ACTION PLAN FOR KAMNIŠKA BISTRICA *(SL)* (D.T3.5.5)

Slovenia June 2020

CONTENT

1. Introduction

Kamniška Bistrica River catchment is located in the northern part of Slovenia and represents almost 3% of its overall area. It was chosen as a pilot catchment because of its diverse character, ranging from wooded subalpine hills to lowland plains, which are highly urbanized. The main problem within the catchment are relatively frequent floods. As for water quality, Kamniška Bistrica River has moderate to very good ecological status. Although a large part of the settlements is connected to a sewage system and central WWTP, water in lower parts of the catchment is occasionally polluted. This is especially so in summer months when the main channel is almost dry, and the water temperature rises. Other sources of water pollution are sewage overflows during flood events.

In its middle and lower part, Kamniška Bistrica river is highly regulated due to its hydropower potential and as protection against floods. This part of the catchment is covered with a dense network of artificial channels that used to supply water for the operation of water and sawmills. Today, they are mainly used for supplying small hydropower plants.

Table 1: Characteristics of the catchment

Characteristic	Unit	Value
Character of catchment		Upper part: highland; wooded, sparsely populated Middle and lower part: lowland; highly urbanized
ent size:	km^2	539
Average flow low/avg/high*	m^3/s	2.2/7.9/67.2
Extreme flow low/high*	m^3/s	0.9/282
Annual precipitation low/avg/high**	mm	998/1383/1851
Annual air temperature min/avg/max**	°C	9/11/13
Agriculture area	%	34.5
Urban area	%	8.2
Forest area	%	54.1
Open Water area	%	2.8
Flooded area (1/100 years)	km2	39.2
Artificial drainage area	km2	12.7

Note: *Hydrological yearbook of Slovenia 2018 (Slovenian Water Agency, 2018) RS[1]

There are five main water bodies within the catchment: Kamniška Bistrica, Pšata, Radomlja, Rača, and Nevljica of lengths 38, 36, 23, 13, and 19 km, respectively.

Flooding is often, especially in late autumn. Based on previous flooding events, we can define five areas of significant impact of floods: Stahovica-Kamnik, Komenda-Moste-Suhadole, Domžale, Nožice, and Ihan- farms.

The upper course of Kamniška Bistrica has near-natural morphological alteration, which changes downstream from slightly modified to severely modified on few points before Nevljica inflow. Nevljica has near-natural to slightly modified morphological alteration, similar Rača with moderately modified morphological alteration before confluence with Radomlja River. On the other hand, Radomlja and

[1]https://www.arso.gov.si/vode/publikacije%20in%20poro%c4%8dila/Poro%c4%8dilo%20o%20hidrolo%c5%a1kem%20monitoringu%20povr%c5%a1inskih%20voda%20za%20leto%202018.pdf

Pšata have mostly moderately to severely modified morphological alteration. Middle and lower course of Kamniška Bistrica has slightly to severely modified morphological alteration.

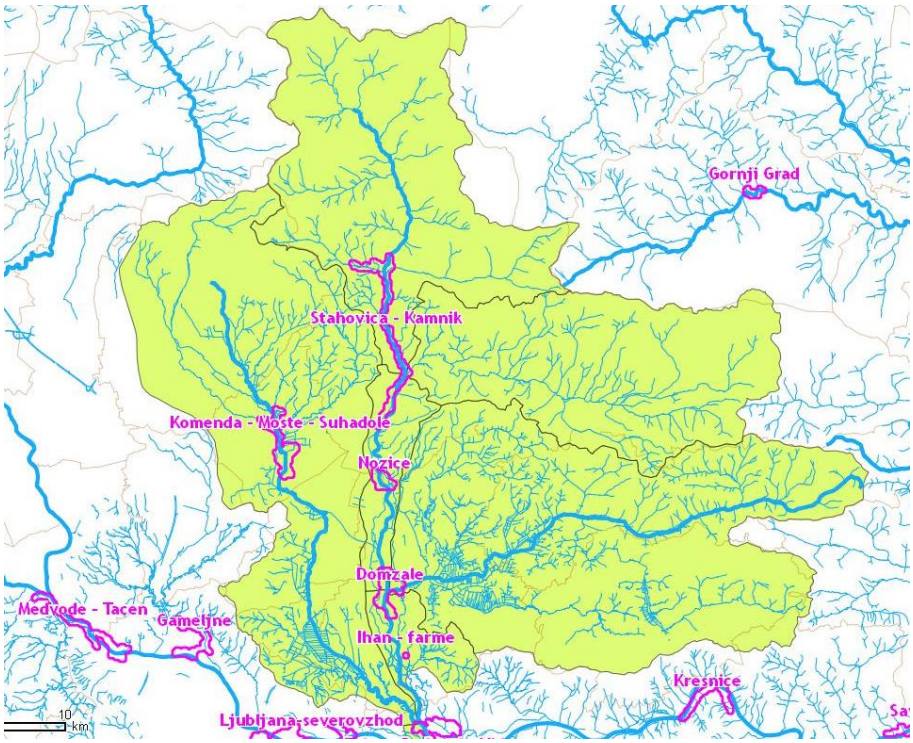


Figure 1: Risk areas (Slovenian Water Agency[2], 2018).

