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Method of Evaluation of Investment Projects for Territorial Communities Taking into Account the Concept of Sustainable Development

Nataliia Maksyshko, Oksana Vasylieva and Alyona Polova

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Method of evaluation of investment projects for territorial communities taking into account the concept of sustainable development

Nataliia Maksyshko[1,*], *Oksana* Vasylieva[1], and *Alyona* Polova[1]

[1] Zaporizhzhia National University, Department of Economic Cybernetics, 66 Zhukovskogo str., Zaporizhzhia 69600 , Ukraine

Abstract. The article is devoted to solving the problem of evaluation and selection of investment projects aimed at the development of territorial communities, taking into account the concept of sustainable development. The problem of choosing from possible alternative solutions is not easy for decision makers and requires qualified justification. This is especially important in the context of decentralization reform, advancement of Ukraine towards openness of society, increase of transparency requirements of the authorities and their results. Decision making on the basis of the concept of sustainable development determines the evaluation of investment projects in terms of their effectiveness in solving problems of social, economic and environmental nature, finding a balance between these components. The peculiarity of the assessments is not so much quantitative as qualitative, which makes it expedient to use the apparatus of fuzzy logic. The fuzzy model of evaluation of investment project aimed at development of territorial community is constructed and substantiated in the work. The model is based on quantitative and qualitative assessments of the social, economic and environmental components of the concept and enables a "soft" - qualitative assessment of the investment project under consideration. Modeling results are based on the method of deciding on the choice of investment projects for the development of territorial communities. The proposed model and method are implemented using the Fuzzy Logic Toolbox application, used to substantiate decisions for the territorial community of Zaporizhzhia region, and can be used in the development of decision support systems for quantitative decision-making, variant calculations.

1 Introduction

The challenges of the 21st century make it necessary to ensure economic growth in the country on a balance basis. This implies the inheritance of the descendants of all environmental components in a condition not worse than that which exists today. This is the concept of sustainable development, which was first emphasized in 1987 in the report "Our Common Future" by the International Commission on Environment and Development [1].

This concept provides an opportunity to provide comprehensive management of territorial socio-economic systems, integrates the agreed aspects of economic, environmental and social development of society, creates conditions under which from one generation to the next the quality and safety of human life will not diminish, the environment will not deteriorate and socio - economic progress will be ensured [2].

Ensuring balanced development of the regions is one of the priority directions of Ukraine's regional policy at the present stage of its transformational transformations. Achieving this priority is facilitated by decentralization reform, which aims at the enhancing self-development of territorial socio-economic systems, their self-regulation, self-improvement with efficient use of available internal and external resources to meet the needs of residents [3,4].

The task of decentralization reform is to create the conditions for local issues to be addressed independently. Thus, in the light of global trends, the newly formed United Territorial Communities (UTC) face the need to create a system of governance that would provide prospects for the development of the territory not only from the point of view of socio-economic efficiency, but also by adhering to the principles of sustainable development oriented on interest of future generations. The Sustainable Development Goals, which were endorsed in 2015 at the United Nations Summit [5], are the baseline that sets out the forward-looking trends of the world, Ukraine and, in particular, the UTC.

Each territorial community is tasked with identifying areas and means that will enable sustainable development, both in the long term and at every step of government.

Thus, the issue of raising capital for the environmentally-oriented development of both the economy of Ukraine and individual communities is currently acute. Ukrainian experts [6] point out that the implementation of European integration reforms in the environmental sector of Ukraine requires the introduction of a «green» economy and development of territorial communities, ensuring human rights for a

* Corresponding author: maxishko@ukr.net

clean environment, decent work. The level and quality of life of the population, as well as the development of human capital, depend on the social aspects of investment. But today, UTC do not always understand and take into account the importance of social aspects of investing.

The problem of choosing from possible alternative solutions is usually not easy for decision makers and requires qualified justification. This is especially important in the context of Ukraine's progress towards openness of society, increasing demands for transparency of government actions and their results.

