REPORTS FROM THE PILOT ACTIONS (CW)

D.T3.3.1

Version 2

November 2019

WP	W T3: Policy integration and economic instruments
Activity	**Act. 3.3. Cost analysis**
Activity leader	GWP CEE
Number and name of the deliverable/output	**D.T3.3.1 - Reports from the pilot actions (WULS, MTDWD, CW)**
Participating partners	all
Type of the deliverable/output (analysis, report, guideline, workshop, brochure, etc.)	Analysis, reports, guideline
Purpose of the deliverable/output	- development of the uniform methodology on how to calculate and analyse N(S)WRM costs on river basin scale - testing of the cost analysis approach
Connection with other deliverables	- D.T3.3.2 – Approach on how to calculate N(S)WRM costs on river basin scale - D.T3.4.1 - Project of Decision Support System (DSS) - O.T3.4 - PILOT ACTION: testing the Decision Support System for N(S)WRM planning
Start date	**July 2018**
End date	**June 2020**

Contents

1 Introduction 3

2 Method testing 3

2.1. Data gathering 3

2.2. Cost estimation 3

2.2.1. Average Cost per unit of measure 4

2.2.2. Pricing basis, costs for the typical group of works 4

3 Measures in the pilot area 6

3.1 T01- Polders, dry flood protection reservoirs, sediment trapping dams 7

3.1.1 General description 7

3.1.2 Basic dimensioning 8

3.1.3 Cost assesment of retention basins 8

3.1.3.1 Cost assessment of retention Čret 9

3.1.3.2 Cost assessment of retention Koruščak 10

3.1.3.3 Cost assessment of retention Kamenica 11

3.2 T02 - Widenning or removing of flood protection dikes 12

3.2.1 General description 12

3.2.2 Basic dimensioning 13

3.2.3 Cost assesment of dikes 13

3.2.4 Comment 13

4 Cost assesment on a river basin scale 14

5 Conclusions 15

1 Introduction

One of the activities in WP 3 is the Cost analysis (A.T3.3). The goal of this activity is to develop a uniform methodology on how to calculate and analyze N(S)WRM costs on river basin scale.

The testing of the developed cost analysis approach has been made using examples from 3 countries-partners (Poland - WULS; Hungary - MTDWD, Croatia - CW). The method of testing provides information on how to estimate investment costs of N(S)WRM on basin scale based on a concept plan (AT2.3) and supports the justification of SWRM in RBMP in decision-making process.

This document presents content for a summary report of pilot actions on testing cost analysis methodology.

This document presents reports from pilot actions on testing cost analysis methodology.

2 Method testing

A simplified approach of the methodology was developed to assess N(S)WRM costs on river basin scale. The purpose of method testing is to analyse developed methodology and to evaluate its usefulness.

2.1. Data gathering

Before implementation of the cost analysis, the following must be identified for all measures, for which cost comparison would be done:

- Type and location of the measure
- Preliminary size
- Investment cost per unit for every measure
- Pricing basis, costs for the typical group of works
- River typology (altitude, catchment area, river width)

Type and location of the measure

Type and location of the measure was defined in the Concept plan (DT.2.3.1), while cumulative effect of the measures on the river basin was assessed with the dynamic model (DT2.4.2).

Preliminary size

For each measure preliminary size was defined for the purpose of modelling.

2.2. Cost estimation

For some of the measures there is no capital investment required, like turning meadows and pastures into arable land. For these measures only detailed approach is useful for cost analysis, with taking into account other costs (land change costs and maintenance costs). The valuation of other agricultural and forest measures in following a simplified approach that is not be too different from

the detailed one. On the other hand the hydro-technical measures are more complicated. Therefore two calculations are presented below.

2.2.1. Average Cost per unit of measure

For some measures from the NWRM catalogue[1] we gathered data of average cost per unit of measure (total investment cost of measure per unit), which are based on the past projects or literature review.

The costs per unit were based on previous similar projects (investment project, NWRM project) and experiences (professionals).

The average cost varies according to the region of the measure, and is therefore only an indicative estimation and provides a rough cost projection we can use for budget planning purposes in the early stages of concept development. It is not a substitute for feasibility study.

