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THE COST-BENEFIT ANALYSIS OF WASTEWATER TREATMENT PLANT DISPOSITION - THE MUNICIPALITY OF PIROT CASE STUDY

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Abstract

Because of the significance of the river Nišava for the city, the Municipality of Pirot has adopted a water protection concept for the city of Pirot and several smaller settlements located upstream along the Nišava River (Krupac, Veliko Selo, Veliki Jovanovac, Mali Jovanovac, Trnjana, Izvor). The wastewater treatment would be done either at the central wastewater treatment plant (WWTP) Pirot or at several decentralized treatment facilities, despite the settlements being smaller than 2000 population equivalent (PE). Three variants were considered for the analysis of water protection in the Municipality of Pirot: the first variant involves the treatment of wastewater from the city of Pirot and all the considered settlements at the central WWTP Pirot; the second variant involves the treatment of wastewater from the city of Pirot and suburban settlements at the central WWTP Pirot, and upstream settlements at the WWTP Krupac; the third variant involves the treatment of wastewater from the city of Pirot and suburban settlements at the central WWTP of Pirot, and the other settlements at their respective decentralized WWTPs. The aim of this paper is to determine the most economically viable solution by applying a cost-benefit analysis, using criteria related to wastewater treatment and water pollution prevention. The paper applied the basic steps of economic cost-benefit analysis, concluding that the third alternative solution with a centralized WWTP Pirot and three decentralized WWTPs is the most cost-effective and ensures the project sustainability, which is crucial for achieving long-term development goals.

Key words: Cost-benefit analysis, Water protection, Wastewater treatment plants

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1. INTRODUCTION

Europe has witnessed growing levels of water stress, both in terms of scarcity and the deterioration of quality. This situation has prompted many municipalities to identify more efficient uses of water resources [1]. The Water Framework Directive (WFD) assigns significance to economic analysis to achieve suitable water resource management [1].

The Urban Waste Water Treatment Directive 91/271/EEC states that all generated wastewater agglomerations of between 2000 and 10000 population equivalent (PE) must set up collection and treatment systems. Therefore, one of the main challenges for European authorities for the achievement of good ecological status of water bodies is to implement the appropriate treatment of wastewater in small agglomerations [2].

In addition, the EU Commission has concluded that additional sensitive areas and their related catchments should be designated. This fact entails the need of upgrading the treatment applied for a significant number of discharges and the development of new facilities in the near future. In this context, it is crucial to find out the most feasible technologies from an integrative point of view to tackle with new wastewater management projects, depending on each specific scenario [2].

The construction of wastewater treatment plants (WWTP) is an economic activity which demands considerable resources (costs) in order to achieve an increase in services in a certain time period, with the end goal of meeting population needs and environmental protection requirements (benefits) [3].

Considering that financial resources are limited, and that use of resources for one project depletes resources for other projects, a concept of wastewater treatment should be chosen so that it brings the biggest benefits compared to the costs [3]. This is why all social benefits as well as all involved costs expected out of a certain project should be systematically researched [3].

The most often used method for assessing the profitability of an investment in a project of public significance, as well as the method required by the EU legislation, is the cost-benefit analysis [4].

Cost-benefit analysis is a method of economic analysis which compares and assesses all advantages and disadvantages of an economic endeavor or project through the evaluation of the involved costs and benefits [2, 5, 6]. This analysis is used not only for investment projects which bring a direct commercial effect which can be measured and quantitively represented, but, most importantly, for projects with significant indirect and immeasurable effects [7].

Based on the results of the analysis it is possible to rank projects or investment alternatives. The project or the investment alternative which when realized is expected to bring the greatest financial profitability and social justification is the most favorable for the investor and should be chosen [8].

Cost-benefit analysis is an analytical approach to decision making, which demands definition of goals and identification of alternatives which bring the biggest benefit for given costs or the required benefit with the least costs [8].

