ACTION PLAN FOR BEDNJA (CRO) (D.T3.5.8)

Croatia June 2020

CONTENT

1. Introduction

The main objective of the FramWat Project is to establish a common regional framework for flood, drought, and pollution mitigation by increasing the buffer capacity of the landscape with the use of Natural (Small) Water Retention Measures (N(S)WRM) in a systematic way.

In the project there is a partnership of 8 partners and 6 associated partners from 6 countries, duration of the project from was from July 2017 to June 2020.

More information about the project: www.interreg-central.eu/FramWat.html.

In six pilot river basins the N(S)WRM approach in six countries was tested with the use of the new FramWat tools. Selected measures combinations aiming at mitigating catchment specific problems were also modelled with the help of dynamic models. The catchment results are provided in a form of »Action Plans« which is here given for Croatia.

The Croatian pilot area in this project is the Bednja river basin. In the basin the problems were analyzed, tools applied and the measures chosen.

This document provides a compilation of the main results of the FRAMWAT Project on Natural Small Water Retention Measures (N(S)WRMs) in the Bednja pilot catchment.

Bednja river basin

The Bednja is a river that flows through Croatia along its entire course and is a tributary of the Drava River. The backbone of the hydrographic network in the Bednja basin is the river Bednja and its tributaries, which are more numerous in the upland (upstream) part of the basin than in the lowland part. It rises near Trakošćan in the Maceljsko gorje hill in Hrvatsko zagorje. It forms a northern natural border separating Mt Kalnik from the Topličko gorje hill in the west and from the Drava plain in the east.

It flows through the settlements of Bednja, Lepoglava, Ivanec, Beletinec, Novi Marof, Varaždinske Toplice, and Ludbreg, and flows into the Drava at Mali Bukovec near Ludbreg. Some 60,000 people or app. 34% of the population of Varaždin County live in the area of the Bednja river basin.

The population is primarily concentrated in: 5 towns (Lepoglava, Ivanec, Novi Marof, Varaždinske Toplice and Ludbreg) and 6 municipalities (Bednja, Donji Martijanec, Klenovnik, Donja Voća, Maruševec and Ljubešćica).

The Bednja is the longest river which has a source and a mouth in Croatia and whose entire course flows through Croatia. The lowland part of the basin spreads along the Bednja riverbed from its confluence with the Drava River upstream up to its 55th km near the settlement of Presečno.

The Bednja river basin was chosen because of a serious problem caused by torrents forming after intensive rainfall, causing the movement and transport of significant sediment quantities into the lowland parts of the watercourse. It is common that torrents are accompanied by landslides.

According to Natura 2000, in the Bednja basin there are 14 sites important for the conservation of endangered species and a total of 12 sites with different levels of protection (1 regional park, 3 nature monuments, 1 significant landscape, 1 park forest and 6 monuments of park architecture).

The most important road in the basin is a section of the motorway cutting the basin into two parts slightly further downstream of the natural borderline between the upland and lowland parts of the basin. Its major part was built on an embankment with several culverts causing obstacles for the flow of high waters of the Bednja and its tributaries. In terms of surface area, the major share (app.70%) of the Bednja basin belongs to the upland part, with the remaining share belonging to the lowland part. In the upland part, with a surface area of app. 480 km², there are 48 torrential basins with approximately 250 km of watercourses.

The Bednja catchment has around 616 km^2 catchment size and is composed of about 30% low hills with the rest 70% being lowland. Due to its pluvial regime, high water levels in the Bednja River form in the spring months (March- April), with the snow melt and spring rains occuring at the same time.

The basin area is 30% covered with agriculture and around 49% is forest area.

From the River Basin Management Plan 2016-2021: There are six water bodies with 2 having bad status, 3 moderate and 1 water body has good ecological status with Phytobenthos, Macrophytes, Macrozoobenthos, Total N and Total P being major problems in achieving good ecological status.

Table 1. Characteristics of the catchment.

Characteristic	**Unit**	**Value**
Character of catchment		lowland 30% / low hills 70%
Catchment size:	km^2	616
Average flow low/avg/high*	m^3/s	0.8/7/77
Extreme flow low/high*	m^3/s	0.003/179
Annual precipitation low/avg/high**	mm	481/931/1312
Annual air temperature min/avg/max**	°C	10.4 (avg)
Agriculture area	%	30
Urban area	%	2
Forest area	%	49
Open Water area	%	0.1
Flooded area (1/100 years)	km^2	37,7
Artificial drainage area	km^2	

* From multiannual statistic 1949-2016

** From multiannual statistic 2007-2016

Figure 1. Bednja river basin in Croatia.

Floods sometimes occur several times a year, as the result of which the flooded area along the Bednja gradually attains swamp-like characteristics and cannot be used for agriculture. In such areas valuable wetlands have developed with endangered species on the county and even national level.

There is a serious problem of flash floods that form after intensive rainfall in a significant number of the Bednja tributaries. A sudden increase in discharges causes the movement and transport of significant sediment quantities into the lowland parts of the watercourses and the Bednja recipient. It is not rare that flash floods are accompanied by landslides that put houses and commercial buildings at risk.

Flash floods put at risk many settlements and facilities in this area: state roads, county roads and numerous local mountain roads, railroads with culverts and bridges, as well as minor industrial plants.

With the present flood protection system, the areas at risk are not adequately protected.

2. Selection of the measures

This document is not meant to be used as a direct planning tool for implementation of the selected set of Natural Small Water Retention Measures (N(S)WRMs) in the Bednja catchment. It points out modeling possibilites and gives insights into N(S)WRMs effectiveness assessment with the help of models. As highlighted by the modeling results, the effectiveness of N(S)WRMs is strongly dependent on local conditions. Therefore, N(S)WRMs always need detailed planning and analyses at the local scale before implementation.

In the Bednja pilot river basin the N(S)WRM approach was tested with the use of the new FramWat tools. Selected measures combinations aiming at mitigating catchment specific problems were also modelled with the help of dynamic models.

