REPORTS FROM THE PILOT ACTIONS (WULS)

D.T3.3.1

Version 1

December 2019

Research co-funded by The Polish Ministry of Science and Higher Education in the frame of the programme: International Cofunded projects during 2017 - 2020.

Authors: Paweł Osuch, Ignacy Kardel, Joanna O'keeffe, Adam Wąs, Arkadiusz Gruchała

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

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).

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

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

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

3.1 A02 – Buffer strip and hedges

3.1.1 General description

Goal: general/water quality; to mitigate nutrient pollution

Location/river topology: roads, homogeneous agricultural areas/ any type of landscape – field/farm scale

Short description: Buffer strips are areas of a natural plant cover (grass, shrubs or trees) at the edge of fields, arable land, transport infrastructure and watercourses. They can have several different vegetation configurations, from regular grass to combinations of grass, trees and shrubs.

3.1.2 Basic dimensioning

Buffer strip:

- Length: 270.900 m = 270,9 km
- Width: crown width of trees / shrubs depending on the species

Buffer strip contains trees and hedges. Planting a tree every 6 m.

3.1.3 Cost assesment

The average cost of planting one tree is approximately: 150 PLN = 35 EUR.

Table 2: Total cost estimate for buffer strips

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Agriculture measure	Buffer strips	270,9 km	5.855 EUR/km	1	1 586 065 EUR

3.1.4 Comment

Buffer strips or areas of natural vegetation cover (trees, shrubs) on the edge of fields or transport infrastructure. They can consist of several different configurations of plants, from grass to the usual combinations of grass, trees and shrubs. Proposed buffer zones along public roads after the analysis of the Digital Terrain Model (reject locations where shrubs are already present), and the rejection of roads in urban areas. Also sections of the communication network system which are parallel to the short side of the plot (cadaster composition) and those that intersect the parcel (when the road is parallel to the long side of the plot - min. on one side of the road) should not be considered. The reason for adopting the above mentioned guidelines is non-interference with any agricultural work carried out in areas (to avoid disturbing agricultural practices such as agricultural machinery operation). The azimuth of the strips was dependent on the wind rose, which indicated the predominance of winds from the west (i.e., span from north-west to north-east). The costs were estimated on the basis of sample

tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.2 A03 - Crop rotation

3.2.1 General description

Goal: general, water quality/ to reduce erosion and increase infiltration capacity, thereby reducing downstream flood risk; to mitigate the build-up of pathogens and pests.

Location/river topology: agricultural land: arable lands – field/farm scale

Short description: Crop rotation is the practice of growing a number of different types of crops in the same area in subsequent seasons. Rationally used (ie the selection of the right crop) crop rotation can improve soil structure and fertility by alternating the planting of deep-rooted and shallow-rooted plants. The traditional element of crop rotation is nitrogen supplementation through the use of green fertilizer in the order of cereals and other crops.

3.2.2 Basic dimensioning

Difficult to estimate due to the type of crop that affects the number of treatments.

Area: 15 752,06 ha.

3.2.3 Cost assesment

Table 3: Total cost estimate for crop rotation

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Agriculture measure	Crop rotation	15.752 ha	1.335 EUR/ha	1	21 029 000 EUR

3.2.4 Comment

Removal of monocultures and introduction of crop mosaics of different heights. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.3 A08 - Green cover

3.3.1 General description

Goal: general/ to protect soil that would otherwise be fallow in winter - soil protection against erosion, overheating and loss moisture. Ground cover plants also improve the soil structure, differentiate the growing system and reduce the loss of soluble nutrients.

Location/river topology: highlands/ agricultural land: arable lands – field/farm scale.

Short description: Green cover (including ground cover crops or catch crops) refers to crops planted in late summer or autumn, usually on arable land.

3.3.2 Basic dimensioning

Potential Area: 142,2 ha.