This paper shows a cost-benefit analysis of three variant solutions for wastewater collection and treatment in several settlements upstream of the city of Pirot, by the banks of the river Nišava (Krupac, Veliko Selo, Veliki Jovanovac, Mali Jovanovac, Trnjana, Izvor) and the choice of the alternative which is expected to bring the greatest financial and social feasibility when implemented, as well as be the most cost-effective for the investor.

2. STUDY AREA

The Municipality of Pirot is located in southeastern Serbia, in the Pirot Basin. It is the administrative center of the Pirot district, and with an area of 1232 km2 is the third largest municipality in Serbia. The city of Pirot is the center of the Pirot Municipality as well as the industrial, economic, cultural and administrative center of the Upper Ponišavlje region.

In accordance with the Urban Waste Water Treatment Directive 91/271/EEC, it is necessary to establish the collection and secondary treatment of urban wastewater for all settlements bigger than 2000 PE, which include only the city of Pirot and the suburban area Gnjilan.

The city of Pirot, along with the suburban areas of Novi Zavoj, Gradašnica, Berilovac, Gnjilan, Barje Ćiflik and Poljska Ržana already have a built sewer system for collection of urban wastewaters of the city and suburban areas. However, sewage is discharged without treatment into the river Nišava downstream of the city. In order to comply with the requirements of the Directive 91/271/EEC it is necessary to build a centralized WWTP for the city of Pirot, for the treatment of urban wastewater collected from the city and suburban areas connected to the existing sewer system. According to the Directive 91/271/EEC collection and treatment of wastewater of other settlements in the Municipality of Pirot is not necessary [8].

Because of the significance the river Nišava has for the city, the Municipality of Pirot has adopted a water protection concept according to which the wastewater collection and treatment would be done for several smaller settlements upstream of the city of Pirot, along the banks of the river Nišava (Krupac, Veliko Selo, Veliki Jovanovac, Mali Jovanovac, Trnjana. Izvor), even though these settlements are smaller than 2000 PE [9]. The treatment would either be done on a centralized WWTP in the city of Pirot or on several decentralized compact WWTPs.

The analyzed settlements are geographically concentrated and a degree of urbanization is present within them. They have a built water supply network and enough drinking water, but no sewer systems for efficient evacuation of wastewater out of the settlement.

The settlement of Krupac, located along the right bank of the river Nišava, around 8 km upstream of the city of Pirot, already has a built sewer system and a compact decentralized WWTP (2500 PE) [8]. The settlement of Izvor, located along the right bank of the river Nišava, around 2 km upstream of the city of Pirot, also has a built sewer system and compact decentralized WWTP (1000 PE) [8]. The remaning settlements of the Municipality of Pirot do not have built sewer systems [8].

According to the devised water protection concept, it is necessary to build sewer systems for collection of wastewater of settlements Veliko Selo, Veliki Jovanovac, Mali Jovanovac and Trnjana, as well as wastewater treatment on the existing (WWTP Krupac) or newly built wastewater treatment plants (WWTP Pirot or decentralized compact WWTP for certain settlements) [9].

The discussed settlements are shown in figure 1.