The scientific works of both domestic and foreign scientists [7-11] are devoted to the study of socio-ecological and economic development of the region, in particular those related to the development of models for assessing its level. However, development issues in the context of the concept of sustainable development in their works are generally covered at the national and regional levels. At the same time, there are practically no relevant developments for the level of territorial systems of the region and the integrated territorial communities, in particular.

In these circumstances, it is extremely important to develop and apply models and methods of quantitative and qualitative substantiation of the decisions made by the united territorial communities and aimed at solving problems of social, economic and environmental character in order to improve their own well-being and quality of life.

The purpose of this work is to develop and validate a fuzzy model for evaluating the quality of investment projects for territorial communities, taking into account the concept of sustainable development and recommendations for its application in the process of strategic decision-making for the community.

2 Materials and Methods

The essence of the problem, which is devoted to this work, lies in the evaluation and comparative analysis of investment projects. These projects are presented to the local community leadership (UTC) for choice and will depend on its further development in the context of implementing a sustainable development strategy.

Sustainable development of territories is ensured by a combination of environmental, economic and social components (spheres), each of which can be assessed by a whole set of relevant indicators.

For further modeling of estimation of the level of development of UTC as a result of realization of the investment project for each component we will select one measurable indicator, which in the further researches can be replaced by, for example, an integral indicator for a certain area. Each of these marks (indicators) characterizes the effectiveness of an investment project for an UTC in terms of a specific area.

It should be noted that the choice of a measured indicator faces the problem of choosing a measurement scale and methods of its measurement / calculation. If a quantitative indicator can be chosen to estimate the level of economic development, for example, the rate of increase / decrease in community budget revenues resulting from the project implementation, and to estimate the social impact, the number of jobs that will be created during the project implementation, then the environmental component is not always suitable for formal quantitative measurement procedure. Therefore, it is often only expert evaluation that can be used to measure it. However, confidence in such estimates may be different. Thus, the rating system, which characterizes the effectiveness of the implementation of the investment project, can contain both quantitative and qualitative indicators.

With this in mind, we come to the conclusion that in order to solve the problem of evaluating investment projects in the context of the concept of sustainable development and to make management decisions on the development of UTC, it is advisable to use data mining tools, namely fuzzy modeling.

Its founders - L. Zade [12], D. Dubois, A. Prad, A. Kofman devoted their research to problems of the use of a fuzzy logic for the analysis of economic systems. The works of A. Matviychuk [13], A. Nedosekin, S. Orlovsky, S. Stovby, N. Maksyshko, V. Shapovalova [14] and others are devoted to the improvement of decision-making methods in the economy based on the use of a fuzzy modeling methods.

The methodology for constructing a fuzzy model, including to obtain a qualitative assessment of an investment project for the development of an UTC, taking into account the concept of sustainable development, consists of the following stages:

-formation of a base of a fuzzy model input variables;

-phasification of input variables;

-formation of a base of rules of a fuzzy logic;

-accumulation of conclusions based on a fuzzy rules;

-defasification of the output variable (fig. 1).

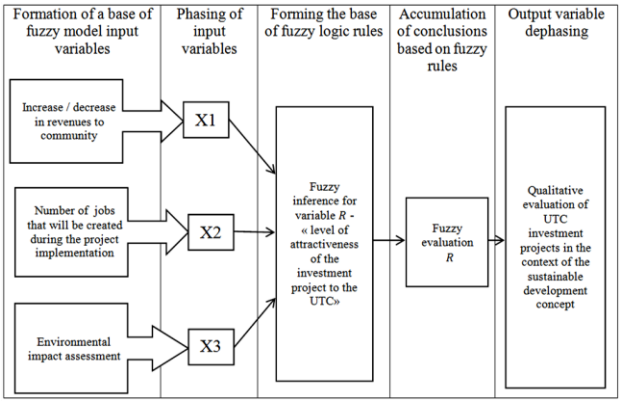


Fig. 1. The general scheme of construction of a fuzzy model of investment project evaluation for the development of UTC.

