

# Modeling the assessment of investment projects for territorial communities in compliance with the concept of sustainable development

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**Abstract.** The article is devoted to the problem of evaluation and selection of investment projects aimed at the development of territorial communities (TC) and take into account the need to pursue the goals of sustainable development at the local level. In the context of decentralization reform, attracting investment funds is the leading activity of local self-government. And to ensure the transparency of management and presentation of its results to the governing bodies of TC need new scientific methods to justify the choice of one or more projects from a variety of alternative solutions. Decision-making taking into account the concept of sustainable development determines the evaluation of investment projects in terms of their effectiveness in finding a balance between social, economic and environmental components. The peculiarity of comparative analysis is taking into account the qualitative assessment, so to make optimal investment management decisions, a model is proposed, developed on the basis of fuzzy logic and implemented using tools Fuzzy Logic Toolbox. The article builds and substantiates an improved fuzzy model for evaluating investment projects for TC development. The improved model is based on a system of 15 quantitative and qualitative indicators of achieving goals in the social, economic and environmental components of the concept and allows for a "soft" assessment of the investment project. This model is used to substantiate the decisions of the TC of Zaporizhzhia region and can be used in the development of decision support systems at the level of TC for quantitative justification of decisions, conducting variant calculation.

## 1 Introduction

In the current conditions of economic development of the territorial communities (TC) in view of the processes of globalization and intensification of competition, the issue of financial security of economic entities of certain regions becomes relevant. Now there is an urgent need for a mechanism of mobilization and optimal management of financial resources of economic entities to protect their investment activities from the consequences of the unstable economic situation in Ukraine and inefficient management.

Ensuring the balanced development of the regions is one of the priority areas of Ukraine's regional policy at the present stage of its transformations. In general, sustainable development is no longer a national or, even more so, a local problem, but encompasses global goals. Significant is the merit of the UN, whose activities are mediated by world summits, declarations, resolutions, final documents of conferences and others. Among the latter are the announced global goals of sustainable development by 2030 [1]. The report presents the results of adaptation of 17 global SDGs taking into account the specifics of national development, 86 national development objectives and 172 indicators for their monitoring, as well as

benchmarking benchmarks to be achieved by 2030. This should be considered as a basis for further planning of Ukraine's development and monitoring the state of achievement of SDGs. Therefore, the urgency of the issue of finding ways to achieve the goals of sustainable development is beyond doubt. This also applies to TC in Ukraine.

Among the general approaches to interpreting the essence of the category of sustainable development, we follow the definition proposed by the World Commission on Environment and UN Development in 1987, according to which sustainable development is development that meets the needs of the present, but does not jeopardize the ability of future generations own needs [3].

This concept provides an opportunity to provide comprehensive management of territorial socioeconomic 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 [3]. 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.

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 [4-8] are devoted to the study of socioecological and economic development of the region, in particular those related to the development of models for assessing its level.

Problems associated with SDGs have been investigated in sources [9, 10]. Methods for determining the degree of achievement of SDGs are considered in the works of Joanna Marszałek-Kawa, Piotr Siemiątkowski [11], Jonathan D. Moyer, Steve Hedden [12]. Foreign direct investment related to SDGs has been considered in the work of Juri Suehrer [13].

However, studies on the quality of investment projects at the regional level [14-17] take into account only certain aspects (environmental, social or economic), indicators of achievement of SDGs are not taken into account. The article [18] proposes a multi-criteria approach to the selection of investment projects. However, there is no analysis of the development of regional systems and integrated territorial communities, especially those that fully take into account the goals and objectives of the concept of sustainable development.

The work [19] of the authors is devoted to solving the problem of evaluation and selection of investment projects aimed at the development of local communities, taking into account the concept of sustainable development. The constructed fuzzy model of evaluation of the investment project gives the chance of "soft" – qualitative estimation of the considered investment project. However, the constructed model is based on selective quantitative and qualitative assessments of the social, economic and environmental components of the concept, but does not take into account the detail of SDGs.

The purpose of this work is to improve and apply a fuzzy model for assessing the quality of investment projects for local communities to take into account the goals and objectives of the concept of sustainable development, recommendations for its application in the strategic decision-making process for the community.

