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Issues in WRM in Croatia in climate change context

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University of Rijeka, Faculty of Civil Engineering - UNIRIFCE

Theme-based training of teaching staff for acquiring new teaching and learning methods, Rijeka, 19/09/2019

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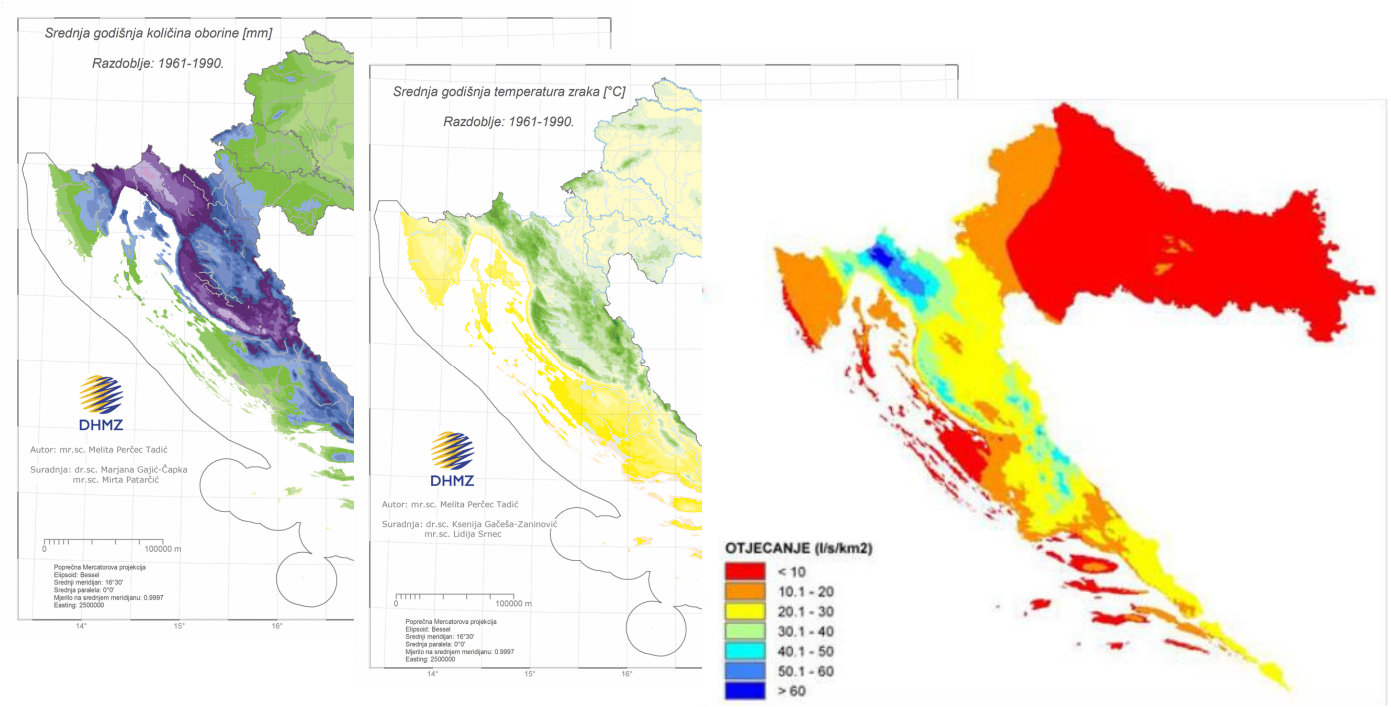
CONTENT:

1. Introduction on water bodies in Croatia
2. Characteristic of climatological and hydrological trends
3. Assessment of climate change effect on Croatia and adaptive measures
4. Research results from various UNIRI-FCE projects
5. Challenges and new solutions in water management in Croatia

1. INTRODUCTION ON WATER BODIES IN CROATIA

Croatia, although relatively small by size (56.578 km^2 land, 31.067 km^2 coastal line), **is climatologically and hydrologically extremely diverse,** which represents a wealth but also a challenge for the appropriate water resources management.



