

## REVITALIZATION OF THE BEGEJ CANAL - CURRENT STATE, PLANED ACTIVITIES AND COST-BENEFIT ANALYSIS

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### Abstract

The subject of the research carried out is the revitalization of 32km long Begej canal that connect city of Timisoara in Romania and city of Zrenjanin in Serbia. The study encompasses the part of the canal on the territory of the Republic of Serbia. Activities planned within this project were: revitalization of the hydro complexes Klek and Itebej, construction of a dual-purpose road, construction of a floating dock with a mooring point in the city of Zrenjanin, designs and dredging works of the Begej canal and analysis of dredging mechanization optimal for use. The research comprises all the required activities for the realization of all works on the rehabilitation and construction of mentioned structures, including the production of complete technical documentation and equipment for the dredging process on the Begej canal on the territory of the Republic of Serbia. The research carried out is targeted for proving of feasibility of this complex project. It is concluded that project is feasible with negative finance parameters and positive economic impact and that has great potential influence on development of north-east region of Serbia and improvement of ecological parameters.

### Key words

cost-benefit analysis; feasibility study; revitalization; risk and sensitivity analysis; scheduling; water canal

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## 1 INTRODUCTION

As a part of joining EU, programs of cross-border cooperation have had a great impact on improvement of infrastructure resources in border regions. Analyzing present state of water ways in Serbia it can be said that these resources are well maintained but additional investment must be implemented especially in order to modernize them. The WFD requires that Member States achieve “good status” for all water bodies [1]. In order to justify investment in certain project, according to EU legislation, feasibility study must be done. It must be done according the recommendations given in Guide to Cost-Benefit Analysis of Investment Projects [2]. Investments of waterways are very important from various aspects. They have capacity to offer society many kinds of socio-economic value. Waterway authorities responsible for management and (re)development need to optimize the public benefits for the investments made [3]. Water problems of the world are neither homogenous, nor constant or consistent over time. They often vary very significantly from one region to another, even within a single country, from one season to another, and also from one year to another [4].

The subject of the analysis carried out within the feasibility study is the revitalization of the Begej canal. The study encompasses the part of the canal on the territory of the Republic of Serbia, whereas the total scope of the project of the cross-border cooperation with Romania includes the section of the Begej canal belonging to the territory of Romania as well. Major activities planned by this study are the following:

- revitalization of the hydro complexes Klek and Itebej (the lock, weir and associated hydro-structures) with the production of required technical documentation [5];
- construction of a dual-purpose lane (work-inspection lane for the needs of the canal maintenance and a cycling lane), with the production of required technical documentation [6];
- construction of a floating dock with a mooring point in the city of Zrenjanin, with the production of required technical documentation [7];
- production of complete project and technical documentation for dredging works of the Begej canal;
- providing the equipment necessary for the canal revitalization (multi-function dredger, aquatic weed harvester, equipment for hydrographic measuring, IT equipment, vehicles);
- initiating the formation of the border crossing on the Begej canal which will include a dual-purpose lane too.

The Feasibility study have analyzed: inland waterways in Europe, inland waterways of Republic of Serbia, The Begej Canal, location of The Begej canal and the importance for social and economic parameters, documents that cover strategic framework, navigation and transport of goods, current state of the Begej canal and its hydro-technical objects, revitalization of the Begej canal and objects, mechanization needed for revitalization, ecological parameters of revitalization, time series analysis and financial and economic parameters of rehabilitation.

## 2 THE BEGEJ CANAL

The network of inland waterways of the Republic of Serbia, of international importance, consists of the River Danube, Sava and the Tisza river. Apart from the transport of goods and

passengers, the activities carried out on those waterways are also in function of basin management (flood protection, land amelioration, water supply of cities and industry and the like), energy generation (hydropower plants), environmental protection, tourism, recreation etc. In addition to the mentioned rivers the canals Hydro system Danube-Tisza-Danube (HS DTD) is also very significant segment of the inland waterways in the Republic of Serbia.

Figure 1 shows the most important segment of the inland waterways of the Republic of Serbia, i.e. waterways in the north of the country.