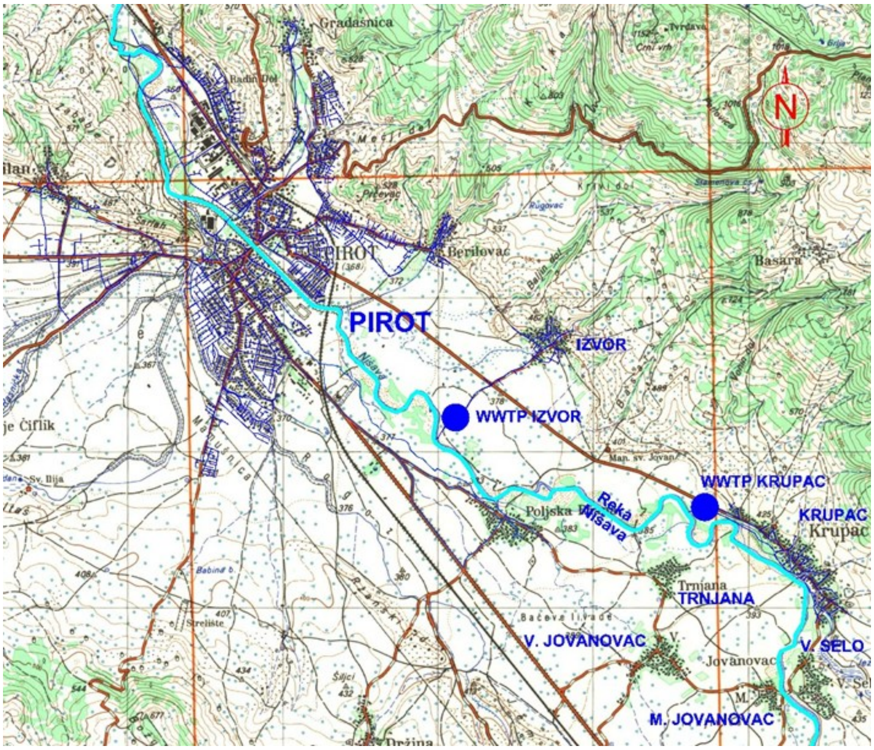

Figure 1. Discussed settlements in the Municipality of Pirot

3. METHODOLOGY

3.1. Variant solutions

With regard to the topographic characteristics and distances of the analyzed settlements from the city of Pirot or the settlement of Krupac, which have already built sewer systems, it is necessary to analyze the method of collection and evacuation of wastewater from the analyzed settlements.

Through the analysis, starting with topographic characteristics, the sizes of the settlements, the distances between each other as well as other relevant factors, the following problems should be solved [9, 10 - 12]:

1) The concept of the sewer systems taking into consideration that the systems of all the analyzed settlements should either be part of the sewer system of the city of Pirot with centralized treatment on the WWTP Pirot, or that each settlement or group of settlements should have its own independent sewer system along with a WWTP;
2) The technical solutions of the sewer system for the analyzed settlements should have the needed operational security and as few problems in operation as possible, meaning that, if possible, the sewer systems should be gravitational;
3) Considering that several variants of the technical solution of wastewater collection and treatment for the analyzed settlements present themselves, an economic analysis should be done and the most cost-effective variant solution should be chosen.

Three variant solutions were considered for the analysis of the problem of water protection in the municipality of Pirot [9]. Figures 1-3. show the planned systems of all three variants, with the color blue representing already built systems including: the city of Pirot sewer system (1), the settlement of Izvor sewer system (2), WWTP Izvor (3), the settlement of Krupac sewer system (4) and WWTP Krupac (5) and the color pink representing planned systems.

The first variant solution includes the treatment of wastewater of the city of Pirot and suburban areas already connected to the city's sewer system (1) as well as wastewater of the considered settlements Veliko Selo, Veliki Jovanovac, Mali Jovanovac and Trnjana on the planned centralized WWTP Pirot (60 000 PE) (7). This variant includes construction of a shared sewer system (1,2,4) for the settlements Veliko Selo, Veliki and Mali Jovanovac and Trnjana which would be connected to the sewer system of the city of Pirot via a main collector (6), as well as a pumping station for the settlement of Veliko Selo (3) and a pumping station for the settlement of Trnjana (5) [8]. The benefits of the first variant solution include the improvement in public health, overall quality of life, economic development and environmental protection as well as improvements in the existing sewer system efficiency and quality of service. The operational security of this variant is lower compared to the other variants, in case of failure of the main collector or WWTP, a large percent of the population on the analyzed area would be left without wastewater collection and treatment services. The variant solution 1 is shown in figure 2.