3.3.3 Cost assesment

Table 4: Total cost estimate for green cover

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Agriculture measure	Green cover	142 ha	234 EUR/ha	1	33 255 EUR

3.3.4 Comment

Cover crop harvested in the spring. Difficult to estimate due to the type of crop and harvesting time, which affects the number of treatments. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.4 D01- Regulated outflow from drainage systems

3.4.1 General description

Goal: general; drought; flood; sediment; water quality

Location/river topology: agricultural land/any type of landscape, field/farm scale

Short description: Effect of proper regulation of water outflow from drained areas through various types of water devices (dams, other damming structures, ponds, objects used to cover surface waters, etc.) - water retention in dry periods (retention of spring and thaw waters) and enabling / flow control (drainage of ditches) in wet periods to prevent local floods. The key preliminary activity is the development of detailed principles of water management in extensively drained areas. Examples of technical measures are: reconstruction, modernization and construction of damming devices: weirs, valves, monks, steps to use water for irrigation, slowdown of surface water outflow, protection of peat soils, counteracting erosion on watercourses with large falls, raising the level of groundwater at adjacent areas (if possible with social restrictions), supplementation and modernization of drainage facilities in terms of maintaining ecological balance of biotopes. Within the Kamienna catchment area, two activities were identified - for modernization (Kochanówka and Grechów) and one new.

3.4.2 Basic dimensioning

Basic dimensioning of regulated outflow from drainage system is presented in the table below.

Table 5: Regulated outflow from drainage systems

No.	Dimensions	Description
1	5 culverts, height 0.9 m width 3 m	Modernization of the existing drainage facility
2	5 culverts, height 0.9 m width 3 m	Modernization of the existing drainage facility

No.	Dimensions	Description
3	Renovation / modernization of closures - 2 weirs and a minimum of 5 valves or culverts with damming	Restoration of active water management in existing drainage facilities by means of existing weirs and gates, planting trees along the southern embankment of the river to increase its shading.
4	5 culverts with damming height 0.9m width 3m.	Modernization of the existing drainage facility.
5	Land purchase - 63.76 ha	These are mainly land purchases in order to stop the process of backfilling the floodplain (urbanisation) of the river.

3.4.3 Cost assesment

Table 6: Total cost estimate for regulated outflow from drainage systems

No.	Dimensions	Total cost [EUR]
1	5 culverts, height 0,9 m width 3 m	81 967
2	5 culverts, height 0,9 m width 3 m	81 967
3	Renovation / modernization of closures - 2 weirs and a minimum of 5 valves or culverts with damming	140 515
4	5 culverts with damming height 0,9m width 3m.	81 967
5	Land purchase – 63,76 ha	671 943
	TOTAL:	1 058 360

3.4.4 Comment

The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.5 D02 - Water damming in ditches, weirs with constant crest (valleys)

3.5.1 General description

Goal: general; drought; flood protection; sediment; water quality

Location/river topology: lowlands, agricultural land/ catchment scale

Short description: Permanent (all-year) damming is a simple solution, not requiring service, carried out with the use of damming structures (weirs, gates, thresholds, etc.) located in a valley outside the river. The effect of the measure is to increase the waterlogging of the area (counteracting the effects of drought), flood protection of the lower lying areas (slowing down the outflow of waters). Permanent damming eliminates the occurrence of high variability of soil moisture. The action works primarily on wasteland, forest areas - no social restrictions. In the Kamienna catchment: introduction of permanent damming on ditches and weirs (in the valley outside the river) – Kunów.

3.5.2 Basic dimensioning

One river step height: 0,5-1,5 m, width 30 m.

3.5.3 Cost assesment

Table 7: Total cost estimate for permanent damming on ditches and weirs (in the valley outside the river) – Kunów

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Drainage area	Water damming in ditches, weirs with constant crest (valleys)	5 ha	9.000 EUR/ha	1	45 000 EUR

3.5.4 Comment

Permanent river step (height 2 m) with a bipartite shape increasing the flooding and at the same time not changing the nature of the medium and low water flows (continuity). The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.6 D03 - Active water management on a drainage system (river valleys)

3.6.1 General description

Goal: general; drought; flood; sediment; water quality

Location/river topology: lowland stream, agricultural land

Short description: The total of measures involving the adaptive control of water outflow from drained areas resulting from the analysis of the current humidity and meteorological forecasts. In particular, it concerns the control of inflow and inflow of water on weirs and active regulation of the level of valves with the use of innovative solutions for improving retention and irrigation. Kamienna catchment: Reconstruction of the Styków pumping station.

