WP5
Pilot Sites: adaptation strategies and measures for increasing resilience to climate change

Activity 5.3.1

Jadro River and Kaštela Bay Decision Process Final Report

Deliverable 5.3.1

DECISION PROCESS FINAL REPORT

Summary of the outcomes of the participatory phase

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PROJECT CHANGE WE CARE

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1. Foreword

This document has been produced in the framework of the INTERREG Italy – Croatia CHANGE WE CARE Project. CHANGE WE CARE fosters concerted and coordinated climate adaptation actions at transboundary level, tested in specific and representative pilot sites, exploring climate risks faced by coastal and transitional areas contributing to a better understanding of the impact of climate variability and change on water regimes, salt intrusion, tourism, biodiversity and agro-ecosystems affecting the cooperation area. The main goal of the Project is to deliver integrated, ecosystem-based and shared planning options for different problems related to climate change (CC), together with adaptation measures for vulnerable areas, to decision makers and coastal communities. Additional information and updates on the CHANGE WE CARE can be found at https://www.italy-croatia.eu/web/changewecare.

2. Aims and content of the document

This document is the final report of the decision process undertaken involving stakeholders in the Jadro River and Kaštela Bay Pilot Area and corresponds to the Deliverable 5.3.1 indicated in the Application Form. It represents the synthesis of participatory process outcomes based on the following WP5 roadmap:

1. **Design of the Participatory Process**, months 03/2021 – 05/2021: design /set up a dedicated participatory process in relation to the issues to be tackled, the nature and characteristics of the stakeholders, main local actors, citizens and associations;
2. **Implementation of the Participatory Process,** months 06/2021 – 10/2021: implementation of the designed process along 4 months, including 3 Participatory Workshops in presence or via online support as Webinar, or other tools as indicated in the following page, and all other means designed/foreseen (as local coordination meetings, public meetings, online virtual squares, blogs, online consultations tools in general, etc.) following the developments of WP3 and WP4 and their specific outcomes for the Pilot Sites;

3. CHANGE WE CARE project and the objectives of WP5

CHANGE WE CARE fosters concerted and coordinated climate adaptation actions both at Pilot Sites and transboundary level. The project explores climate risks faced by coastal and transition areas contributing to a better understanding of the impact of climate variability and change on water regimes, salt intrusion, tourism, biodiversity and agro-ecosystems affecting the cooperation area.

WP5 main objective is the preparation of climate change Adaptation Plans in Pilot Site, containing the assessment of present state and of foreseen scenarios, the indication of measures and intervention priorities, monitoring strategies and jurisdictional references.

The Planning options presented are the result of participated processes involving local authorities and stakeholders. The Adaptation Plans include actions and interventions, where appropriate, indicating the timeline and the financial strategy for the implementation of the envisaged activities and Monitoring Plans (taking stock also of WP4 indications) for observing and ensuring the durability of the project outcomes and of the implementation of the Plan.

4. Description of the participatory process designed for the Jadro River and Kaštela Bay Pilot Area

Participatory process on the impact of climate change on the Jadro River and Kaštela Bay Pilot Area

4.1 Area, themes, sectors of intervention

Workshops focused on the impact of climate change on the area of the Jadro River and Kaštela Bay Pilot Area.

The river has two characteristic catchment areas, the topographic catchment of the river and the groundwater catchment area of the Jadro spring, and has three common characteristic parts, upper, middle and lower. According to various authors the total area of the Jadro and Žrnovnica spring inner catchment covers ca. 450 km2 while topographic catchment area is small and covers 28.2 km2.

Tha main characteristics of the area is strong urbanization process and therefore the main sectors of interventions are the following:

- Local and regional administrative units as they define spatial plans and policies for further urban development (City of Solin, Municipality of Klis, Split Dalmatia county);
- Croatian waters company as company that manages the river basin;
- Water and sewer company as there is undeveloped sewer infrastructure;

Other institution that manages nature protected areas, entrepreneurs and developers, citizens and NGOs, and researchers (institutes, university) are important as stakeholders to be involved in the process of development of the Adaptation plan.

4.2 General aim of the operation

The overall objective of the participatory process is to achieve communication with local stakeholders. Establishing communication with local stakeholders can contribute to raising awareness of climate change challenges and synergy among stakeholders in the realization of climate change adaptation measures.

An important objective of this activity is to deepen existing knowledge. Establishing communication with the local community through workshops can significantly contribute to the complementarity of existing knowledge.

4.3 Synthesis of the participatory process

For the successful implementation of participatory process, it was important to:

- Organize participatory workshops;
- Prepare presentation of drafted studies with the aim of deepening research topic;
- Develop workshop activities with the aim of encouraging stakeholders to discuss;
- Bring together a number of stakeholders from the public, private and civil sectors in order to achieve better discussion and
- Prepare reports on conducted workshops.

4.4 Context of the participatory process

Participants from local and regional administration, Croatian waters company, Water and sewage utility company, as well as participants representing entrepreneurs, developers and citizens were present at the workshops.

Anthropogenization of the river basin is recognised as the main cause of today and future threats, and climate change will increase all the negative trends. Urbanization causes the reduction of infiltration, base runoff and low waters. Urban waters, diffuse sources of pollution and air pollution are the main threats to the environment. The quantity and quality of water will deteriorate over time and with the flow of water from the source to the sea, and thus the safety of the environment, natural and built is threatened. Transitional waters and the coastal sea are the most endangered by climate change and urban development.

Problems are complex and they have to be solved in already built environment and in karts area (hydrologically partially always unknown). Therefore, there must be an integral approach implemented in river basin management. An important precondition for that is successful cooperation between all the stakeholders.

4.5 Objectives of the participatory process

The aims of the participatory process are:

- Achieve communication with stakeholders from the local community;
- Increasing the number of stakeholders involved in active reflection of adaption of the are to climate change;
- To make local stakeholders aware of the importance of adaptation of areas to climate change;
- To deepen knowledge on climate change challenges in the area;
- Achieve synergy among different stakeholders in the area with a view to realizing defined climate change adaptation measures.

4.6 Expected results of the participatory process

The expected results of the participatory process are:

- Communication with stakeholders from the local community;
- At least 20 local stakeholders involved in active reflection on adaptation of areas to climate change;
- Increased awareness of local stakeholders about the importance of adaptation of areas to climate change;
- Acquired new and deepened existing knowledge on climate change challenges in the area;
- Synergies between different stakeholders in the area have been achieved with the aim of implementing defined climate change adaptation measures.

4.7 Timing foreseen for the participatory process

Start date:	01/04/2021
Duration (in months):	6

4.8 Phases of the process

Stakeholder mapping – defined number of stakeholders from civil, public and private sectors to be included in the process.

Designing phase – defined dates and topics of workshops, defined methods for participatory process, designing questionnaires.
Implementation phase – preparation of presentations, questionnaires, invitations; inviting stakeholders and media, preparing press releases, reporting about workshops.

4.9 Description of the phases (and timing)

1. Stakeholder mapping (February/2021-March/2021)
During this phase, identification of key stakeholders was made which, with their knowledge and experience, contributed to better development of the adaptive plan.
2. Design phase (April/2021-May/2021)
This phase includes the workshop programme. In accordance with the programme, participant invited to workshops were defined.
3. Implementation phase (June/2021-October/2021)
During this phase, planned workshops were realized, bringing together a wide range of different stakeholders from the public, private and civil sector.
4. Finalisation phase (October/2021-November/2021)
During this phase, workshop results were implemented into existing documents and strategies.

5. Elements and context of the participatory process for the Jadro River and Kaštela Bay Pilot Area

5.1 Stakeholders involved

During stakeholder mapping process, the following stakeholders are identified as relevant for the Jadro River Pilot Area and also to the issues to be tackled.

