales allow to make a lexical assessment of the priority of criteria for assessing the development of a region and the degree to which the projects meet these criteria. In the second stage of calculations, the obtained expert assessments make it possible to determine a fair sharing in project financing. These shared assessments and project priorities allow developing a model of an optimal set of projects for the development of a region, taking into account the allocated financial resources. The system of expert assessments and models is implemented in the Excel-VBA program. This system has been applied to solve the problem of selecting social, environmental and economic development projects in the Russian Arctic regions.

Keywords: regional development, business, state, society, priority, optimization, project equity financing, project implementation costs, paired comparisons, financing constraints, maximization of overall priority.

Introduction. Problem statement

Socio-economic development at the national and regional levels requires the implementation of significant projects, aimed at industrial growth and agricultural production, improvement of infrastructure, transport accessibility, environmental protection and sustainable environmental management, etc. These projects require substantial investments, which can be obtained from a budget account and private investors [1].

Currently, the management of the economy uses a wide range of instruments related to the financial sustainability of projects and programs [2], including environmental and social orientation. Among these sources of raising funds, along with the state budget funds of different levels, we can mention companies´ own funds, a public-private partnership, investment funds, grants, loans, public funds and others [3,4].

The Government of the Russian Federation at the meeting of the State Council on December 27, 2017, designated the increase of the investment attractiveness of the regions as a strategic priority for the development of the country. At this meeting, it was indicated that with a fall in the volume of capital investment in Russia for three years, by 7.9 %, investment increased in 21 regions of the country. Leading this list, Amur, Arkhangelsk, Vologda, Kaliningrad, Leningrad, Murmansk, Tula, Yakutia, Kabardino-Balkar, Yamalo-Nenets Autonomous Okrug, in which investment growth was around 40 %[1]. The implementation of this approach requires the solution of a set of tasks oriented to increase the interest of private investors to participate in regionally significant projects. At the same time, the most important priorities for the development of regions are improving the society´s quality of life, providing a favourable environment, creating convenient and comfortable conditions for opening and running a business, launching new industries, creating new jobs and increasing the citizens´ level of income.

In the economic security strategy of the Russian Federation for the period up to 2039, approved on May 13, 2017 by the Decree No. 208 of the President of the Russian Federation, among the main challenges and threats to economic security, there is insufficient volume of investment in the real sector of the economy, due to the unfavourable investment climate, high business costs, excessive

[1] Vladimir Putin predosteryog regiony ot "dolgovykh yam" [Vladimir Putin warned the regions against "debt pits"]. Rossiyskaya gazeta [Russian newspaper]. Retrieved from: https://rg.ru/2017/12/27/putin-predostereg-regiony-ot-dolgovyh-iam.html (date of access: 27.12.2017). (In Russ.)

administrative barriers, ineffective protection of property rights as well as weak innovation activity. At the same time, one of the objectives for the development of the public administration system, forecasting and strategic planning in the economic sphere is the adoption of a set of additional measures aimed at reshoring of the regional economy[2]. Projects implemented in the regions should create new jobs, reduce the environmental burden, initiate related projects and increase the cash flows of budgets at different levels.

The scientific literature has already developed a methodology for the justification of priority projects of environmental investment in limited conditions of financial resources [5]. Currently, funding for such projects is being actively developed through a public-private partnership.

Current projects that are relevant for the development of regions are associated with the creation of high-tech industries, agricultural production growth, the development of tourism, the preservation of historical, cultural and natural objects, the extraction and transportation of mineral resources, environmental protection, the ecological rehabilitation of degraded territories, etc.

The justification and implementation of priority projects in terms of environmental and social factors will reduce risks for the welfare and territory of the population, for example, the risk of poverty, the risk of health problems, the risk of deindustrialization and others [6]. Ecological investment projects have been developed in the world economy as a way to solve the problems of compensation for environmental damage [7] in the process of mining activities for land restoration and the rehabilitation of degraded areas [8].

Criteria for assessing the interest of stakeholders

The stakeholder within the region (Federal entities, municipal district, cities) include population, the state represented by the regional administration and business. Stakeholder´s interest overlap partly, and the preferences of the criteria for assessing these interests are different for every different party concerned. The interests of the investors are primarily related to the profitability of a project and the initiation of new projects [9].