*Fig. 1: Inland Waterways in Republic of Serbia* (source: european-waterways)

The Canal Network Hydro system Danube-Tisza-Danube (HS DTD), in terms of the regulation of water regime, is of vast significance for sustainable development of this part of the Republic of Serbia. At the same time, throughout all its construction phases, this canal network is designed as a single waterway integrated in waterways of the rivers Danube and Tisza in the region of Vojvodina. Total navigable length of the canal network is about 600 km, out of which 13,1 km belongs to the category Va, and 289,8 km to the category III as determined by state waterways categorization in 2013. Out of the total number of 17 built ship locks, 12 of them have the following dimensions: 85 x 12 x 3 (including the ship lock The Dam on Tisza) and all are in function. Authority for technical maintenance of waterways on the canals HS DTD is PWMC “Vode Vojvodine”. At the same time, they are in charge of this water resource management structure.

In the past centuries, the Becej Canal formed an important navigation route between the Danube River in Vojvodina in the northeast area of Republic of Serbia and the city of Timișoara in the county of Timiș, Romania. It still fulfils an important function in the water regime of the Becej-Tamis system, which covers a great part of the Banat Region.

In 1958 the Becej Canal was closed for navigation as a result of political issues, causing a serious deterioration of the environmental situation in general and specifically of the water quality. In the 1990’s this became a great concern for the regions through which the Becej and Tamis rivers flow. In 1998, Serbia and Romania made a draft agreement “Establishing Co-operation for the Elaboration of a Feasibility Study on Restoring the Becej Canal to its

Navigation Function”. The agreement, in which German parties also participated, was not followed up.

However, in the spring of 2000, Romanian, Serbian and Hungarian representatives agreed to support a revitalisation of the Begej Canal. This decision was a result of discussions held in the Euro Region Danube-Kris-Mures-Tisza meetings on water management and navigation development, and earlier in the meeting of the Yugoslav-Romanian Hydro-technical Commission held in Timisoara in may 1998.

The Begej Canal (Romanian name is ‘Bega’) lies in the Banat region, which stretches from the eastern part of the Pannonian Valley to the southwest hillsides of the Carpathian mountain range and up to the Tisza River crossing the borders of Serbia, Romania and Hungary. The Canal accounts for 120 km, of which 75 km lie in Serbia and 45 km in Romania. It has a depth of ca. 2.50m, a width of ca. 30m and an average discharge of 10-25m<sup>3</sup>/s. It should be noted that the canal itself forms a part of the border between Serbia and Romania over a distance of 2.10 km (from km 30.365 to 32.258).

Construction of the Begej Canal started in 1718 and works were completed in 1756. During the period 1910-12 four lock/weir complexes were constructed in the Begej Canal, two in Serbia; Klek and Itebej and two in Romania; Sîntmartinu and Sînmihaiu Roman (Figure 2). The locks enabled the passage of 500-ton vessels. As a result of these constructions, the Begej became an important navigation route for 500-ton ships in the first half of the 20th century.