For each measure investment costs are calculated, using the equation below:

$$Invesment\ cost = Units\ of\ a\ mesure * Average\ price\ per\ unit$$

To put it another way

$$IC\ [€] = U\ [m] * PU[\frac{€}{m}]$$

Where,

IC=investment costs [€]

U=units / dimensions (length, height, width. volume, area) of a measure

PU=average price per unit [€]

Table 1: Required data for cost assessment with simplified approach

Group of measures	Measure	Unit	Price [EUR/unit]	Difficulty factor [1; 1.5; 5]	Other works [25 %]	Total cost [EUR]

2.2.2. Pricing basis, costs for the typical group of works

For other measures the method described above (simplified estimation of costs) can't be realistic, due to their complexity, different version of execution, etc. Therefore the typical group of works were defined for each measure. Their costs per unit were estimated (pricing basis). These costs should be multiplied by the difficulty factor (difficulty of accessing and performing works). The examples are shown below.

[1] *http://nwrm.eu/measures-catalogue*

Table 2: Pricing basis, costs for the typical group of works

Item	Unit	Price [EUR/unit]
Soil excavation, transport to the off-site disposal	m^3	15-50
Soil excavation, relocation, installation	m^3	15-50
Earthfill / rockfill for dikes	m^3	20
Broken shrubs (workspace preparation)	m^2	5
Supply and installation of concrete C12/15	m^3	150
Supply and installation of concrete C25/30 (including reinforcement steel, formwork, supporting)	m^3	300
Supply and installation of concrete with additive OMO 100, osmo 25 (including reinforcement steel, formwork, supporting)	m^3	350
Outlet structure (the depth up to 2 m)	pcs	2.000
Outlet structure (the depth from 2 – 4 m)	pcs	3.000
Rehabilitation works on “old” dikes (improvements)	m´	800 – 1.000
Special solutions on dikes – with sealing material	m´	1.200 – 4.000
Dikes	m´	1.200 – 1.500
Dam up to 3m	m	1.500
Dam from 3m – 5m	m	2.000
Dam over 5m	m	5.000
Weir (rock – wood)	m^3	275
Weir (rock – concrete)	m^3	410
Wooden sill, wooden weir (small)	m^2	150 - 300
Small weir (wooden) inside the drainage/ditch/channel	m2	150
Flood protection dikes - sealing foil	m^2	20
Small outflow regulation with elements/mechanism for regulation/operation	pcs	50.000-100.000
Crushed gravel in dry over fi 50 cm	m^3	130

.

.

.

The prices include transportation up to 10 km and installation of the material. The price per unit includes the total cost of a measure (access routes, diversion dikes, pumping, earthworks, construction / rehabilitation of the facility). The price does not include the cost of purchasing land, project documentation and preparatory and finishing works.

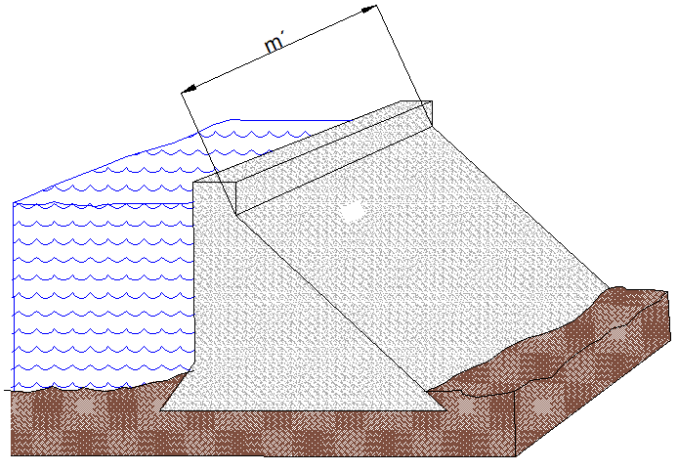

Figure 1: Scheme of dam and its´ unit for the estimation of cost

For each measure the investment costs are calculated, using the equation below:

$$IC\ [€] = U_{excavation}\ [m^3] * PU\left[\frac{€}{m^3}\right] + U_{sam}\ [m^3] * PU\left[\frac{€}{m^3}\right] + U_{riprap}\ [m^3] * PU\left[\frac{€}{m^3}\right]$$

Where,

IC=investment costs [€]

U=units / dimensions (length, height, width. volume, area) of a measure

PU=average price per unit [€]

River typology

The resulting costs have to be multiplied by the factor of difficulty of access and performance of works. This factor depends of the location, altitude, river topology (catchment area, width of river stream), etc. The applicability of a factor is decided upon designer experiences.