The administration of region is especially concerned in increasing employment and the people´s income, reducing environmental pollution, launching new projects and raising investment in the economic development of the region [10]. From a perspective of the interest of society, the following criteria are the further growth in employment and people´s income, the reduction of environmental pollution. Based on the degree of compliance with the criteria in which society, the state represented by the regional administration, and business are interested, projects will be financed and their optimal choice.

In order to solve this task, the following three-stage scheme has been developed:

1. Stage 1 — Expert assessment about the significance of criteria for stakeholders and the level of satisfaction of criteria for implementing socio-economic projects in the region.

2. Stage 2 — Assessment of the degree of preference of projects for each stakeholder based on the used system of criteria and funding proportions of each of the projects by the state and business.

3. Stage 3 — Composition of an optimal set of projects with regard to the preference of these projects and funding structure, as well as the ultimate potential funds allocated by co-investors to implement these projects.

Consider the numerical implementation of each stage in detail.

Stage 1. Expert assessment about the significance of criteria for stakeholders and the level of satisfaction of criteria for implementing socio-economic projects in the region.

For a mathematical representation of the features of the procedures performed, we introduce the following designation:

— $i = 1, 2, 3$ — multiple stakeholders ($j = 1$ — business; $j = 2$ — the state represented by regional administration; $j = 3$ — society);

— $l = 1, 2, \ldots, m$ — criteria numbers;

— $j = 1, 2, \ldots, n$ — many social, environmental and economic projects, to be implemented in the region.

[2] Strategiya ekonomicheskoy bezopasnosti Rossiyskoy Federatsii na period do 2039 goda. Utv. Ukazom Prezidenta Rossiyskoy Federatsii ot 13 maya 2017 g. No. 208 [The economic security strategy of the Russian Federation for the period up to 2039. Approved by Decree No. 208 of the President of the Russian Federation, of 13 May 2017]. Retrieved from: http://legalacts.ru/doc/ukaz-prezidenta-rf-ot-13052017-n-208-o-strategii/ (data of access: 09.01.2018). (In Russ.)

Since carrying out expert assessments is a very difficult task, it is appropriate to use lexical assessments, which can then be converted into numerical values.

These goals can be achieved if we use the fuzzy sets theory and fuzzy numbers, which are broadly in line with lexical assessment [11]. This approach is successfully used to solve various tasks in the socio-economic sphere [12]. The present paper applied triangular fuzzy numbers [13], to provide estimates of boundaries of a numerical characteristic, that is, minimum and maximum values with minimum confidence, as well as expected value with maximum confidence. A triangular fuzzy number is marked on the top with the symbol ^ which is written as a triple number. For example, to the "interesting" lexical assessment the appropriate number takes the form: $\hat{B} = (B^{\min}, B^{avg}, B^{\max}) = (0.00, 0.25, 0.50)$, the confidence that the estimate value is 0.00 or 0,50 is equal to zero, and the confidence that this value will be 0,25, is equal to one.

For expert assessment, a fuzzy assessment was used, using the developed scales. Table 1 shows the scale for assessing the significance of the criteria.

Table 1

Scale for assessing the significance of the criteria

Lexical assessment of the significance of the criteria	Fuzzy triangular number corresponding to lexical assessment		
	Minimum (min)	Expected (*avg*)	Maximum (max)
Uninviting	0,00	0,00	0,25
Interesting	0,00	0,25	0,50
Important	0,25	0,50	0,75
Very significant	0,50	0,75	1,00
Extremely important	0,75	1,00	1,00

Figure 1 provides a graphical representation of the scale with a guidance lexical assessment and the corresponding triangular fuzzy numbers.

The proposed scale to assess the degree of achievement criteria in the implementation of projects also has five lexical gradations; nevertheless, their wording is different (table 2).