The pumping station drains the inhabited areas lying in the backwater of the dam and reservoir. Its renovation includes:

-Reconstructing and extending the compensating reservoir

-Reconstruction and extension of the intake chamber

-Reconstruction of the pumping station building

-Reconstruction and extension of the discharge chamber and the discharge ditch

-Replacement of the pumping sets.

3.6.2 Basic dimensioning

Difficult to estimate in this measure.

3.6.3 Cost assesment

Table 8: Total cost estimate for reconstruction of pumping station

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Drainage area	Active water management on a drainage system (river valleys)	-	-	1	1 170 960 EUR

3.6.4 Comment

The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.7 F01- Forest riparian buffers

3.7.1 General description

Goal: to mitigate nutrient pollution/ to slow down the outflow/ general; water quality; sediment

Location/river topology: arable areas, any type of landscape, <50% tree/bush area in 10 m river buffor (lidar)

Short description: Establishment of forest riparian buffers, along watercourse, to reduce pollution from agricultural run-off. Coastal buffers are areas along streams and other bodies of water. Alluvial rushes most often associated with fallow after forest harvests can also be found in urban, agricultural and waterlogged areas. By maintaining a relatively unobstructed area adjacent to open water, coastal buffers can perform a number of functions related to water quality and a slowdown of the outflow. Typically, buffers have a fixed width of 2 to 20 m. The efficiency of the buffer is approximately proportional to its width. Forest coastal buffers may provide synergies with the agents used in the stream or in the catchment, as they exist in contact between the terrestrial and aquatic environments.

3.7.2 Basic dimensioning

Forest riparian buffers:

- Length: 41.005 m
- Width: crown width of trees / shrubs depending on the species

Planting a tree every 6m.

3.7.3 Cost assesment

The average cost of planting one tree is approximately: 150 PLN = 35 EUR.

Table 9: Total cost estimate for forest riparian buffer along watercourses

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Forests	Forest riparian buffers	41 km	5.855 EUR/km	1	240 076 EUR

3.7.4 Comment

Buffer strips of 5 m (areas of natural plant cover - bushes and trees) along watercourses (on both sides of the watercourse) and bushes along reservoirs were proposed. The watercourses were selected on the basis of DTM (Digital Terrain Model) analysis. No buffer strips were proposed for watercourses (or parts of watercourses) running through urban areas and for watercourses with dikes. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.8 F06 - Continuous cover forestry

3.8.1 General description

Goal: general; reduce the local increase in runoff, reductions in sediment pollution

Location/river topology: forests

Short description: Forest maintenance covers a wide range of forest management practices that can have beneficial hydrological effects. The main idea is to reduce the number or size of the cutbacks. Some definitions of continuous forestry include the statement that no clearings will be greater than 0.25 ha. Protection / maintenance of forest areas provides an unbroken 'canopy' of trees, and the surface of the soil is never exposed. An unbroken tree canopy will be characterized by greater interception than a place with discontinuous tree coverage. Ensuring that the soil is never exposed will reduce sludge production.

3.8.2 Basic dimensioning

Difficult to estimate in this measure.

Area: 685,94 ha (after analysis reduced to 148 ha cover by forest)

3.8.3 Cost assesment

Table 10: Total cost estimate for continuous cover forestry

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Forests	Continuous cover forestry	148 ha	77.380 EUR/ha	1	11 452 240 EUR

3.8.4 Comment

Limiting the number and area of forest clearings. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic (foresters) and local water management staff.

3.9 F08 - Appropriate design of roads and stream crossings

3.9.1 General description

Goal: general; sediment; water quality

Location/river topology: road; flowing water

Short description: Reconstruction of a fragment of Graniczna Street in Suchedniów, consisting in raising its crown along with increasing the diameter of the culvert at the intersection of the above road with the Tributary from Kleszczyn. Graniczna Street in Suchedniów is damaged due to the swampy nature of the adjacent area, and thanks to its reconstruction this area can be preserved.

3.9.2 Basic dimensioning

Table 11: Description of roads and stream crossings

No.	Dimensions	Description
1	Renovation of a 2-lane asphalt road over a distance of 400 m, possibly replacement of a concrete rectangular culvert about 4 m wide	Protection of the asphalt road against flooding by Bobrów dam. Raising the asphalt road by 0,5 m. Modernization or replacement of the culvert, renovation of the two-lane road over a distance of 400 m.
2	Length approx 30 m, width 4 m	Raising the elevation of the existing transit ford by 0,3 m.