## 2 Materials and methods

The essence of the problem to which this work is devoted, is the evaluation and comparative analysis of investment projects. These projects are presented to the territorial community (TC) management for selection and influence its further development in the context of the implementation of the sustainable development strategy.

To take into account the concept of sustainable development when choosing investment projects for territorial communities, it is necessary to address two issues:

- 1) what indicators to take into account when evaluating them;
- 2) how to take into account the selected indicators.

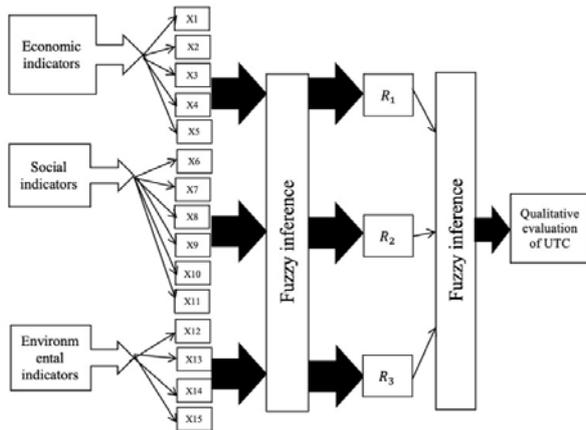
The last question is equivalent to the choice of a relevant mathematical model, which should be used to build an integrated assessment of the project and develop recommendations for choosing the best project available. The solution of the first question should be based on the use of a system of national indicators of achievement of SDGs, which are used to monitor the degree of implementation of the Concept of Sustainable Development [20].

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 TC 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 TC 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 TC, it is advisable to use data mining tools, namely fuzzy modeling. Its founders – L. Zade [21], D. Dubois and H. Prade [22] devoted their research to problems of the use of a fuzzy logic for the analysis of economic systems. The works of A. Matviychuk [23], A. Nedosekin [24], N. Maksyshko, V. Shapovalova [25], E. Kanaeva [26] and others are devoted to the improvement of decision-making methods in the economy based on the use of a fuzzy modeling methods.

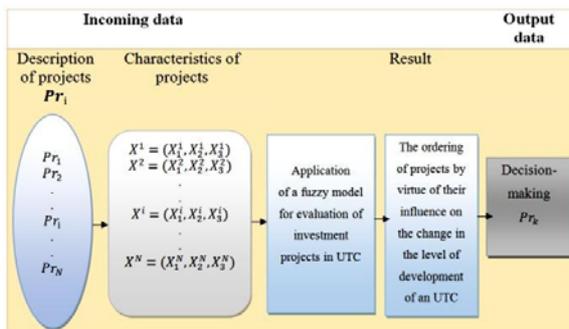
The methodology for constructing a fuzzy model, including to obtain a qualitative assessment of an investment project for the development of TC, taking into account the concept of sustainable development, consists of the following stages:

- formation of a base of a fuzzy model input variables;
- fuzzification of input variables;
- formation of a base of rules of a fuzzy logic;
- accumulation of conclusions based on a fuzzy rules;
- defuzzification of the output variable (see Fig. 1).



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

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

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

### 3 Results

#### 3.1 Assessment of the attractiveness of the project in three areas: economic, social and environmental

The assessment of the investment attractiveness of projects for TC will consist of two parts: first we evaluate each of the three areas, and then we combine the obtained estimates in a generalized model. This approach will allow you to determine the advantages and disadvantages of projects in each area, and choose the best project that will take into account the requirements of all components of sustainable development.

We build a model for assessing the attractiveness of investment projects based on the use of fuzzy logic. Taking into account the three areas of sustainable development for which the assessment and general

assessment will be carried out, we are building four models.

To assess the attractiveness of investment projects, taking into account the concept of sustainable development, we will define three assessments  $R_1$  - assessment of economic attractiveness of the project,  $R_2$  - assessment of social impact,  $R_3$  - assessment of environmental impact. The generalized estimate obtained as a result of applying the integrated model is denoted by  $R$ .