As a result of the expert assessment, fuzzy assessment matrices will be acquired $\hat{V}$ and $\hat{W}$, which are composed by the following elements:

— $\hat{W}_{il}$ — matrix element $\hat{W}$, showing an assessment if the significance of the criteria l for stakeholders i and representing a triangular number, corresponding to the lexical assessment in accordance with the adopted scale (table 1);

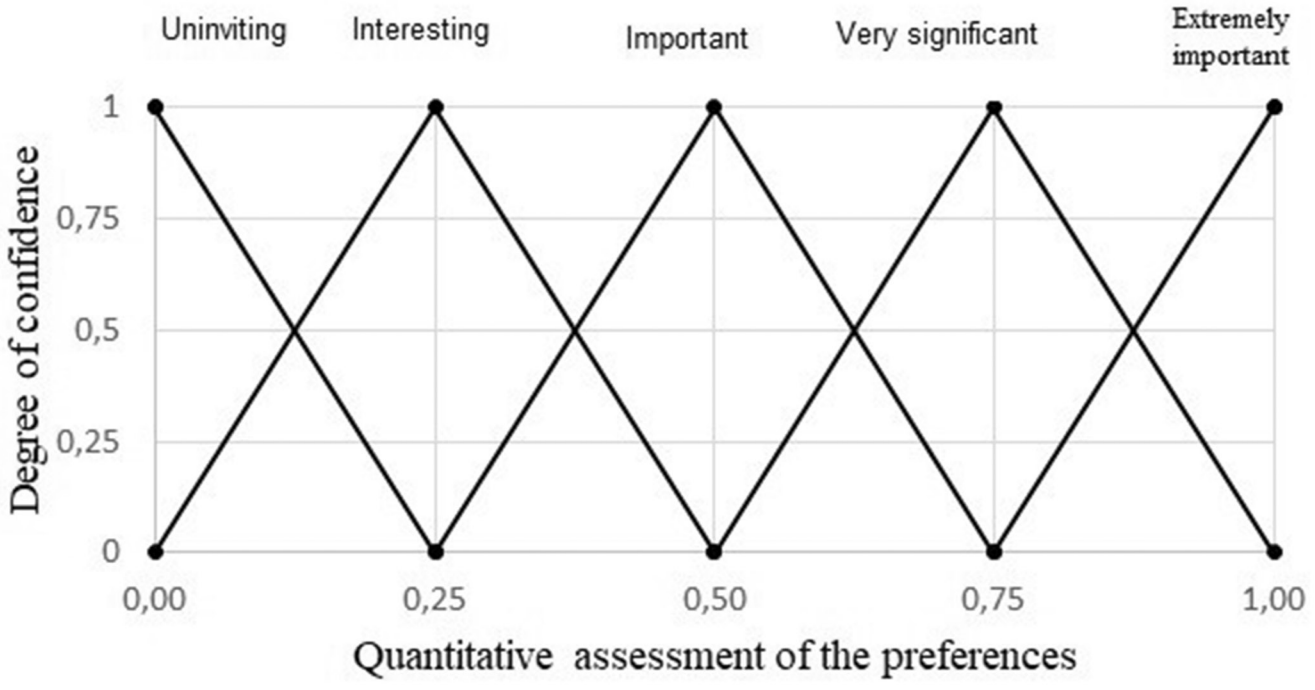

Fig. 1. *Graphical representation of the scale to assess the preference of the criteria*

Translation

Table 2

Scale for assessing the degree of achievement of the criteria for the implementation of projects

Lexical assessment of the degree of achievement of the criteria in the implementation of projects	Triangular fuzzy number corresponding to lexical assessment		
	Minimum (min)	Expected (*avg*)	Maximum (max)
Insignificant	0,00	0,00	0,25
Little	0,00	0,25	0,50
Significant	0,25	0,50	0,75
High	0,50	0,75	1,00
Very high	0,75	1,00	1,00

— $\hat{V}_{jl}$ — matrix element $\hat{V}$, showing an assessment of the degree of achievement of the criteria l during project implementation j and representing a triangular number, corresponding to the lexical assessment in accordance with the adopted scale (table 2).

Stage 2. Assessment of the degree of preference of projects for each stakeholder based on the used system of criteria and funding proportions of each of the projects by the state and business.