All rivers in Kamniška Bistrica basin have moderate ecological status, except upper course of Kamniška Bistrica has a very good ecological status. Chemical status of Kamniška Bistrica and Nevljica is very good while Pšata, Radolmlja, and Rača have a good chemical status. The main problem to achieve a good ecological status lies in hydro morphological alteration.

Project FramWat initiated the development of potential areas of action from high to low need for water retention. The best results produced by FroGIS were obtained from the equal width method of division into classes. However, valorisation map indicates a high demand for water retention on steep upstream slopes (SPU 12 and 36) where measures are not feasible; map divided into classes by natural breaks eliminates SPU 12 from areas with a high need for water retention, which is correct. None of the methods does not show SPU 79 as an area with a high need for water retention even though there are planned three water retention basins. Division in natural breaks with variable weight shows higher potential for water retention in the western part of the catchment, which coincidence with planned measures.

[2] http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/voda/opvp/09_Kamniska_Bistrica_OPVP.jpg

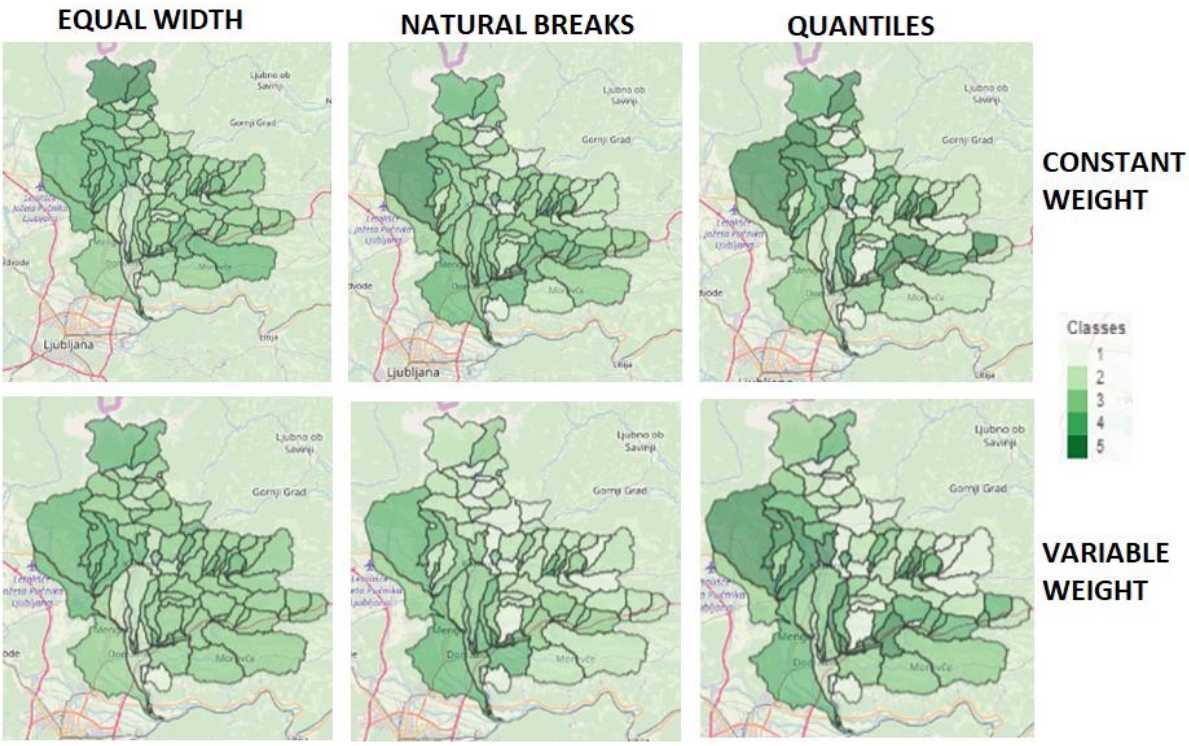


Figure 2: Division into classes.

2. Selection of the measures

A vision for Kamniška Bistrica was to use dispersed SWRM as a flood protection mechanism on a river basin scale. The selection of measures started with the review of two key strategic documents: river basin management plan (Danube RBMP 2016-2021) and flood risk management plan (FRMP 2017-2021). Already planned measures were taken as a base in the planning process of NWRM. Through two national events in 2018 and 2019, stakeholders` and local authorities` inputs were gathered. The expert knowledge list of NSWRM was elaborated in the Concept plan. The document gives information on proposed locations and types of measures.