#### 3.2 Assessment of the economic attractiveness of the project

The first two stages of construction of the fuzzy model (formation of the base of input variables of the fuzzy model and fuzzification of input variables) will be performed in parallel. At the first stage we determine the content of variables, sets of their linguistic evaluations (terms), and at the second stage – fuzzification – we determine the sets of terms of variables and the type of membership functions. To construct a fuzzy model, three types of membership functions are used: triangular, trapezoidal, and Gaussian. The first two of them express a linear relationship between the parameters and the value of its correspondence to the linguistic variable. Moreover, when full correspondence is achieved only with one value of the parameter (for example, 0 with the linguistic variable "neutral influence"), then a triangular function is used, if several values then trapezoidal function is used. The Gaussian membership function expresses a nonlinear dependence that corresponds to the normal distribution and is closest to natural processes. The Gaussian function is used for parameters that contain a significant share of uncertainty or are estimated by experts.

The output variable  $R_1$  means economic impact, and includes 4 input variables:

- $X_1$  – the rate of increase / decrease in community budget revenues;
- $X_2$  – assessment of the impact on productivity growth;
- $X_3$  – the volume of net inflow of direct investment;
- $X_4$  – assessment of the impact of the project implementation on the optimal level of agricultural land use.

Consider each variable in more detail.

Variable  $X_1$  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  $X_1$  will be calculated by the formula:

$$X_1 = \frac{F_i}{F_{i-1}} \times 100\%, \quad (1)$$

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  $[70; 150]$  ( $X_1 \in [70; 150]$ ). 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 [20].

The next variable  $X_2$  – assessment of the impact on productivity growth, which means comparing output per unit of working time with the previous similar period.  $X_2$  is in the range [-10; 10] and is determined by three Gaussian membership functions.

Variable  $X_3$  means the volume of net inflow of direct investment in total community income, and is measured in percent.

It should be noted that direct investment can have a positive impact on the host, not only through direct cash flows, but also the transfer of technology and management resources, which, in the absence of investment, would be unavailable. Such a transfer of resources can stimulate the economic growth of the local community. The value of the variable  $X_3$  is within  $X_3 \in [0; 25]$ . The limit of 25% is explained by the fact that all investments with 25% of income and more are considered absolutely important (membership function  $\mu = 1$ ).

Variable  $X_4$  – assessment of the impact of the project implementation on the optimal level of agricultural land use. According to the Law of Ukraine “On the circulation of agricultural land” [27] the basic principles of state policy in the field of circulation of agricultural land purpose is: rational use of land; priority of land use for its intended purpose; establishment of a special legal regime for the purchase and sale of land; prevention of land monopolization; prevention of speculative transactions.  $X_4$  is in the range [-10; 10] and is determined by three Gaussian membership functions.

Using four input variables that characterize the economic impact, it is necessary to obtain an overall assessment of the economic attractiveness of the project – the output variable  $R_1$ , which indicates the level of attractiveness of the investment project to TC (measured in points).  $R_1$  is defined on the interval [0; 100].

The parameters of fuzzification of input and output variables are given in the Table 1.

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

Decisive rules are based on the following considerations. The leading indicator is  $X_1$ , which reflects the level of income generated by the project.

Therefore, if  $X_1$  is increasing and  $X_2$ -  $X_4$  are not negative, then the economic effect is considered significant. If  $X_1$  decrease and  $X_2$ -  $X_4$  also do not show positive indicators, then the economic effect is slight.

**Table 1.** Parameters of fuzzification of input variables  $X_1$ ,  $X_2$ ,  $X_3$ ,  $X_4$  and output variable  $R_1$ .

Linguistic assessment	View membership function	Function options
$X_1$		
Decrease	Trapezoidal	[70;70; 90; 100]
Permanence	Triangular	[93; 100; 107]
Increase	Trapezoidal	[100; 120; 150;

		[150]
$X_2$		
Negative	Gaussian	[3.739; -10]
Neutral	Gaussian	[1; 1.665e-016]
Positive	Gaussian	[3.738; 10]
$X_3$		
Low	Triangular	[0; 0; 5]
Middle	Triangular	[2; 10; 15]
High	Trapezoidal	[10; 20; 25; 25]
$X_4$		
Negative	Gaussian	[3.539; -10]
Neutral	Gaussian	[1.123; 0]
Positive	Gaussian	[3.538; 10]
$R_1$		
Slight	triangular	[0 0 35]
Medium	triangular	[25 50 75]
Significant	triangular	[65 100 100]

For other combinations of input indicators the corresponding rules are developed, in total the model includes 29 rules.

