ECONOMIC EFFICIENCY OF THE DRAINAGE IN SOUTHERN BANAT

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Abstract: *This paper examines efficiency of building drainage system on the territory of Pancevo rit (south Banat). In this case, the research incorporates hydro-technical and economic indicators on which building of drainage systems depends. Analysed area covers over 90 000 ha of agricultural and building land. Hydro-technical solution offers 6 possible alternatives that can be applied in stages. For these alternatives total surface in risk of flood (ha) and total defended surface (ha) have been estimated. In addition to this, potential investments into building (€) and consumption of energy for powering pumping station (kWh) have been calculated for each alternative. Operational expenses of these systems include expenses of energy, expenses of maintenance and expenses of management. Expenses per defended ha, depending on the chosen alternative, amount from 34 to 76,5 €/ha. Considering the fact that the efficiency of drainage was examined using hydro-technical and economic indicators, the order of building of particular alternative was determined using multi-criteria optimization. In this case, method Electra 2 has been chosen. The input data matrix contained 6 variants and 6 criteria. One criterion regarding defended surface (ha) converged to maximum, while total investment (€), consumed energy (kWh), investment per defended ha (€/ha), operational expenses per defended ha (€/ha), expenses per defended ha (€/ha) to the minimum. The result of ranking coincides with hydro-technical analysis.*

Key words*: drainage, efficiency, variants, ranking*

INTRODUCTION

Making decisions about new construction or reconstruction of already built drainage system depends on the hydrotechnical and economic indicators on which is based assessment of feasibility of the planned works.

Construction of the drainage system in the southern Banat requires significant investments that depend on the areas of the system, the type and number of facilities, je complementing measures and other works. Depending on the size of the system and the amount of available financial resources planned facilities and works are performed in stages and variants. Therefore, it may be important to determine the time and sequence of construction of individual variants.

The selection of representative indicators for the assessment of efficiency of the drainage system is a complex scientific task on which may depend the success of the planned venture. These indicators can be hydro-technical, economic, financial, social, macro and micro, quantitative and qualitative. Sectors where drainage systems have major contribution are: agriculture, forestry, construction and building, tourism etc.

The most responsible branches for the functioning of drainage systems that connect natural factors of soil and water are agriculture and water management (POTKONJAK ET AL., 2005).

MATERIAL AND METHODS

Data collection was carried out on the basis of the survey conducted by the water management enterprises in southern Banat. In addition, there is an extensive project documentation on how to resolve the problem of drainage of agricultural and urbanized land in this area, which covers over 90,000 ha. Collected data has been quantified in appropriate units of measurement. The same analysis was done using valid and advanced methods. The investment and operational cost analysis were the basis for further calculations.

Calculation of the amount of investment in this case is synchronized with the proposed hydro-technical drainage solution. The surface covered in this case is about 90,000 ha of agricultural, urbanized and forest land. Five variants have been proposed, each of them can be run in stages. The task of investment analysis in this case, is to determine necessary funds for the construction and sequence of construction.

After the construction of the drainage system, related costs of functioning emerge. Identification of potential cost in this case is particularly important. After studying details of the system it was determined that it was necessary to calculate the following costs: maintenance, energy and management costs. Different methods and models of water management system analysis have been studied in order to find those which can be used for ranking and selection of potential variant sequence of construction.

RESULTS AND DISCUSSIONS

Cost of water regulation at the area Pancevacki rit. Hydrotechnical studies have shown that the area Pancevacki rit requires complex regulation of land territory. Investments in this case are related to the construction and reconstruction of multiple objects and performing additional works. Potential objects and works for the implementation are: pumping stations, dams, reconstruction of the channel dividing of basin areas, excavation of drainage lines, creation of drainage curtain, horizontal pipe drainage, land consolidation. Potential objects and works could be carried out in stages according to variants (V1 to V6) where it is possible to set different sequence of building with a total duration of about 5 years. Therefore, it is necessary to calculate the required amount of investments for implementation for each variant (Table 1). Investment per defended ha ranges in this case from 79.18 to € 661.36 €/ ha.