Method of estimation of investment projects for territorial communities will be based on use of the constructed fuzzy model

A fuzzy model for evaluating the attractiveness of investment projects will be used to benchmark them on

the development of UTC in line with the sustainable development concept. The general scheme of the decision-making method for choosing an investment project is presented in fig. 2.

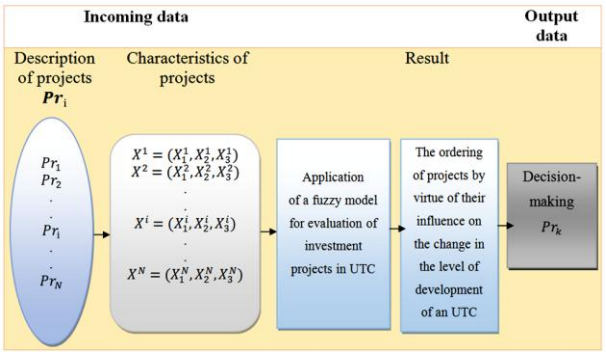


Fig. 2. The general scheme of the method of deciding on the choice of investment project for the development of UTC.

To implement fuzzy evaluation model of project development UTC editor uses Fuzzy Logic Toolbox, which is built into the application software package Mathworks.

3 Results

We build a fuzzy model for evaluating attractiveness of investment projects for integrated territorial communities, based on use of fuzzy logic and taking into account the concept of sustainable development.

The first two stages of a fuzzy model construction will be done in parallel. In the first stage, we define the content of its variables, the sets of their linguistic estimates (terms), and in the second stage - phasification - we define the sets of definition of variables and the type of membership functions.

Variable X1 reflects the rate of increase / decrease in community budget revenues. This indicator characterizes relative velocity (%) of changes in budget revenues resulting from project implementation.

The indicator X1 will be calculated by the formula:

$$X_1 = \frac{\mathrm{F}_i}{\mathrm{F}_{i-1}} \times 100\% \qquad (1)$$

where X_1- Economic growth (%);

F_i- the amount of budget receipts after project implementation (at time i);

F_{i-1} - the amount of budget revenues before the implementation of the project (during *i*-1).

Based on the analysis of existing investment business projects for the set of values of variable X_1 we will select the segment [70; 150] (X1∈ [70; 150]). The 70% limit is explained by the fact that, despite the potential environmental and social benefits of the investment, the project will not be considered if its losses can exceed 30% of the community budget. The upper limit is set at 50% of all budget revenues and is 150. Variable X1 is given by three linguistic estimates (term). Their parameters at the stage of phasing are shown in table 1.

Table 1. Phasing of the Economic Growth (X_1) variable

Linguistic assessment	View membership function	Function options
Decrease	trapezoidal	[70;70; 90; 100]
Permanence	triangular	[93; 100; 107]
Increase	trapezoidal	[100; 120; 150; 150]

A visual representation of variable X_1 is shown in figure 3.

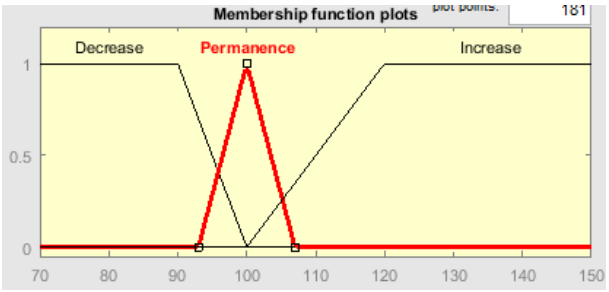


Fig. 3. Graphical representation of the term-sets of variable Economic growth (X_1).

The choice of the triangular membership function for linguistic assessment «Permanence» is explained by the fact that only the value 100 fully corresponds to the term "stable" and the value of the membership function μ of the linguistic variable "Permanence" at X_1 = 100 equals one (μPermanence(X_1=100)=1). When deviation from 100 at intervals [93; 100) and (100; 107] the membership function decreases linearly to zero.