The description of the tools used for the Bednja catchment follows below.

2.1 FroGIS

A publicly available web application to analyse the needs and possibilities of water retention, the result of which is the valorisation map supporting the N(S)WRM planning process. Available at https://WaterRetention.sggw.pl it is free software, the development of which is conducted at https://gitlab.com/framwat.

We tested SPU (Spatial Planning Unit) based on county data which proved too coarse, then an SPU based on settlement spatial data was used but that also proved too coarse, so a spatial analysis was done which resulted in finer distribution and that SPU was chosen which has 101 spatial planning units ranging from 0.5 km^2 to 18.5 km^2.

Input data were collected from local datasets. Correlation matrices were computed based on indicator values obtained for each SPU. Different classification methods have been used to split the indicators into 5 classes and to test the sensivity of the tool to classification method.

Statistics of indicator values are used (Equal Width, Natural Breaks, Quantile). Results of division of indicator values were given with five classes.

For all map variants there is a range of 5 classes ranging from 1 for low potential to 5 for high potential for water retention.

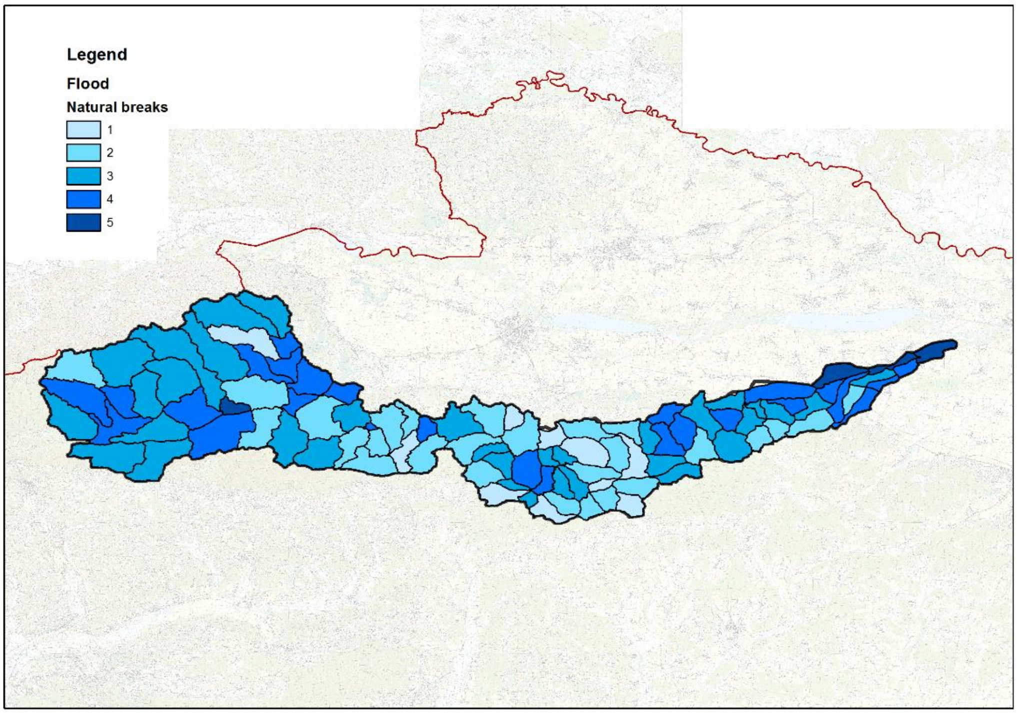

Figure 2. Valorization for flood mitigation purpose (Natural breaks).

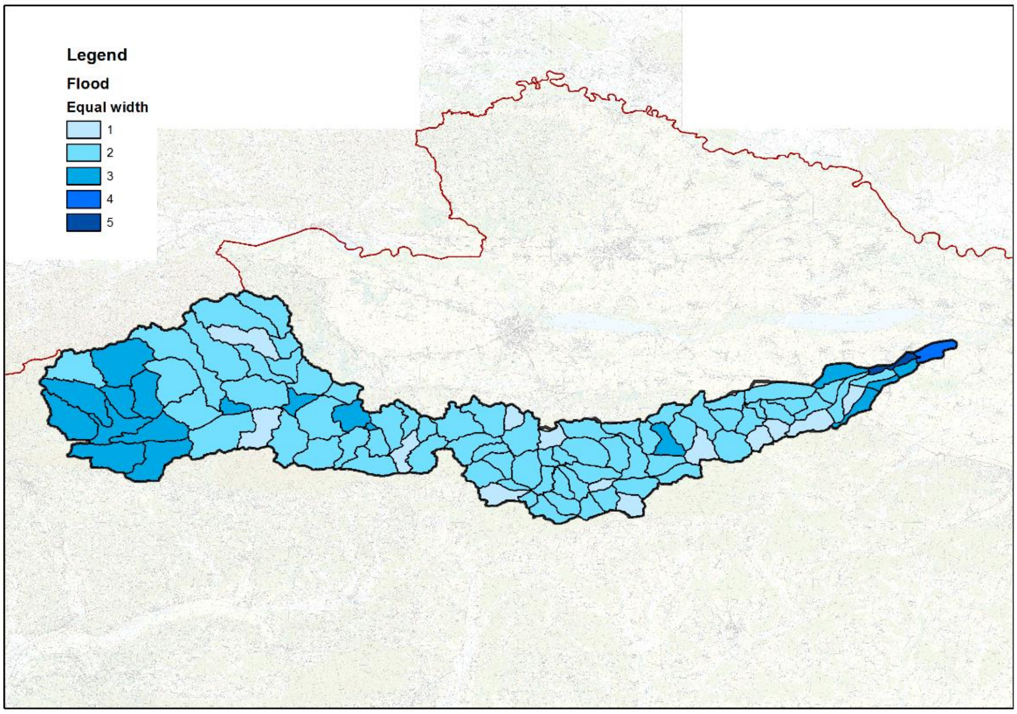

Figure 3. Valorization for flood mitigation purpose (Equal width).