	Stakeholders and beneficiaries individual professional identification and contacts			Geographic location			
	Name	**First name**	**Email**	**Country**	**Region / County/ Province**	**City**	**Phone number**
1				Croatia	Split Dalmatia county	Kaštela	
2				Croatia	Split Dalmatia county	Kaštela	
4				Croatia	Split Dalmatia county	Kaštela	
5				Croatia	Split Dalmatia county	Kaštela	
6				Croatia	Split Dalmatia county	Kaštela	
7				Croatia	Split Dalmatia county	Solin	
8				Croatia	Split Dalmatia county	Solin	
9				Croatia	Split Dalmatia county	Klis	
10				Croatia	Split Dalmatia county	Klis	
11				Croatia	Split Dalmatia county	Split	
12				Croatia	Split Dalmatia county	Split	
13				Croatia	Split Dalmatia county	Split	
14				Croatia	Split Dalmatia county	Split	
15				Croatia	Split Dalmatia county	Split	
16				Croatia	Split Dalmatia county	Split	
17				Croatia	Split Dalmatia county	Split	
18				Croatia	Split Dalmatia county	Split	
19				Croatia	Split Dalmatia county	Kaštela	
20				Croatia	Split Dalmatia county	Solin	
21				Croatia	Split Dalmatia county	Split	
22				Croatia	Split Dalmatia county	Split	
23				Croatia	Split Dalmatia county	Split	

24				Croatia	Split Dalmatia county	Split	
25				Croatia	Split Dalmatia county	Split	
26				Croatia	Split Dalmatia county	Split	
27				Croatia	Split Dalmatia county	Split	
28				Croatia	Split Dalmatia county	Solin	
29				Croatia	Split Dalmatia county	Solin	
30				Croatia	Split Dalmatia county	Kaštela	
31				Croatia	Split Dalmatia county	Split	
32				Croatia	Split Dalmatia county	Split	
33				Croatia	Split Dalmatia county	Solin	
34				Croatia	Split Dalmatia county	Split	
36				Croatia	Split Dalmatia county	Split	
37				Croatia	Split Dalmatia county	Split	
38				Croatia	Split Dalmatia county	Split	
39				Croatia	Split Dalmatia county	Solin	
40				Croatia	Split Dalmatia county	Kaštela	
41				Croatia	Split Dalmatia county	Split	
42				Croatia	Split Dalmatia county	Solin	
43				Croatia	Split Dalmatia county	Solin	
44				Croatia	Split Dalmatia county	Kaštela	
45				Croatia	Split Dalmatia county	Kaštela	
46				Croatia	Split Dalmatia county	Split	

Furthermore, the identified stakeholders are grouped according to the type of beneficiary and participation in the project, area of intervention, domain of expertise and they are described by their institutional identification.

	Type	Nature	Area	Domain	Stakeholders and beneficiaries institutional identification		
	of stakeholder or beneficiary	of participation in the project	of intervention	of expertise	Institution or body name	Type of body	Function of the person
1		Project partner	Kaštela bay and Jadro River	Technical expert	PI RERA SD	Regional developement agency	Expert advisor
2		Project partner	Kaštela bay and Jadro River	Technical expert	PI RERA SD	Regional developement agency	Head of unit
3		Project partner	Kaštela bay and Jadro River	Technical expert	PI RERA SD	Regional developement agency	Expert advisor
4	policymaker	stakeholder	Kaštela bay and Jadro River	Technical expert	Kaštela	Municipality	Head of unit
5	policymaker	stakeholder	Kaštela bay and Jadro River	Technical expert	Kaštela	Municipality	Head of unit
6	policymaker	stakeholder	Kaštela bay and Jadro River	Technical expert	Kaštela	Municipality	Expert advisor
7	Policymaker	Stakeholder	Local government	Economy, environment EU funds	Solin	County	Head of department
8	Policymaker	Stakeholder	Local government	Economy, environment	Solin	County	Head of department
9	Policymaker	Stakeholder	Local government	Management	Klis	Municipality	Policy/elected
10	Policymaker	Stakeholder	Local government	Communal activity and physical planning	Klis	Municipality	Head of department
11	Policymaker	Stakeholder	Regional government	Management	Split Dalmatia county	Regional	Policy/elected
12	Policymaker	Stakeholder	Regional government	Economy, EU funds, agriculture	SD županija	Regional	Head of department
13	Policymaker	Stakeholder	Regional government	Concstruction and spatial planning	SD županija	Regional	Head of department
14	Category association	Stakeholder	Environmnet	Management	JU MORE I KRŠ	Public body	Director
15	Category association	Stakeholder	Environmnet	Management	JU MORE I KRŠ	Public body	Senior advisor oceanographer/project manager
16	Category association	Stakeholder	Environment	Management	JU MORE I KRŠ	Public body	Senior associate - biologist

17	Category association	Stakeholder	Water management	Management/provision	Hrvatske vode – Split	Agency public	Director
18	Category association	Stakeholder	Water management	Management /provision	Vodovod i kanalizacija Split	Agency public	CEO / Director
19	Category association	Stakeholder	Tourism	Administration	TZ Kaštela	County	Director
20	Category association	Stakeholder	Tourism	Administration	TZ Solin	County	Director
21	Category association	Stakeholder	Tourism	Administration	TZ Split	County	Director
22	Category association	Stakeholder	Tourism	Management	TZ SD županije	Regional	Director
23	Research centre	Partner	Environment	Science	Institut za oceanografiju i ribarstvo	Public body	Scientific Adviser
24	University	Stakeholder	Environment	Education and science	Sveučilište u Splitu	Public body	Head of the graduate study Marine fisheries
25	University	Stakeholder	Environment	Education and science	Sveučilište u Splitu	Public body	Head of the graduate study Ecology and Marine Protection
26	University	Stakeholder	Environment	Education and science	Sveučilište u Splitu	Public body	Head of the undergraduate study of Marine biology and technology
27	Citizan committee	Stakeholder	Environmnet	Environment	Udruga Sunce	NGO	President
28	Citizan committee	Stakeholder	Environment	Sport /fishing	Sportsko ribolovno nautičko društvo Jadro	NGO	Official
29	Enterprise	Stakeholder	Meat production and distribution	Production	Petason doo	Private body	Director
30	Enterprise	Stakeholder	Construction	Production	Cemex Hrvatska d.d.	Private body	
31	Enterprise	Stakeholder	Production and sales	Management	Nirs doo	Private body	Director
32	Enterprise	Stakeholder	Design and construction	Management	Tromont doo	Private body	Manager
33	Enterprise	Stakeholder	Production of car components	Management	AD Plastik doo	Private body	Technical director for Solin area – Manager

34	Citizan committee	Stakeholder	Environmnet	Environmnet	Udruga Oceanus – udruga studenata sveučilišnog odjela za studije mora	NGO	President
35	Citizan committee	Stakeholder	Civil protection	Provision	Hrvatska gorska služba spašavanja – stanica Split	NGO	Official
36	Museum	Stakeholder	Museum	Planning/programing/provision	Prirodoslovni muzej grada Splita	Public body	Official
37	Citizan committee	Stakeholder	Environmnet	Environmnent	Udruga za istraživanje i zaštitu prirode Codium	NGO	Official
38	Citizan committee	Stakeholder	Environment	Environment	Udruga za istraživanje, zaštitu i očuvanje mora i podmorja Triton Split	NGO	Official
39	Citizan committee	Stakeholder	Environmnet	Environment	Ronilačko ekološki klub Solin	NGO	Official
40	Category association	Stakeholder	Waste management	Management/provision	Zeleno i modro doo	Public body	Manager
41	Category association	Stakeholder	Forest	Management	Hrvatske šume – UŠP Split	National	Manager
42	Enterprise	Stakeholder	Production	Chocolate production	Nadalina Luxor doo	Private body	Director
43	Enterprise	Stakeholder	Fishing	Production	Ritterman doo (Trotta)	Private body	Director
44	Enterprise	Stakeholder	Transportation/ Tourism	Production	Damor doo	Private body	Director
45	Enterprise	Stakeholder	Transportation/ Tourism	Administration	Marina Kaštela	Private body	Director
46	Enterprise	Stakeholder	Waste management	Administration	Čistoća Split	Public body	Director

5.2 Participatory techniques and tools

Firstly, the Working group for the management of the participatory process was established. One member represents RERA S.D., one is representative of the Faculty of civil engineering, architecture and geodesy University of Split (FGAG) - the developer of the Adaptation Plan for the Pilot area, and one is external expert for the facilitating the participatory process and media/public relations.