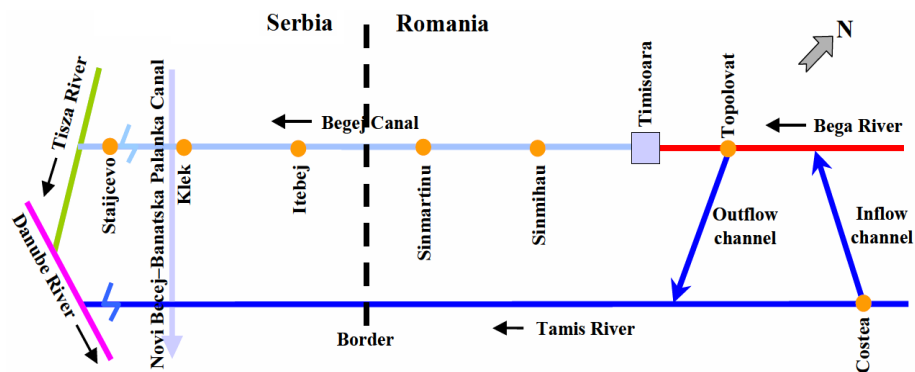


Fig. 2: The Begej – Tamis System

### 3 CURRENT STATE OF THE BEGEJ CANAL AND ITS HYDRO-TECHNICAL OBJECTS

The Serbian part of the canal is supplied with water from its tract in Romania. A legislation from 1902 stipulated that during high waters, the Begej could receive a maximum discharge of 100 m<sup>3</sup>/sec. In 1955 an agreement was reached between the former Republic of Yugoslavia and Romania fixing the maximum discharge allowed through the Begej Canal at 83.50m<sup>3</sup>/s. Serbia and Romania also agreed that during the winter months from 25 December to 21 March, the weirs are lowered completely to allow a free passage for ice and potential large discharges. This process takes 5 days.

The following hydro-technical structures are in the section of the Navigable Begej from the Klek lock to the Romanian border:

- Two locks and weirs (constructed in 1910-1912):
  - Itebej (Fig. 3 and Fig. 5);
  - Klek (including an additional chamber, constructed during the 1960’s, Fig. 4 and Fig. 6);

- Four Pump stations located on the southern bank of the Begej.



*Fig. 3: Weir in Itebej seen from downstream*



*Fig. 4: Weir in Klek seen from downstream*

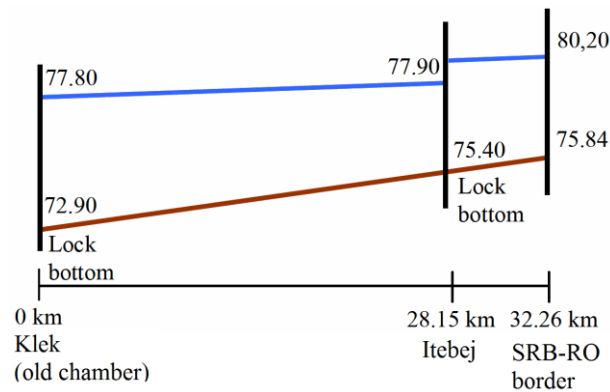


*Fig. 5: Navigation lock in Itebej*



*Fig. 6: Old navigation lock in Klek*

The average flow velocity is 0.50m/s. In order to prevent the canal water to become still water, the minimum flow is kept at 5.00m<sup>3</sup>/s. In the last decade of the 20th century, extreme high discharges of approximately 70.00m<sup>3</sup>/s occurred twice in the canal. Water levels in the Begej Canal are measured in relation to the average level of the Adriatic Sea (abbreviated to 'asl' = Adriatic Sea Level). Normal operational water levels in the canal and distances of the stretches with (almost) constant water levels are shown in Figure 7. Water levels are measured daily at the Itebej and Klek locks, data is available for a period up to 80 years ago. Extreme minimum water levels are usually measured in the winter and maximum levels in spring.



*Fig. 7: Water levels and distances for the Begej Canal*

### 3.1 Current state of buildings and objects

Based on a visual inspection, the dikes along the canal seem to be in a fairly good condition. With the exception of the hydro-technical structures, the canal has natural embankments. Due to lack of maintenance, trees and tall shrubs have grown along the canal. This vegetation needs to be removed unless it specifically serves to provide shipping with protection against the wind. Minor repair works need to be carried out for the (stone and concrete) bank protection works at the complexes;

There is a considerable backlog in maintenance of the Itebej, and slightly less of the Klek complex. Movable parts need to be replaced or treated against corrosion, the masonry needs to be repaired and the area in and around the weir and locks must be dredged to an appropriate navigable depth. All the woodwork must be replaced and the guiding structures should be repaired and modernized. Electrical area lighting and navigational signalling lights should be installed for safe and continuous navigation;

The navigation facilities (docks, loading sites etc.) along the canal are small, derelict and need to be modernized. There are no markings in the canal and the km-signalling along the canal is mostly missing or hidden behind the vegetation. The turning basins for the boats are too small and need to be deepened.

### 3.2 Current state of the sediment and water quality

The canal contains large amounts of heavily contaminated sediments. The contamination significantly exceeds the natural background concentration, and mainly concerns heavy metals, of which cadmium and copper are the severest. According to the Dutch system on judging soil and sediment contamination, remediation is necessary and urgent [8].