Chosen measures, shown in the next Figure, were then evaluated in terms of efficiency with the use of static and/or dynamic tool. Static tool, which proved to be less appropriate for the challenges of Kamniška Bistrica, was replaced with dynamic tool for the whole river basin of Kamniška Bistrica. The dynamic tool enables analysis of the effects of different measures on different parts of the river basin. Selected NSWRM have been analysed and quantified.

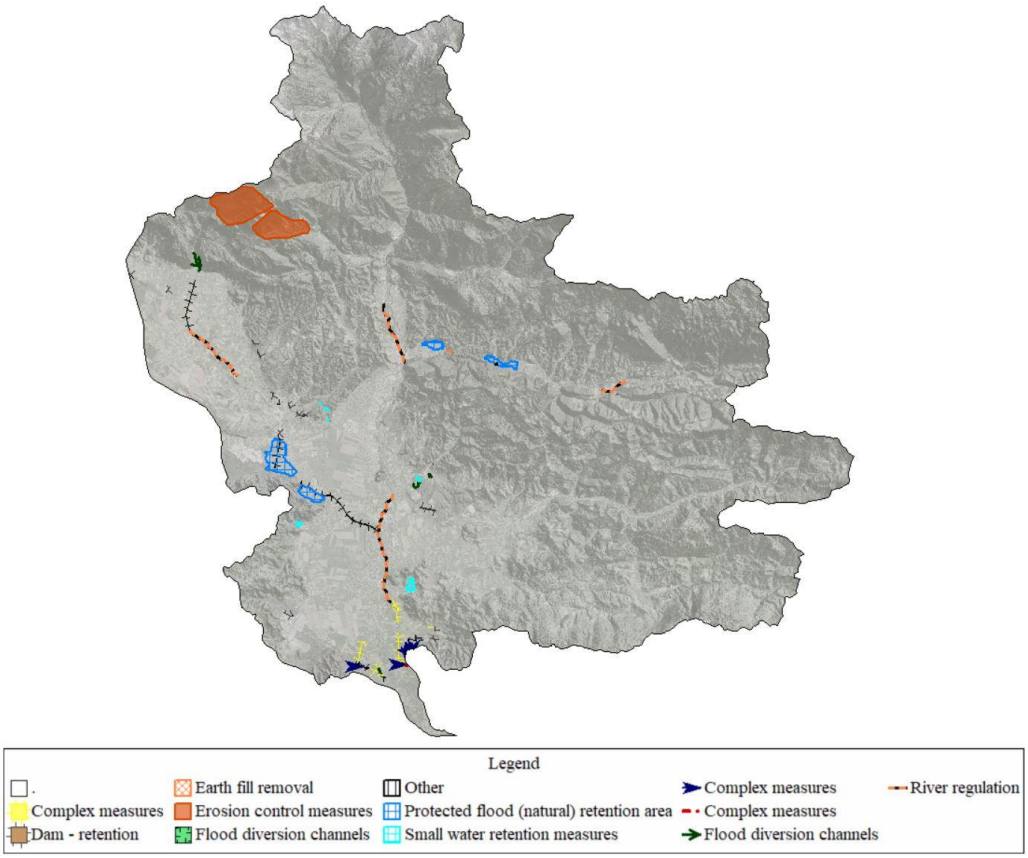
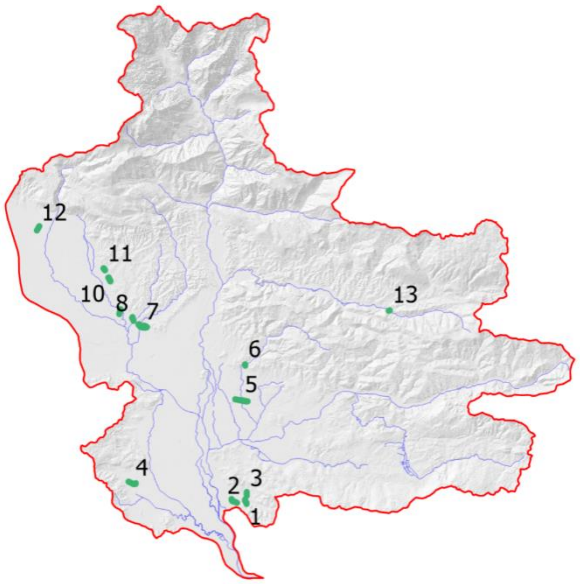