- Normal availability 1.00;
- More difficult accessibility (special machinery) 1.50;
- Extremely difficult work (manual work only, helicopter) 5.00.

One has to emphasize that the pricing basis and therefore the costs are only rough estimations of actual investment costs. A large number of factors (location, method of implementation, difference prices from site to site, river typology, geomorphological conditions, catchment area, etc.) effects the costs. There is no general methodology to be used. The rough cost estimation is used for measures' screening or deciding which to proceed with.

3 Measures in the pilot area

Expert measures are foreseen for flood defence in the Bednja basin, with proposed construction of three water retention basins (Koruščak, Kamenica 1 and Čret). In addition to the retention basins, the existing dikes in the lower part of the basin should be moved away from the river. These measures would reduce direct potential flood damage in the Bednja basin. Furthermore, by moving the dikes

away from the river, riparian habitats are protected better, floods have a weaker impact, and maintenance requirements are lower.

According to the catalogue of measures and based on the basin analysis, the following basin-wide measures have been selected on the Bednja river:

- Polders, dry flood protection reservoirs, sediment trapping dams (T1);
- Widening or removing of flood protection dikes (T2).

3.1 T01- Polders, dry flood protection reservoirs, sediment trapping dams

3.1.1 General description

Goal: Flood protection in the Bednja basin

Location/river topology: Lowland stream, easily accessible, agricultural land

General description: Construction of dams to reduce peak flow, controll discharge into the downstream basin and to reduce erosion on the downstream river.

Selected measures: Construction of three water retention basins for flood defense:

- Koruščak;
- Kamenica 1; and
- Čret.

Below are illustrated potential locations of retention basins in the Bednja basin.

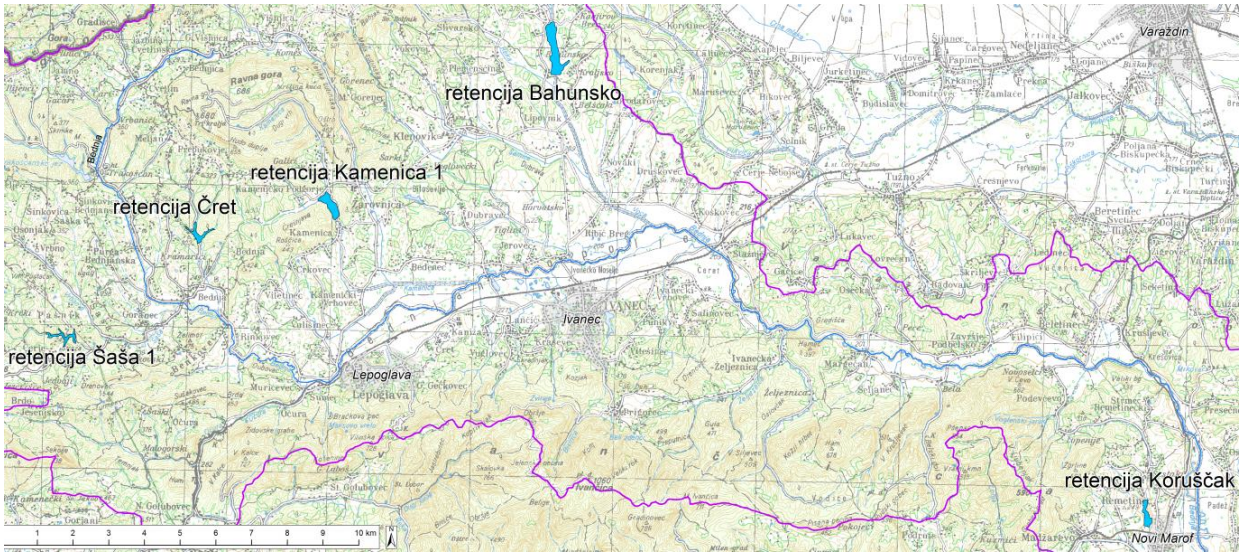

Figure 2: Potential locations of retention basins in the Bednja basin.