Results of the FroGIS valorization method for the Bednja catchment show that the best method depends on the usage of data. It looks like for general and flood mitigation purposes Natural breaks give better results and on the other hand for drought and water quality better valorization results are obtained through the Equal width method. Weighting has very little influence on the final results.

Only flood data was available for comparison. On the whole, FroGIS is a good and valuable tool for planning of small water retention measures in the Bednja catchment.

2.2 Dynamic model

Since in the Bednja river basin there is no sufficient data for the modeling of nutrient (P, N) transport, dynamic modeling was done for the quantities or change in the volume of water over time for the selected measures.

Even though in the initial phase of the preparation of this analysis an attempt was made to use the SWAT software, due to the lack of adequate data describing the basin the efficiency of the selected measures was checked using the hydrologic and hydraulic model.

A hydrological-hydraulic analysis of the Bednja basin has been made for 3 upstream retention basins (Čret, Kamenica and Koruščak) and a dike on both sides downstream of Ludbreg for the hydrological state with 2-, 5-, 10-, 25-, 50-, 100- and 1000-year return period floods.

The goal was to test the dynamic models with the purpose of assessing effectiveness of measures (retention basins and dikes).

The mathematical models in the Bednja River basin were developed for the purpose of simulating flood events with selected measures for the present and planned state.

Used models were:

- HEC-HMS 4.0 (Hydrologic Engineering Center–Hydrologic Modeling System)
- MIKE 21 (DHI) - 2D model - Hydraulic analyses and flow modelling.

The efficiency is presented through the possibility of transformation of the entry water wave by using the retention basin volume.

Statistical analyses of flows at the hydrological station and precipitation at the meteorological stations were made in order to obtain inputs for precipitation and flow information for hydrological model calibration.

Running the HEC - HMS hydrological model requires the division into sub-basins which are shown schematically in the model. The model simulates the precipitation-runoff process at the design points, division into subbasins.

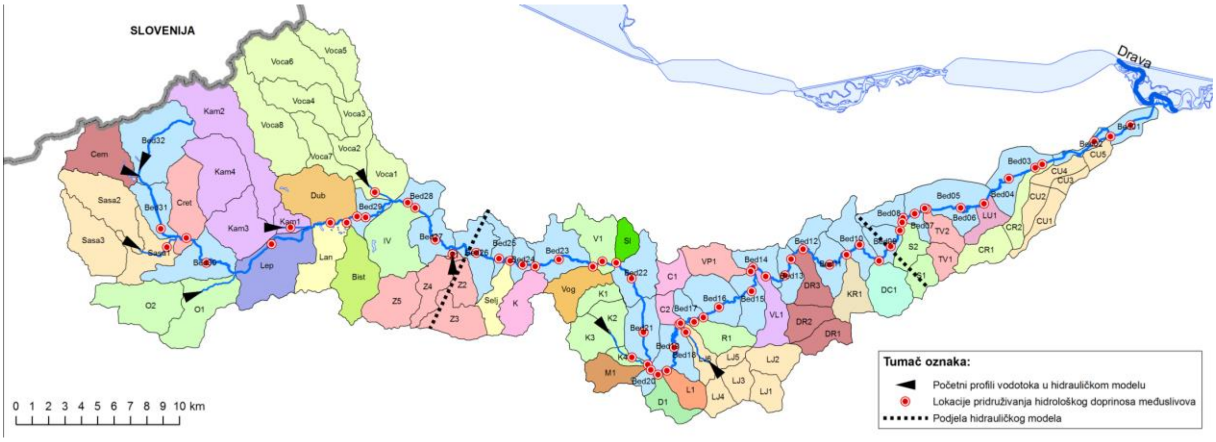

Figure 4. Division into sub-basins (101) in the Bednja catchment.

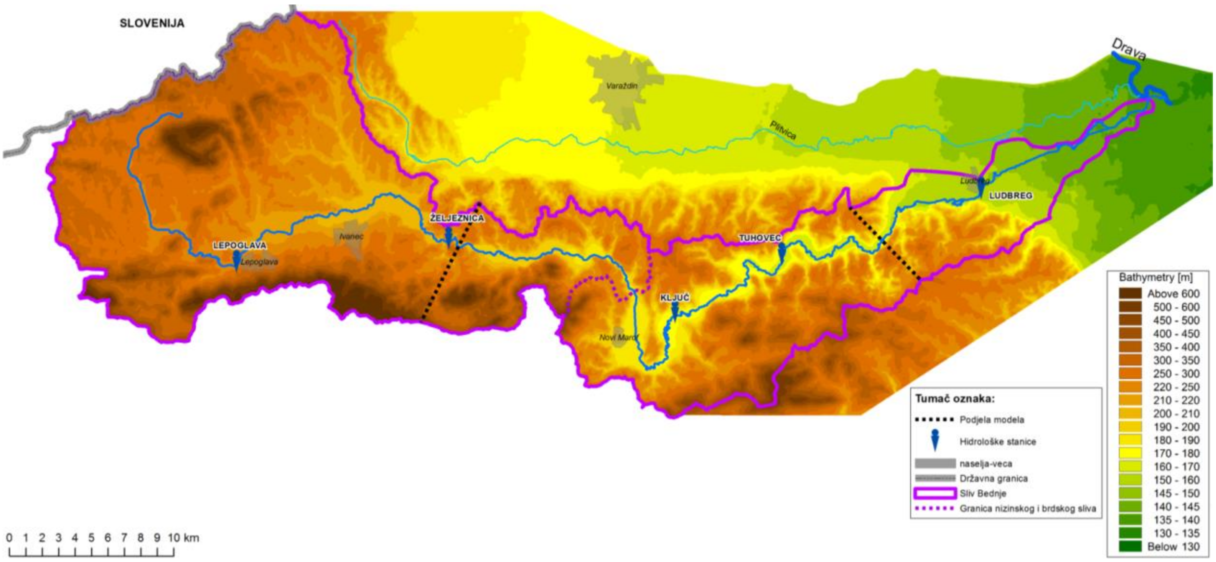

Figure 5. The 2D model is based on the Digital Elevation Model (DEM) which shows the configuration of the terrain.