3.9.3 Cost assesment

Table 12: Total cost estimate for roads and stream crossings

No.	Dimensions	Total cost [EUR]
1	Renovation of a 2-lane asphalt road over a distance of 400 m, possibly replacement of a concrete rectangular culvert about 4 m wide	98 361
2	Length approx 30 m, width 4 m	17 586
	TOTAL:	115 947

3.9.4 Comment

The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.10 F14 - Overland flow areas in peatland forests

3.10.1 General description

Goal: general; water quality; sediment; flood

Location/river topology: flowing water/any type of landscape

Short description: Backwaters, floodplains in the area of forest ditches - areas intended for flooding in the spring at a high water level, which improve the retention capacity of the area and biodiversity.

3.10.2 Basic dimensioning

Wooden dam height 1 m or ford height 0,8 m and width 3 m.

3.10.3 Cost assesment

Table 13: Total cost estimate for Construction of a stone ford or wooden river step

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Forests	Overland flow areas in peatland forests	-	-	1	37 470 EUR

3.10.4 Comment

Construction of a stone ford or wooden river step. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.11 N02 - Wetland restoration and management

3.11.1 General description

Goal: general/ to provide water retention, increase biodiversity and improve water quality, they are the most important land "stores" of organic carbon.

Location/river topology: flowing water; wetlands; meadow; pasture/any type of landscape

Short description: Reclamation and management of wetlands may include: technical, spatial activities on a large scale (including the installation of ditches for re-watering or liquidation of embankments to enable flooding / flooding); technical small-scale measures, such as cutting down trees; changes in land use and agricultural measures, such as adaptation of cultivation practices in wetlands. These activities can improve the hydrological regime of degraded wetlands and generally improve the quality of habitats. The creation of artificial wetlands in urban areas can also contribute to reducing the scale of floods, improving water quality and improving habitat and landscape.

3.11.2 Basic dimensioning

Table 14: Basic dimensioning of wetland restoration

No.	Dimension	Description
1	1x barrage 1m high, dyke height 0,5m and length 30m	Includes the creation of an artificial wetland for reducing nutrients, damming water (permanent) on the Wolanka River (whose lower riverbed is highly infiltrating and is a groundwater supply) on sections with a small slope, including the construction of small dikes allowing for water spillage, purchase of land.

2	3 x culverts with damming height 1 m width 3 m;	Preservation of permanent grassland in the floodplain. Adjustable water outflow through existing ditches.

3.11.3 Cost assessment

Table 15: Total cost estimate for wetland restoration

No.	Dimension	Total cost [EUR]
1	1x barrage 1 m high, dike height 0.5 m and length 30 m	44 496
2	3 x culverts with damming height 1 m width 3 m;	49 180
	TOTAL:	93 676

3.11.4 Comment

The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.12 N03 - Floodplain restoration and management

3.12.1 General description

Goal: general/ to provide space to stop the flood/ to restore the retention capacity and ecosystem functions, by re-connecting the flood plains with the river.

Location/river topology: lowlands; flowing water; wetlands; meadow; pasture

Short description: A floodplain is the area bordering a river that naturally provides space for the retention of flood and rainwater. Floodplain soils are generally very fertile and they have often been dried-out to be used as agricultural land. Floodplains in many places have also been separated from the river by dikes, berms or other structures designed to control the flow of the river. They have also been covered by legacy sediments. Major floodplainsroleshave thus been lost, due to land drainage, intensive urbanization and river channelization. The objective is to restore them, their retention capacity and ecosystem functions,by reconnecting them to the river.

3.12.2 Basic dimensioning

3 x culverts with damming height 1 m and width 3 m, 1 wooden dam height 1 m and width 5 m, clearing 8 km of ditches.