3.1.2 Basic dimensioning

Basic dimensioning of retentions is presented in table below.

Table 3: Typical group of measures for retention basin Kamenica

Retention basin	The catchment area upstream of the dam (km2)	Dam height (m)	Dam length (m)	Dam crest width (m)	Dam crest elevation (m a.s.l.)	Dam volume (*10^3 m^3)	Retention volume (*103 m^3)	Reten-tion area (ha)
Cret	4.21	5.50	130.0	5.0	245.5	10.9	124.3	9.3
Kamenica	13.08	6.30	140.0	5.0	232.8	17.7	370.9	17.7
Koruscak	25.98	4.1	260.0	5.0	198.1	10.6	358.8	9.5

3.1.3 Cost assesment of retention basins

Cost assessment was done with the use of prices of typical group of works and assessment of difficulty of building related to the location of measure, preparatory and finishing works.

Comprehensive river planning has to be taken into account, upstream regulations and downstream retentions.

Every measure was assessed in two ways:

- Option 1 – deriving from dam price per m
- Option 2 – deriving from typical group of works (pricing basis)

Below two options are presented; one is a constructed dam with embankment reinforcement, the the other is implemented with used material from dam construction and embankment reinforcement.

3.1.3.1 Cost assessment of retention Čret

Results of cost assessment of retention Čret are presented in tables below.

Table 4: Typical group of works for retention basin Čret – Option 1

Typical group of works	Unit	The number of units	Price [EUR/unit]	Difficulty factor (access, performing)	Preparatory and finishing works [25%]	Total cost [EUR]
Dam over 5m	m	130	5.000 €/m	1,0	1,25	812.500,00
Crushed gravel in dry over fi 50 cm for erosion protection	m^3	1500	130 €/ m^3	1,0	1,25	243.750,00
					TOTAL:	1.056.250,00

Table 5: Typical group of measures for retention basin Čret - Option 2

Group of measures	Unit [m^2 or m^3]	Price [EUR/unit]	Difficulty factor [1;1,5;5]	Preparatory and finishing works [25%]	Total cost [EUR]
Earth-clay materials for surrounding dikes and dam construction - (m^3)	7.300,0	20 €/m^3	1	1,25	182.000,00
Gravel material for drains and filter bed in dams and access roads - (m^3)	1.700,0	20 - 50 €/m^3	1	1,25	42.500,00-106.250,00
Rock crease (construction of lining on upstream sloping dam) - (m^3)	1.500,0	20 - 50 €/m^3	1	1,25	37.500,00- -93.750,00
Geotextile for vertical drainage separation and drainage transverse separation - (m^2)	2.600,0	20 €/m^2	1	1,25	65.000,00
Concrete (various) - installation in the underlayment, installation in the gallery, waterfall of the basic discharge and overflows- (m^3)	650,0	150 - 350 €/m^3	1	1,25	121.875,00 - 284.375,00
Small outflow regulation with elements/mechanism for regulation/operation	1	50.000-100.000 €/pcs	1	1,25	62.500,00-125.000,00
				TOTAL:	511.375,00-856.375,00
Crushed gravel in dry over fi 50 cm for erosion protection	1500	130	1,0	1,25	243.750,00
				TOTAL:	755.125,00-1.100.125,00

The estimated investment costs for retention Čret range from 755.125,00 EUR to 1.110.125,00 EUR.

3.1.3.2 Cost assessment of retention Koruśćak

Results of cost assessment of retention Koruščak are presented in tables below.

