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The Method for Evaluation and Selection of Investment Projects in the Field of Municipal Waste Management

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Abstract

Background/Objectives: Relevance of the work is determined by the fact that one of municipal authorities' tasks is to create conditions for a comfortable residence of the citizens. The article deals with the procedure for evaluation and selection of investment projects relating to municipal solid waste management. **Methods:** The main methods for the evaluation and selection of investment projects are expert method enabling to evaluate the social significance of the project; risk assessment method based on the theory of fuzzy sets to overcome the drawbacks of the probabilistic and the minimax approaches; Pareto method to form a set of projects according to the attractiveness and the risk criteria; cluster analysis to allocate implementation priority to the projects. **Findings:** A methodology of socially significant investment projects selection in the field of municipal solid waste is provided, taking into account the social, environmental, and economic impacts of the projects implementation. The social significance of investment projects must be the main criteria for their selection. An investment program for the development of municipal solid waste management is drawn up based on the selected investment projects. **Improvements/Application:** The technique allows forming a municipal program of investment in the development of the municipal solid waste sphere, which for the first time takes into account the social, environmental, and economic imperatives as a whole, based on public-private partnership.

Keywords: Cluster Analysis, Investment Project, Risk, Municipal Solid Waste

1. Introduction

The municipal facilities define the vital activity of a city or a town; to ensure it, socio-economic development plans are elaborated. The environmental safety of the territory, including the sphere of collection, removal, and disposal of municipal solid waste, is an integral part of the socio-economic development of the city. The city has to have a system that allows tracking the overall sphere condition and constructively responding to changes and threats, providing friendly and comfortable accommodation facilities[1,2].

To solve these problems, a policy must be worked out by local authorities as well, aimed at creating a favorable investment climate underlying increment in the investment activity.

The method of substantiating investment decisions is well developed and applied in the investment projects evaluation in business. At the same time, the evaluation of socially significant projects from the standpoint of investors and the society as a whole is less conventional. This is due to the fact that it is necessary to take into account the industry-specific character of a project and the business investment vehicle, which requires a special study. Similar studies are conducted by many scientists[3–9].

The authors devote considerable attention to empirical studies taking into account different neighborhood effects in implementing investment projects. At the same time,

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in Russia, accounting for the investment specificity and the common practice of its evaluation are the most topical issues of investment projects implementation. One of the approaches to solving this problem is the subject of this work.

The waste management sphere is of great socio-economic importance to the local authorities; therefore, investment projects are drawn up and submitted for consideration at their initiative. Investment projects may represent different stakeholders, including business representatives from other cities and regions[10]. Investment projects are diverse in nature and contain a variety of technical and economic parameters. Projects are analyzed on the basis of a multifaceted examination, taking into account a variety of different, often contradictory, project performance indicators, being quantitative or qualitative in nature. Some of these characteristics relate to the economic, environmental, and social impacts of the project implementation, and some of them describe various risks associated with the project implementation process. Development of project evaluation techniques for further competitive selection process and their inclusion in the municipal solid waste sphere development program is essential for the development of qualitative strategic development programs[11–13].

The social significance of investment projects must be the main criteria for their selection (defined by the population segment which is covered by the project implementation benefits), their public utility (characterized by the population's level of requirements, which is covered by the project implementation benefits), the fiscal and cost-effectiveness[2].

An investment program of municipal solid waste sphere development is drawn up based on the selected investment projects.

2. The Methodology Model

The methodology for evaluation and selection of investment projects can be presented as a sequence of steps: technical analysis; evaluation of a project; project risk assessment; project selection.

During the technical analysis, experts (usually municipal officials) establish a correspondence of the submitted documents to the formal requirements set for the format and form of investment projects (by presence of the documents that constitute the project, their layout, compliance with other requirements for them). The technical analysis results must be brought to the information of the performers seeking to eliminate the defects, to submit the corrected or missing documents to a deadline. If within the time specified the deficiencies are not rectified, the project is considered to be withdrawn. After elimination of the identified defects, the investment project may be resubmitted for consideration according to the standard procedure.

In the next stage, an expert assessment of the investment projects, having undergone technical analysis in terms of their attractiveness for the municipal solid waste sphere, is made.

Evaluation by this criterion is made based on the following factors:

- The prospectively level of the sphere development.
- The degree of resistance to the economic downturn.
- The level of demand for processed raw materials.
- The degree of government development support (credit, tax, resource support)
- The level of competition.
- The social significance.
- The progressive use of engineering and technology.
- The return on investment
- The investment activity.