Figure 2. Variant solution 1

The second variant solution includes treatment of wastewater of the city of Pirot and suburban areas already connected to the city's sewer system (1) on the centralized WWTP Pirot (60 000 ES) (6). The wastewaters of settlements Veliko Selo, Veliki Jovanovac, Mali Jovanovac and Trnjana would be treated on the reconstruted and upgraded WWTP Krupac (upgraded to 3 500 PE, from the existing 1 000 PE) (5). In this variant the newly constructed sewer system of the settlement of Veliko Selo (1) would connect to the existing sewer system of the settlement of Krupac (4), while for Veliki Jovanovac, Mali Jovanovac and Trnjana a shared sewer system (2) would be constructed and connected to the sewer system of the settlement of Krupac via collector (3) and pumping station (4) [8]. The social and environmental benefits of the second variant solution are the same as the first solution, with improved operational security compared to the first solution, the failures on the network or WWTPs would have a reduced, localized impact. The variant solution 2 is shown in figure 3a.

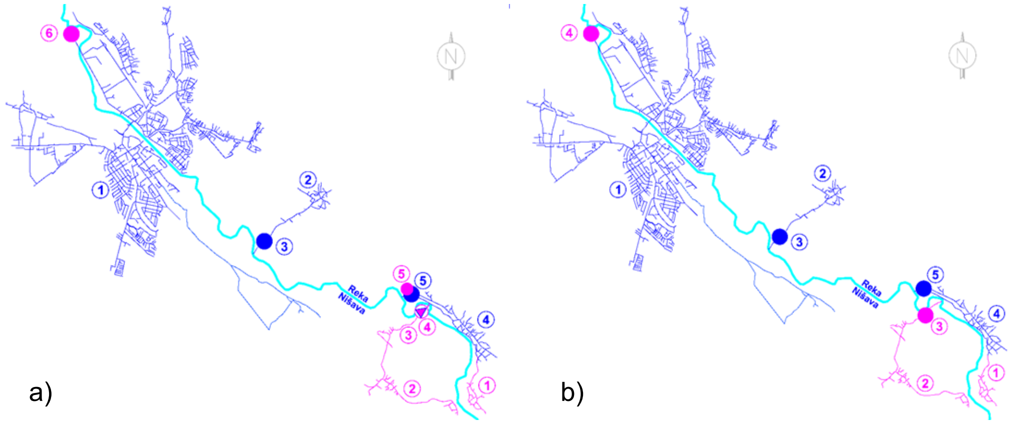

Figure 3. a) Variant solution 2; b) Variant solution 3

The third variant solution includes treatment of wastewater of the city of Pirot and suburban areas already connected to the city's sewer system (1) on the centralized WWTP Pirot (60 000 ES) (4). The wastewater of the settlement of Veliko Selo would be treated on the reconstruted and upgraded WWTP Krupac (2 500 PE) (5), while the wastewater of the settlements of Veliki Jovanovac, Mali Jovanovac and Trnjana would be treated on a newly constructed shared WWTP Trnjana (900 PE) (3). This variant includes construction of a sewer system for the settlement of Veliko Selo (1), which would be connected to the existing sewer system in the serttlement of Krupac, as well as a shared sewer system for the settlements of Veliki Jovanovac, Mali Jovanovac and Trnjana (2). The social and environmental benefits of the second variant solution are the same as the previous two variant solutions, with the highest operational security out of all analyzed solutions and a further reduced failure impact area compared to the second solution. The variant solution 3 is shown in figure 3b.

3.2. Cost-benefit analysis

Cost-benefit analysis is a comprehensive and complex process which encompasses numerous evaluations, sums and comparisons [1]. This is why the analysis is realized following a defined procedure, as the basis of completing a valid economic analysis in the macro aspect. In accordance with the legislation of the European Union, it is recommended the cost-benefit analysis be completed in the following six phases [4]:

1. contextual analysis and definition of project goals,
2. project identification,
3. feasibility and options analysis,
4. financial analysis,
5. economic analysis,
6. risk assessment.

Financial analysis enables the calculation of desired indicators of financial gain during the planned period based on the estimated cash flows of the project. For calculation of financial indicators, the only relevant parameters are cash inflow and outflow. Only the cash flows which will occur if the analyzed project is realized should be taken into consideration. The main focus point of the analysis is the financial gain the investors or financiers of the project could expect from said project. The prices relevant in financial analysis are market prices.