The linguistic variables "Increase" and "Decrease" are better described by the trapezoidal function, since the membership functions μ are equal to 1 not only at one discrete value X_1, but at the interval X_1∈[70; 90]: μDecrease(X_1) =1 та при X_1∈ [120; 150]: μIncrease (X_1)=1.

The next variable is X_2, which characterizes the social inclusion of the project, which will be estimated by the percentage reduction in the unemployment rate in the community (calculated as the ratio of the number of jobs created during the implementation of the project to total number of unemployed communities):

$$X_2 = \frac{W}{\mathrm{U}} \times 100\% \qquad (2)$$

where X_2 - Social inclusion (%);

W - number of new jobs created during the project implementation;

U is total number of unemployed communities.

The value of variable X_2 is within X_2∈[0; 100]. Thus, if no new jobs are created during the investment, then X_2 = 0, if the number of jobs created is equal to the number of unemployed communities, then X_2 = 100 (%). Cases where the number of jobs exceeds the number of unemployed persons should be considered separately and are not the subject of this study, as they cover the issue of changing the social policy of the community regarding labor attraction.

The basic phasing parameters for variable X_2 are shown in table 2.

Table 2. Phasing of the Social inclusion variable (X_2)

Linguistic assessment	View membership function	Function options
Slight	triangular	[0;0; 20]
Medium	triangular	[10; 30; 50]
Significant	trapezoidal	[30; 60; 100; 100]

The visual representation of variable X_2 is shown in figure 4.

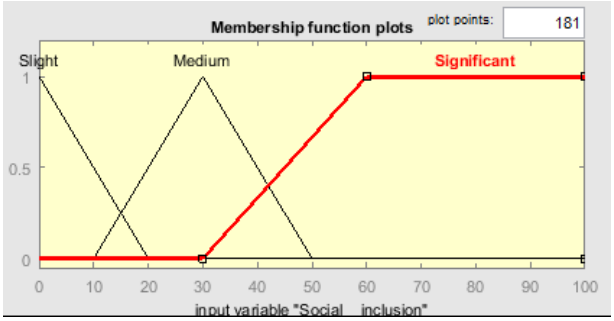


Fig. 4. Graphical representation of the terms of the sets of variables Social inclusion (X_2).

The indicator X_3 describes the environmental impact that the investment project has on the environment. The value of $X_3$is determined on basis of expert evaluation, measured in points and is in the range of $X_3 \in$ [-100; 100]. That is, at the most destructive value of environmental impact X_3= -100, at neutral impact X_3 = 0, and at the most positive 100. The basis for determining the indicator X_3 can be the results of the report on the environmental impact assessment conducted on the basis of Law of Ukraine No. 2059-VIII [15].

The basic phasing parameters for variable X_3 are shown in table 3.

Table 3. Phasing of the environmental protection variable (X_3)

Linguistic assessment	View membership function	Function options
Extremely negative	Gaussian	[-20; -100]
Negative	Gaussian	[15; -50]
Neutral	Gaussian	[10; 0]
Positive	Gaussian	[15; 50]
Extremely positive	Gaussian	[20; 100]

A visual representation of the variable X_3 is shown in figure 5.

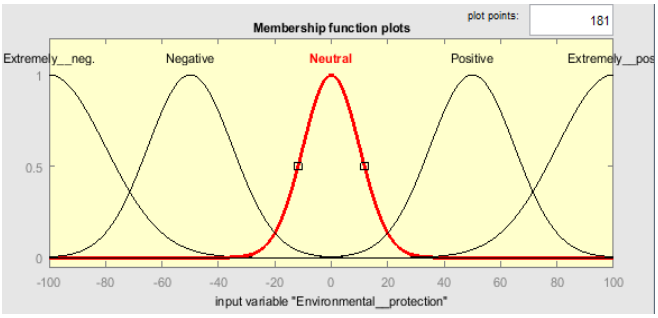


Fig. 5. Graphical representation of the terms of the sets of variable Environmental protection (X_3).

The application of the five linguistic terms and Gaussian membership functions is explained by the complexity of the procedure for formalizing environmental impact assessment, which is determined only by expert opinion, and the Gaussian type of membership function is analogous to the normal law of distribution of random variables, which is the most inherent in natural environmental processes.