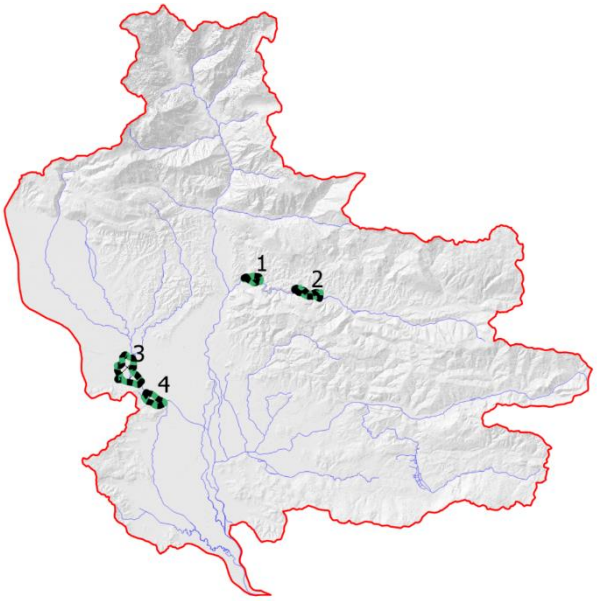
Figure 3: Elaborated measures in the Concept plan.

Detailed overview of the NWRM shown on the picture above, is presented in the table below.

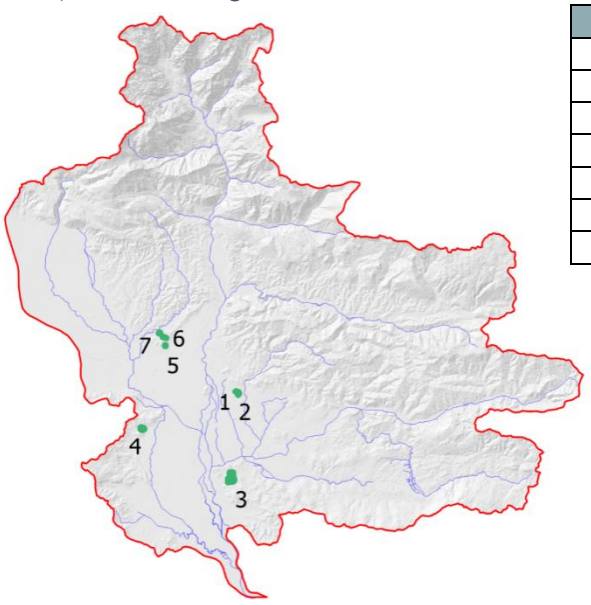
Table 2: Overview of selected measures and their description

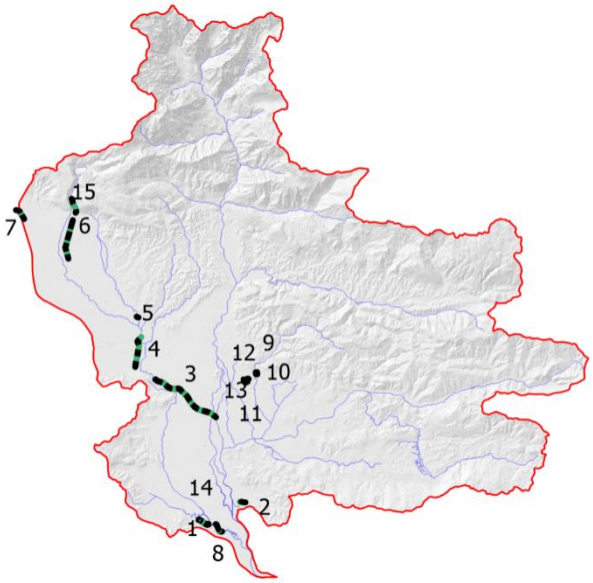
NWRM	Description
Dam retentions	- The main goal is to accumulate excessive precipitation and gradually release accumulated water after the main precipitation/flood event. - For modelling purposes, we assumed indefinitely high dams with no water releasing wherever possible. If not possible, the dam spill deck was positioned at the height of the surrounding. - Initially, we located 13 possible dam retention locations, which were analyzed in a HH model (shown on the picture below).

<table>
<tr><th>NWRM</th><th>Description</th></tr>
<tr><td></td><td>


<table>
<tr><th>Dam Nr.</th><th>River/stream</th></tr>
<tr><td>1</td><td>No name</td></tr>
<tr><td>2</td><td>Zabnica</td></tr>
<tr><td>3</td><td>Zabnica</td></tr>
<tr><td>4</td><td>Blatnica</td></tr>
<tr><td>5</td><td>Rovski potok</td></tr>
<tr><td>6</td><td>Rovski potok</td></tr>
<tr><td>7</td><td>Tunjscica</td></tr>
<tr><td>8</td><td>Knezji potok</td></tr>
<tr><td>9</td><td>Psata</td></tr>
<tr><td>10</td><td>Doblic</td></tr>
<tr><td>11</td><td>Dobovsek</td></tr>
<tr><td>12</td><td>No name</td></tr>
<tr><td>13</td><td>Nevljica</td></tr>
</table>
- The biggest impact of dam retentions in comparison to existing conditions is seen right next to dams themselves to reduce peak hydrographs flows. Further on downstream, impact weakens and is hardly evident at the downstream boundary condition of the whole catchment.
</td></tr>
<tr><td>Protected natural retention area</td><td>
- Measures fall under Hydro-morphology measures N03 (Floodplain restoration and management) in the catalogue of measures;
- can have positive impact on flood safety and flood wave propagation;
- in general, they should not be urbanized, nor should their available volume be decreased in any other way.