The Working group made a plan for the participatory process, including workshops themes, structure, and timing, used techniques and design of the questionnaires. Also, the Working group organized the workshops and prepared all the reports.

Two participatory techniques were used:

- Codesign

FGAG expert team prepared draft documents that were presented to the participants during the workshops. The participants actively evaluated and commented draft documents during the workshops and also after via questionnaires. All that was recorded and summarized in the workshops reports.

- Self-compiled questionnaire

Participants were using questionnaires for providing additional information after the workshops (in case they needed additional documents or consultations, not available during the workshops).

5.3 Accessibility to the documentation

The working group shared all the documents with the FGAG expert team members via Google diskdrive.

For the workshops participants, documents were shared via e-mail prior to the workshops, during the workshop as printed materials and if requested by e-mail.

Documents distributed prior to the workshops and as printed materials during the workshops includethe following:

- developed draft documents;
- presentations;
- summary of the project (goals and objective);
- summary of the workshop (goals and objectives) and
- workshop agenda.

6. Synthesis of the preliminary document to feed the process for the Jadro River and Kaštela Bay Pilot Area

6.1 What are the conditions now?

The current state of water and threats of climate change

The Jadro river starts with spring Jadro as a karst overflow spring in the hilly karst area between the Kozjak and Mosor massifs at a height of about 33 m above sea level. The length of the river is 4.41 km. The average slope of the river bed is 7.48 ‰. It flows into the sea by flowing through a canyon formed by limestone cliffs north on the Kozjak slope and south by the Split Peninsula. The river has two characteristic catchment areas, the topographic catchment of the river and the groundwater catchment area of the Jadro spring. Jadro spring karst aquifers is nonhomogeneous underground reservoirs in which water collects in network of interconnected cracks, caverns, and channels. The behavior of karst aquifer is most often explained through three types of porosity, which include the porosity of micro pores, the porosity of small cracks and fractures, and the porosity of large fractures, pipes/openings. The density, frequency and number of cracks in the Dinarides vary with depth so that it is greatest on the surface and decreases significantly with depth. Due to these characteristics, the aquifer is rapidly filling and at high water levels it empties relatively quickly, while at low water levels it is much slower.

The present-day hydrological system of the Jadro river spring consists of the inner recharge area and outer catchment areas which include part of catchment area of river Cetina, Figure 2. Building in period from 1960-1986 a four Hydroelectric Power Plants on the Cetina River has changed the water regime and increase water level of the Cetina River, which resulted in infiltration of Cetina River waterinto the Jadro aquifer. In this way, the inner catchment area has extended and, as a result, it indirectlycomprises a part of the Cetina river catchment area. The Jadro spring and the nearby Žrnovnica springcatchments are generally perceived as one. According to various authors the total area of the Jadro and Žrnovnica spring catchment covers ca. 450 km^2, while spring Jadro catchment area is officially 130km^2 (Bonacci, 1987; Kapelj et al., 2001). Topographic catchment area of river downstream from springis small and covers 28.2 km^2. It is a typical karst spring with an uneven flow rate. Basic information about the river is given in Table 1. and Figure 1, 2 and 3.

Table 1. Basic data for Jadro river

Label	**JKRN935013**	**Hydrology Station No. 7221- Majdan**	**Characteristic Flows**
Name	JADRO		
River basin district	Jadran	Data period 1984-2013	
Sub-basin	Jadro and Ozrnja	Min flow	0.219 m^3/s
Ecotype	T21B	Max flow	78.13 m^3/s
Topographic catchment area	28.2 km^2	Ecological Min. monthly	2.0 m^3/s
Spring catchment area	130 km^2	Ecological Min. daily	1.8 m^3/s
Length	4.41 km	Min month average - August	2.83 m^3/s

Length of all streams	14.20 km	Max month average-December	14.64 m^3/s

Spring elevation	33 m above sea level	Yearly average flow	7.41 m^3/s
Average slope of river bad	7.48 ‰		

Precipitation (P) and Evapotranspiration (E) in the inner catchment area have the greatest impact on the spring discharge. According to the Köppen climate classification the wider area of the Jadro Spring is classified as Csb/Csa. These climates have warm, dry summers and cool, wet winters. Mean monthly temperature is about 13.2^{0}C. January appears to be the coldest month with a mean temperature of 3.9^{0}C and July the warmest month with a mean temperature of 23.3^{0}C. The long-termmean annual precipitation is about 1200 mm with a minimum of 796 mm and a maximum of 1775 mm. Precipitation is, on average, lowest in July (24 mm) and highest in November (233 mm). Variableprecipitation is characteristics of coastal areas, and the great inter-annual variability in total precipitation reflects the maritime character of the climate in the region.

As results fluctuations in the water level in the aquifer during the wet period of the year are significant, and the aquifer often responds relatively quickly to rainfall with a rapid increase (about 5-15 m/day) followed by a slower recession (1-5 m/day), and the mode of recession is often exponential-like. The magnitude of the discharge is a function of the previous state water table in aquifer and current water input (P-E).

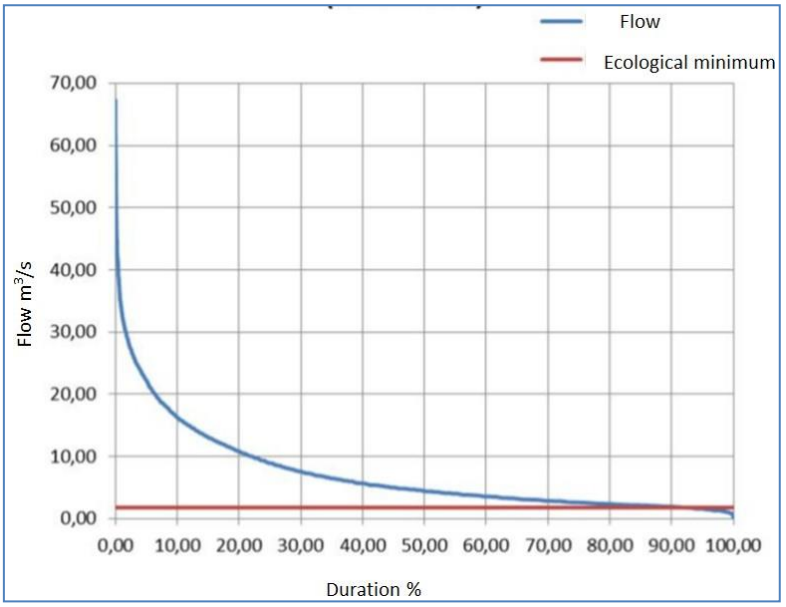


Figure 1. Flow duration curve of River Jadro (period 1984-2013)

The linear trend of min, max and average river flow changes is analyzed for the period 1984–2015. The statistically insignificant increasing trends characterize the time series of annual maximum, minimum and average discharges. The significant coefficient of determination (R^2 = 0.532) were determined for minimal discharge, poor for average (R^2 = 0.0784) and maximal discharge (R^2 = 0.0998),which indicates higher variability of maximal and average discharge and very low variability of minimaldischarge in

relation to the linear trend.