For calculation of financial indicators, it is necessary to define cash flows, namely the costs and the benefits of the project. Costs and benefits can be categorized in multiple groups based on type. The primary categories to be taken into consideration are direct/indirect, material/immaterial and real costs and real benefits [13]. The total costs and benefits should be calculated and presented with the defined categories. It is important to take into account the short-term and long-term costs, therefore the projections should be completed based on project duration, including analysis of how the costs would evolve and change over time. The basic costs should be included, but thinking outside the box is desirable as it can lead to identification of unforeseen costs which could impact the project both short-term and long-term [13]. When analyzing future costs and benefits it is important that they be transformed into their current values through discounting using the appropriate discounting rate.

The calculation of benefits in water management can be done in various ways, depending on the specific goals and terms of the project. It is important to note that the calculation of benefits in water management can be very challenging because some benefits, like the improvement of public health or ecological benefits, are difficult to quantify in monetary values.

The value assigned to costs and benefits depends on when they are realized. In some cases, public policies, new regulations or their changes, cause immediate costs, but certain costs and benefits can emerge only after a certain time period.

Net present values of costs and benefits for the i-th variant solution and a time period of N years, where the parameter r is the fixed discount rate [14], are given in the following equations:

$$C_{i,N} = \sum_{n=1}^{N} \frac{C_{i,n}}{(1+r)^n} \quad (1)$$

$$B_{i,N} = \sum_{n=1}^{N} \frac{B_{i,n}}{(1+r)^n} \quad (2)$$

where: n – observed time period; N – considered time period; r – discount rate; Ci,N – costs over time period n, Bi,N – benefits over time period n.

Contemporary methods for evaluation of cost-effectiveness of an investment are based on evaluating expected future cash flows and the concept of the time value of money. The most often used methods for evaluating cost-effectiveness of a project are financial net present value (FNPV) and financial rate of return (FRR), given in the following equations [4]:

$$FNPV_{i,N} = \sum_{n=0}^{N} \frac{NT_{i,n}}{(1+r)^n} \quad (3)$$

$$NSV_{i,N} = \sum_{n=0}^{N} \frac{NT_{i,n}}{(1+FRR)^n} = 0 \quad (4)$$

where NSVi,N represents the net summary value while NTi,n represents the cash flows for individual years.

When it is needed to choose one option out of multiple ones with FRR ≥ r, the option with the largest FRR value should be chosen [6]. The rule of ranking can be represented in the following way:

if FNPVA > FNPVB and/or FRRA > FRRB option A is chosen

if FNPVB > FNPVA and/or FRRB > FRRA option B is chosen

Economic analysis aims to evaluate the contribution of the project to economic prosperity of the region or country. In economic analysis the focal point are benefits and costs that society as a whole will gain from the project. In contrast to financial analysis, where market prices are relevant, for economic analysis accrual prices, also called shadow prices, are used [4].

In order to compare cash flows occurring during different years of project realization in economic analysis, discounting should be done using an appropriate social discount rate [4].

To evaluate the feasibility of a project the most used economic indicators are the economic net present value (B - C) which is calculated as the difference between the discounted benefits and discounted costs of a project, along with the ratio of discounted benefits and discounted costs (B/C) [14].

The conditions for economic feasibility of a project are the following:

(B – C)i,N > 0

(B/C)i,N > 1

Information on costs, benefits and risks when it comes to future projections of a project, can rarely be known with certainty. This is why risk analysis, also known as what-if analysis or sensitivity analysis, is recommended for validation of collected and projected data, as well as for prediction of outcomes depending on changing values of different, and especially key factors [13]. Key factors are factors whose positive or negative changes have the biggest effect on the financial and economic feasibility of a project. In order for these factors to be discovered it is necessary to vary each factor of the analysis one by one, and observe how the project feasibility changes as a result. Numerous factors can be identified with regard to sensitivity analysis, but some of the more important ones are: population, rate of inflation, real wage growth rate, electricity price, project implementation delay, equipment lifespan, energy use, tariffs, etc. [4].