Table 1

Input data for investment analysis

No.	Parameters-variants	V1	V2	V3	V4	V5	V6
1	Investment (€)	0	500,000	2,000,000	6,400,000	8,400,000	15,900,000
2	Energy (kWh)	1,300,000	1,500,000	2,600,000	2,600,000	3,900,000	8,100,000
3	Total endangered surface (to 1 m, prob. 50%), ha	8,259	5,307	3,322	4,025	1,895	0
4	Total endangered surface(0-2 m), ha	1,605	1,394	1,130	1,253	912	0
5	Defended surface (prob. 10%), ha	0	4,217	9,486	7,038	13,845	32,092
6	Threatened acreage (to 1m, prob.50%), ha	6,654	3,913	2,192	3,949	0	0
7	Defended acreage (prob. 10%), ha	0	2,048	3,333	2,639	4,970	4,970
8	Total defended, ha	0	6,265	12,919	9,677	18,815	37,063
9	Investment per ha defended, €/ha		79,18	154,36	661,36	466,15	421,96

After a complex arrangement i.e. installation of drainage system, functioning of the system requires some costs. In this case, for all variants are calculated energy, maintenance and management costs. According to our legislation these systems are not subject of amortization. Costs of functioning based on defended ha have range from 45 to 110 €/ha. These costs should be covered by fees paid by owners of agricultural, urbanized and forest land. Bearing in mind the current sum, fees should increase significantly. This would provide funds for profitable operation of the drainage system.

Table 2

Input data for cost analysis

No.	Parameters-variants	V1	V2	V3	V4	V5	V6
1	Amortization, €	0	0	0	0	0	0
2	Energy costs, €	131,589	147,747	264,136	256,009	390,217	805,646
3	Maintenance costs, €	300,000	300,000	300,000	300,000	300,000	300,000
4	Management costs, €	86,318	89,549	112,827	111,202	138,043	221,129
5	Total costs, €	517,907	537,296	676,963	667,211	828,260	1,326,775
6	Surface of defending, ha	0	7,030	14,100	10,600	19,400	39,600
7	Costs per ha defended, €/ha		76.5	48.00	63	38.4	33.5

Graph 1 shows the costs per defended ha €/ha.

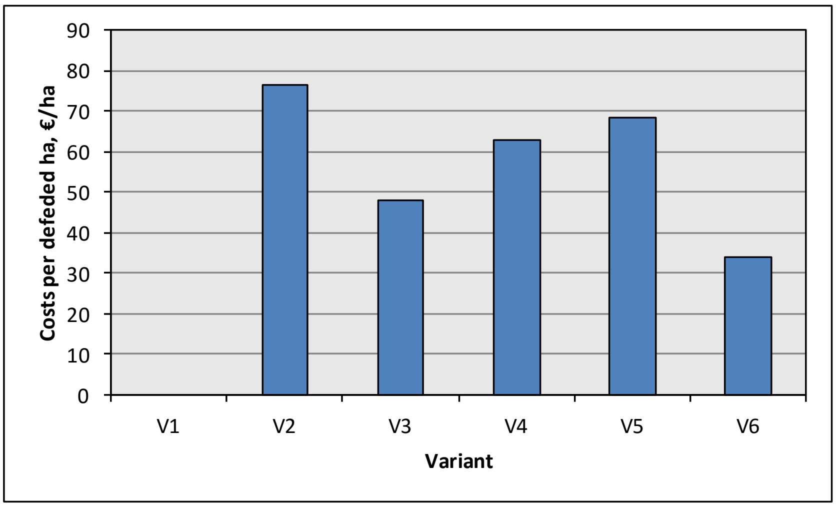

Figure 1: Costs per defended ha, €/ha

Ranking variant using methods ELECTRE

Bearing in mind that the efficiency of the drainage system in this case was examined through hydrotechnical and economic indicators, the ranking was made capitalizing on indicators from both groups. Assessment of the effects is reduced, in this case, to multiple criteria optimization of the parameters that define the most representative suggested technical solutions provided in the form of 6 variants that are to be implemented.

The criteria in this case, the most representative are:

K1 – Overall investment (000 €) necessary for completion of individual variants. This criterion originates from proposed technical solutions. Economically, planned undertaking should be fullfilled with investments that aimes to reach minimum.

K2 – Energy (000 kWh). This criterion is a function od installed power on pumping stations, number of working hours of pumping engine-generator (h) that depends on seasonal water surplus. Considering price of energy, in the best interest is to achieve minimal consumption.

K3 – Deffended area (ha) is a criterion that has been calculated in technical-technological studies. This criterion can vary depending on hidrological condition in certain years (dry, average or rainy year);

K4 – Investments per deffended ha (€/ha) represents overall investments and deffended area ratio. In this case, it should aim to reach minimum of investment per unit;

K5 – Operational exprences (000 €) include maintenance, energy and management costs. These costs are function parameters of specific technical solution for building variants. In addition, amount of use of certain parts of the system, maintenance and management method also depends on this criterion.

K6 – Expences per deffended ha (€/ha) represent operational costs to deffended area ration. Criterion, in this case, should be minimized.