To keep the volume of contaminated sediment at a minimum, it is advisable not to mix the polluted sediment with the unpolluted soil. It will be difficult and expensive to clean the contaminated sediment. A possible solution is isolated storage, using depots along the canal. (Fig. 8) The contamination is a trans-boundary problem. This means that discharge inventories need to be carried out in both Romania and Serbia. Based on this inventory, reduction levels should be agreed upon and implemented according to the EU Water Framework Directive (2000/60/EC) and through integral management of the river basin. This approach, in combination with a stringent monitoring system, will ensure that the measures taken to preserve and improve the sediment and water quality will be successful [8].



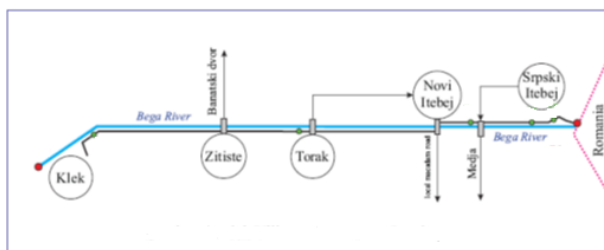
Fig. 8: Positions and areas of potential locations of depots

#### 4 REVITALIZATION OF THE BEGEJ CANAL AND OBJECTS

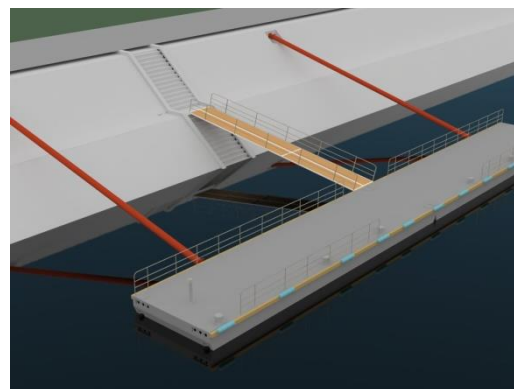
Revitalization of the canal must cover all works necessary in order to bring canal and all supporting facilities in function, accordingly to defined current state of the canal and buildings in the complex Klek and the complex Itebej as well as needs for bringing canal into full operation (border crossing with Romania and mooring point). Revitalization works are divided into phases and buildings (canal and associated buildings) as shown in Table 1. In the context of this study it is planned to realize activities of Stage 1.

*Tab. 1: Activities divided by buildings and stages of revitalization*

<b>Buildings</b>	<b>Stage 1</b>	<b>Stage 2</b>
Canal Begej bed and slopes	<ul style="list-style-type: none"> <li>• control testing of sediment (mud) with all the necessary supporting documentation</li> <li>• preparation of technical documentation for the canal dredging, which includes definition of dredge removal procedure with obtaining of all necessary approvals and permits</li> <li>• preparation of designing documentation for adequate landfill for dredge storing</li> </ul>	<ul style="list-style-type: none"> <li>• realization of dredging works in canal and the rehabilitation of slopes</li> </ul>
Hydrocomplex Itebej	<ul style="list-style-type: none"> <li>• preparation of missing designs and other technical documentation and obtaining approvals for the rehabilitation of facilities in the complex Itebej</li> <li>• realization of rehabilitation works in hydrocomplex Itebej</li> </ul>	×
Hydrocomplex Klek	<ul style="list-style-type: none"> <li>• preparation of missing designs and other technical documentation and obtaining approvals for the rehabilitation of facilities in the complex Klek</li> <li>• realization of rehabilitation works in hydrocomplex Itebej</li> </ul>	×
Dual-use path (working-inspection and cycling path), Fig. 8	<ul style="list-style-type: none"> <li>• preparation of missing designs and other technical documentation and obtaining approvals for the construction of dual-use path (working-inspection and cycling path)</li> <li>• realization of construction works for dual-use path</li> </ul>	×
Floating dock and mooring point for tourist vessels in Zrenjanin, Fig. 9	<ul style="list-style-type: none"> <li>• preparation of missing designs and other technical documentation and obtaining approvals for the construction of floating dock and mooring point</li> <li>• realization of construction works of floating dock and mooring point</li> </ul>	×
Border crossing between Serbia and Romania	<ul style="list-style-type: none"> <li>• initiation of the process for forming the border crossing</li> </ul>	<ul style="list-style-type: none"> <li>• preparation of designs and other technical documentation</li> <li>• realization of construction works</li> </ul>