### 3.3 Assessment of the social attractiveness of the project

Rating  $R_2$  means social impact, and includes 6 input variables:

$X_5$  – assessment of the degree of compliance of the TC development strategy and the region and action plans for their implementation;

$X_6$  – the impact of the project on the unemployment rate in the community;

$X_7$  – assessment of the impact of the project on the state of public health;

$X_8$  – assessment of the impact of the project implementation on the development of education for the population;

$X_9$  – assessment of the impact of the project implementation on infrastructure development;

$X_{10}$  – assessment of the impact of the project implementation on the level of public service provision.

Consider each variable in more detail.

Variable  $X_5$  – assessment of the degree of compliance of the TC development strategy and the region and action plans for their implementation. Projects financed from the State Budget of Ukraine must meet the priorities of regional development strategies and action plans for their implementation. In 2015, the order of the Ministry of Regional Development, Construction and Housing of Ukraine on the selection of investment programs and regional development projects for further implementation at the expense of the State Fund for Rural Development was adopted. The order, in particular, states that the project should be aimed at development, and to this end, project applicants are required to determine the problem to be solved, justify the expected quantitative and 11 qualitative results of project implementation and innovation. In turn, the regional commissions that evaluate the project are responsible, among other things,

for determining the relevance of the project, as well as the social and economic effect of its implementation [28].

Variable  $X_6$  characterizes the impact of the project on 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):

$$X_6 = \frac{W}{U} \times 100\%, \quad (2)$$

where  $X_6$  – reduction in the unemployment rate in the community (%);

$W$  – number of new jobs created during the project implementation;

$U$  is total number of unemployed communities [20].

The value of variable  $X_6$  is within  $X_6 \in [0; 100]$ . Thus, if no new jobs are created during the investment, then  $X_6=0$ , if the number of jobs created is equal to the number of unemployed communities, then  $X_6 = 100$  (%). 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 next variable  $X_7$  is the assessment of the impact of the project on the state of public health. Population health is one of the greatest values, a necessary condition for the socio-economic development of the country. Creating optimal conditions for the realization of the potential of each person throughout life, achieving European standards of quality of life and well-being is one of the main tasks set by the Sustainable Development Strategy “Ukraine – 2020”, approved by Presidential Decree of 12 January 2015 № 5, and part of the obligations under the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their Member States, on the other hand [29].

Variable  $X_8$  – assessment of the impact of the project implementation on the development of education for the population. In the field of education, the work is primarily aimed at ensuring the right of all citizens to education, improving the functioning and innovative development of education at the level of all its components, improving quality and competitiveness, creating the necessary conditions for a good modern European education.

Input variable  $X_9$  – assessment of the impact of the project implementation on infrastructure development. Ukraine lags far behind the level of development and efficiency of infrastructure in comparison with developed countries. The main reason for the current state of infrastructure is chronic underfunding from the state budget and inefficient state property management system.

The next variable  $X_{10}$  – assessment of the impact of the project implementation on the level of public service provision. Building an efficient and competitive national economy involves a systemic reform of public financial management as part of the public administration system in general, the problems and inconsistencies of which pose a serious risk to the resumption of economic growth. An effective public financial management system is the basis

for the implementation of public policy and the achievement of strategic development goals by ensuring compliance with general budget discipline, strategic allocation of budget funds and effective provision of public services.

Using six input variables that characterize the social impact, it is necessary to obtain an integrated assessment – the output variable  $R_2$ , which indicates the level of attractiveness of the investment project to TC (measured in points).  $R_2$  is defined on the interval  $[0; 100]$ .

**Table 2.** Parameters of fuzzification of input variables  $X_5, X_6, X_7, X_8, X_9, X_{10}$  and output variable  $R_2$ .