Considering suggested criteria, a matrix of input data has been assembled. That matrix has later been used for optimization.

Table 3

Input data for ranking

variants/criteria	K1	K2	K3	K4	K5	K6
V1	0	1300	0	0	518	0
V2	500	1500	7,030	79	537	110
V3	2000	2600	14,100	154	677	67
V4	6400	2600	10,600	661	667	65
V5	8400	3900	19,400	466	828	46
V6	15900	8100	39,600	422	1327	45
weight	0.2	0.2	0.15	0.15	0.15	0.15
criteria	min	min	max	min	min	min

After choosing criteria for ranking variants, weighting coefficient for every criterion for each variant have been determined. Sum of weighting coefficients should be 1. Stakes for each individual coefficient are determined by experts' assessment. In this case, first two criteria attained 0.2, other 4 attained 0.15 weighting coefficient. Other alternative stakes were available as well as widening the number of coefficients to include qualitative coefficients (protecting environment, cross-border cooperation, demografic influence and others).

Afterwards, solution method had to be chosen. Among numerous available methods for multi-criteria optimization and ranking (Electra, Promethee and AHP), Electra 2 has been selected as optimal for this case.

In this case, there is 6 variants with important order of completion. It is multi-criteria function where only one criterion aims to reach maximum (K3), while other 5 minimum. The results of ranking are following:

- V1 dominates over V2,V3,V4,V5 and V6 ;
- V2 dominates over V4,V5 and V6:
- V3 dominates over V5 and V6 ;
- V4 dominates over V6 ;
- V5 dominates over V6 ;
- V6 does not dominate.

Achieved result was as expected since it matches hydrotechnical research in an order determined there. As it was expected, inclusion of qualitative criteria could affect the change in building order. On graph 2 the dynamics of investment completion according to the results of applying Electra 2 method is shown.

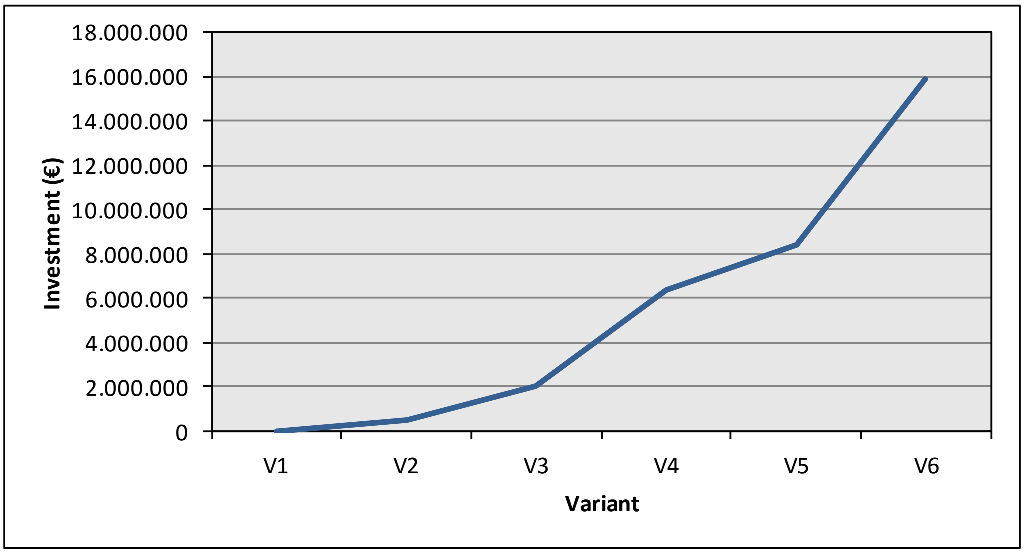

Figure 2: Dynamics of realization of investments

CONCLUSIONS

This paper demonstrates merely one part of the research accomplished on the area of southern Banat (which part is Pancevo rit) regarding drainage. Examining drainage efficiency on this area required interdisciplinary approach: hydrotecnics, economics, water management system analysis.

In hydrotechnical research basic parameters for complex regulation of land territory have been defined. Building objects and construction works have been proposed in order to optimally regulate water regime in land.

Economical research is related to estimate of required investments for completion of suggested hydro-technical solutions. In addition, assessment of needed funding in the working phase i.e. drainage fees. Drainage fees are currently funded from fee payed from owners of agricultural, urbanized and forest land.

Electra method (that belongs to water management system analysis) has been used, in this research, for determing order of building 6 proposed variants. In addition, 6 criteria had been chosen on which basis variants were ranked. To acquire better quality results additional criteria parameters should be included: environmental, cross-border cooperation, social, demografic and others.

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