3.12.3 Cost assesment

Table 16: Total cost estimate for floodplain restoration

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Hydromorphology	Floodplain restoration and management	-	-	1	105 386 EUR

3.12.4 Comment

Construction of a river step in the lower part of the oxbow lake to stop the outflow of water during periods of medium and low flow (in the case where the embankment lock has no water level control). Creating a spillway on the right embankment (in the upper section of the oxbow lake) to let the water enter the other side of the embankment during winter and spring floods. Clearing the oxbow and ditches to allow faster drainage of water after the spring flood. Construction of three culverts with damming in order to limit the outflow of water from the upper and middle parts of the oxbow lake during the summer. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.13 N06 - Restoration and reconnection of seasonal streams

3.13.1 General description

Goal: general/ flood protection and irrigation.

Location/river topology: flowing water/ any type of landscape

Short description: Seasonal streams or periodic rivers are rivers for which surface waters cease to flow at some point in space and time. The reconstruction and re-joining of seasonal streams with the river therefore consists in restoring lateral connections, diversifying flows and ensuring the proper functioning of seasonal streams to improve water retention. Kamienna catchment: reconstruction of water supply to the Nietulisko mill/ Nietulisko oxbow.

3.13.2 Basic dimensioning

Table 17: Basic dimensioning of restoration and reconnection of seasonal streams

No.	Dimensions	Description
1	1x wooden dam height 1 m, width 10 m; 2 x ford height 0,8 width 10 m or 2x culvert with damming height 1 m, width 3m	"Implementation of a river step at the outlet of the oxbow lake to the Kamienna River in order to stop the outflow of water in periods of medium and low water levels. Construction of two culverts with damming or stone fords near existing backwaters on the oxbow lake.
2	Permanent river step (max. height 2 m) with a width of 35 m with a bipartite shape increasing the flooding in order to enable fish migration during medium and low water levels.	Execution of a river step and exit basin on the Świślina River and opening of old canals supplying the Staszicowski Canal and the reservoir.

3.13.3 Cost assesment

Table 18: Cost assessment for restoration and reconnection of seasonal streams

No.	Dimensions	Total cost [EUR]
1	1x wooden dam height 1 m, width 10 m; 2 x ford height 0.8 width 10 m or 2x culvert with damming height 1 m, width 3 m	114 754
2	Permanent river step (max. Height 2 m) with a width of 35 m with a bipartite shape increasing the flooding in order to enable fish migration during medium and low water levels.	50 000

No.	Dimensions	Total cost [EUR]
	TOTAL:	164 754

3.13.4 Comment

The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

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

3.14.1 General description

Goal: flood protection (to take over and retain outflows caused by torrential rain)

Location/river topology: any type of landscape/ flowing water; meadow; pasture; forest; wasteland; wetlands.

Short description: The measure that relies on construction / planning in the catchment basin: polders (usually the flood plain area, during the river flooding period allows for overflow of the excess water and its natural retention), dry flood protection reservoirs and anti-rubble dams. As part of this measure, in the Kamienna river basin there is planned to build 4 dry storage reservoirs (with a capacity: 163 900, 18 400, 162 700, 276 300 m3) with damming barriers equipped with bottom drains on the Modła river. The task of the reservoirs is to take over and retain outflows caused by torrential rain. The implementation is planned under the measure: "Flood protection of the city of Ostrowiec Świętokrzyski, the Ostrowiec Świętokrzyski commune and the Bodzechów commune covering the regulation of the Modła River using the existing reservoir in Częstocice as a flood polder to reduce flood waves."

3.14.2 Basic dimensioning

Table 19: Basic dimensioning of 4 dry storage reservoirs

No.	Dimensions
1	Reservoir area: 5,6 ha, Total capacity: 162 700 m^3, damming dam length - approx. 115 m, height in relation to the bottom of the valley 13 m"
2	Reservoir area: 0,82 ha, total capacity: 18 400 m^3, damming dam length - about 75 m, height in relation to the bottom of the valley - 8 m
3	Reservoir area: 4,9 ha, total capacity: 163 900 m^3, damming dam length - about 170 m, height in relation to the valley bottom - 14 m
4	Reservoir area: 4,9 ha, total capacity: 276 300 m^3, damming dam length - approx. 135 m, height in relation to the valley bottom - 15 m

3.14.3 Cost assesment

Table 20: Cost assessment of 4 dry storage reservoirs in EUR/ha

No.	Price [EUR/unit]	Total cost [EUR]
1	38 578 EUR/ha	490 632

2	25 001 EUR/ha	55 503
3	38 665 EUR/ha	494 145
4	57 410 EUR/ha	833 255
	Total cost [EUR]	**1 873 535**

3.14.4 Comment

Earth-filled dam with a concrete double spillway and pass, shaping the reservoir bowl and reinforcement of embankments. The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

3.15 T02 - Widenning or removing of flood protection dikes

3.15.1 General description

Goal: to reduce the erosive trend of the channel and to create a nature close to the development of the flood plains.