To solve this task, it is advisable to calculate a fuzzy matrix $\hat{A}$ depicting the relationship between stakeholders and potential projects. Each element of this matrix is a triangular fuzzy number defined by the formula:

$$\hat{A}_{ij} = \frac{\sum_{l=1}^{m} \hat{V}_{jl}\hat{W}_{il}}{\sum_{l=1}^{m} \hat{W}_{il}},\ i = 1, 2, 3; j = 1, 2, \ldots, n. \quad (1)$$

$\hat{A}_{ij}$ represents the weighted degree of preference of the project j by stakeholder i. The numbers $\hat{A}_{1j}$ represent an assessment of the degree of preference of the projects j = 1, 2, ..., n from a business perspective; $\hat{A}_{2j} + \hat{A}_{3j}$ are estimates of the degree of preferences of the projects j = 1, 2, ..., n from the point of view of the state. For further calculation, it is necessary to move from a triangular fuzzy number to exact values based on the calculation of the distance of triangular numbers from the origin of coordinates. To do this, we recommended applying the following formula for the conversion of triangular numbers $\hat{B} = (B^{\min}; B^{avg}; B^{\max})$:

$$\rho(\hat{B}) = 0.25(B^{\min} + 2B^{avg} + B^{\max}). \quad (2)$$

The project implementation costs are to be fairly set in accordance with the interest of each stakeholder, that is, the implementation cost of the projects j, equal to C_j, should be shared among co-investors in the following proportion:

Business financing:

$$C_j \frac{\rho\left(\hat{A}_{1j}\right)}{\rho\left(\hat{A}_{1j}\right) + \rho\left(\hat{A}_{2j}\right) + \rho\left(\hat{A}_{3j}\right)}. \quad (3)$$

Budget financing:

$$C_j \frac{\rho\left(\hat{A}_{2j}\right) + \rho\left(\hat{A}_{3j}\right)}{\rho\left(\hat{A}_{1j}\right) + \rho\left(\hat{A}_{2j}\right) + \rho\left(\hat{A}_{3j}\right)}. \quad (4)$$

The obtained priorities make it possible to identify the most interesting projects, which correspond to the assessment of interests for the stakeholders, business, state and society. These priorities should determine the composition of an optimal set of projects with regard to the restrictions on the volume of funds allocated from two sources — business funds and the state budget.

Stage 3. The composition of an optimal set of projects with regard to the preference of these projects and funding structure, as well as the ultimate potential funds allocated by co-investors to implement these projects.

The optimal set of projects of socio-economic development of the region is based on the following mathematical model. The maximization of the total priority of selected projects is considered to serve as an optimization criterion:

Translation

$$f(x)=\sum_{j=1}^{n}\rho\left(\hat{A}_{1j}+\hat{A}_{2j}+\hat{A}_{3j}\right)u_j\rightarrow\max, \tag{5}$$

where $\rho(\hat{A}_{1j}+\hat{A}_{2j}+\hat{A}_{3j})$ is the priority j of the project; u_j is the required variable, which takes the value 1, if the project l is chosen for implementation, or the value 0 otherwise.

In regard to the funding structure of each project from the two sources (for example from the state budget and business funds), determined by the formulas (3–4), restrictions on the selection of projects within the allocated funds for their implementation are presented in the formulas (6–7).

Restriction on the financing of projects by business.

$$\sum_{j=1}^{n}\left[C_j\frac{\rho\left(\hat{A}_{1j}\right)}{\rho\left(\hat{A}_{1j}\right)+\rho\left(\hat{A}_{2j}\right)+\rho\left(\hat{A}_{3j}\right)}\right]u_j\le B_1, \tag{6}$$

where B_1 is the volume of financing of projects in the region by business.

Restriction on financing from the budget:

$$\sum_{j=1}^{n}\left[C_j\frac{\rho\left(\hat{A}_{2j}\right)+\rho\left(\hat{A}_{3j}\right)}{\rho\left(\hat{A}_{1j}\right)+\rho\left(\hat{A}_{2j}\right)+\rho\left(\hat{A}_{3j}\right)}\right]u_j\le B_2, \tag{7}$$

where B_2 is the volume of financing of projects in the region from the regional budget.

This model also needs to consider the discreteness of the required variable, which can take the values 1 or 0:

$$u_j=\begin{cases}1,\\0,\end{cases}\ j=1,2,\ldots,n. \tag{8}$$

The developed optimization model (5–8) allows finding the optimal set of socio-environmental and economic projects, which are funded with the regional budget and business funds and provide the maximum total value of priority. This economic-mathematical model is a linear programming model with Boolean variables. In order to solve it, it is possible to use different methods such as Lemke and Spielberg method [14], Fora and Malgrange methods [15] etc.