Thus, at this stage an investment attractiveness assessment of each investment project G_k(k=1,2,…K), approved by the experts, is formed.

At the next stage, a risk assessment of the investment project is made.

An investment project is characterized over time with three major money flows: the investment flow, the flow of current (operating) charges, and the revenue stream. Each of these indicators cannot be planned exactly, since there is no absolute certainty about future market conditions. The cost environmental parameters upon their implementation in the future may differ from those the plan values anticipated, which are measured from a present-day perspective. This entails the risk of investment decisions. There is always a possibility that a project, recognized as feasible, would de-facto turn unprofitable, as the parameter values achieved in the investment process deviate from the plan values, so it is necessary to measure the riskiness of investment decisions, both at the project development stage and in course of the investment process. If the risk level rises to non-accepted values, and the investor is not aware of it, they are doomed to go blind.

In this case, the minimax approach can be applied. A number of scenarios are generated, and two scenarios are selected, at which the process reaches its maximum and minimum efficiency. Then, the expectation effect is evaluated by Hurwitz's criterion[14]. The decision making is based on the most pessimistic assessment of the project performance, when, under the conditions of the most adverse scenario implementation, everything has been done to reduce the anticipatory losses. This approach is sure to minimize the risk, but if it is used, many projects, even with the chances of success, will be rejected.

To assess the risk, the method developed by the authors is used[15].

Let three net present indicator values (C) be obtained during the multivariate investment project evaluation: C_{min} is the minimum indicator value, C_{max} is the maximum indicator value, C_{av} is the average indicator value. At the same time, as is customary, such investment projects are considered effective, for which C is above zero.

The authors suggest assessing the degree of risk presented in the form of the indicator V, which characterizes the inefficiency of the raised investments, using the following formula:

$$V = R \cdot \left[1 + \frac{1-a}{a} \cdot \ln\left(1-a\right)\right], \quad (1)$$

where, $a = -\frac{C_{min}}{C_{av} - C_{min}}$;

$$R = -\frac{C_{min}}{C_{max} - C_{min}}$$

The indicator V ranges from 0 to 1. A manager can classify the indicator V values, specifying the range of risk values allowable to them.

According to the results of the indicator V calculation, its belonging to a certain range is determined. This allows for an assessment of the investment project.

The above method, based on applying the fuzzy sets theory, enables to cope with disadvantages of the probabilistic and minimax approaches associated with taking uncertainty into account. The main advantages of the method are:

- the ability to generate a fairly complete set of investment process flow scenarios;
- make decisions not on the basis of two project performance assessments, but rather on the totality of possible assessments;
- the interval indicator value allows assessing the risk level of an investment project.

Thus, as a result of the indicator calculation, a risk assessment Q_k is formed for each investment project P_k.

Hereafter, the selection of investment projects is carried out according to the criteria of attractiveness and risk.

For the selection of investment projects let us use the Pareto domain discrimination method.

- Select a project P_k assuming k=1.
- The project P_k is compared with the rest in terms of the indicators (G_k, Q_k), and those that are strictly worse than P_k are marked.
- The marked projects are excluded from further consideration.
- The next project k=k+1 is selected.
- If k≤K and the project P_k has already been marked in previous iterations, then proceed to step 4.
- If k≤K and the project has not been marked, then proceed to step 2.
- If k> K, where K is a number of compared projects, then proceed to step 8.
- The projects remaining unmarked form a set of effective solutions (Pareto domain).

Thus, a set of investment projects P=P_1,P_2,…, P_K has been formed, which can be included in the investment program. However, it should be noted that each municipality may generate additional requirements for investment projects.

Each municipality has its own special aspects, so there is no consistent approach to solving this issue; taking into account the experience and practices of many municipalities, one can organize these requirements and draw them up in general terms:

- priority projects;
- projects with guaranteed funding (municipal, regional, federal);
- commercial projects.

To range the projects by these groups, each municipality can use different approaches to their classification. It is worth noting that projects with guaranteed funding, as well as commercial projects, can be classified as the set of priority projects.

Cluster analysis can be used to range investment projects by these groups[16].

Let the set $P = \{P_1, P_2, \dots, P_K\}$ include K projects that have been selected at the previous stages. To range the set into clusters, the method of expert assessments is used. Each expert *i* (*i*=1, 2,…, N) evaluates the project P_k, i.e. they range the projects into classes. In the present task, let us select 3 classes: M_1 is the class of priority projects; M_2 is the class of project with guaranteed funding; M_3 is the class of commercial projects.