Table 6: Typical group of works for retention basin Koruśćak – Option 1

Typical group of works	Unit	The number of units	Price [EUR/unit]	Difficulty factor (access, performing)	Preparatory and finishing works [25%]	Total cost [EUR]
Dam 3-5m	m	260	2.000 €/m	1,0	1,25	650.000,00
Crushed gravel in dry over fi 50 cm for erosion protection	m^3	1.400	130 €/ m^3	1,0	1,25	227.500,00
					TOTAL:	877.500,00

Table 7: Typical group of measures for retention basin Koruśćak – Option 2

Group of measures	Unit [m^2 or m^3]	Price [EUR/unit]	Difficulty factor [1;1,5;5]	Preparatory and finishing works [25%]	Total cost [EUR]
Earth-clay materials for surrounding dikes and dam construction - (m^3)	7.400	20 m^3	1	1,25	185.000,00
Gravel material for drains and filter bed in dams and access roads - (m^3)	1.700	20 - 50 m^3	1	1,25	42.500,00 - 106.250,00
Rock crease (construction of lining on upstream sloping dam) - (m^3)	1.400	20 - 50 m^3	1	1,25	35.000,00 - 87.500,00
Geotextile for vertical drainage separation and drainage transverse separation - (m^2)	5.200	20	1	1,25	130.000,00
Concrete (various) - installation in the underlayment, installation in the gallery, waterfall of the basic discharge and overflows- (m^3)	650	150 - 350	1	1,25	121.875,00 - 284.375,00
Small outflow regulation with elements/mechanism for regulation/operation	1	50.000-100.000 €/pcs	1	1,25	62.500,00-125.000,00
				TOTAL:	576.875,00-918.125,00
Crushed gravel in dry over fi 50 cm for erosion protection	1.400	130	1,0	1,25	227.500,00
				TOTAL:	804.375,00-1.145.625,00

The estimated investment costs for retention Koruščak range from 804.375,00 EUR to 1.145.625,00 EUR.

3.1.3.3 Cost assessment of retention Kamenica

Results of cost assessment of retention Kamenica are presented in tables below.

Table 8: Typical group of works for retention basin Kamenica – Option 1

Typical group of works	Unit	The number of units	Price [EUR/unit]	Difficulty factor (access, performing)	Preparatory and finishing works [25%]	Total cost [EUR]
Dam over 5m	m	140	5.000 €/m	1,0	1,25	875.000,00
Crushed gravel in dry over fi 50 cm for erosion protection	m^3	2.400	130 €/ m^3	1,0	1,25	390.000,00
					TOTAL:	1.265.000,00

Table 9: Typical group of measures for retention basin Kamenica – Option 2

Group of measures	Unit [m^2 or m^3]	Price [EUR/unit]	Difficulty factor [1;1,5;5]	Preparatory and finishing works [25%]	Total cost [EUR]
Earth-clay materials for surrounding dikes and dam construction - (m^3)	12.400	20 m^3	1	1,25	310.000,00
Gravel material for drains and filter bed in dams and access roads - (m^3)	2.800	20 - 50 m^3	1	1,25	70.000,00 - 175.000,00
Rock crease (construction of lining on upstream sloping dam) - (m^3)	2.400	20 - 50 m^3	1	1,25	60.000,00 - 150.000,00
Geotextile for vertical drainage separation and drainage transverse separation - (m^2)	2.800	20	1	1,25	70.000,00
Concrete (various) - installation in the underlayment, installation in the gallery, waterfall of the basic discharge and overflows- (m^3)	980	150 - 350	1	1,25	183.750,00 - 428.750,00
Small outflow regulation with elements/mechanism for regulation/operation	1	50.000-100.000 €/pcs	1	1,25	62.500,00-125.000,00
				TOTAL:	756.250,00 - 1.258.750,00
Crushed gravel in dry over fi 50 cm for erosion protection	2.400,0	130	1,0	1,25	390.000,00
				TOTAL:	1.146.250,00-1.648.750,00

The estimated investment costs for retention Kamenica range from 1.146.250,00 to 1.648.750,00 EUR.

3.2 T02 – Widenning or removing of flood protection dikes

3.2.1 General description

In addition to the retention basins, the existing dikes in the lower part of the basin should be moved away from the river. These measures would reduce direct potential of flood damage in the Bednja basin. Furthermore, by moving the dikes away from the river, riparian habitats are protected better, floods have a weaker impact, and maintenance requirements are lower.