Linguistic assessment	View membership function	Function options
$X_5$		
Slight	Gaussian	[17; 0]
Medium	Gaussian	[10; 50]
Significant	Gaussian	[17; 100]
$X_6$		
Slight	Triangular	[0; 0; 20]
Medium	Triangular	[10; 30 ;50]
Significant	Trapezoidal	[30; 60; 100; 100]
$X_7$		
Slight	Gaussian	[17; 0]
Medium	Gaussian	[10; 50]
Significant	Gaussian	[17; 100]
$X_8$		
Slight	Gaussian	[17; 0]
Medium	Gaussian	[10; 50]
Significant	Gaussian	[17; 100]
$X_9$		
Slight	Gaussian	[17; 0]
Medium	Gaussian	[10; 50]
Significant	Gaussian	[17; 100]
$X_{10}$		
Slight	Gaussian	[17; 0]
Medium	Gaussian	[10; 50]
Significant	Gaussian	[17; 100]
$R_2$		
Slight	triangular	[0 0 30]
Medium	triangular	[8 50 90]
Significant	triangular	[50 100 100]

Given that the variables  $X_5, X_7, X_8, X_9, X_{10}$  have a similar nature (determined by experts, are in the same ranges), the same parameters of fuzzification are applied to them (three terms expressed by Gaussian membership functions). The input variable  $X_6$  is determined by calculation by formula (2), so for its fuzzing applied triangular and trapezoidal membership function. The main parameters of fuzzification for input and output variable model of social impact assessment of the project  $R_2$  are given in the Table 2.

The base of the decision rules of this model consists of only three rules:

1. If at least one of the input variables of the project is Significant – that is, one that significantly affects the improvement of social conditions of the community, the project is important from a social point of view.

2. If the social impact of all six input variables of the project is assessed as weak, then the social impact of the project will also be Slight.

3. In other cases, the social impact of the project is assessed as Medium.

This is due to the fact that the project may not cover all areas of social life of the community, but if it gives a positive result in at least one area, it is considered a socially effective project.

### 3.4 Assessment of the attractiveness of the project, in terms of the environmental component

Rating  $R_3$  means social impact, and includes 5 input variables:

$X_{11}$  – environmental protection;

$X_{12}$  – assessment of the impact of the project implementation on access to safe drinking water;

$X_{13}$  – assessment of the impact of the project on the management of household and non-household waste;

$X_{14}$  – assessment of the project impact on the increase / decrease of electricity production.

Indicator  $X_{11}$  describes the environmental impact of the investment project. The value of  $X_{11}$  is determined on the basis of expert judgment, measured in points and is in the range  $X_{11} \in [-100; 100]$ . That is, at the most destructive value of environmental impact  $X_{11} = -100$ , at neutral impact  $X_{11} = 0$ , and at maximum positive 100. The basis for determining the indicator  $X_{11}$  can be the results of the report on the environmental impact assessment based on the Law of Ukraine № 2059 -VIII [3] or calculations, for example, by the method [15].

The next variable –  $X_{12}$  characterizes the assessment of the impact of the project implementation on access to safe drinking water. The existing inequalities between urban and rural populations in access to quality drinking water and sanitation in Ukraine remain quite significant. According to the National Report on Drinking Water Quality and the Status of Drinking Water Supply, centralized water supply covers more than 99 percent of cities and only 30 percent of villages. Therefore, access to sustainable and safe water supply remains problematic for many Ukrainians.

Variable  $X_{13}$  – assessment of the impact of the project on the management of household and non-household waste. The value of  $X_{13}$  is determined on the basis of expert judgment, measured in points.

The next variable  $X_{14}$  means the assessment of the project impact on the increase / decrease of electricity production. The value of  $X_{14}$  is determined on the basis of expert judgment, measured in points.

Using four input variables that characterize the environmental impact, it is necessary to obtain an integrated assessment – the output variable  $R_3$ , which indicates the level of attractiveness of the investment

project to TC (measured in points).  $R_3$  is defined on the interval  $[0; 100]$ .

The output variable  $R_3$  means environmental impact, it includes 4 input variables (table 3).