The conclusion is that so far nothing significant negative is happening for the water supply system related to natural supply (water stress). In the near-future the situation will probably remain as it is now. Biggest change is related to high flow (water hazard). In the future when significant climate change is predicted, the hydrological system of the Cetina and Jadro rivers will change, and will influence spring discharge. The question is how much? Answering this question is still challenge for researchers due to uncertainty of future climate variability predictions.

Figure 2. Jadro river spring catchment and the Cetina River

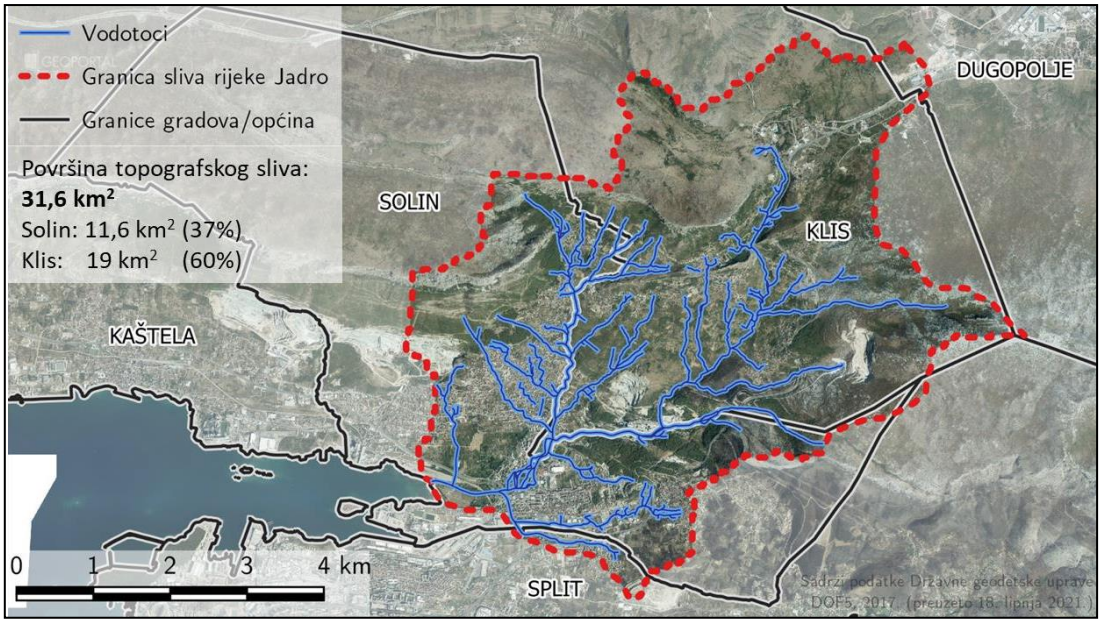


Figure 3. Jadro river topographic catchment area

In accordance with Water Framework Directive, Directive 2000/60/EC, River Jadro is a sub-basin of Adriatic river basin district. Consist of coastal water (No. O313-KAS), transitional water (No. tip P1_2, tip P2_2) , surface water (No. šifra JKRN935013) and groundwater (No. JKGIKCPV_10), Figure 4.

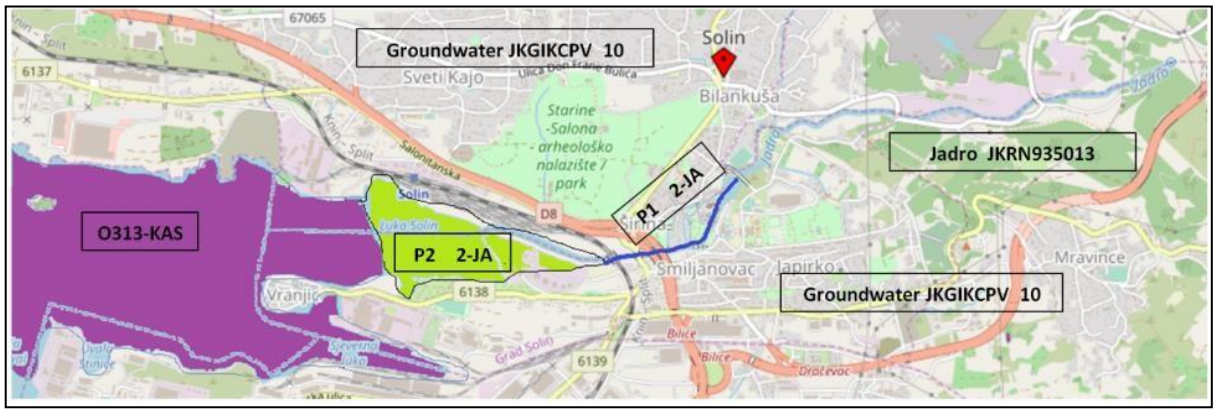


Figure 4. Jadro river water bodies

Current status of Jadro sub-basin waters are the following.

Coastal water — O313-KAS: Polychalic coastal sea of fine-grained sediment

Table 2. Status of coastal water

Status		Element	O313-KAS
Elements	Status	Phytoplankton	Good
		Nutrient concentration	Good

		Oxygenation concentration	Good
		Chlorophyll concentration α	Very good
		Makroalge	Poor
		Posednia oceanica	Poor
		Bentoski beskralježnici	N/A
	Hydromorphological status		Moderate
Ecological status			Poor
Chemical status			Good
General condition			bad

Transitional waters - The types of water bodies listed are:

- P1_2: Oligohaline estuary of coarse-grained sediment;
- P2_2: Mesohaline estuary of coarse-grained sediment.

Table 3. Status of transitional waters

Status		Element	Conditions	
			P1_2-JA (type P1_2)	P2_2-JA (type P1_2)
Elements	Status	Phytoplankton	Very good	Good
		Nutrient concentration	Very good	Very good
		Oxygenation concentration	Very good	Very good
				Good
		Chlorophyll concentration α	Very good	Very good
		Fish fauna	Good	Good
	Hydro morphological status		Moderate	Moderate
Ecological status			Moderate	Moderate
Chemical status			Good	Good
General condition			Not good	Not good

Groundwater - JKGIKCPV_10

Table 4. Status of groundwater

Mark	JKGIKCPV_10
Name	Cetina
Porosity	Fracture-cavernous
Area (km^2)	3,086.54
Average discharge ($x10^6$ m^3/year)	1,318
Natural vulnerability	Average - high
Quantitative status	Good
Chemical status	Good
General condition	Good

Summary for the Jadro river water bodies conditions:

- morphological and ecological conditions are mostly bad;
- chemical and physic-chemical conditions are good to very good.

The main generator of change is urbanization in catchment area which has direct impact on the infiltration and surface water flow regime, morphology of water bodies and biodiversity. Urbanization and human activities in catchment area (deforestation, wild fire) generates erosion and pollution of the water, especially by storm water. Climate change does not have a significant impact on water status for now (P – E), which does not mean that it will not have it in the future!

Due to the climate changes, the quantity and quality of water will change, as well as the safety of the environment (biodiversity), natural and built (vulnerability is growing). The cumulative negative effect is growing downstream from spring and environmental safety is declining. Transitional waters and the coastal sea are the most endangered by climate change and urban development. Ecosystem services in these areas will be reduced especially regulating services include pollination, decomposition, water purification, erosion and flood control, and carbon storage and climate regulation, etc.