Location/river topology: lowlands/

Short description: The construction of flood embankments, the purpose of which is flood protection, in fact, limits river flood areas and increases water levels and flow rates. Moving the embankments away from the river bed brings significant benefits. The dike may then be lower, and thanks to the greater capacity of the embankment, the level of freshets will decrease, and the flow rate will decrease flood waters, the river banks will be less damaged and vegetation. As part of this measure, it is planned to implement 9 sections of new embankments with a total length of 9505 meters. Carrying out embankments along a new route and limiting protected areas to a minimum. The new embankments will not narrow the beds of large waters and will allow the ordinates of flood waters to decrease.

3.15.2 Basic dimensioning

9 sections of new dikes with a total length of 4,905 linear meters.

3.15.3 Cost assesment

Table 21: Cost assessment for new dikes

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Difficulty factor [1,;1,5;5]	Total cost [EUR]
Hydrotechnical structures	Widening of flood protection dikes	4.905 m	265 EUR/m	1	1 298 044 EUR

3.15.4 Comment

Leading the dikes along the new route and limiting protected areas to a minimum. The new embankments will not narrow the bed of large water flows and will allow the elevation of flood waters to decrease. The costs were estimated on the basis of sample tenders/valuations, estimates found in

online resources and after consulting with people familiar with the topic and local water management staff.

3.16 T03 - Construction of small reservoirs on rivers (dammed reservoirs)

3.16.1 General description

Goal: increase the catchment retention/ flood control, water supply function, recreation

Location/river topology: any type of landscape/flowing water/

Short description: Small reservoirs on the river - artificial water reservoirs, which were created as a result of water river damming by the water structure (damming up).

3.16.2 Basic dimensioning

Table 22: Basic dimensioning of small reservoirs on the river

No.	Dimensions	Description
1	Changing the shape of the concrete river step which is 3 m wide and dividing it into a double one; making dikes 0,3 m high; 200 m long	Changing the shape of the existing river step with stone protection so that it directs more water into the reservoir during the periods of high streamflow. Construction of a dike in order to direct the water to the ditch supplying the reservoir.
2		Reconstruction of weirs (3 spans, water damming 6m) of reservoir Brody Iłżeckie together with the modernization of the closure structure in Brody (Świętokrzyskie voivodeship) including: Renovation of concrete surfaces of the weir and in the exit basin together with painting of concrete surfaces. Replacement of the weir bottom discharge pipelines together with the replacement of sliders and the execution of emergency closures. Replacement of segment closures together with the replacement of segment drive mechanisms. Replacement of steel elements in the weir (chamber exit clamps, ladders, footbridges, security). Repair, maintenance and painting of steel components. Completing closing monitoring, execution of automatic control and measurement system. Modernization of electrical installation with lighting installation of weir chambers.
3	An area of 99 hectares	A 99 ha reservoir, 5 m high, which captures/collects rainwater to prevent the effects of drought.
4	The length of about 1,9 km; average width - 460 m.	Retention reservoir designed to mitigate the effects of drought and flooding, about 1,9 km long and about 460 m wide.
5	Length - 2000 m, an average width of 180 m, the average height – 2,5 m.	Reservoir whose primary function is storage of water, recreation and tourism; implementation from the start, length: about 2000 m; Average width: 180