Depending on the objects under study, various scales can be used to evaluate them. To estimate the projects, a classification scale is used. At this scale, the numbers are used as labels.

Expert *i* (*i*=1,2,…,N) rates each project in accordance with:

- 1, if the project is considered to refer to M_1 class;
- 2, if the project is considered to refer to M_2 class;
- 3, if the project is considered to refer to M_3 class;

The results of estimating the project P_j by the i-th expert are denoted by x_{ij}, and the vector $X_j = [x_{ij}]$ corresponds to each series of measurements for the j-th project.

For a set *P* of projects, there are many vectors X= $\{X_1, X_2, \ldots, X_K\}$ that describe the set P.

Let *m* be an integer $(m < K)$. On the basis of the vectors set data X, the set P of projects is divided into m clusters (subsets)) $\pi_1, \pi_2, \ldots, \pi_m$, so that each project P_j belongs to one and only one subset of a partition (cluster).

Let us consider one of the cluster analysis algorithms (the number of clusters is prescribed).

Step 1. Calculating the data totality average values.

Step 2. Calculating the mean-square deviations of each indicator on the strength of all the evidence.

Step 3. Calculating normalized differences matrix for each indicator.

Step 4. Calculating Euclidean distances between each pair of population unit combinations

$$R_{ij} = \sqrt{\sum_{k=1}^{K} (x_{ik} - x_{jk})^2}. \tag{2}$$

Step 5. Determining the minimum value R_{ij}.

Step 6. Assigning the projects with the minimum values R_{ij} to one cluster.

Step 7. Calculating new average values of all the indicators for the merged cluster.

Step 8. Calculating new indicators of normalized differences between a certain cluster and the others. Including these differences in matrices instead of the totality units' indicators pooled together.

Step 9. Calculating new merged cluster Euclidean distances from the other units or clusters.

Step 10. Selecting the least of the Euclidean distances.

Step 11. Clustering is stopped once the predetermined number of clusters is achieved.

Step 12. Evaluation of the classification quality. Upon the classification completion it is necessary to evaluate the results with the help of quality functionals. The partition, where the extreme (min, max) value of the functional is achieved, is considered the best.

The following procedure is used as such a functional:

The sum of the squares of the distances to the centers of clusters (F_1)

$$F_1 = \sum_{m=1}^{M} \sum_{j \in \pi_m} d^2 (X_j, \overline{X_m}), \tag{3}$$

where, *m* is the number assigned to a cluster (m=1,2,…M);

$\overline{X}$ is the center of the *m*-th cluster;

X_j is the vector of variable values for the *j*-th project included in the *m*-th cluster;

d(X_j,$\overline{X_m}$) is the distance between the *j*-th project and the center of the *m*-th cluster.

The partition, where the minimum value F_1 is achieved, is considered the best.

The sum of intra-cluster distances between the objects (F_2)

$$F_2 = \sum_{m=1}^{M} \sum_{j \in \pi_m} d_{jm}^2, \tag{4}$$

The partition, where the minimum value F_2 is achieved, is considered the best.

The sum of the intra-cluster variances (F_3)

$$F_3 = \sum_{m=1}^{M} \sum_{j \in \pi_m}^{p} D_{mj}^2, \tag{5}$$

where, D_{mj} is the dispersion of the *j*-th variable in the *m*-th cluster.

The partition, where the sum of the intra-cluster dispersions is minimal, is considered optimal.

To assess the quality of partitions, some other elementary techniques are used. If the group mean values differ significantly from the overall average, this may be a sign of a good partition. The judgment on differences significance can be made using Student's t-test[14].

Using the cluster analysis algorithm allows dividing investment projects P=$\{P_1, P_2, \ldots, P_K\}$ into three groups:

- priority projects ($P^1 = \{P_1, P_2, \ldots, P_{K^1}\}$);
- projects with guaranteed funding (P^2=

$\{P_1, P_2, \ldots, P_{K^2}\}$);

- commercial projects ($P^3 = \{P_1, P_2, \ldots, P_{K^3}\}$).

3. Conclusions

An evaluation and selection methodology of investment projects has been developed. The methodology is based on the fact that projects are analyzed on the basis of a multifaceted examination, taking into account a great number of different, often contradictory, project performance indicators, bearing the quantitative or qualitative characteristics. Some of these characteristics relate to the economic, environmental, and social impacts of a project. The proposed method application allows improving the investment activity management in the municipal solid waste sphere in a municipality, implementing strategic priorities for the development of this sector taking into account the economic, social and environmental imperatives.

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