Numerical example

For a detailed illustration of the developed approach of an optimum set of social, ecological and economic projects based on co-financing, which consists of three steps, consider the following example.

Let´s consider eight projects of socio-economic development. The first stage provides an expert assessment of the interest of the regional administration, society and business in the criteria by which these projects are evaluated, as well as the degree of achievement of the used criteria in the implementation of each project. The assessment is carried out by using lexical variables and fuzzy scales, which are given in Tables 1 and 2. Table 3 presents the baseline information for the assessing of the projects´ priority.

Table 3

Assessment results of the significance of the criteria

Criteria	Stakeholders		
	Business	Society	Regional administration
Creation of new jobs	Interesting	Extremely important	Important
Increase in people´s income	Interesting	Extremely important	Extremely important
Increase in budget allocations	Uninviting	Very significant	Extremely important
Opportunities for a new project	Extremely important	Important	Important
Attraction of investments in the region	Interesting	Very significant	Extremely important
Market growth	Very significant	Interesting	Extremely important
Project revenue growth	Extremely important	Interesting	Interesting
Environment improvement	Interesting	Very significant	Very significant

Translation

The information on the degree of achievements of the considered criteria in lexical assessments is shown in Table 4. Due to the limited length of the article, tables provided estimates for several projects. However, it does not interfere with the integrity of the perception of a numerical example.

Table 4

Degree of achievement of the criteria for the project implementation (Fragment)

Criteria	Assessment of the degree of satisfaction of the criteria in the context of project *j*			
	1	2	3	4
Creation of new jobs	Insignificant	High	Very high	Little
Increase in people´s income	Insignificant	High	Very high	Little
Increase in budget allocations	Insignificant	Significant	Very high	High
Opportunities for a new project	High	Insignificant	Insignificant	Significant
Attraction of investments in the region	Very high	Insignificant	Little	High
Market growth	Significant	Little	High	Little
Project revenue growth	Little	High	High	Little
Environment improvement	Little	Significant	Little	Very high

The results of the fuzzy assessment of the relationship between stakeholders and potential projects for the socio-economic development of the region were obtained using the formula (1) and are shown in Table 5.

Table 5

Fragment of the fuzzy assessment of the relationship between stakeholders and potential projects

Stakeholder	Fuzzy assessment of interest in projects j, scores											
	j = 1			*j* = 2			*j* = 3			*j* = 4		
	min	avg	max	min	avg	max	min	avg	max	min	avg	max
Business	0,58	0,70	0,72	0,00	0,16	0,54	0,17	0,34	0,65	0,38	0,64	0,83
Population	0,00	0,13	0,44	0,44	0,64	0,82	0,53	0,75	0,82	0,16	0,46	0,72
Administration	0,08	0,20	0,49	0,35	0,55	0,75	0,63	0,80	0,83	0,19	0,47	0,74

In terms of implementation of investment projects in the Artic zone in the Russian Federation, stakeholders can appear as the companies that use natural resources (business), indigenous peoples of the North and their ancestral communities (Population) and government authorities at various levels (administration).

Based on data presented in Table 5, it is necessary to find the exact values according to the calculation of the distance of triangular numbers from the origin of coordinates using formula (2) (Table 6).

Table 6

Accurate estimates of priority projects

Stakeholder	Project priority assessment *j* = 1, 2, …, 8, scores							
	1	2	3	4	5	6	7	8
Business	0,68	0,21	0,38	0,62	0,36	0,42	0,63	0,37
Population	0,17	0,64	0,71	0,45	0,60	0,36	0,43	0,50
Administration	0,24	0,55	0,77	0,47	0,54	0,31	0,46	0,46
Amount	1,09	1,40	1,85	1,54	1,50	1,09	1,52	1,33

The first row of Table 7 shows the required amount of investment for the implementation of projects of socio-economic development of the region. Based on the formulas (3–4), the equity financing of projects is determined (Table 7).

The total amount of funding that can be allocated by the regional administration is no more than 850 billion roubles, and business can assign not more than 400 billion roubles.