Using the three input variables that characterize the economic, social and environmental impact of the project, it is necessary to obtain an integrated investment estimate - the output variable R, which indicates the level of attractiveness of the investment project to the UTC (measured in points). Some variable R is defined in the interval [0; 100], where R = 0 corresponds to an absolutely unattractive investment and R = 100 to an absolutely unattractive investment. The main parameters of the variable phasing of R is given in table 4.

Table 4. Phasification of the variable R-estimation of attractiveness of investment

Linguistic assessment	View membership function	Function options
Slight	triangular	[0;0; 35]
Medium	triangular	[25; 50; 75]
Significant	triangular	[65; 100; 100]

A visual representation of the variable R is shown in figure 6.

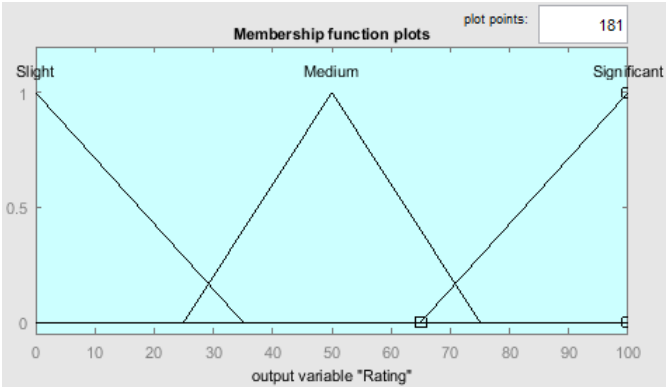


Fig. 6. Graphic representation of the terms of the sets of the original variable R.

Stage 3 - building a fuzzy knowledge base and decision-making rules.

The rules will be based on the following considerations. First, let's set the rules for the extreme values of X_3 - the environmental component. If the value of X_3 is "Extremely negative", then the investment estimate will be low, regardless of the values of X_1 and X_2. This means that with significant environmental damage, despite the high economic or social impact, the attractiveness of this project will be considered as low.

Accordingly, with the Extremely positive value of the environmental component, the benefit of the investment will be considered significant, regardless of the economic or social component. Recall that the negative economic effect is limited to 30% even when determining incoming X_1 (projects that lead to a decrease in community budget revenues by more than 30% are not considered).

Other rules of the database of fuzzy knowledge will be presented in the form of table 5.

Table 5. Knowledge base for R-evaluation of the investment attractiveness

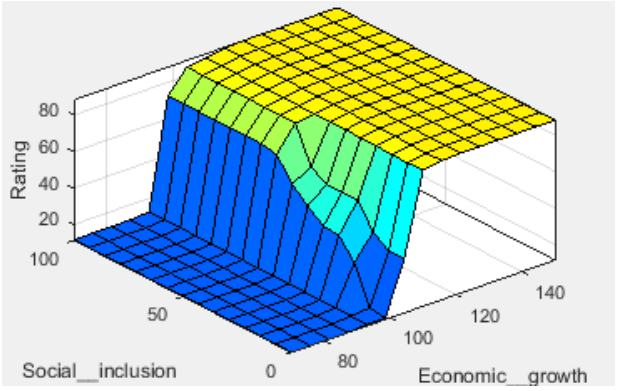
Variables		**X3 (Negative)**	**X3 (Neutral)**	**X3 (Positive)**
X1	**X2**	***R***	***R***	***R***
Decrease	Slight	Slight	Slight	Slight
Decrease	Medium	Slight	Slight	Medium
Decrease	Significant	Slight	Slight	Medium
Permanence	Slight	Slight	Slight	Medium
Permanence	Medium	Slight	Medium	Significant
Permanence	Significant	Slight	Significant	Significant
Increase	Slight	Slight	Significant	Significant
Increase	Medium	Medium	Significant	Significant
Increase	Significant	Medium	Significant	Significant

Based on the Table 5 and the assertions of extreme values of environmental effects generated 16 rules:

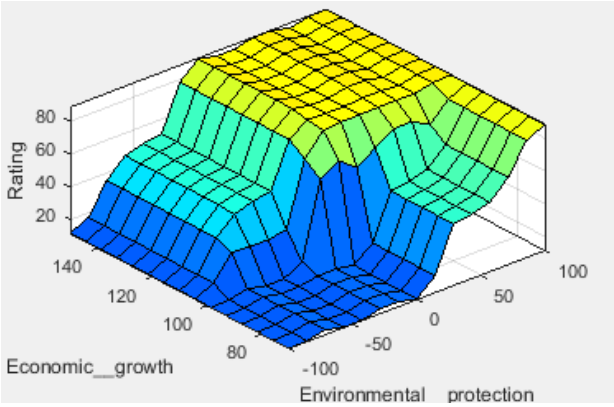
1. If (Environmental protection is Extremely negative) then (Rating is Slight).
2. If (Environmental protection is Extremely positive) then (Rating is Significant).
3. If (Economic growth is Decrease) and (Environmental protection is Negative) then (Rating is Slight).
4. If (Economic growth is Decrease) and (Environmental protection is Neutral) then (Rating is Slight).
5. If (Economic growth is Increase) and (Environmental protection is Positive) then (Rating is Significant).
6. If (Economic growth is Permanence) and (Environmental protection is Negative) then (Rating is Slight).
7. If (Economic growth is Increase) and (Social inclusion is Slight) and (Environmental protection is Negative) then (Rating is Slight).
8. If (Economic growth is Increase) and (Social inclusion is not Slight) and (Environmental protection is Negative) then (Rating is Medium).
9. If (Economic growth is Permanence) and (Social inclusion is Slight) and (Environmental protection is Neutral) then (Rating is Slight).
10. If (Economic growth is Permanence) and (Social inclusion is Medium) and (Environmental protection is Neutral) then (Rating is Medium).
11. If (Economic growth is Permanence) and (Social inclusion is Significant) and (Environmental protection is Neutral) then (Rating is Significant).
12. If (Economic growth is Increase) and (Environmental protection is Neutral) then (Rating is Significant).
13. If (Economic growth is Decrease) and (Social inclusion is Slight) and (Environmental protection is Positive) then (Rating is Slight).
14. If (Economic growth is Decrease) and (Social inclusion is not Slight) and (Environmental protection is Positive) then (Rating is Medium).
15. If (Economic growth is Permanence) and (Social inclusion is Slight) and (Environmental protection is Positive) then (Rating is Medium).
16. If (Economic growth is Permanence) and (Social inclusion is not Slight) and (Environmental protection is Positive) then (Rating is Significant).

The absence of a statistical sample of quantifiable estimates of the indicators under study and the qualitative nature of the variable X_3 (environmental component) and the output indicator R (investment project estimate), determine the choice of a logical inference using the Mamdani fuzzy inference system mechanism.

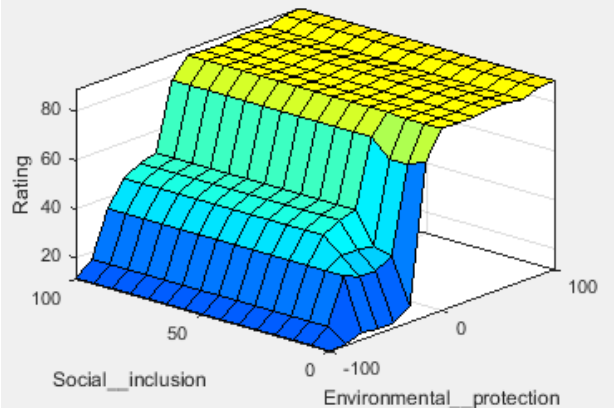
As a result of the built model, it is possible to build a surface that will give a graphical idea of the project estimates depending on the values of the input indicators (fig. 7).



a)



b)



c)

Fig. 7. The output surface for the variables:

a). Social inclusion (X_2) and Economic growth (X_1);

b). Economic growth (X_1) and Environmental protection (X_3);

c). Social inclusion (X_2) and Environmental protection (X_3).