<table>
<tr><th>Nr.</th><th>River/stream</th></tr>
<tr><td>1</td><td>Nevljica</td></tr>
<tr><td>2</td><td>Nevljica</td></tr>
<tr><td>3</td><td>Pšata</td></tr>
<tr><td>4</td><td>Pšata</td></tr>
</table>
</td></tr>
</table>

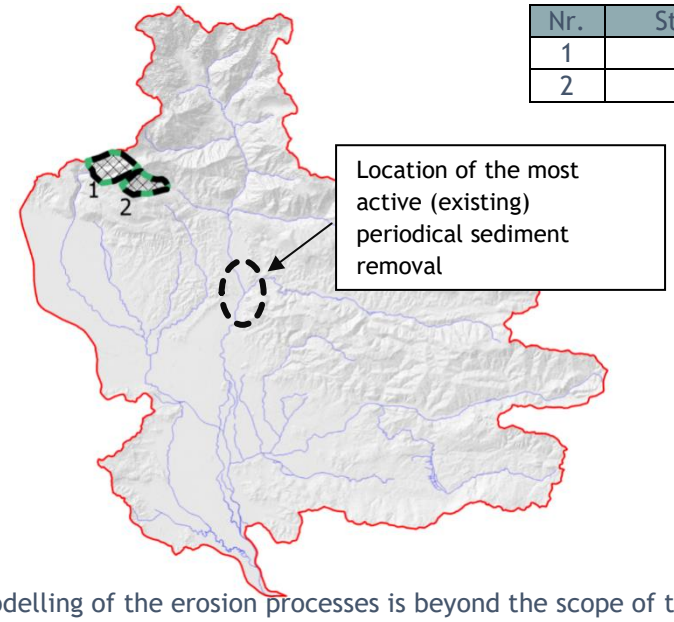
<table>
<tr><th>NWRM</th><th>Description</th></tr>
<tr><td>Small water retention areas</td><td>- Identified/proposed small water retention measures are envisaged in the way of renaturation of existing or abandoned ponds, wetlands, etc;
- they should not be urbanized, nor should their available volume be decreased in any other way.
- Seven identified locations (these measures are already included in all calculations as they already exist in nature, and need renaturation).
-The proposed measure falls under Hydro-morphology measures N01 (Basins and Ponds) in the catalogue of measures.
 

<table>
<tr><th>Nr.</th><th>Measure</th></tr>
<tr><td>1</td><td>Existing pond/reservoir</td></tr>
<tr><td>2</td><td>Existing pond/reservoir</td></tr>
<tr><td>3</td><td>Existing pond/reservoir</td></tr>
<tr><td>4</td><td>Existing pond/reservoir</td></tr>
<tr><td>5</td><td>Pond restoration</td></tr>
<tr><td>6</td><td>Pond restoration</td></tr>
<tr><td>7</td><td>Pond restoration</td></tr>
</table></td></tr>
<tr><td>Flood diversion channels</td><td>- Diversion channels are primarily used for carrying excess flood water, whether in surface or underground channels, as a way to improve flood safety on target areas.
- We have chosen 15 locations appropriate to apply them to.
- This measure is specific for Slovenian watershed and does not have official coding from the catalogue of measures.
 

<table>
<tr><th>Nr.</th><th>Stream</th></tr>
<tr><td>1</td><td>Psata</td></tr>
<tr><td>2</td><td>Zabnica</td></tr>
<tr><td>3</td><td>Psata</td></tr>
<tr><td>4</td><td>Psata</td></tr>
<tr><td>5</td><td>Psata</td></tr>
<tr><td>6</td><td>Reka</td></tr>
<tr><td>7</td><td>/</td></tr>
<tr><td>8</td><td>Psata</td></tr>
<tr><td>9</td><td>Rovski potok</td></tr>
<tr><td>10</td><td>Rovski potok</td></tr>
<tr><td>11</td><td>/</td></tr>
<tr><td>12</td><td>/</td></tr>
<tr><td>13</td><td>/</td></tr>
<tr><td>14</td><td>Psata</td></tr>
<tr><td>15</td><td>Reka</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>NWRM</th><th>Description</th></tr>
<tr><td></td><td>– Flood diversion channels per se are not water retention measures, although they can contribute in terms of water retention, but are many times needed to enhance the performance of other measures that do have retention effects.
– Within the scope of the project, flood diversion channels should be treated as a support measures for other NSWRM – specifically dam retentions and protected natural flood retention areas, hence were not calculated separately.</td></tr>
<tr><td>Erosion control measures</td><td>- Predicted in two locations.
- Some of these measures are specific for Slovenian watershed and do not have official coding from the catalogue of measures. Proposed regulation would comprise of several Forest measures e.g. F09 (sediment capture ponds) and potentially some others not defined in the catalogue of measures.