Mathematical models for Bednja catchment were calibrated and validated. Meteorological stations were used for modelling and flow gauges were used for calibration/validation.

Results of hydrological model calibration and verification at the locations of hydrological stations.

- The model was used for the calculation of hydrographs at locations of hydrological stations and in the defined sub-basins.
- Based on the design precipitation defined earlier and hyetographs of different return periods (RPs), the model calculated hydrographs at the locations of hydrological stations which were compared with the synthetic hydrographs of corresponding RPs calculated and construed based on the statistical analyses of the measured data.
- The model was validated with the recorded flood events in the basin. Comparison between a historical flood event and the modelled flood area.

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

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

Water retention basins for flood defense and control discharge into the downstream basin and to reduce erosion on the downstream river.

The selected measure was the construction of three water retention basins for flood defense (Koruščak; Kamenica 1; and Čret).

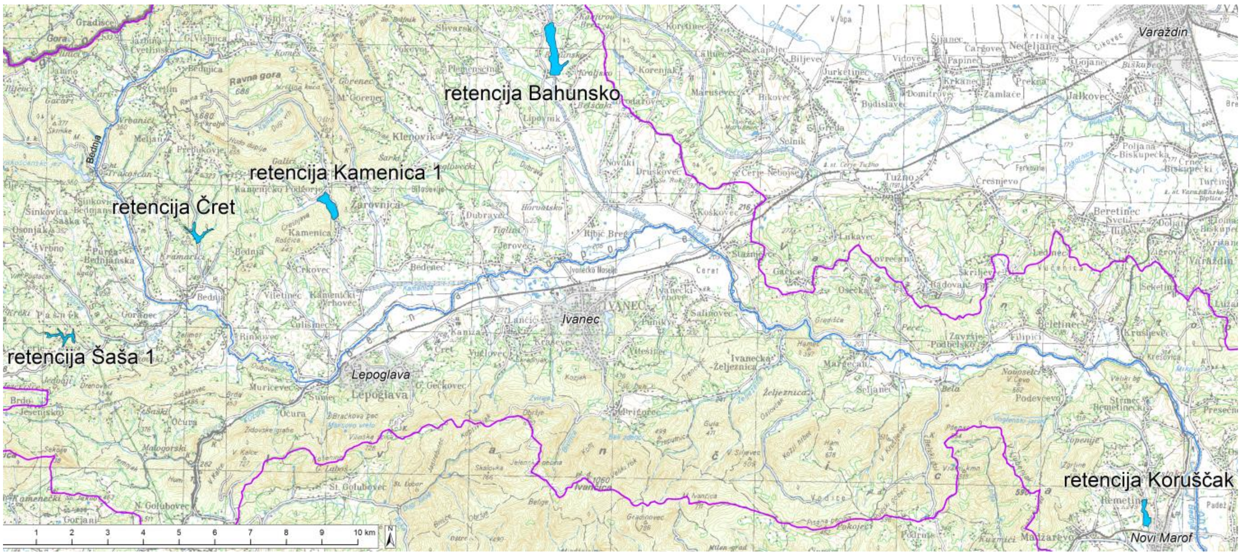

Figure 6: Locations of retention basins in the Bednja basin.

T02 - Widening or removing of flood protection dikes

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

Dikes along the 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.

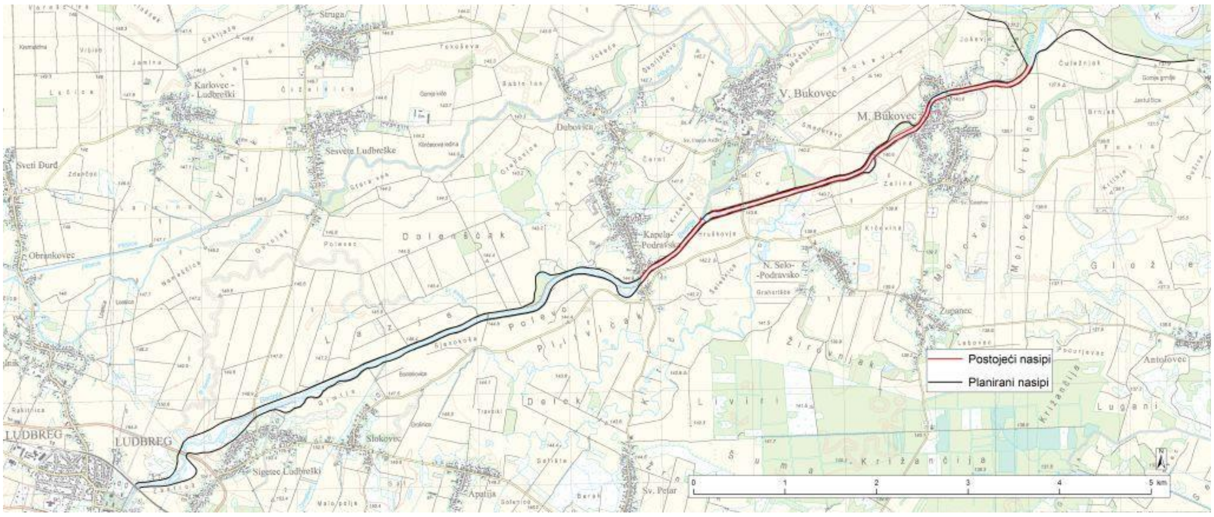

Figure 7: Existing and planned dikes along the Bednja along the stretch from Ludbreg to the mouth of the Drava

A hydrological-hydraulic analysis of the Bednja basin has been made for measures T01 and T02 for the hydrological state with 2, 5, 10, 25, 50, 100 and 1000 year return period floods.