The constructed model can be applied to support decision-making in the development and justification of a strategic plan for the development of a unified territorial community.

To verify the model, let's test it on the example of Veselivska United Territorial Community of Veselivska district of Zaporizhzhia region. According to the official site of Veselivska UTC, the population (excluding preschool and school-age children) is 10 640 people, and the amount of income (estimated) of the territorial community is 12.679 million UAH. [16]. According to the State Statistics Service of Ukraine, the average unemployment rate in the Zaporizhzhya region is 9.9% among the population aged 15-70 years [17]. Then the number of unemployed Veselovskaya OTG is approximately 1,053 persons.

Consider two alternative investment projects for the development of the territorial community: the traditional activity for Ukrainian farmers is sunflower cultivation and the construction of a solar power plant.

Let's look at project characteristics in more detail.

Project 1 - Sunflower cultivation.

Sunflower growing is a profitable business, it is the most profitable oilseed crop in our country. The basic data for the calculation were obtained from the source [18], in particular, the results of sunflower cultivation of LLC "Dokuchaevsky Chernozem", Karlovsky district of Poltava region .

It is known that the territorial community is considering the use of 20 hectares of land owned by it.

The costs of growing and harvesting in this case amount to 280 thousand UAH, the increase in cash flow from the project is also 280 thousand UAH. The number of jobs created is 10.

The cultivation of sunflower is associated with such negative effects as the depletion and drying of the soil, increased water and wind erosion [19]. Considering that the problem of soil depletion and erosion is solved, and the problem of drying is smoothed by the correct cultivation of land, the expert assessment of environmental impact is 10 points.

Thus, the input variables of the sunflower cultivation project are:

X_1 = 102.2%;

X_2 = 1%;

X_3 = -10 points.

The result of the evaluation of project 1 in the dephasing step is shown in figure 8.

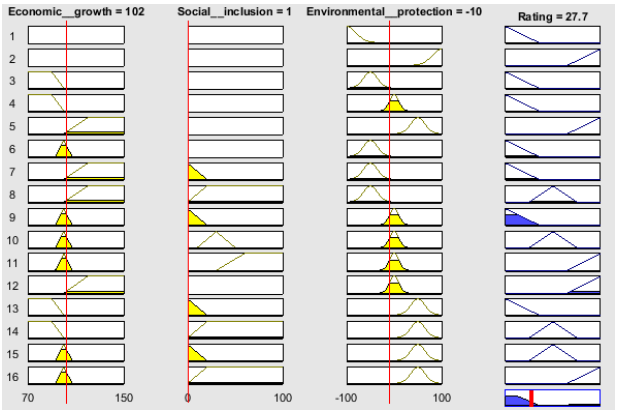


Fig. 8. Rule Wiewer for sunflower growing.

According to the results of the evaluation, the attractiveness of this investment is 27.7 points out of 100 possible.

Project 2 - construction of a solar power plant.

A solar grid power plant is used to sell electricity to the grid at a «green» rate.

Suppose that solar power plant want to build on a plot of 20 ha.

The cost of its construction is $8 million, the profitability of the project will be 25.3%, the payback period of the project - 5 years. As a result, we receive $2.078 million revenues, 25 jobs, and a positive environmental impact assessment at 50 points (used for calculations [20]).

However, it should be noted that the territorial community does not have the financial resources to implement such a large-scale, in terms of initial investment, project, so the implementation of this project is possible only with the participation of the investor. If the community finds an investor and receives only land and taxes, the annual income will be 250,000 UAH.

Thus, the input variables of a project involving an investor to build a solar power plant are:

X_1 = 101.9%;
X_2 = 2.4%;
X_3 = 50 points.