Goal: flood risk reduction in the Bednja basin

Location/river topology: lowland stream (riparian area), easily accessible, agricultural land

General description: Dikes along Bednja will enable effective flood protection, limited pouring into the inundation that would be expanded by this measure; nutrient reduction is expected as a result of this measure. Moving the embankments away from the river bed brings significant benefits, such as flood risk reduction throughout the whole course, integration of sleeves and oxbow lakes, limited outpouring into the inundation (expanded by this measure) and nutrient reduction.

Selected measures: Reconstruction and construction of new dikes along Bednja river

As illustrated on the figure below, existing and planned dikes are stretching from Ludbreg to the mouth of the Drava.

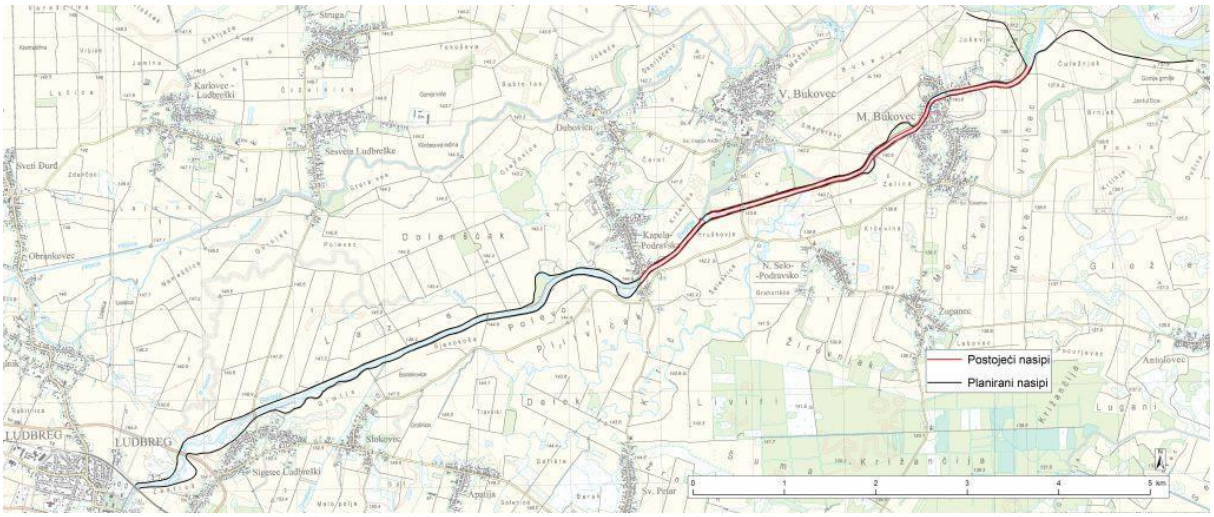

Figure 3: Existing and planned dikes along Bednja along the stretch from Ludbreg to the mouth of the Drava

3.2.2 Basic dimensioning

Basic dimensioning of retentions is presented in table below.

Table 10: Basic dimensioning of the dikes

Dike	Reconstruction of existing dike (river mouth - Kapela Podravska)	Construction of new dike (Kapela Podravska - Ludbreg)	Total length (reconstruction existing dike + construction of new dike)	Average height of the dike
Unit	km	km	km	
Left dike	5,28 km	6,25	11,8	1,4
Right dike	5,35 km	5,75	11,1	1,62

The maximum distance planned from the existing dike on the left bank is about 90 m, and on the right bank, about 50 m. The planned dikes have, for the most part, a trapezoidal profile with a crest width of 3 m and a slope of 1: 2. An access road of 4.0 m width is predicted at dike foot. In some sections it is not possible to construct an access road to the dike due to space limitations. The dike structure is made of a suitable mixed material that ensures stability of the dike and sufficient resistance to leakage.

3.2.3 Cost assesment of dikes

Results of cost assessment of dike relocation and construction are presented in tables below.