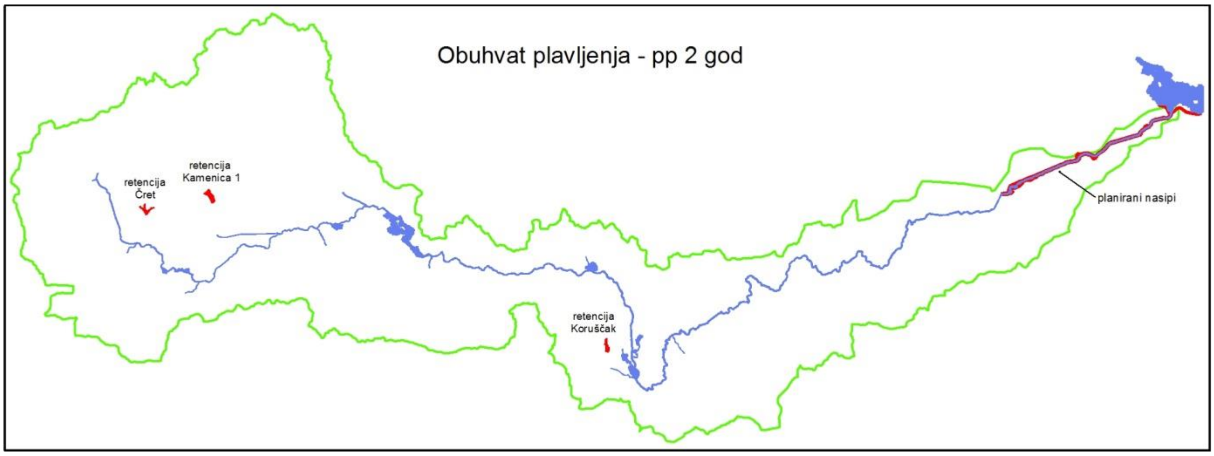

Figure 8. Resulting floodlines for a 2-year return period.

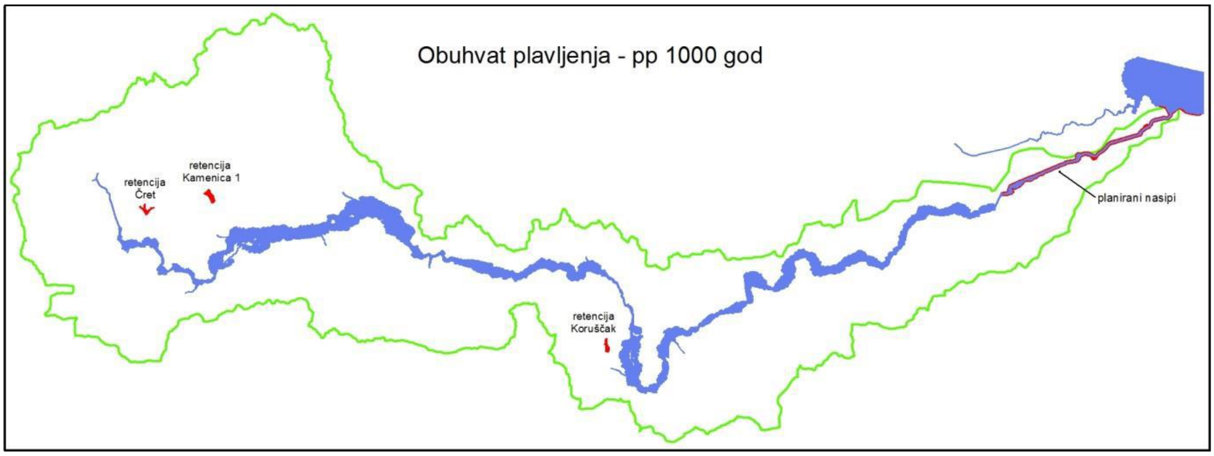

Figure 9. Resulting floodlines for a 1000-year return period.

By comparing the results it is clear that the effect of reducing floodplains is the largest in the area in the downstream part of the basin.

The effects of retention basins in the upland part of the basin are present only locally, through the reduction of individual flooding depths caused by the retention of water volumes in the retention basins.

2.3 Static Tool

Static tool (Landscape Valorisation Method) allows the assessment and comparison of different variants of N(S)WRM. It uses a simplified approach to assess the effect of implemented measures. The core element is a set of relationships between measures intensity and expected change in water retention properties of a catchment.

The purpose of developing the StaticTool method and the computer application StaticTool.xlsm is to enable the estimation of the effects of the implementation of a program of natural, small water retention measures (N(S)WRM) in a simplified way, which does not require the time-consuming and costly development of detailed models, hydrological or/and hydraulic, of the analysed catchment. This estimate is a grading, based on expert knowledge and is used to compare variants of the N(S)WRM program.

The potential effects of individual N(S)WRM measures may be different, depending on the climatic and physiographic conditions (e.g. slopes, ground permeability) of the analysed area, so the method parameters should be adapted to local conditions (climate type, landscape type). The StaticTool method thus consists of two parts:

- developing method parameters for local conditions
- estimation of the effects of activities planned under the Natural Small Water Retention Program.

The StaticTool method assumes that the expected effect of the N(S)WRM is to improve catchment retention properties, which is understood as increasing low flows, reducing high flows and/or limiting the load of pollutants yielded from the catchment area. This effect depends on the planned measures, in particular their type and the level of intensity. The measures included in the StaticTool method are summarized in the local catalogue of measures. For each measure, an intensity criterion is formulated, and threshold values are defined that correspond to the characteristic intensity levels (low, medium, high). Each measure is also assigned the expected improvement of retention properties of the spatial planning units (SPU), expressed on a point scale (0-5 points). The greatest improvement that can be achieved (maximum points for a given measure) corresponds to the implementation of the measure with maximum intensity. For lower intensity levels, the assigned grades are proportional to the level of intensity of planned measure. Hence, developing parameters of the StaticTool method means defining a set of functions that make grade assessment dependent on the type of planned measures and their intensity for each measure from the local catalogue.