*Fig. 8: Schematic presentation the route for dual use path from the border with Romania to the Klek weir*



*Fig. 9: Preliminary solution for the floating dock and mooring point for passenger ships in Zrenjanin*

#### **4.1 The Project Financing**

Provided the complexity of the project, as regards construction of the new facilities (the dual-use path and floating dock with mooring point), rehabilitation of the existing Itebej and Klek hydro-complex facilities, machinery procurement, as well as development of the lacking project documentation, we have envisaged to obtain finances from three sources:

- IPA fund for cross border cooperation
- PWMC “Vode Vojvodine“
- Government of the AP Vojvodina – financing of preparation of planning documentation.

The IPA cross - border cooperation fund will finance: works on construction of a dual-use path and floating dock with mooring point, lacking technical documentation for the facilities, works on the hydro-complex remediation, lacking technical documentation needed for execution of works, procurement of machinery necessary for rehabilitation and maintenance of the Begej Canal and preparation of technical documentation for the Begej Canal dredging.

PWMC “Vode Vojvodine“ as the project partner will finance of the project’s costs, and as the primary beneficiary will also finance all operational costs, as well as the refinancing costs.

Government of the AP Vojvodina will finance preparation of the planning documentation that is necessary for the Begej Canal dredging project i.e. the Begej Canal rehabilitation.

#### **4.2 Investment costs**

As it has been mentioned in the previous article, investment costs have been generated through the implementation of six out of seven activities, namely:

- Itebej hydro-complex rehabilitation
- Klek hydro-complex rehabilitation
- Construction of the dual-purpose road (working-inspection and cycling route)
- Machinery procurement for the Begej Canal rehabilitation
- Preparation of the design and technical documentation for the Begej Canal dredging and
- Construction of floating dock with mooring point on the Begej River in Zrenjanin.

The only item that does not generate investment costs is the “Initiation of establishment of the border crossing procedure on the dual-use path and the Begej Canal”. An overview of the investment costs is presented in table 2, with a view to provide a clear structure of the investment costs.