Regarding water regimes, the trends are the following.

- Low waters:
  - Longer low flow period in the dry season – increase of water stress;
  - The trend is further lowering of low flow waters;
  - The trend is a longer duration of low flow periods;
  - Ecological and socio-economic drought.
- High waters:
  - More precipitation in the rainy season;
  - The trend is increase in variability and of the extremes quantities;
  - Increase in frequency of the extremes occurrence;
  - Increase in surface and peak runoff and related water pollution;
  - Increase of land erosion;
  - Increased erosion of shores and riverbeds;
  - Floods hazard (Figure 5).

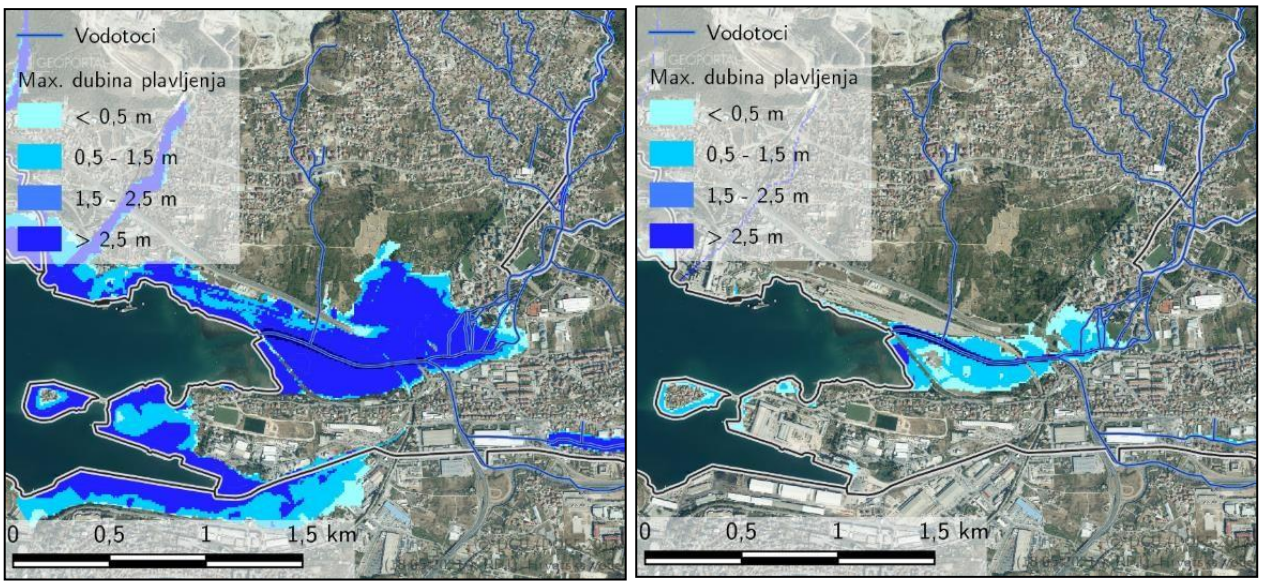


Figure 5. The Jadro river flood hazard map for low (left picture) and high (right picture) probability of occurrence

- Average annual water quantities:
  - The trend is declining;
  - Impact on the natural environment and water budget;
- Drought:
  - Meteorological drought increased- less precipitation in total;
  - Hydrological drought increased - less water in water resources;
  - Agricultural drought increased - less water in the soil;
  - Socio-economic drought increased - smaller supply capacities;
  - Ecological drought increased - less water for biological communities and ecosystems.

Water quality will progressively deteriorate over time and with the flow of water from the source to the sea. Water quality deteriorates as water flows from the spring to the sea, that is, as the size of the basin from which the water flows into the river increases.

Rain duration and intensity and built environment characteristics are the main drivers of water quality changes. Urbanization causes the reduction of infiltration, base runoff and low waters. Urban waters, diffuse sources of pollution and air pollution are the main threats to the environment.

Consequently, biodiversity will progressively deteriorate over time and with the flow of water from spring to the sea. The sustainability of nature protected areas and the planned use of water is questionable.

Climate change is increasing all the negative trends!

The current state of urbanization and the threats of excessive urbanization

Considering the current state of urban areas in the topographic catchment area of the Jadro river, the following negative impacts of climate change have been selected as the most important:

- Coastal flooding;
- Flash floods;

- Stormwater;
- Heatwaves;
- Droughts;
- Wild fires.

Thus, the three specific endangered areas and corresponding threats are identified:

- Mouth of the Jadro river and coastal flooding and pollution;
- Permeability of urban areas and flash / stormwater floods (undeveloped storm water drainage);
- Anthropogenized river and watershed area.

Figure 6. The estuary of the Jadro River with elevation line showing 1.5 m above sea level

Mouth of the Jadro river represents the most vulnerable part due to the risks of coastal flooding, accumulation of the pollution from the whole river basin, sediments input and hence endangered biodiversity, natural environment and protected environment of the estuary and preservation of the quality of coastal waters in the Kaštela Bay (Figure 6).

In the topographic catchment of the Jadro river, there is a high proportion of urban areas (Figure 7). Today, storm water drainage is largely undeveloped and future climate changes will cause more occurrences of heavy rains and thus surface water and risk of flash floods. Furthermore, flow of rainwater through urban space will cause and increase water pollution and furthermore pollution of the waters in the Jadro river and finally at the end coastal sea of the Kaštela Bay.

Permeability of built / artificial (gray) areas in the topographic catchment of the Jadro river is derived from the Copernicus Land Monitoring Service (Copernicus Programme, implemented by the European Commission), Figure 8. The results are as follows.

In the area of the City of Solin, the permeability of urban areas is the following:

- Built settlement areas, mixed use - developed: approx. 50% impermeable;
- Built settlement areas, mixed use - undeveloped: approx. 10% impermeable.

In the area of the Municipality of Klis, the permeability of urban areas are the following:

- Built settlement areas: approx. 13% impermeable;
- Unbuilt settlement areas: approx. 4% impermeable.