Translation

Table 7

Financing structure of projects by stakeholders

Key indicators	Value of project cost (RUB billion)							
	1	2	3	4	5	6	7	8
Project cost	200,00	180,00	240,00	260,00	160,00	200,00	220,00	250,00
Business financing	124,08	27,59	48,60	104,78	38,66	77,68	90,86	68,77
Administration funding	75,92	152,41	191,40	155,22	121,34	122,32	129,14	181,23

From data given in Tables 6–8, a numerical view (5–8) of the formation model of the projects' optimal set is formed:

$$f(u) = 1{,}09u_1 + 1{,}40u_2 + 1{,}85u_3 + 1{,}54u_4 + 1{,}50u_5 + 1{,}09u_6 + 1{,}52u_5 + 1{,}33u_6 \to \max, \quad (9)$$

$$124{,}08u_1 + 27{,}59u_2 + 48{,}60u_3 + 104{,}78u_4 + 38{,}66u_5 + 77{,}68u_6 + 90{,}86u_7 + 68{,}77u_8 \le 400, \quad (10)$$

$$75{,}92u_1 + 152{,}41u_2 + 191{,}40u_3 + 155{,}22u_4 + 121{,}34u_5 + 122{,}32u_6 + 129{,}14u_7 + 181{,}23u_8 \le 850, \quad (11)$$

$$u_j = \begin{cases} 1, \\ 0, \end{cases} \; j = 1, 2, \ldots, 8. \quad (12)$$

As a result of solving the task (9–12) the 1, 2, 3, 5, 6, 8th projects got included into the optimal plan, which enables to achieve a $f(u) = 8.27$ score value, that is 73 % of the maximum level, equal to the sum of priority projects (See last row of Table 6) — 11,33 point score.

According to Figure 2, it can be seen a detailed assessment of the achievement degree of maximum level of preference of the projects by stakeholders. Above the bars of diagrams, the percentage of attaining the maximum possible preference score is indicated.