Tab. 2: *Activities divided by buildings and stages of revitalization*

<b>INVESTMENT COSTS (1 + 2 + 3 + 4 + 5 + 6 + 7)</b>		<b>6,348,765.87 €</b>
<b>1</b>	<b>REHABILITATION OF HYDRO-COMPLEX KLEK</b>	<b>976,562.77 €</b>
1.1	Building costs	941,562.77 €
1.2	Designs costs	20,000.00 €
1.3	Technical supervision of works	15,000.00 €
<b>2</b>	<b>REHABILITATION OF HYDRO-COMPLEX ITEBEJ</b>	<b>1,028,372.72 €</b>
2.1	Building costs	993,372.72 €
2.2	Designs costs	20,000.00 €
2.3	Technical supervision of works	15,000.00 €
<b>3</b>	<b>CONSTRUCTION OF DUAL USE PATH (WORKING INSPECTION AND CYCLING PATH)</b>	<b>2,007,445.73 €</b>
3.1	Building costs	1,942,445.73 €
3.2	Designs costs	40,000.00 €
3.3	Technical supervision of works	20,000.00 €
3.4	Technical control of design	5,000.00 €
<b>4</b>	<b>PROVIDING EQUIPMENT FOR DREDGING AND MAINTENANCE OF BEGEJ CANAL</b>	<b>1,194,000.00 €</b>
4.1	Multi Purpose Dredger with all attachments (Back hoe bucket, Dredging bucket, Clamshell, Ripper rake, Hydraulic mowing bucket, hydraulic cutter head)	562,000.00 €
4.2	Aquatic weed harvester	295,000.00 €
4.3	Equipment for hydrographic measuring	295,000.00 €
4.4	Terrain vehicles (2 pieces)	34,000.00 €
4.5	IT equipment	8,000.00 €
<b>5</b>	<b>MAKING OF TECHNICAL DOCUMENTATION FOR DREDGING AND REMEDIATION OF BEGEJ CANAL</b>	<b>310,000.00 €</b>
5.1	Making of Pre-feasibility study with General design for dredging and remediation of the Begej Canal	108,000.00 €
5.2	Making of Preliminary solution for dredging and remediation of the Begej Canal	10,000.00 €
5.3	Making of Feasibility study with Preliminary design for dredging and remediation of the Begej Canal	85,000.00 €
5.4	Making of Environmental Impact Assessment Study	33,000.00 €
5.5	Making of Design for building permit for dredging and remediation of the Begej Canal and Technical review of design	35,000.00 €
5.6	Technical control of design	15,000.00 €
5.7	Making of Performing design for dredging and remediation of the Begej Canal and Technical review of design	24,000.00 €
<b>6</b>	<b>CONSTRUCTION OF FLOATING DOCK AND MOORING POINT ON BEGEJ IN ZRENJANIN</b>	<b>615,443.46 €</b>
6.1	Building costs	585,443.46 €
6.2	Designs costs	20,000.00 €
6.3	Technical supervision of works	5,000.00 €
6.4	Technical control of design	5,000.00 €
<b>7</b>	<b>MANAGEMENT OF THE PROJECT ADMINISTRATION</b>	<b>216,941.19 €</b>
<b>8</b>	<b>ACTIVITIES NECESSARY FOR PROJECT REALIZATION WHICH ARE NOT PART OF THE THIS PROJECT</b>	<b>200,000.00 €</b>
8.1	Making of Spatial Plan of the Region of Special Use with Elements of Detailed Training and Report on Environment Impact of the Plan	200,000.00 €

#### 4.3 Operating and maintenance (O&M) costs

Operating and maintenance costs are shown in table 3 and they pertain to four facilities i.e. two hydro-complexes, a dual – use path and a floating dock with mooring point. It should be mentioned that complete operational and maintenance costs have been financed by PWMC “Vode Vojvodine“. Costs pertaining to the hydro-complexes have been adopted based on the data available at the competent company PWMC “Vode Vojvodine“, whereas the costs that

pertain to the dual-use path have been determined based on the empirical data related to the road maintenance in the Republic of Serbia.

*Tab. 3: Recapitulation of the operating and maintenance costs per year for the project facilities*

<b>TOTAL O&amp;M COSTS PER COMPLEX PER YEAR (A+B)</b>	<b>73,378.14 €</b>
Hidro-Complex Klek	24,039.07 €
Hidro-Complex Itebej	24,739.07 €
The dual-purpose path (working-inspection and bicycle path)	12,000.00 €
Floating dock and mooring point on Begej in Zrenjanin	12,600.00 €

#### 4.4 Financial revenues

Potential revenues may be realised from the following sources:

- Fees for the use of the hydro system “Danube –Tisa – Danube” Canal, for cargo vessels navigation, regulated by the “Regulation on the Amount of Fees for Waterways for the Year 2015 “,
- Fees for the use of the hydro system “Danube –Tisa – Danube” Canal, for navigation of non – cargo vessels used for commercial purposes, regulated by the “Regulation on the amount of fees for waterways for the year 2015“
- Lock operation service fee for non-commercial ships, regulated by the “Regulation on the Amount of Fees for Waterways for the Year 2015 “
- Fees for the dock and mooring services on the Begej River in Zrenjanin, and
- Fees for the use of the dual – use path.

Due to the aforementioned, the Table 4 is created, demonstrating the recapitulation of all financial incomes.