The StaticTool method and the StaticTool.xlsm application were developed as part of the project FramWat, Work Package T2 (Effectiveness of the Natural Small Water Retention Measure). This report presents the results of testing the static method to assess cumulative effect of N(S)WRM for the Bednja catchment in accordance with the following rules.

- When comparing variants, the same SPU layers were used so that the results correspond with each other.
- The tool cannot replace modelling or designing.

- It is recommended to compare the effectiveness assessment map with the map of needs and possibilities of small water retention development, because then it is possible to additionally assess whether measures are planned where they are needed.
- StaticTool.xlsm is a good solution to enable the estimation of the effects of the implementation of a program of natural, small water retention measures (N(S)WRM) in a simplified way, which does not require the time-consuming and costly development of detailed hydrological or/and hydraulic models of the analysed area (catchment).
- Tool results depend on the quality of data input, but it gives consistent results for the right inputs.

Siting of measures to be tested

The basis for analysis is a catalogue of measures and the division of the Bednja basin into spatial planning units (SPU), presented in Figure 10.

The Static tool was used to analyze the selected measures in several spatial planning units (SPU) assumed as having a favourable impact.

The measures which were tested in the catchment are presented in Table 2, where the individual selected measures are assigned to the spatial planning units in the Bednja basin (SPU).

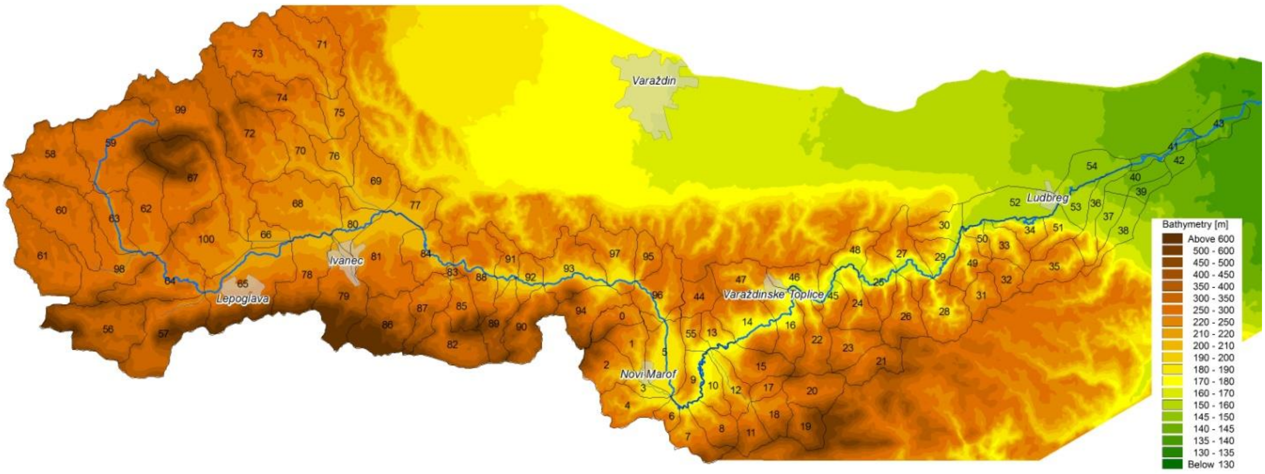

Figure 10. Division of the Bednja basin into spatial planning units (SPU).

Table 2. Measures tested in the catchment.

IdNSWRM	Agregated measure	Number of SPU	ENG NameOfNSWRM	Descrption
F02	KF	99, 59, 58, 60, 61, 56, 57, 78, 79, 86, 87, 82, 89, 90, 94, 78, 11, 18, 19, 20, 21, 26, 31, 32, 35	**Maintenance of forest cover in headwater areas**	Waters of the upper course of the river are the sources of rivers and streams. Forests in the upper reaches of the river can therefore have a beneficial effect on the amount of water and its quality. Indeed, forest soils tend to have better infiltration capacity than other types of soil cover, acting like a "sponge", slowly releasing rainwater. In areas with a convex sculpture, afforestation of the upper reaches of the river can contribute to the stabilization of the slope, which may reduce the risk associated with landslides. Forests often have a high rate of evapotranspiration and high water capacity of tree crowns. Therefore, the forest areas of the upper course of the river are able to reduce the absolute amount of water that can ultimately contribute to the runoff. In addition, forest soils are characterized by high porosity, high content of organic matter, good infiltration capacity and high water retention capacity, enabling delays of water runoff and increasing the infiltration rate (replenishment of groundwater resources). Therefore, forest waters in the upper reaches of the river can play an important role in reducing the risk of flooding.
N07	ER	53, 54, 36	**Reconnection of oxbow lakes and similar features**	Oxbow lakes are usually formed in valleys of meandering rivers by cutting meanders (cut off a fragment of a river). They are quickly disappearing by silting and backfilling with sediments from floods and vegetation. Reconnection with the river involves removing barriers between the main channel and the oxbow lake, improving the overall functioning of the river by restoring lateral communication, diversifying flows and cleaning the section of the current oxbow river to improve water retention during floods.
T1	T1	0, 1, 2, 3, 4 - retention Koruščak; 62 - retention Čret; 99, 67 - retention Kamenica1	**Polders, dry flood protection reservoirs, sediment trapping dams**	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 (their entire capacity is designated for flood protection purposes, these are reservoirs that collect water only during floods, except for fences, their bowls are used for agriculture as meadows and pastures - there are no intensive crops) and anti-rubble dams (dams whose main purpose is to retain sediment, mainly rubble on the fraction of wleczyn and wleczyn, and thus, protection of areas located below the structure before floods and rubble).
T2	T2	40, 41, 42, 43	**Widenning or removing of flood protection dikes**	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 shafts 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. The larger area of the valley floor will improve the conditions of flood water filtration through the ground, the valley retention will increase, reducing the risk of catastrophic flooding in lower lying areas sections of the river. If liquidation of shafts or their removal from the trough it is not possible, then you can make culverts or local depressions in order to allow controlled flooding land falls at higher water levels in the river. Thanks to the action, it is possible to reduce the erosive trend of the channel and to create a nature close to the development of the flood plains. In the acquired floodplains, it is possible to recreate oxbow lakes in

Changing of parameter values for measure groups in algorithm table had an effect on valorisation improvement in the catchment. In our case measures „KF” and „T1” have a larger impact on total improvement in the catchment than measures „ER” or „T2”.