The results of the evaluation of project 2 in the dephasing step are shown in figure 9:

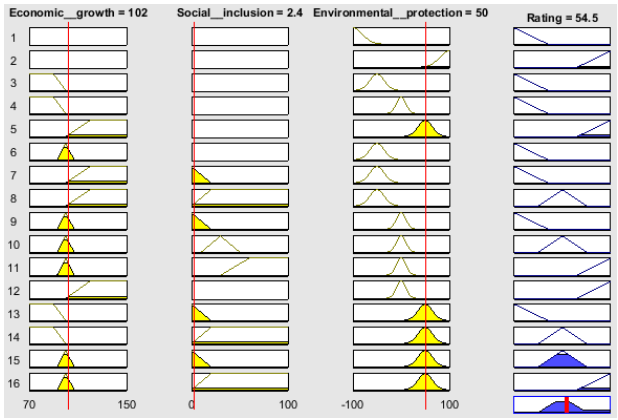


Fig. 9. Rule Wiewer for attracting an investor to build a solar power plant.

The attractiveness of the project for the construction of a solar power plant with the involvement of the investor is 54.5 points out of 100, which is almost twice better than the project for growing sunflower.

Thus, the results of applying the valuation method and deciding on the choice of an investment project for the development of an UTC have shown that Project 2 is the most beneficial.

Although the budget of the community does not allow to allocate sufficient amount of money for the construction of its own solar power plant, the decision to build a solar power plant with the involvement of investors is more advantageous than the cultivation of sunflower. Of course, the community income will be less than if the power plant belonged to the community, and the number of jobs and the share of electricity generated from renewable sources will remain unchanged.

4 Conclusion

The concept of sustainable development at the level of territorial communities aims at harmonious and balanced management of their resources in order to ensure social, economic and ecological development of the community, increase its economic potential, create a complete living environment for modern and future generations.

The achievement of this goal is facilitated by the decentralization reform, which requires the formation of an effective system of public authority. The delegation of powers to the local area activates the economic activity of local self-government bodies, motivates them to use their existing potential effectively and rationally, to take management decisions to find alternatives and additional opportunities to increase the competitiveness of territorial communities.

Decision-making at the level of the territorial community on providing additional services to local residents, improving their living conditions, forming a complete living environment is of central importance in the implementation of the concept of sustainable development. At the same time, important aspects of this activity are its publicity, transparency, coherence of interests of the authorities, business and the public.

Managing the development of a territorial community requires a constant search for a balance between its economic, social and environmental components, involving all stakeholders in the decision-making process; flexibility and effectiveness of management actions.

All these problems and tasks will necessitate the widespread use of new digital technologies (digitization) to optimize and automate decision-making processes, ensure transparency of decisions, and improve communication with community members. There is a need to develop and improve decision support systems that accumulate community-based databases and model databases that address management challenges.

In this work is developed and substantiated a fuzzy model of investment project evaluation which aimed at the development of a territorial community, based on taking into account its qualitative assessments from the point of view of the main components of the sustainable development concept. This model makes it possible to give a "soft" - a qualitative assessment of the investment project under consideration, while taking into account not only its quantitative characteristics but also their qualitative estimates.

The model has the potential for further improvement due to the detailing of the process of evaluating the component indicators (estimates), the formation of a branched tree of goals, the extension of gradations (the number of terms) of qualitative estimates, determining the benefits of each indicator for a particular community, etc.

However, the model already proposed underpins the method of deciding on the choice of investment projects for the development of territorial communities, based on a comparative analysis of their qualitative assessments.

The proposed method has been tested for making decisions on the choice of investment project based on the data of the Veselivska United Territorial Community of Veselivsky District of Zaporizhzhia Region.

As a result of use of a fuzzy evaluation model, a comparative analysis of two investment projects - Sunflower Growing and Solar Power Plant Construction - was made. The results of the calculations showed that all the parameters of the model are correctly defined, there is all the necessary information for their calculation. The management of the territorial community confirmed the expediency of deciding on the choice of investment project, which was obtained as a result of the application of the developed method (construction of a solar power plant with the involvement of investors).

The use of standard mathematical software (Fuzzy Logic Toolbox application) creates opportunities for model implementation and its use in the development of territorial decision support systems to quantify decisions, to make variant calculations for choosing the best investment options.

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