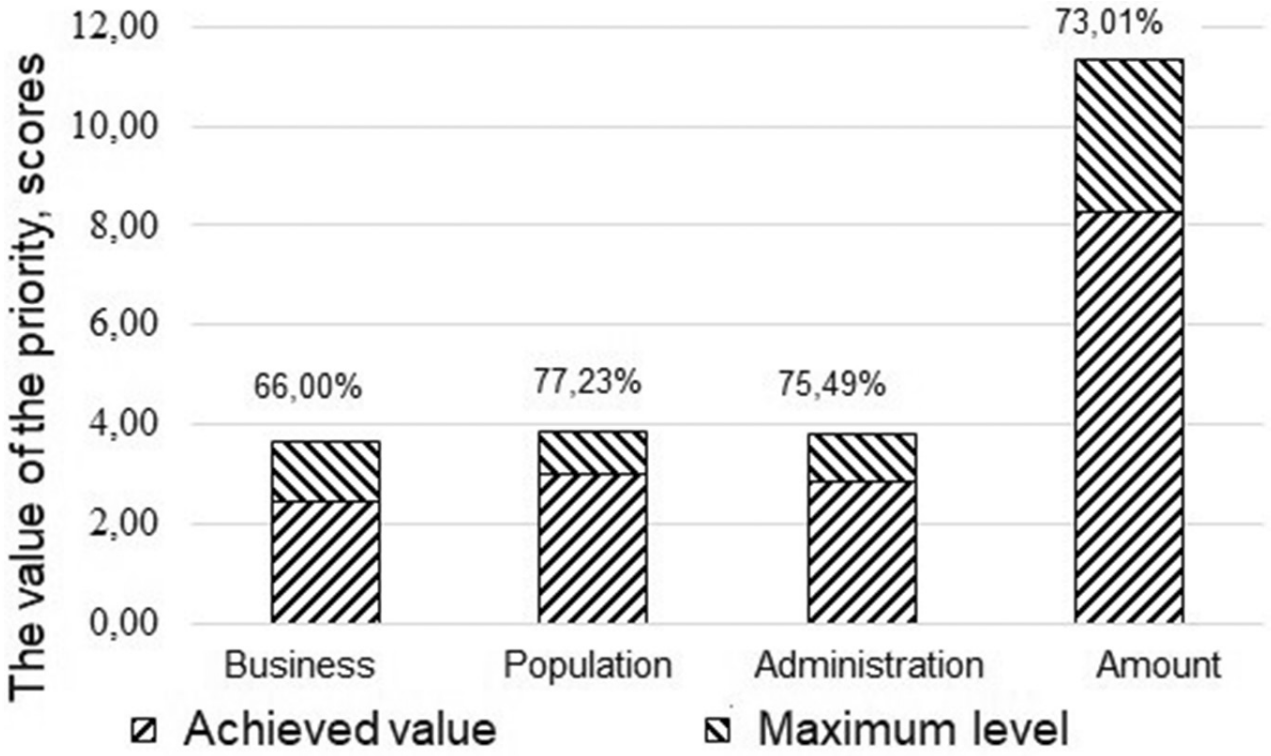

Fig. 2. *Assessment of achieving the maximum level of preferences with the optimal set of projects found*

Practical use of the developed methodological tools

The developed tools have been used to substantiate and implement a number of investment projects for the industrial development in the Russian Artic, mainly in the Republic of Sakha (Yakutia). In order to implement all three stages of the developed approach, a software package in Excel was used for which the authors wrote special macros that allowed performing large-scale calculations.

Currently, companies such as "JSC Almazy Anabara" (a subsidiary of ALROSA Company PJSC), holding "LLC Artic-Capital" and others are carrying out an active investment policy in the Artic regions

of the Republic of Sakha (Yakutia). The proposed recommendations for investment sustainability for industrial development projects in the Artic are reflected in the substantiation of mechanisms and programs of stakeholder's interaction in the districts of Anabar national (Dolgan-Evenk) ulus, Olenek Evenk national district, Bulun, Nizhni-Yansk, Srednekolymsky district and in other Artic areas of the Republic of Sakha (Yakutia). Such mechanisms for the implementation of investment projects can be the basis for the development of appropriate agreements between business, government authorities and the population for the socio-economic development of the territory, including measures to promote employment, develop ecological and social infrastructure, preserve the ethnic group and culture of the indigenous peoples of the North [16, 17]. Thus, for example in March 2018, JSC Almazy Anabara signed agreements on socio-economic development with the following four districts: Bulun, Zhigansky Evenk, Olenek Evenk and Eveno-Bytantai national district of the Republic of Sakha (Yakutia), which will serve as the basis to work together for the benefit of the inhabitants of the Artic regions. In 2018, more than 100 million roubles will be allocated in the framework of the agreement on the social and economic development of the district. The use of these funds has a targeted character, this is co-financing of various government programs, which involve districts, housing renovation, transport, as well as other areas related to the development of municipal infrastructure. The signed documents represented an important complement to the long-term agreements with the districts that were signed previously and will be implemented during the license period for subsoil use. This new mechanism was adopted by the company to ensure that people living in the territories were protected for the entire period of subsoil. At the same time, compliance with the environmental requirements, retraining and employment for the local population in places where the company is present, remain indisputable priorities[3].

In August 2018, an agreement on cooperation was signed between ALROSA Company PJSC and Olenek district. Under the agreement between the ALROSA Company and the Olenek district, it is planned to finance the ulus for five years is provided for 100 million roubles. This approach can become, in a certain way, a model behaviour and investment for a new venture of the company at the Verkhnechonskoye field, for profits from the extraction of diamonds, which will work to benefit the people. The funds received by the district within the framework of this agreement will be a business aid for the development of this territory, primarily infrastructure and social projects [18, 19]. These funds are used to build a school and kindergarten located in the Kharyyalakh village and ethno-cultural center in the Olenek Evenk district[4].

It is important to point out that the Olenek Evenk national ulus of the Republic is already becoming an industrial area along with Lensky, Mirninsky and Aldansky. On the ulus territory, "JSC Almazy Anabara" conducts the exploration and production of loose diamonds; "LLC Vostok Inzhiniring" develops the Tomtor deposit of rare-earth metals and "LLC Artic-Capital" and the "JSC ROSGEO" carry out the active geological exploration.

The implementation of the proposed mechanism for financing environmentally and socially significant projects based on equity financing provides a framework for harmonizing the interests of stakeholders and improving the quality of life of the population.

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