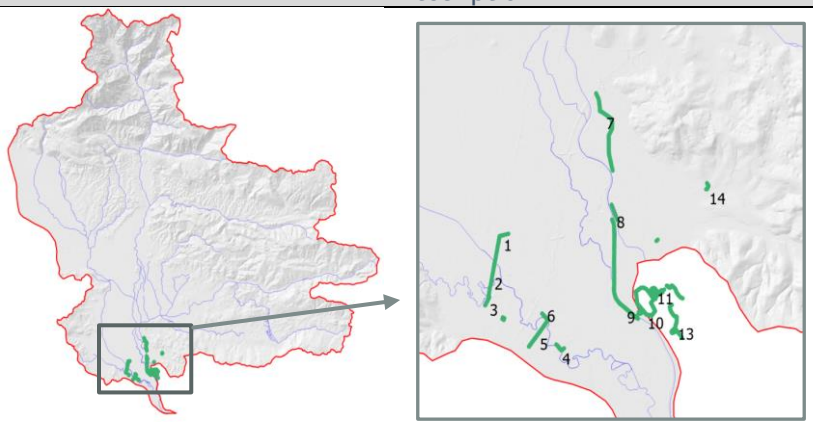
Options of measures:
- measures intended to prevent localized erosion (stream stabilization, river geometry alteration by reducing slope and bank inclination, planting plants with higher shear stress resistance),
- measures intended to trap and collect sediment (suspended and bed load sediment) e.g debris trap dams,
- measures intended to remove deposited sediment, e.g. machine excavation.

<table>
<tr><th>Nr.</th><th>Stream catchment</th></tr>
<tr><td>1</td><td>Reka</td></tr>
<tr><td>2</td><td>Bistričica</td></tr>
</table>

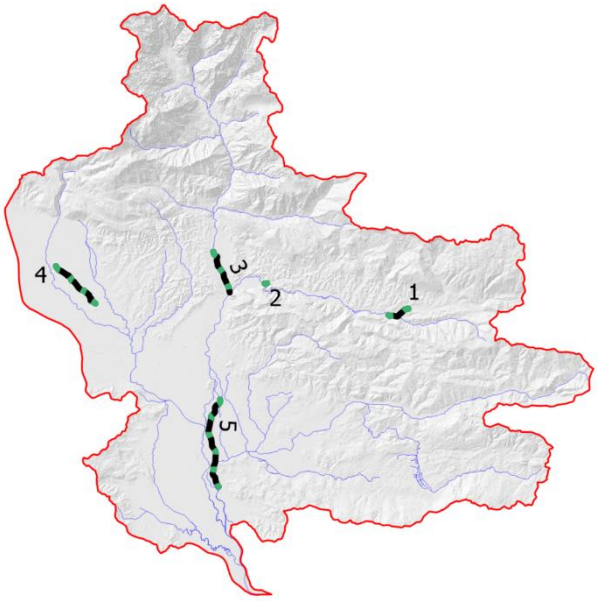
- Modelling of the erosion processes is beyond the scope of the project, hence the effects of erosion control measures are only estimated based on available data.
- Based on estimations, effects of erosion measures on flooding are negligible.</td></tr>
<tr><td>Complex measures</td><td>– All proposed complex measures are located at the downstream end of the catchment,
– measures include levees and road heightening - these two measures could lead to increased water retention, and culverts which do not have significant impact on water retention,
– these measures are specific for Slovenian watershed and do not have official coding from the catalogue of measures,</td></tr>
</table>

NWRM	Description

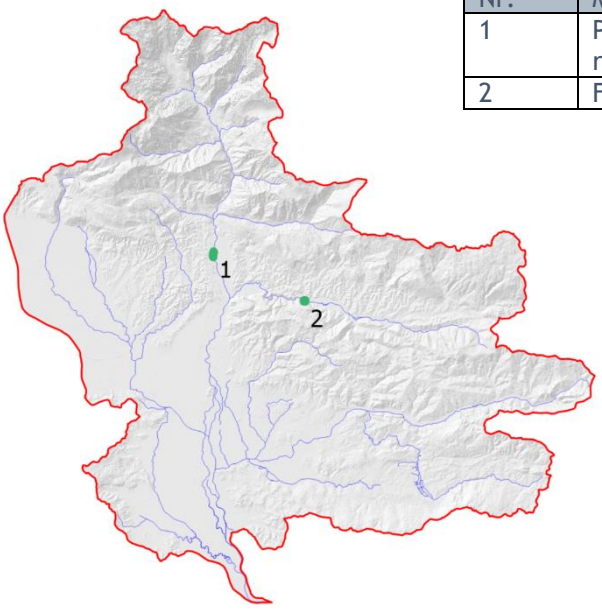


Nr.	Measure	Nr.	Measure	Nr.	Measure
1	levee	11	levee	21	culvert
2	levee	12	levee	22	culvert
3	bypass	13	levee	23	road heightening
4	levee	14	levee	24	road heightening
5	levee	15	culvert		
6	levee	16	culvert		
7	levee	17	culvert		
8	levee	18	culvert		
9	levee	19	culvert		
10	levee	20	culvert		