No.	Dimensions	Description
		m; the average height of 2,5 m; maximum height of 4,0 m.
6	Area of approximately 7 hectares, damming height of about 3 m	Reconstruction of the dam and desludging of the old reservoir bowl, strengthening the embankments.
7	Length 2,9 km; average width 400 m	Retention reservoir designed to mitigate the effects of drought and flooding, about 2,9 km long and about 400 m wide.
8	F = 2,9 ha, mean depth 1 m, construction of a permanent wooden overflow 1,5 m high, 3 m long	A small forest reservoir in the location of a small backwater area with an existing dike. Only a wooden spillway should be prepared.
9	F = estimated surface 100 ha damming height of about 6 m	Construction of the dam with a damming weir and reservoir.
10	Area of 24 ha	The reservoir with an area of 24 ha, 2100 m long, 5 m high, capturing/collecting rainwater to prevent the effects of drought.
11	F = approximately 3 hectares, damming height of about 1,5 m	Removal of the existing dam build with concrete slab and railway sleepers and building in its place a new dam and desludging the existing reservoir bowl.
12		Dry reservoir in a wetland area.
13	F=33,7 ha; VNPP=674.000 m3; V=253.000 m3	Construction of the dam with a damming weir and reservoir.
14	Area 78 ha	The reservoir with an area of 78 ha, 5 m high for capturing/collecting rainwater to prevent the effects of drought.

3.16.3 Cost assesment

Table 23: Cost assessment for small reservoirs on the river per measure

No.	Name	Estimated total cost [EUR]
1	Dam Biernatka	€ 32 786
2	Weir Brody Iłzycikie renovation	€ 819 672
3	Reservoir Boria	€ 6 955 503
4	Reservoir Lemierze (2 - Baltow)	€ 6 323 185
5	Reservoir Michałów	€ 2 529 274
6	Reservoir Mroczków	€ 491 803
7	Reservoir Rudka Bałtowska (nr 1 - Bałtów)	€ 7 025 761
8	Reservoir Stary Gostów	€ 93 676
9	Reservoir Bzin	€ 7 025 761
10	Reservoir Ćmielów	€ 1 686 182
11	Reservoir Górki-Gilów	€ 210 772

No.	Name	Estimated total cost [EUR]
12	Dry reservoir Brody Lublianka	€ 168 618
13	Reservoir Wołów	€ 2 388 758
14	Reservoir Ruda Kościelna	€ 5 480 093

Table 24: Cost assessment for small reservoirs on the river

Group of measures	Measure	Unit (area)	Price [EUR/unit]	Estimated total cost [EUR] All proposed hydrotechnical constructions
Hydrotechnical structures	Construction of small reservoirs on rivers	ha	70 257 EUR/ha (average)	41 231 850 EUR

3.16.4 Comment

The costs were estimated on the basis of sample tenders/valuations, estimates found in online resources and after consulting with people familiar with the topic and local water management staff.

4 Cost assesment on a river basin scale

The table below summarizes all the costs grouped for individual measure.

Table 25: Cost assessment for small reservoirs on the river

Measure	Estimated total cost [EUR]
A02 – buffer strip and hedges	€ 1 586 065
A03 - Crop rotation	€ 21 029 000
A08 - Green cover	€ 33 255
D01- Regulated outflow from drainage systems	€ 1 058 360
D02 - Water damming in ditches, weirs with constant crest (valleys)	€ 45 000
D03 - Active water management on a drainage system (river valleys)	€ 1 170 960
F01- Forest riparian buffers	€ 240 000
F06 - Continuous cover forestry	€ 11 452 240
F08 - Appropriate design of roads and stream crossings	€ 115 947
F14 - Overland flow areas in peatland forests	€ 37 470.00

Measure	Estimated total cost [EUR]
N02 - Wetland restoration and management	€ 93 677
N03 - Floodplain restoration and management	€ 105 386
N06 - Restoration and reconnection of seasonal streams	€ 164 754
T01 - Polders, dry flood protection reservoirs, sediment trapping dams	€ 1 873 535
T02 - Widenning or removing of flood protection dikes	€ 1 298 044
T03 - Construction of small reservoirs on rivers (dammed reservoirs)	€ 41 231 850

5 Conclusions

Main conclusions are presented below:

- The cost estimation quantitative data and type of measures are based on the Concept Plan of the FramWat project.
- The costs provided are estimates.
- Implementation costs have been presented - they do not include land purchase, project execution and operating costs.
- Difficulties in estimating one amount per unit for one measure are result of local prices (varying depending on the location of the measure).
- A large part of the costs / parameters of the measures required consultation with local water management staff.
- Calculations and parameters were consulted with forestry and agriculture economists.
- The parameters of measures reported by stakeholders were often not complete – information should be completed by the experts.
- Cost calculation was made on the bases of 2019 Polish prices in €, including VAT.