Necessary attention should be given to changes in project feasibility depending on the change of discount rate. If the increase of the discount rate still brings a positive result, the project is financially feasible [13].

Based on the results of the conducted analysis a clear decision can be made, based on real data of the performed projections [13]. When the net present value and the B/C ratio are calculated for several options (variants), the options can be compared.

Out of multiple options the advantage is given to the option with the greater net present value and B/C ratio. The ranking rule can pre presented in the following way:

if (B – C)A > (B – C)B and/or (B/C)A > (B/C)B option A is chosen

if (B – C)B > (B – C)A and/or (B/C)B > (B/C)A option B is chosen

However, when other options have advantages which cannot be quantified, it is possible that the first-ranked option based on net present value or the B/C ratio is not first-ranked in the complete analysis [13].

A big part of the risk related to cost-benefit analysis can be connected to the human factor. Participants or interested parties can influence the results of the analysis by enlarging or minimizing costs and benefits. In some cases, participants supporting the project can be personally or institutionally biased [13].

3.3. Costs

Costs can be categorized into direct costs, related to the use of resources in construction of the WWTP (e.g. construction of the plant and supporting structure, operational and maintenance costs, land purchase or expropriation costs) and indirect costs, related to secondary negative effects of the project such as environmental degradation, effect on the wastewater recipient, loss of income from WWTP land not being used for other purposes (e.g. agriculture, urbanization), electricity use, exchange rate losses for chemicals and spare parts if imported mechanical devices are used, losses in income from increased water price, nuisances from noise and mosquitoes, negative sentiment from the local population.

In this paper for the total cost of the project investment costs for construction of all elements of the wastewater collection and treatment system for a certain variant were taken into consideration, along with the operational costs (gross pay of employees hired for system maintenance, electrical energy costs, costs of chemicals).

The investment costs of WWTP construction were obtained based on the unit price of 220 EUR/PE, obtained based on the unit price of similar WWTP built in the country (WWTP Kruševac, WWTP Leskovac). The prices for the remaining elements of the technical solution were obtained based on the bill of quantities and the priced bill of quantities in the project documentation [15 - 17].

The gross employee income was determined for 6 workers who would be employed on the WWTP Pirot, who would occasionally oversee and maintain WWTP Trnjana as well, since WWTP Trnjana is a compact automated plant which does not need a constant operation crew, meaning that the number of employees and their gross income is the same in all three variant solutions. The gross employee income was estimated based on the average gross employee income of 1063.11 EUR per month [15].

The use of electricity was estimated based on the installed capacity of the WWTP (WWTP Pirot 30 kW, WWTP Trnjana 5 kW, WWTP Krupac 7.5 kW in variant solution 2, 2.5 kW for variant solution 3) and installed capacity of the pumping stations (PS Veliko Selo 2.2 kW, PS Trnjana 2.2 kW) for individual variants using the assumption that the pumping stations operate 8 hours a day, with a unit electricity price of 0.11 EUR/kWh for the industry [1].

Chemical use (sodium hypochlorite, coagulant) was estimated basted on the relevant average daily flow of wastewater into the WWTPs (WWTP Pirot 140.52 l/s, WWTP Trnjana 2.11 l/s, WWTP Krupac 1.17 l/s) with the unit price of 0.025 EUR/m3 adopted based on experiential data from similar WWTPs.

3.4. Benefits

Benefits can be categorized as direct benefits, encompassing obvious services produced by the project, such as water and soil protection from uncontrolled dispossession of wastewater, improvement in cleanliness and public health protection services, wastewater recycling for irrigation or urban use, employment opportunities, and indirect benefits or secondary positive effects, such as protection of consumer health from polluted water, quality of life improvement on a local level, protection of pastures and grazing animals, indirect employment opportunities [3].