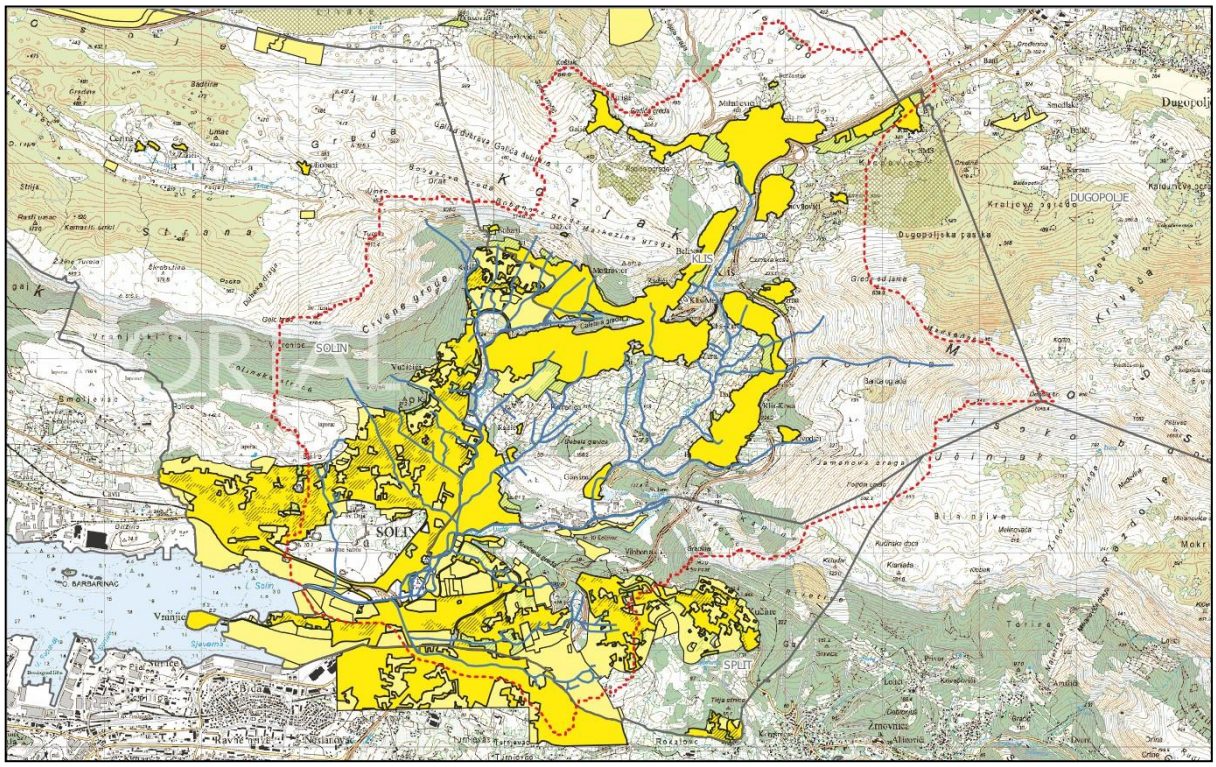


Figure 7. Urban areas in the topographic catchment of the Jadro river

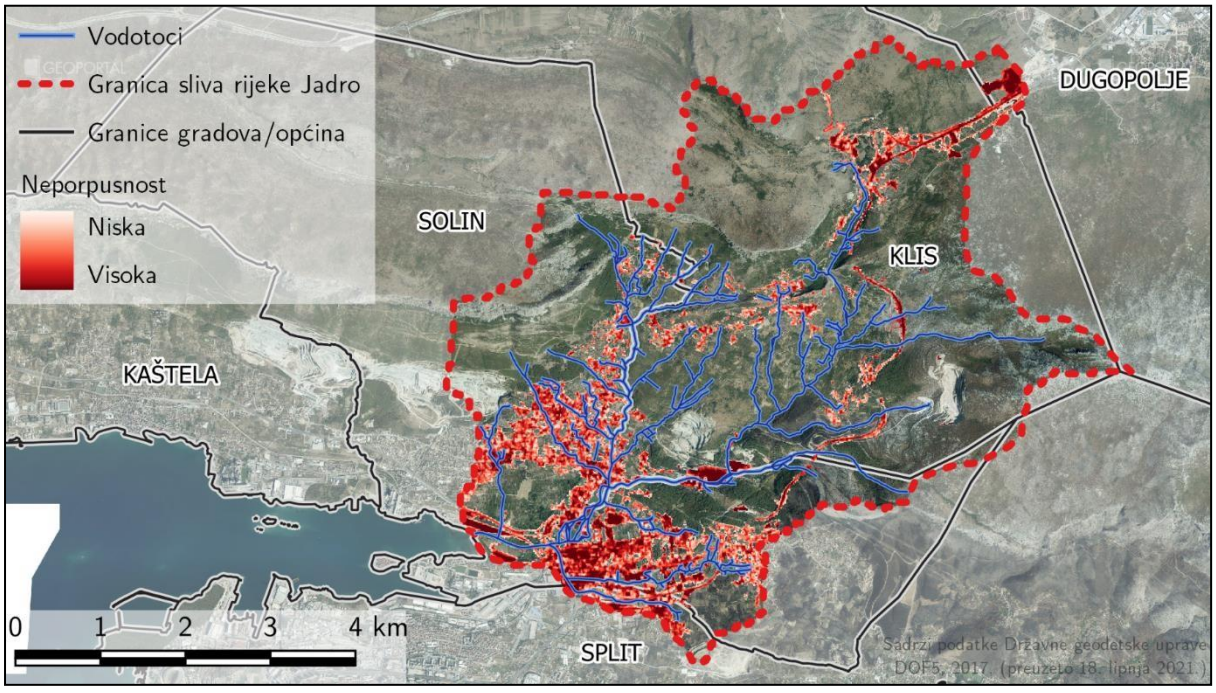


Figure 8. Permeability of artificial areas in the topographic catchment of the Jadro river (data derived from the Copernicus EU land monitoring programme)

Regulation / construction of the river banks (Figure 9) leads to the destruction of the natural environment and biodiversity, and further negative impact comes from the direct local use of the river for the disposal of impurities and waste, mooring and maintenance of ships, recreation and fishing, etc. The middle and lower course of the river has built-up concrete banks and bed and so the natural river has already turned into an urban channel.

Figure 9. The Jadro river banks and beds in lower course of the river

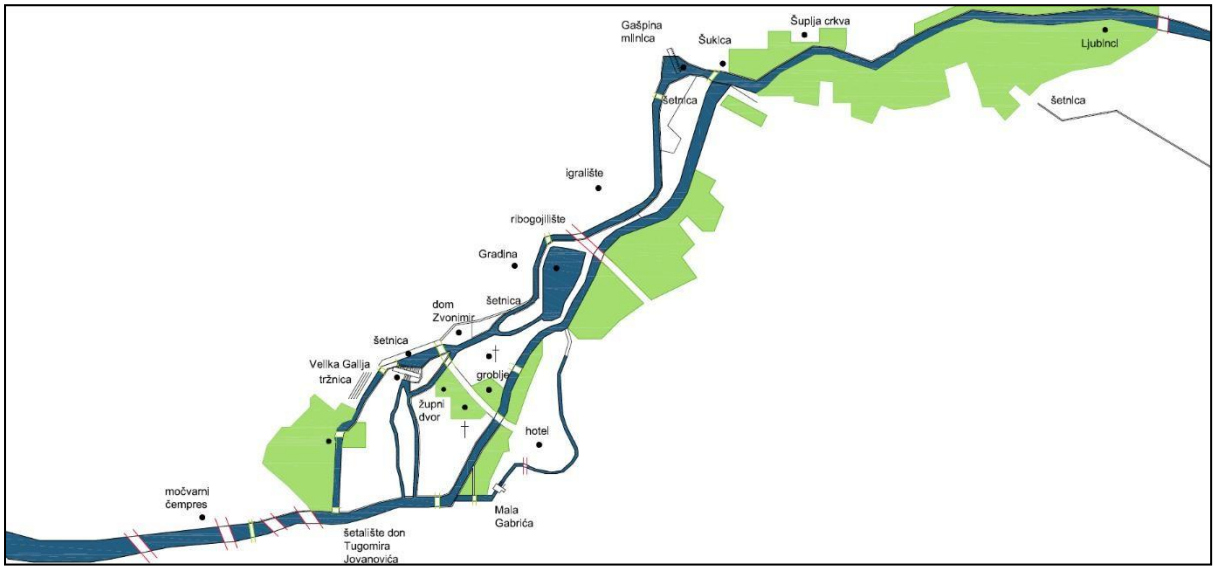


Figure 10. Highly urbanized area with anthropogenized rive: heart of the city of Solin in the lower course of the Jadro river

Further urbanization of the topographic catchment of the Jadro river is foreseen through continuous demographic growth in the area. In the period 2001.-2011. the population growth was 26% for the City of Solin and 10% for the Municipality of Klis. The growth comes from migration (extension of the Split urban agglomeration) and not from natural population growth.