- results show, that effects of complex measures are only local which is logical and in accordance with their intention,
- their impact on watershed scale is not significant.

<table>
<tr><th>NWRM</th><th>Description</th></tr>
<tr><td>River regulation</td><td>- Predicted in five locations.
- At preliminary stage, it is hard to predict exact measures needed and appropriate at a specific location, but based on existing situation measures are to be rather conservative – river bed slope regulation, bridge openings optimizations, stream stabilizations, etc.
- Overall length of the proposed measures is relatively short with being slightly longer than 12 km,
- all altered sections are located on existing river streams.
- Some of these measures are specific for Slovenian watershed and do not have official coding from the catalogue of measures. Proposed regulation would comprise of several hydro-morphology measures from the catalogue, N05 (stream bed denaturalization), N08 (riverbed material renationalization) and N10 (natural bank stabilization).
- measures themselves do not have any significant impact on water retention on the catchment scale.
 

<table>
<tr><th>Nr.</th><th>Stream</th></tr>
<tr><td>1</td><td>Confluence of Tuhinjscica and Nevljica</td></tr>
<tr><td>2</td><td>Confluence of Porebrscica and Nevljica</td></tr>
<tr><td>3</td><td>Kamniška Bistrica</td></tr>
<tr><td>4</td><td>Voje</td></tr>
<tr><td>5</td><td>Kamniška Bistrica</td></tr>
</table></td></tr>
<tr><td>Other measures</td><td>- Include periodically bed load removal performed by concessionaire and facility purchase which is located on area prone to sever flooding;
- these measures are specific for Slovenian watershed and do not have official coding from the catalogue of measures.</td></tr>
</table>

NWRM	Description
	

Nr.	Measure
1	Periodical bed load removal by concessionaire
2	Facility purchase

- We estimate, that these processes do not affect water retention possibility on a basin scale, and possible negative effects are only local. Sediment excavation on the whole watershed is estimated to less than 20x103 m3 on a yearly basis.
- Facility purchase is meant as a supporting measure for natural flood retention areas, as it is located on a frequently flooded Nevljica area.
- Hydraulic modelling of the erosion processes is beyond the scope of the project, hence the effects of erosion control measures are only estimated based on available data.

3. Final cumulative efficiency

Based on the hydraulic calculations we can conclude that the biggest impact on the hydraulic conditions in the way of increasing water retention have dam retentions theoretically followed by natural reserved flooding areas and pond renaturation/restoration. Total retained volumes are presented in the table below.

Table 3: Potential retained volume with NWRM application

NWRM	Retained volume (mil m^3)	Ranking (based on retained volume)
Dam retentions	4,6	1
Natural retention area	1,2	2
Small water retention areas	up to 0,4	3
Flood diversion channels	0,28	4
River regulation	<0.01	5

Of the three, only dam retentions are the ones that add/increase actual water retention as they are currently not existent. The other two already exist and are, therefore, very important to maintain and prevent any extensive land use in those areas.

By implementing proposed dam retentions, peak flows could be significantly lowered at downstream locations close to the dams themselves. Still, going further downstream, the impact

weakens and becomes hardly evident at the very downstream end of the catchment.

With dynamic models growing in size, it also becomes harder to analyze all the details that can contribute to an efficient analysis; hence it is crucial to use smaller, detailed models still to analyze exact impacts on a smaller scale.

Flood safety is a big issue on the Kamniška Bistrica catchment. It cannot be resolved by only implementing NSWRM but will require a broader targeted approach with other available engineering solutions. Regarding modelled results from our study, we see NSWRM as complementary measures whose impact (in case of proper NSWRM type selection) can significantly contribute to flood safety only on targeted isolated areas (areas located immediately nearby the measures) but not on a bigger scale.

4. Implementation framework

The above-presented list of measures and assessment of their efficiency is only the first step in the planning process of catchment scale based NWRM. The challenge ahead of us is to find the right combination of measures that responds to management issues of Kamniška Bistrica and the planning process (RBMP, FRM biodiversity protection, climate change adaptation, and urban planning).

Potential legal restrictions are associated mainly with environmental protection. Thus, we reviewed special protection areas in the Kamniška Bistrica river basin. They are presented in the table below.