*Tab. 4: Recapitulation of the income generated by the usage of the Canal Begej and the mooring point in Zrenjanin*

Income description and time period		Revenues per year before canal dredging (from 2019 till end of 2022)	Revenues per year after canal dredging (after 2023)
<b>Total</b>		<b>2,422.00 €</b>	<b>79,298.20 €</b>
<b>A.I</b>	The fee for using Hydro channel "Danube-Tisa-Danube" for cargo vessels	- €	<b>68,821.20 €</b>
<b>A.II</b>	The fee for using Hydro channel "Danube-Tisa-Danube" for sailing of other vessels that are not cargo but are used for commercial purposes	- €	<b>7,680.00 €</b>
<b>A.III</b>	The fee for lock service for non-commercial boats	<b>2,422.00 €</b>	<b>2,422.00 €</b>
<b>A.IV</b>	Fee for dock and mooring service on Begej in Zrenjanin	- €	<b>375.00 €</b>
<b>A.V</b>	Fee for using of dual-use path	- €	- €

#### 4.5 Economic benefits

Beside revenues generated through the fees for using the Canal, locks and docks with mooring points which are already explained in detail other economic benefits can be observed from the aspects presented in table 5.

*Tab. 5: Recapitulation of the economic benefits*

<b>ECONOMIC BENEFITS - TOTAL FOR OBSERVED PERIOD OF 25 YEARS</b>		<b>12,333,054.00 €</b>
<b>A.I</b>	Residual value of the facilities	- €
<b>A.II</b>	Benefits from the employment in the operative phase	- €
<b>A.III</b>	Benefits from the employment in the construction phase	<b>1,567,500.00 €</b>

<b>A.IV</b>	Benefits from increasing the land value	<b>90,000.00 €</b>
<b>A.V</b>	Benefits from increasing the household value	<b>125,000.00 €</b>
<b>A.VI</b>	Benefits from increasing the quality and quantity of tourist infrastructure	<b>4,968,000.00 €</b>
<b>A.VII</b>	Consumer's willingness to pay	<b>3,600,000.00 €</b>
<b>A.VIII</b>	Benefits from reducing the gas emissions	<b>1,982,554.00 €</b>

#### **4.6 Financial and economic parameters**

Observed operational period for parameters calculation is 25 years. The financial discount rate is 5% and economic discount rate is 5.5%. This discount rate reflects the opportunity costs of investing money in the observed region. Regarding the detailed analysis of the financial costs and revenues calculations of FNPV(C) and FRR(C) are completed [5]. The parameter values are as follows:

$$\text{FNPV(C)} = - 5,719,663.42 \text{ €}; \text{FRR(C)} = \text{N/A } \%$$

A negative value of FNPV confirms the fact that the project does not generate a financial refund and that it is financially unprofitable. The negative value of FNPV and the expected lower value of FRR in comparison to the discount rate (in the negative territory, too) demonstrates that the project has to be co-financed from the EU/IPA funds [5]. This is not a type of investment that can be considered financially viable and attractive for private financiers, under certain assumptions related to the tariff policy, the cost of construction, etc. The financial profitability analysis of the own capital contribution is also made. The analysis is similar to the previous one, except the fact that it also includes the capital contribution to the project, not including the co-financing from the grant. The results of the FNPV (K) calculation are:

$$\text{FNPV(K)} = - 985,424.46 \text{ €}; \text{FRR(K)} = \text{N/A } \%$$

Regarding the detailed analysis of the economic costs and revenue the calculations of ENPV and ERR are completed. The values of the parameters are as follows:

$$\text{ENPV} = 1,176,257.85 \text{ €}; \text{ERR} = 8.08 \text{ } \%; \text{B/C} = 1.30$$

A positive result of the economic analysis (ENPV is greater than zero) indicates that, from the standpoint of the public, the project should be implemented. The results demonstrate, from the socio-economic point of view, that the project creates obvious benefits for society and thus it should be financed [5]. The value of the benefit-cost (B/C) ratio is moderate and in favor of a positive decision that the project should be implemented.

## **5 CONCLUSIONS**

The subject of this paper is to present the current state and the potential of the Begej Canal for interregional connection and development between Republic of Serbia and Romania. In the paper were presented legal background documents, brief reviews of prepared designs for reconstruction and revitalisation of buildings on the Begej Canal as well as financial and economic analysis of investment in revitalisation of canal and its buildings. The planned project has negative financial parameters and positive economic parameters because of which is suitable for financing through EU/IPA funding program.

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