**Table 3.** Fuzzing of  $X_{11}$ ,  $X_{12}$ ,  $X_{13}$ ,  $X_{14}$  variable.

Linguistic assessment	View membership function	Function options
$X_{11}$		
Negative	Gaussian	[38; -100]
Neutral	Gaussian	[10; 10]
Positive	Gaussian	[30; 100]
$X_{12}$		
Negative	Gaussian	[37; -100]
Neutral	Gaussian	[7; 0]
Positive	Gaussian	[37; 100]
$X_{13}$		
Negative	Gaussian	[37; -100]
Neutral	Gaussian	[7; 0]
Positive	Gaussian	[37; 100]
$X_{14}$		
Negative	Gaussian	[37; -100]
Neutral	Gaussian	[7; 0]
Positive	Gaussian	[37; 100]
$R_3$		
Slight	triangular	[0 0 35]
Medium	triangular	[25 50 75]
Significant	triangular	[65 100 100]

To form a database, we define that the leading (generalizing) indicator is the indicator  $X_{11}$ . Indicators  $X_{12}$ -  $X_{14}$  are ancillary, showing the degree of coverage of environmental problems. And even with one significantly bad indicator  $X_{12}$ -  $X_{14}$ , the indicator  $X_{11}$  can not be good. Therefore, with a negative  $X_{11}$ , the project is considered bad from an environmental point of view; when  $X_{11}$  is positive, the project is considered good. At neutral values of  $X_{11}$ , we turn to the consideration of differentiated indicators for water ( $X_{12}$ ), waste ( $X_{13}$ ) and electricity ( $X_{14}$ ). For such cases the base of rules including 24 rules is formed.

### 3.5 Integral assessment of the attractiveness of the project in three areas: economic, social and environmental

Thus, we obtain three assessments that characterize the projects in three areas: economic, social and economic. In order to obtain an integrated assessment based on the concept of sustainable development, we will build a generalized model. Its input variables will be  $R_1$ ,  $R_2$  and  $R_3$ . Output: integral estimate  $R$ . All input variables have the same interval  $[0 100]$  and are given by three Gaussian membership functions. Initial – three triangular functions (Table 4).

The rules of the fuzzy knowledge database will be presented in the form of Table 5.

**Table 4.** Parameters of fuzzification of input variables R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub> and output variable R.

Linguistic assessment	View membership function	Function options
R <sub>1</sub>		
Slight	Gaussian	[17 0]
Medium	Gaussian	[10 50]
Significant	Gaussian	[17 100]
R <sub>2</sub>		
Slight	Gaussian	[17 0]
Medium	Gaussian	[10 50]
Significant	Gaussian	[17 100]
R <sub>3</sub>		
Slight	Gaussian	[17 0]
Medium	Gaussian	[10 50]
Significant	Gaussian	[17 100]
R		
Slight	Triangular	[0 0 35]
Medium	Triangular	[25 50 75]
Significant	Triangular	[65 100 135.3]

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

Variables		R3 (Negative)	R3 (Neutral)	R3 (Positive)
R1	R2	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

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

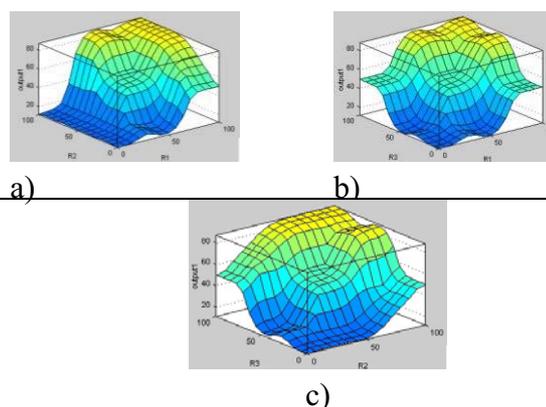
As a result of the built model, it is possible to build a surface that gives a graphical idea of the project estimates depending on the values of the input indicators (Fig. 3).

The constructed model can be applied to support decision-making in the development and justification of a strategic plan for the development of Veselivska territorial community [30].