6.2 Which future we see for this area?

Further urbanization of the topographic and hydrological catchment area without the construction of appropriate infrastructure, primarily drainage and treatment of sanitary and storm water and waste disposal without negative effects on the environment will endanger the following:

- quality of water at source;
- cause river pollution from tributaries and dirty water from urban areas;
- cause coastal sea pollution.

Climate change will further worsen this situation as it will increase the risks of coastal flooding at the most densely urban area - the center of the Solin, increase the risk of flashfloods and fires followed by increased soil erosion and additional water pollution. Ultimately, the safety of environment and sustainability and quality of livelihood in this area will be reduced.

A possible improvement and prevention of the above scenario is in a paradigm shift - building settlements in a way that maximally preserves, even restores the natural environment (e.g., renaturalization of rivers and tributaries) and biodiversity.

Ecosystems - such as forests, waters, estuaries, wetlands and grasslands - are a critical part of the global water cycle. All fresh water ultimately depends on the continued healthy functioning of the ecosystem. Ecosystems mitigate the effects of floods and droughts. 'Ecosystem services' can contribute to wastewater treatment as an alternative to or complement to conventional water treatment systems, especially urban rainwater and road water. The water purification process provided by aquatic and terrestrial ecosystems provides water suitable for drinking, industry, recreation and wildlife habitat. Healthy ecosystems clean water, purify the air, maintain the soil, regulate the climate, recycle nutrients and provide us with food. Biodiversity improves water quality and helps ecosystems withstand increasing pollution pressures.

Therefore, it is necessary to preserve ecosystems and biological diversity in the area of the Jadro River basin, and especially in the hydrological basin of the Jadro spring (water supply).

6.3 Which objectives and strategies?

The main objective is: Preservation and improvement of the quality of life, through the preservation of water and the natural environment.

The main strategies are:

Jadro river

Blue-green heart of Solin, the backbone of urban life (continuous promenade - rest areas, access to the sea, connecting key points of cultural and historical importance), protection of natural features of the northern part of the stream, renaturalization (redevelopment) of the river, green belt corridor establishment, and ecological riverfront design.

Mouth of the Jadro river

Protection from coastal flooding, protection from pollution from the whole basin, sediments management, protection of biodiversity and natural environment, enabling access to the sea for citizens, preservation of water quality in the Kastela Bay.

Basin of the Jadro river

Preservation of water quality, natural environment and quality of life through controlled urbanization; preservation of green areas; construction and landscaping with careful attention to parameters to ensure permeability; affirmation of green typologies of construction (gardens, green terraces and roofs, etc.); revision of density guidelines with the aim of freeing up space, and in accordance with demographic projections and housing policies and tourism strategies, implementation of Water Sensitive Urban Design.

6.4 What we suggest doing in this frame?

Jadro river

Protection of natural resources, biodiversity and endemic species of the river Jadro (restoration ofnatural functions of the river Jadro):

- Control the implementation of measures on protected parts of the stream (e.g. fishing ban);
- Identify zones suitable for re-naturalization /redevelopment of the main stream;
- Preserve the landscape values of the flow of the river Jadro:
- Sustainable development by implementation of Ecologically Sustainable Development;
- Riverbanks, shorelines, riparian buffers, and river habitat development.

Mouth of the Jadro river

- Coastal flooding protection by use of nature based solutions.

Basin of the Jadro river

- Preservation of natural tributaries / torrents of the river Jadro;
- Determination of zones suitable for re-naturalization/redevelopment of tributaries / torrents of the river Jadro;
- Water Sensitive Urban Design;
- Integrated management for urban water conservation, wastewater minimisation, and storm water management;
- Construction of sanitary and storm sewer with treatment plants;
- Incorporate a green-blue infrastructure development plan into the planning with the aim of reducing the volume of water to be evacuated, thus significantly reducing the cost of the system and preserving natural processes;
- Control of the functioning of already built sewer systems;
- Managing the demand for water;
- Assessing the appropriate potable or alternative supply of water for the end purpose;
- Applying best practice to storm water management;
- Strengthen fire protection activities and the capacity of fire protection forces;
- Afforestation of the burnt areas;
- Protection against water pollution of the basin from the exploitation fields of raw materials (open pits and plants);
- Redefining the provisions for construction in the area of the hydrological basin;
- Establishment of a system for monitoring aquifer capacity in the basin.

7. Synthesis of the participatory process and outcomes

7.1 Workshops

Participatory workshops for the Jadro River and Kaštela Bay Pilot Area covered three topics, as defined by the Project:

- Climate change impacts;
- Scenarios and adaptation measures and
- Planning options.

Due to the covid-19 health crisis and imposed measures that limit organisation of workshops, the Working group decided to organise two live workshops covering all three topics. The goal was to ensure active participation of the attendants and discussion in live. Two workshops were carried out as follows.

The first workshop

- Covered topics: Climate change impacts on the River Jadro and Kaštela Bay including first proposal of scenarios and adaptation measures
- Date: 23rd June 2021. 9:00-11:30
- Location: Kaštel Lukšić
- Participation: 22 participants (representing 8 stakeholders)

The second workshop

- Covered topics: Scenarios and adaptation measures including proposal for planning options
- Date: 15th October 2021. 11:00-13:30
- Location: Solin
- Participation: 24 participants (representing 7 stakeholders)

7.2 The first workshop

Workshop title

Climate change impacts on the River Jadro and Kaštela Bay including first proposal of scenarios and adaptation measures

Workshop content

09:00 - 09:15
Introductory about the project and the plan
mr.sc. Mili Novak, RERA S.D. and Ph.D. Martina Baučić, FGAG

09:15 - 10:00
The current state of water and the dangers of climate change
dr.sc. Jure Margeta, Professor Emeritus, FGAG
The current state of urbanization and the dangers of excessive urbanization
dr.sc. Ana Grgić, Ph.D. Hrvoje Bartulović, FGAG

10:00 - 10:30
Discussion and supplementation of findings by stakeholders (filling in the questionnaire)
Visions and measures for the future use of the Jadro river area

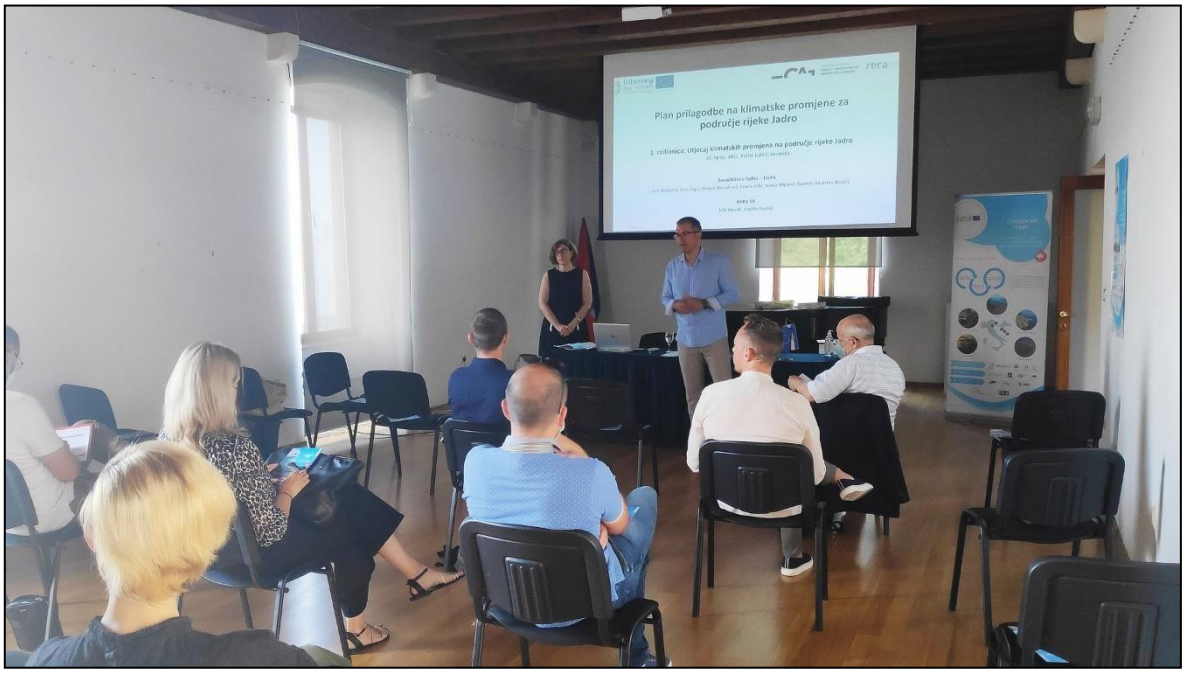
10:30 - 11:00
Socializing

Media clipping

The first workshop was accompanied by media reports, radio reports and publications of articles on portals and on the following media:

- HRT – REGIONALNI DNEVNIK (https://drive.google.com/drive/folders/18jImEDVfCTRN3YXrWBsLxicYrZCtfPNm)
- TV JADRAN, VIJESTI (https://drive.google.com/drive/folders/18jImEDVfCTRN3YXrWBsLxicYrZCtfPNm)
- PORTAL GRADA KAŠTELA - http://kastela.org/novosti/aktualnosti/55310-odrzana-radionica-u-sklopu-plana-prilagodbe-na-klimatske-promjene-za-podrucje-jadra-i-kastelanskog-zaljeva
- GRAD KAŠTELA - https://www.kastela.hr/novosti/clanak/utjecaj-klimatskih-promjena-na-podrucje-rijeke-jadro-i-kastelanski-zaljev
- GRAD SOLIN - https://www.solin.hr/novosti/utjecaj-klimatskih-promjena-na-podrucje-rijeke-jadro-i-kastelanski-zaljev/
- DALMATINSKI PORTAL - https://dalmatinskiportal.hr/vijesti/radionica-plan-prilagodne-na-klimatske-promjene-rijeke-jadro-i-kastelanskog-zaljeva/101670
- DALMACIJA DANAS - https://www.dalmacijadanas.hr/u-dvorcu-vitturi-odrzana-prva-radionica-na-temu-utjecaj-klimatskih-promjena-na-podrucje-rijeke-jadro-i-kastelanski-zaljev/
- JUTARNJI.HR -https://www.jutarnji.hr/planet/podrucje-rijeke-jadro-i-kastelanski-zaljev-jedno-su-od-pet-pilot-podrucja-u-okviru-projekta-change-we-care-15083119
- 021 PORTAL - https://021portal.hr/odrzana-radionica-na-temu-utjecaj-klimatskih-promjena-na-podrucje-rijeke-jadro-i-kastelanski-zaljev/
- LOKALNA HRVATSKA - https://lokalnahrvatska.hr/vijest.php?nw=1422_1624453660

Photographs



7.3 The second workshop

Workshop title
Scenarios and adaptation measures including proposal for planning options

Workshop content
11:00 - 11:15
Introduction
Ivica Rakušić, Deputy Mayor of Solin, Jakov Vetma, Mayor of Klis
mr.sc. Mili Novak, RERA; dr.sc. Martina Baučić, FGAG
11:15 - 12:00
Adaptation measures scenarios, planning options
dr.sc. Jure Margeta, Professor Emeritus, FGAG
dr.sc. Ana Grgić, Ph.D. Hrvoje Bartulović, Ph.D. Martina Baučić, Frane Gilić FGAG
12:00 - 12:15
Report on the collection of data on coastal and related systems
dr.sc. Luka Babić, Faculty of Geodesy, Zagreb
12:15 - 13:00
Discussion and supplementation of findings by stakeholders (filling in the questionnaire)
13:00 - 13:30
Socializing with refreshments

Media clipping
The second workshop was accompanied by media reports, radio reports and publications of articles on portals and on the following media:

- TELEVIZIJA DALMACIJA - https://drive.google.com/drive/folders/1nKhuFQMnkmEXHQB0S9K9Y2dwN0jnF9ZK
- TV JADRAN - https://drive.google.com/drive/folders/1nKhuFQMnkmEXHQB0S9K9Y2dwN0jnF9ZK
- PORTAL GRADA KAŠTELA – NAJAVA https://kastela.org/novosti/hr/57903-u-petak-radionica-scenariji-adaptacijskih-mjera
- DALMATINSKI PORTAL - https://dalmatinskiportal.hr/vijesti/odrzana-druga-radionica-u-sklopu-projekta--change-we-care-pokrenutog-s-ciljem-ocuvanja-jadra/112733
- DALMACIJA DANAS - https://www.dalmacijadanas.hr/scenariji-adaptacijskih-mjera-odrzana-druga-radionica-u-organizaciju-ju-rera-i-fakulteta-gradevinarstva-arhitekture-i-geodezije
- JUTARNJI.HR – https://www.jutarnji.hr/planet/kako-bi-ojacala-odrzivost-i-otpornost-vodenih-resursa-naselja-treba-transformirati-iz-tvrdih-i-sivih-u-meka-i-zelena-15110438
- KASTELA.ORG - http://www.kastela.org/novosti/aktualnosti/57979-odrzana-druga-radionica-scenariji-adaptacijskih-mjera
- RADIO JAVLJANJE za HRT SPLIT i radio Dalmaciju.

Photographs

8. Inclusion of the process outcomes in the Adaptation Plan for the Jadro River and Kaštela Bay Pilot Area

By studying and summarizing the records from the workshops discussions and filled questionnaires, the main outcomes from the participatory process are as follows. The participants have recognized the following issues as threats/problems and also suggested several measures.

Threats:

- Pressure for “urbanization” in all areas of the river basin but also in agriculture fields (asphalting of roads, surfaces…);
- Potential problems of water pollution due to highway impact;
- During summer the amount of water in the river Jadro is below the set biological minimum;
- Uncontrolled "use" of the river (waste disposal, fishing?);
- Rain and urbanism are the main drivers of water quality degradation;
- Tributaries/torrents are serving more and more as storm water drainage from urban areas (polluted waters) and also place for garbage disposal.

Measures:

- Necessity for one institution that will take care of the river Jadro and its basin (goal: to unite the efforts of Solin, Klis and competent companies and institutions, to achive integral approach for river management);
- Urbanization - need for control: built on site versus built permit;
- Jadro as main source of drinking water for the whole agglomeration: the need for an investigation for alternative source;
- Development of sanitary and storm water drainage system with water treatment and purification for all the settlement on the basin;
- Development of new construction specifications and national laws for systems based on “green infrastructure” concept (to allow development of green infrastructure, e.g. for parking areas);
- Development of plans for green infrastructure and implementing green infrastructure features in spatial plans.

All the above outcomes are incorporated in the Adaptation Plan for the Jadro River and Kaštela Bay Pilot Area.

9. Closing remarks on the experience, future implementation and transferability

During the workshops discussion, it turned out that this was a rare opportunity for all stakeholders to express their views and problems. Particularly in the case of the management of the Jadro river basin, where an integral approach is required, and the basin is divided between several administrative units and several sectors. That complicates the management of both the strategic and daily operational activities. As an illustration, one bank of the river is in one municipality and the other in another municipality.

Most of the Croatian coastal cities has storm water drainage system undeveloped, has hilly area behind and green infrastructure is potential solution for future. Therefore, any experience in analyzing the needs for green infrastructure, planning and preferably implementing is highly transferable for any Croatian coastal city.