The total benefits of the project taken into consideration in this paper are the wastewater treatment fee [17] and the cost savings from wastewater pollution, obtained as the difference between pollution costs for untreated wastewater and pollution costs for treated wastewater [18].

Wastewater treatment fees were determined based on the WWTP capacities (WWTP Pirot 140.52 l/s, WWTP Trnjana 2.11 l/s, WWTP Krupac 1.17 l/s) with the unit price for wastewater treatment of 0.35 EUR/m3 adopted based on the data for similar WWTPs [17, 19, 20].

The cost savings of wastewater pollution were also determined based on the WWTP capacities with the assumption that the average amount of pollutants in wastewater are SM 150 mg/l, BPK 250 mg/l, HPK 500 mg/l, while in treated wastewater in accordance with the requirements of the Directive and plant treatment level the amounts are SM 35 mg/l, BPK 25 mg/l i HPK 125 mg/l. The cost savings of wastewater pollution were determined with unit prices of pollution for relevant pollutants (using the so-called shadow prices) SM 0.01 EUR/kg, BPK 0.03 EUR/kg i HPK 0.21 EUR/kg [20]. The unit prices per kilogram of pollutants emitted into water, or shadow prices, represent benefits achieved through reduction of environmental degradation, hospital care costs, loss of live costs, etc.

3.5. Financial and economic analysis of variant solutions

Financial and economic analysis was conducted based on the obtained values of costs and benefits. All cost and benefit values are given in table 1.

Discount rates from 1% to 10% were used for calculation of present values of costs and benefits. For further financial analysis discounted future values of costs and benefits were obtained using the recommended financial discount rate of 4 %, based on the recommendation of the Ministry of Finance of the Republic of Serbia [21].

Table 1. Investment and operational costs

	VARIANT 1	VARIANT 2	VARIANT 3
INVESTMENT COSTS (EUR)			
Sewer Systems	1 947 620.73	1 165 629.71	
Pumping Stations	102 514.14	44 301.41	
WWTP	13 200 000.00	13 430 770.86	
TOTAL	15 250 134.87	14 640 701.97	14 558 406.64

OPERATION COSTS (EUR/year)			
Gross employee income (6 employees)	76 543.71	76543.71	76543.71
Energy used	29 905.92	36336.96	356 40.00
Chemicals used	109 264.64	110175.18	111 814.15
TOTAL	215 714.27	223 055.84	223 997.85
BENEFITS (EUR/year)			
Wastewater treatment fee	82497.25	86839.21	86839.21
Pollution cost savings	1507782.7	1587139.67	1587139.67
TOTAL	1590279.94	1673978.89	1673978.89

For further economic analysis discounted future values of costs and benefits were used, obtained by using the recommended social discount rate of 7%, recommended by the Ministry of Finance of the Republic of Serbia [21].

4. RESULTS AND DISCUSSION

Based on the discounted values of costs, benefits and cash flows thfinancial feasibility factor FNPV (financial net present value) was calculated, using the recommended financial discount rate of 4%. Results of the calculation are given in table 2.

Table 2. Determining present value of cash flow

Year	Net present value of cash flow NT (EUR)		
	Variant 1	Variant 2	Variant 3
0	-15 250 134.87	-14 640 701.97	-14 558 406.64
30	423 804.26	447 346.66	447 056.22
FNPV	8 518 900.55	10 448 707.56	10 514 713.64

Taking into account the time value of money and the recommended discount rate of 4 % per year, based on the results shown in table 2, it can be concluded that the analyzed investment, with the observed cash flow, is feasible for all three variants, since it brings in greater net benefits than costs.