This is to be expected since measures „KF” and „T1” are selected for a larger number of spatial planning units and cover a bigger area.

Measures „ER” and „T2” contribution to total catchment improvement is less than 1.

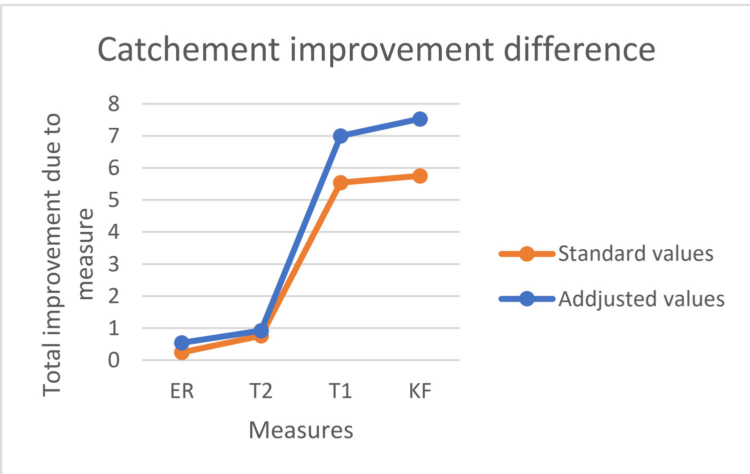

Figure 11. Total catchment improvement difference due to adjustment of parameters.

2.4 Cost Analysis

Methodology to calculate the costs of selected measures. Allows to choose the most suitable financing resources and instruments for the NSWRM and prepare a financial plan for implementation of the measures.

One of the activities in WP 3 was the cost analysis. The goal of this activity was 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 and supports the justification of N(S)WRM in RBMP in decision-making process.

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

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 in decision-making process.

Table 3. Projects in Bednja catchment.

No.	Activities/Measures	Duration of the activity or time needed to be completed	Estimated costs and potential Financial resources	Responsible organisation
1.	Čret retention basin	2022-2023	€ 1,100,000	Hrvatske vode
52.	Koruščak retention basin	2022-2023	€ 1,350,000	Hrvatske vode
3.	Kamenica 1 retention basin	2022-2023	€ 1,350,000	Hrvatske vode
4.	Dike along the Bednja from its mouth to Ludbreg	2023-2025	€ 4,000,000	Hrvatske vode

3. Final cumulative efficiency

The human impacts of the measures implemented in the natural river basins through history (felling, monoculture, intensive cattle breeding, regulation of river channels, and excessive use of water for agricultural needs) have, generally speaking, in addition to the primarily set objectives also brought many negative consequences, which are to a large extent present even today, despite the efforts to reduce the effects through the restoration and revitalization measures.

The Bednja river basin is no exception in that sense, but the consequences are small or moderate. For example, the nutrients are present in excess in the water in the lower part of the basin.

All of that is no reason not to, expecting the negative effects of climate change, prepare conditions in the basin for the implementation of small retention measures which would have cumulative impacts.

From the point of view of cumulative impacts of small water retention measures which aim at the reduction of nutrients and the improvement of flood protection in the Bednja basin, the first step was made in the selection of locations for the implementation of the measures.

The following criteria for nutrient retention and favourable water balance in terms of flood protection have been defined:

- The reduction of peak flows has a favourable impact on flood protection in the downstream area and on the reduction of erosion;

- The reduction of sediment has a favourable impact associated with retaining the sediment in a restricted area with a possibility for nutrient content testing, and thus with reducing downstream sediment transport;

- The protection of soil in terms of preventing soil washout in flood conditions has a positive impact on the reduction of nutrient transport;

- The protection of habitats in terms of more favourable water balance, the reduction of unfavourable consequences of floods through the transport of solid substances and pollution in biodiversity areas;

- Flood protection – improvement of hydrological conditions during high water events;

- Drought protection in terms of retaining water volumes and moisture in the soil.

Based on the applied assessment method, the advantage of a cumulative impact is seen at the locations of the Koruščak retention basin and the dikes along the Bednja.

The measure of relocating the existing inadequate dikes along the Bednja river channel further away from the channel and extending the route of the dike at a section from Ludbreg to the entry into the Drava River is a complex measure. It integrates flood protection and river restoration at that section. Based on expert judgement, it is assumed that it will also contribute to the objective of reducing the transport of nutrients from agricultural areas, which needs to be demonstrated through monitoring in the next planning period.

4. Implemenation framework

Policy background

Hrvatske vode is a legal entity for water management established pursuant to the Water Act.

Hrvatske vode is organized on the territorial and functional principles. In organizational terms, Hrvatske vode is divided into two basic units: the Head Office and the Water Management Departments. The territorial units in water management are six Water Management Departments (VGO) with local Water Management Branch Offices (VGI).

Legislation

EU legislation addressing NSWRM in the field of water management comprises the Water Framework Directive (WFD), the Floods Directive (FD) and the Habitats and Birds Directive. N(S)WRM can contribute to both WFD and FD goals, can enhance synergies between the implementation of both directives, and can support the coordination between the River Basin Management Plans (RMBPs) and Flood Risk Management Plans (FRMPs). NSWRM are a potential solution to improve or preserve hydro-morphological conditions as well as water quantity and quality issues.

Considering the multifunctional aspects of NSWRM, they are addressed also in different policy fields and policy documents. Croatian policy documents that are directly or indirectly addressing the application of N(S)WRM in the main laws in water management.