Table 11: Typical group of works for dike relocation and construction

Typical group of works		Unit	The number of units	Price [EUR/unit]	Difficulty factor (access, performing)	Preparatory and finishing works [25%]	Total cost [EUR]
Excavation, relocation, installation	Left dike	m^3	42.874	15 €/m^3	1	1,25	851.400,00
	Right dike		50.750		1	1,25	950.963,00
New dike	Left dike	m^3	54.082	15 €/m^3	1	1,25	1.007.813,00
	Right dike		58.126		1	1,25	1.022.063,00
						TOTAL:	3.832.239,00

3.2.4 Comment

In the calculations average profile of the dike was taken into account.

4 Cost assesment on a river basin scale

For the purpose of the assessment of appropriateness of the simple approach, we have compared costs estimated of the simple approach with the costs elaborated in the project documentation (bill of quantities). Results are presented in tables below.

Table 12: Comparison of costs determined by simple approach methodology with the costs determined in the bill of quantities for retention basins

SWRM: Retention	SIMPLE APPROACH		BOQ*	
	Option 1 - using pricing basis	Option 2 - using pricing basis	BOQ without land purchase costs	BOQ with land purchase costs
Unit	EUR	EUR	EUR	EUR
ČRET	1.056.250	755.125-1.100.125	1.012.604	1.112.821
KORUŠČAK	877.500	804.375-1.145.625-	1.066.483	1.358.667
KAMENICA	1.265.000	1.146.250-1.648.750	1.142.641	1.332.506
TOTAL:	**3.198.750**	**2.705.750-3.894.500**	**3.221.728**	**3.803.994**

** with preparatory works and unforeseeable costs*

The lower range (starting point) of pricing bases has proved to be too low. Option 1 is more appropriate to assess costs of dam construction.

The costs in BOQ of such projects include the project documentation, construction of a dam on the watercourse with associated structures (sedimentation trap, spillway, outlet), as well as purchase of land for dam and retention area. The costs shown in Table 12 for each retention include the following works and activities:

- Land acquisition;
- Preparatory works;
- Dam body construction;
- Design of the lining of the dam body;
- Design of perimeter canal;
- Construction of evacuation structures (canal, sedimentation trap, spillway, outlet);
- Installation of hydro-mechanical and electrical equipment;
- Construction of the access road.

The costs within the simple approach include: transportation up to 10 km, implementation of the material, access routes, diversion dikes, pumping, earthworks and construction of the dam, preparatory and finishing works (25% of the investment). The price does not include the cost of purchasing land and project documentation elaboration.

When comparing the costs taken into account in simple approach to BOQ approach, the difference occurred are costs of project documentation and optional land purchase.

Table 13: Comparison of costs determined by simple approach methodology with the costs determined in the bill of quantities for the construction of the dikes

SWRM: Dikes		SIMPLE APPROACH	BOQ with land purchase costs
Unit		EUR	EUR
Left	Relocation of 5,28 km and new dike of 6,25 km	2.340.590,00	2.083.531,00
Right	Relocation of 5,35 km and new dike of 5,75 km	2.805.192,00	2.403.604,00
	TOTAL:	**5.145.782,00**	**4.487.135,00**

The bill of quantities (BOQ) includes: relocation of an old dike, construction of a new dike, construction of a service road along the dike and prior purchase of the land. The cumulative costs of removing and constructing new flood protection dikes are lower in BOQ approach, even though the simple approach excludes costs of land purchase. A difference occurs due to factor 1,25 for preparatory works, used in simple approach. Therefore preparatory works seem a bit overrated for such type of construction. Furthermore price/needed volume of material for dike implementation in simple approach is a rough estimation based on an average conclusions. In BOQ it the material available on site is considered, which means less required volume of material and lower average cost for material and its transportation.

5 Conclusions

Comparison of costs determined by simple approach methodology with the costs determined in the bill of quantities for project estimation has shown that the cost analysis in the simplified approach (based on many conclusions through the cost analysis process for a specific measure) is not reliable, cannot be generalized and it easily leads to major errors. Big errors in decision making process have a big effect. A question of feasibility of simplified approach arises.