According to the data provided by Veselivska TC, the population (excluding preschool and school age children) is 10,640 people, and the amount of income (according to estimates) of the territorial community is 12.679 million UAH. According to the State Statistics Service of Ukraine, the average unemployment rate in Zaporizhia region is 9.9% among the population aged 15-70 years [31]. Then the number of unemployed Veselovskaya TC is about 1053 people.

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.



**Fig. 3.** The output surface for the variables: a) R<sub>1</sub> and R<sub>2</sub>; b) R<sub>1</sub> and R<sub>3</sub>; c) R<sub>2</sub> and R<sub>3</sub>.

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 [32], 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.

It has been expertly determined that the implementation of the project will not affect labor productivity, and there is no need to attract investment. Since agricultural work does not require a change of purpose or land monopolization, the indicator X<sub>4</sub> is also zero.

Support and development of agricultural production is one of the main strategic directions of the community, but the implementation of the project does not involve significant changes and improvements, so the degree of compliance of the TC development strategy with experts is set at 10 points. The number of jobs created is 10, which is 1% of the unemployment rate. Due to the fact that the implementation of the project does not affect the level of health care, education, infrastructure or public services, the X<sub>7</sub>- X<sub>10</sub>, respectively, will be zero.

The cultivation of sunflower is associated with such negative effects as the depletion and drying of the soil, increased water and wind erosion [33]. 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. The impact of the project on access to safe drinking water, on the management of household and non-household waste and on the increase / decrease in electricity production is zero.

So the input variables of the sunflower cultivation project are:

- For R<sub>1</sub>: X<sub>1</sub> = 102.2%; X<sub>2</sub> = 0 points; X<sub>3</sub> = 0%; X<sub>4</sub> = 0 points.

- For R<sub>2</sub>: X<sub>5</sub> = 10 points; X<sub>6</sub> = 1%; X<sub>7</sub> = 0 points; X<sub>8</sub> = 0 points; X<sub>9</sub> = 0 points; X<sub>10</sub> = 0 points.

- For R<sub>3</sub>: X<sub>11</sub> = -10 points; X<sub>12</sub> = 0 points; X<sub>13</sub> = 0 points; X<sub>14</sub> = 0 points.

As a result of application of the developed models project estimations on three directions of sustainable development were received:

- - economic impact R<sub>1</sub> = 50 points; - - social R<sub>2</sub> = 9.9 points; - - ecological R<sub>3</sub> = 46 points.

This means that Project 1 has average economic and environmental impacts on the development of a TC and low social impact.

Let's calculate the value of the generalized evaluation of the project R.

The result of the evaluation of the project 1 in the defuzzing step is 14.3 points out of 100 possible, which is quite low.

Let's make similar calculations for 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 [34]).

However, it should be noted that the TC doesn't 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. This will increase the community's income to 101.9%.

Increasing labor productivity (X<sub>2</sub>) by attracting labor at a solar power plant is estimated by experts at 2 out of 10 possible.

The project will attract \$8 million, which is more than 63% of the annual income of the community. Since the maximum value of the input variable is 25, and the value of X<sub>3</sub> at which the membership function reaches one is 20% (i.e., all investments greater than 20% of income are considered the most useful), we assume that X<sub>3</sub> is 25%.

Since the implementation of the project involves a change in the purpose of the land, X<sub>4</sub> is estimated at -2.

The assessment of the degree of compliance of the TC development strategy with the region and the action plans for their implementation (X<sub>5</sub>) is 40 points. Project 2 does not affect the level of development of health care, education, infrastructure or public services.

The construction of the power plant is associated with waste generation, so the indicator X<sub>13</sub> is estimated at -10. One effect on the energy component is the most positive X<sub>14</sub> = 100 points.

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

- For R<sub>1</sub>: X<sub>1</sub> = 101.9%; X<sub>2</sub> = 2 points; X<sub>3</sub> = 25%; X<sub>4</sub> = -2 points.

- For R<sub>2</sub>: X<sub>5</sub> = 40 points; X<sub>6</sub> = 2.4%; X<sub>7</sub>, X<sub>8</sub>, X<sub>9</sub>, X<sub>10</sub> = 0 points;

- For R<sub>3</sub>: X<sub>11</sub> = 50 points; X<sub>12</sub> = 0 points; X<sub>13</sub> = -10 points; X<sub>14</sub> = 100 points.