The Water Act regulates the legal status of waters, the water estate and hydraulic structures, the management of water quantity and quality, the management of risks from adverse effects of water, detailed amelioration drainage and irrigation, activities of public water supply and public wastewater collection, special activities for the purpose of water management, institutional organization of performing these activities, and other issues related to water and the water estate.

The Water Management Financing Act establishes the funding sources for financing the activities of water management, in particular the water fees, including the obligation to pay, the payer, the basis for payment, the method of calculation, the method for determining the rate, the purpose of those funds, enforcement, statue of limitations, and other matters related to the collection and use of the said funds.

The Water Services Act regulates the institutional framework for the provision of water services, the price of water services, the legal position and sustainable performance of the providers of water services, the activities of the Council for Water Services, and other issues related to the provision of water services.

Planning documents

The Water Management Strategy is a document based on which the water sector reforms will be implemented in order to achieve the European standards in water management. As such, it is the basis for gradual amendments of the Water Act and the Water Management Financing Act and the accompanying supporting legislation.

The River Basin Management Plan (RBMP) 2016-2021 was prepared by Hrvatske vode together with numerous collaborating scientific and technical institutions and companies that provided their data. Some investigations, such as systematic biological monitoring, were then carried out for the first time throughout the country, which is why some of the data used was deficient. In the past period, the monitoring of water status in accordance with the Monitoring Harmonization Programme has intensified, all up to the level necessary for efficient and credible water management. Work on further preparation of scientific and technical reports has intensified in order to provide data of the highest possible quality for the preparation of the next RBMP for the 2022-2027 period. The Monitoring Harmonization Programme foresees the improvement of the organization of the implementation of monitoring with a tendency to strengthen the capacities of Hrvatske vode with additional investment in the premises/office spaces, equipment and staff, which is already gradually under way.

The Long-Term Construction Programmes 2013-2023 are prepared based on the provisions of the Water Act. The Programmes are prepared by Hrvatske vode in the form of a proposal, in accordance with the Water Management Strategy and the RBMP, and are adopted by the Government once a strategic environmental assessment has been completed. Through investment measures, the Long-

Term Construction Programmes integrate the commitments from numerous EU Directives, in particular the Directive on the assessment and management of flood risks (2007/60/EC), the Directive on the quality of water intended for human consumption (98/83/EC) and the Directive concerning urban waste water treatment (91/271/EEC).

The Programmes identify individual projects, the method and period of their implementation, actors in implementation, investment amounts and sources of funds, the order of priority in implementation and the monitoring of implementation.

The procedure of adoption of the Long-Term Construction Programmes is preceded by the implementation of strategic environmental assessment procedures. The procedures of strategic and transboundary environmental impact assessment are conducted in accordance with the provisions of the Environmental Protection Act and the Regulation on strategic environmental impact assessment of plans and programmes. The strategic assessment is implemented during the drafting of the programme prior to the definition of the final proposal and its submission for adoption. During the strategic assessment procedure, the provision of information to the public and the participation of the public is ensured. Prior to its submission for adoption, when identifying the final programme proposal, the results of the strategic assessment and the opinions of the bodies and/or persons laid down by a special regulation are mandatorily taken into account, and the comments, suggestions and opinions of the public and the results of the transboundary consultations are considered.

5. Monitoring

The past period was characterised by intensive investment in monitoring, both in terms of improving the water monitoring programme and in terms of investment in the laboratory capacities of the Central Water Management Laboratory. Based on its obligations, Hrvatske vode as an institution responsible for the monitoring of water status works intensively on the improvement of monitoring in two development directions – organization of the implementation of monitoring and the strengthening of the laboratory capacities of Hrvatske vode.

With the purpose of improving the water status, the measures from the RBMP are divided into basic, additional and supplementary:

- The basic measures cover the following measures:

- Recovery of costs of water services and promotion of efficient water use;
- Protection of water intended for human consumption;
- Control over the abstraction of water;
- Groundwater recharge control;
- Control of point sources of pollution;
- Control of diffuse sources of pollution;
- Control and reduction of hydromorphological pressures to water;
- Control of other significant impacts on water status, in particular on the hydromorphological status;
- Prohibition of direct discharges of pollutants into groundwater;
- Elimination and reduction of pollution with priority substances;

- Prevention of accidents/incidents.

Additional measures are the measures established in order to achieve the water protection objectives of the protected areas or areas of special water protection.

Supplementary measures are implemented in addition to the basic and additional measures if the water protection objectives haven't been achieved with the implementation of the basic and additional measures.

N(S)WRM will be incorporated in a set of measures which are planned in third RBMP for Croatia and will be monitored within the existing monitoring system and it will be further developed where it is needed.

6. Summary

For the FramWat project six pilot catchments in Central Europe were chosen to test the NSWRM approach and the project tools. The pilot study report that presents the main outcomes for the pilot areas is called “Action plan”.

The Action plan of the project summarizes the work carried out in the Bednja pilot area during the project development that is considerable in terms of flood and water quality.

The Action plan was developed based on the Concept plan for the Bednja pilot catchment.

Within the scope of the project, a range of measures were selected in the Concept plan for the Bednja pilot river basin. The most important task of the Concept plan was to provide a proposal for the small water retention measures (NSWRM) that can be applied in the catchement, and also present a method how to identify the location of each measure in the area.

The existing Action plan for the Croatian pilot catchment Bednja provides a compilation of the modeling results and presents the effectiveness of a selected set of NSWRM in the Bednja catchment. The overall goal of the Action Plan is to support sustainable water management in the pilot area.

The Action plan provides steps, timeline, financial resources, and responsible actors for integrating NSWRMs into river basin management plans. The Action plan also includes monitoring of the measures implementation.

The Action plan for Bednja summarizes the work done in the pilot area during the project and provides the compilation of the catchment modeling results and presents the effectiveness of a selected set of NSWRM in the catchment.