For calculation of FRR (financial rate of return) analysis of future values of costs and benefits was conducted, using discount rates from 1% to 10%. It was calculated that NPV = 0 for ERR = 8.1% in variant 1, ERR = 9.2% in variant 2, and ERR = 9.25% variant 3. Considering that:

FNPV3,30 = 10 514 713.64 EUR > 0 and FRR3,30 = 9.25% > r = 4%

FNPV2,30 = 10 448 707.56 EUR > 0 and FRR2,30 = 9.2% > r = 4%

FNPV1,30 = 8 518 900.55 EUR > 0 and FRR1,30 = 8.1% > r = 4%

it can be concluded that all three variant solutions are financially feasible.

Considering that:

FNPV3,30 = 10 514 713.64 EUR >

FNPV2,30 = 10 448 707.56 EUR >

FNPV1,30 = 8 518 900.55 EUR and

FRR3,30 = 9.25% > FRR2,30 = 9.2% > FRR1,30 = 8.1%

it can be concluded that, based on financial analysis, the most feasible variant solution is variant 3, followed by variant 2, and lastly variant 1.

Based on discounted values of costs, benefits and cash flows, indicators of economic feasibility were determined, using the recommended social discount rate of 7%. Results of the calculation are given in table 3.

Table 3. Analysis of economic feasibility indicators

		Variant 1	Variant 2	Variant 3
Total costs [EUR]	C	17 926 942.09	17 408 611.14	17 338 005.24
Total benefits [EUR]	B	19 733 849.29	20 772 472.93	20 772 472.93
Economic indicators	B – C	1 806 907.20	3 363 861.79	3 434 467.69
	B/C	1.10	1.19	1.20

Considering that:

(B – C)1,30 = 1 806 907.20 EUR > 0 and (B/C)1,30 = 1.10 > 1

(B – C)2,30 = 3 363 861.79 EUR > 0 and (B/C)2,30 = 1.19 > 1

(B – C)3,30 = 3 434 467.69 EUR > 0 and (B/C)3,30 = 1.20 > 1

it can be concluded that all three variant solutions are economically feasible.

Sensitivity analysis was conducted with a variable social discount rate ranging from 1% to 10 %. Based on the results of the sensitivity analysis it can be concluded that all suggested variant solutions are economically feasible with the increase of the social discount rate up to 8% for variant 1, or 9% for variants 2 and 3, considering that the B/C > 1. If the social discount rate is increased above 8% or 9% respectively, the B/C ration becomes less than 1 for the suggested variant solutions, meaning that the solutions are no longer economically feasible.

Considering that:

(B – C)3,30 = 3 434 467.69 EUR > (B – C)2,30 = 3 363 861.79 EUR > (B - C)1,30 = 1 806 907.20 EUR and

(B/C)3,30 = 1.20 > (B/C)2,30 = 1.19 > (B/C)1,30 = 1.10

it can be concluded that, based on economic analysis, the most economically feasible variant solution is variant 3, followed by variant 2, and finally variant 1.

Based on the sensitivity analysis it can be concluded that variant 3 is the most favorable with the increase of the financial and social discount rate.

Considering that variant 3 is the most feasible in both the financial and economic analysis, it is finally concluded that the most favorable option in the cost-benefit analysis is variant 3.

5. CONCLUSION

Because of increased complexity, numerous challenges, a wide spectrum of insecurity and high investment costs in the field of water management, it is very important to conduct a feasibility analysis of an investment project, no matter how big the project may be.

When evaluating feasibility of realization of water management investment projects, the effects on the project on the wider community should be taken into account. Investment projects like these can optimally be evaluated if the total effects of the project are considered. Project realization feasibility analysis is most often done using the cost-benefit analysis which is based on a great number of variables and assumptions, which makes it very complex. The cost-benefit analysis gives a clear picture of a favorable ratio between investment and benefit, and highlights the importance of economic efficiency in the choice of investment projects.

In this paper, the basic steps of the cost-benefit analysis were applied, and it was concluded that out of three suggested water protection solutions in the Municipality of Pirot, variant solution 3 was shown to be the most feasible. This shows that applying even a relatively simple analysis for economic valuation of alternative solution enables the choice of the most feasible one, which ensues the economic benefits and sustainability of a project, both of which are key for attaining long-term development goals.

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