As a result of the project evaluation by areas, the following were obtained:

- economic impact R<sub>1</sub> = 60.4 points; - social R<sub>2</sub> = 17.4 points; - ecological R<sub>3</sub> = 84.7 points.

That is, Project 2 also has a weak social impact, albeit a larger one than Project 1. The economic impact is above average and the environmental component is high.

The generalizing result of the evaluation of project 2 in the defuzzing step is 62.6 points out of 100, which is better than the project for growing sunflower.

Comparing the two projects, it can be noted that the “weak spot” of both projects is low social impact; project 2 is better than project 1 in all areas, and if the difference is not large for the economic and social component, the environmental positive impact of project 2 is almost twice that of project 1.

As a result of application of the developed two-stage model to two alternative investment projects of the community, the numerical characteristic of projects on separate directions of sustainable development (economic, social and ecological), and the general estimation taking into account all structural components is received.

Thus, when making decisions, it is possible not only to establish which project is more reasonable, but also to identify “weaknesses” and the advantages of each of them.

## 4 Conclusion

The development of TC is aimed at coordinated and balanced management of its resources, taking into account the concept of sustainable development to ensure social, economic and environmental development of TC, expanding its economic opportunities, creating a full living environment for present and future generations. To achieve this goal, it is necessary to form an effective system of state power, which is facilitated by decentralization reform. The transfer of competencies to TC increases the economic activity of local governments, encourages them to rationally and skillfully use available resources, to make effective decisions when choosing alternatives to increase the competitiveness of TC.

Finding a balance between economic, social and environmental components is one of the main tasks in managing the development of TC, taking into account the concept of sustainable development. To solve these problems, it is necessary to use new digital technologies to optimize and automate decision-making processes, transparency in the activities of local governments and improve connection with community members.

This article develops and describes a fuzzy evaluation model of an investment project for TC development, consisting of two stages. At the first stage, three fuzzy

models were created that allow evaluating an investment project in three areas of sustainable development: economic (R1), social (R2) and environmental (R3) impact. For the assessment of the economic in the project, the four most important, according to the authors, input indicators were emphasized:  $X_1$  – the rate of increase / decrease in community budget revenues;  $X_2$  – assessment of the impact on productivity growth;  $X_3$  – the volume of net inflow of direct investment;  $X_4$  – assessment of the impact of the project implementation on the optimal level of agricultural land use. To assess the social impact, the input parameters are  $X_5$  – assessment of the degree of compliance of the TC development strategy and the region and action plans for their implementation;  $X_6$  – the impact of the project on the unemployment rate in the community;  $X_7$  – assessment of the impact of the project on the state of public health;  $X_8$  – assessment of the impact of the project implementation on the development of education for the population;  $X_9$  – assessment of the impact of the project implementation on infrastructure development;  $X_{10}$  – assessment of the impact of the project implementation on the level of public service provision. The impact of the project on the environment is determined by the 5 input variables:  $X_{11}$  – environmental protection;  $X_{12}$  – assessment of the impact of the project implementation on access to safe drinking water;  $X_{13}$  – assessment of the impact of the project on the management of household and non-household waste;  $X_{14}$  – assessment of the project impact on the increase / decrease of electricity production.

As a result, three diverse indicators that characterize the project were obtained. In addition, using the developed integrated fuzzy model, we obtain an integrated indicator of investment attractiveness of the project, which includes all areas of sustainable development.

The developed models were tested on the data of the Veselivska Territorial Community of Veselivsky District of Zaporizhzhia Region. A comparative analysis was conducted for two investment projects – Sunflower Growing and Solar Power Plant Construction. As a result, the attractiveness assessments were obtained in different areas of each project, weaknesses and strengths were identified, as well as integrated indicators were obtained, which allowed to select the most attractive project for the territorial community.

Application of the proposed models creates opportunities for the formation and development of territorial decision support systems for quantifying decisions, carrying out variant calculations to select the best investment options. The development and improvement of a decision support system is extremely important for TC, as it will help to accumulate and model a database that solves management problems.

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