Table 4: Table of measures that are planned on special protection areas (Natura 2000)

NWRM	River	Protected area
Flood diversion channels (restoration of natural infiltration to ground water)	Reka, surface bypass, 4.6 km	Forest Olševek - Adergas
Erosion control measures (i.e. afforestation)	Unnamed stream	Kamniško - Savinjske Alpe
Dam - retention (i.e. reservoirs) Pšata	Pšata	Rašica
Dam - retention (i.e. reservoirs) Blatnica	Blatnica	
Dam - retention (i.e. reservoirs) Rovski potok	*Rovski potok*	*Češeniške gmajne z Rovščico*
Rovski potok, underground bypass, 0.1 km		
Rovski potok, underground bypass, 0.1 km		
New Dam Zabnica	*Zabnica*	*Ihan*
levee, Kamniška Bistrica	*Kamniška Bistrica*	
levee, Zabnica	*Zabnica*	

In the next table, all measures are shortly described. All of these measures have been analysed, whether numerically with a hydraulic-hydrologic model or estimated based on previous experience. Base on analyses, it has been acknowledged that the most notable effect on the flooding conditions has dam retentions; all other measures impacts are far less noticeable.

Many of the measures are located in more the one municipalities thus, communication regarding all involved parties should also be addressed in the whole further design/implementation/funding process.

Ranking based on implementation priorities is not entirely straightforward, as many of the measures demand other measures implemented to be efficient. Nevertheless, the most important measures have proved to be dam retentions. They are the ones considered the top priority measures, followed by the natural retention areas and small water retention areas.

Table 5: NWRM's rankings and estimated cumulative cost

Measures	Ranking (based on implementing priorities)	Category (micro/macro)*	Estimated cumulative cost (mil €)
Dam retentions	1	Macro	>1 mil
Protected natural retention area	2	macro	< 1 mil
Small water retention areas	5	micro	< 1 mil
Flood diversion channels	3	macro	>1 mil
Erosion control measures	6	micro	< 1 mil
Complex measures	4	micro	>1 mil
River regulation	3	macro	>1 mil
Other measures	7	micro	< 1 mil

**mikro – effects are strictly local and are not intended to have impact seen in other municipalities, macro – effects could be seen in other municipalities as well*

Measures addressing flooding, which are being directly affected by climate change, should be addressing financial aid by the state climate fund and possibly other EU cohesion and structural funds as well as funds of all municipalities involved.

All measures comply with the EU flood directive and Slovenian legislation (NZPO), which addresses water management (namely Decree on the establishment of flood risk management plans).

5. Monitoring

Monitoring of the measures is a tedious task and usually depends on existing measuring equipment and additional staff. On Kamniška Bistrica catchment, there are already some water gauging stations to be used for monitoring the effects of proposed measures in terms of discharge hydrographs, which in general are closely related to flooding extents.

Ideally, mayors of the municipalities could assign this task to a standard working body whose members would be from all involved municipalities and would do periodical checks.

6. Recommendations

The FramWat demonstrated that NSWRMs could contribute to the flood safety, even in small amounts, which for Kamniška Bistrica, having an exclusively Alpine character, is quite expected.

However, there are several other catchments in Slovenia that can benefit from the developed approach. Therefore, it would be useful to include the NSWRM approach and results into the next RBMP that in Slovenia steps into force in 2022, for five years.

Different pilot actions have shown that dynamic approach was primarily needed in some pilot catchments (especially Kamniška Bistrica catchment) due to their specifics. Hence, we propose that particularly a dynamic approach towards NSWRM modelling and implementation can be a useful starting point for every Slovenian water entity/municipality having an issue with floods or/and droughts.

Further implementation of NWRM on Kamniška Bistrica should enclose:

- Identification of priority NWRM for integration into the 3rd cycle RBMP 2022-2027. The FramWat project's findings could be taken into account during the preparation and drafting of the third RBMP.
- Integrated vision of the river basin should include sustainability of land resources, environmental, social and economic dimensions of NWRM;
- National guidelines for NWRM implementation are addressing many existing water and land policies. Attention should be paid to the placement of NWRM (incl. spatial planning process);
- Coordination of NWRM implementation activities among multiple stakeholders (i.e., water agency, municipalities, and different sectors) is missing. The establishment of a water board for Kamniška Bistrica could be useful to overcome these issues.
- Continuous improvement of stakeholder`s technical knowledge (education) about NWRM alternatives/suggestions on a river basin;
- FramWat carried out the analysis and modelling of NWRM on the entire river basin. In the next phase, narrow technical problems should be addressed including the elaboration of feasibility studies (incl. assessment of consequences of not taking action), project and investment documentation;
- Governing stakeholders should program financial resources for identified priorities and needs on a local level (crucial collaboration among Water agency and municipalities).