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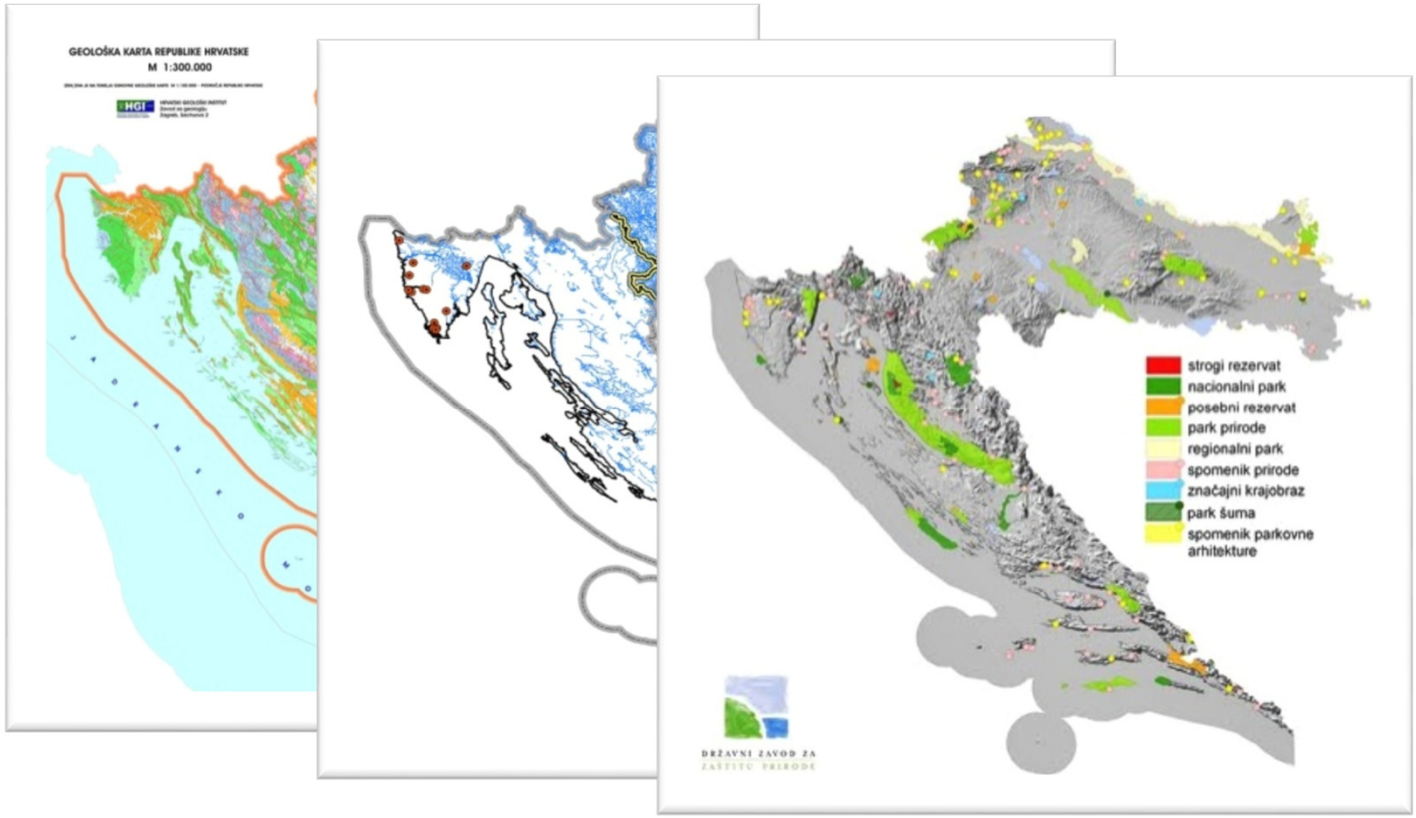
With **different climatic conditions**, the **hydrographic features** and **water resources** are greatly influenced by the **geological structure**, **with karst and protected areas** with a particularly pronounced risk of water management being highly represented.



Extremes are also becoming **more frequent** and affect larger regional areas, some of which can be attributed to **climate change/climate variation.**

Extreme drought 2003., **2011.- 2012.** and 2015.g

Extreme high waters and floods in Sava, Kupa and Una basins 2014., 2015., 2018.

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Croatia is also characterized by the **increasing occurrence of precipitation extremes and the floods caused by them**

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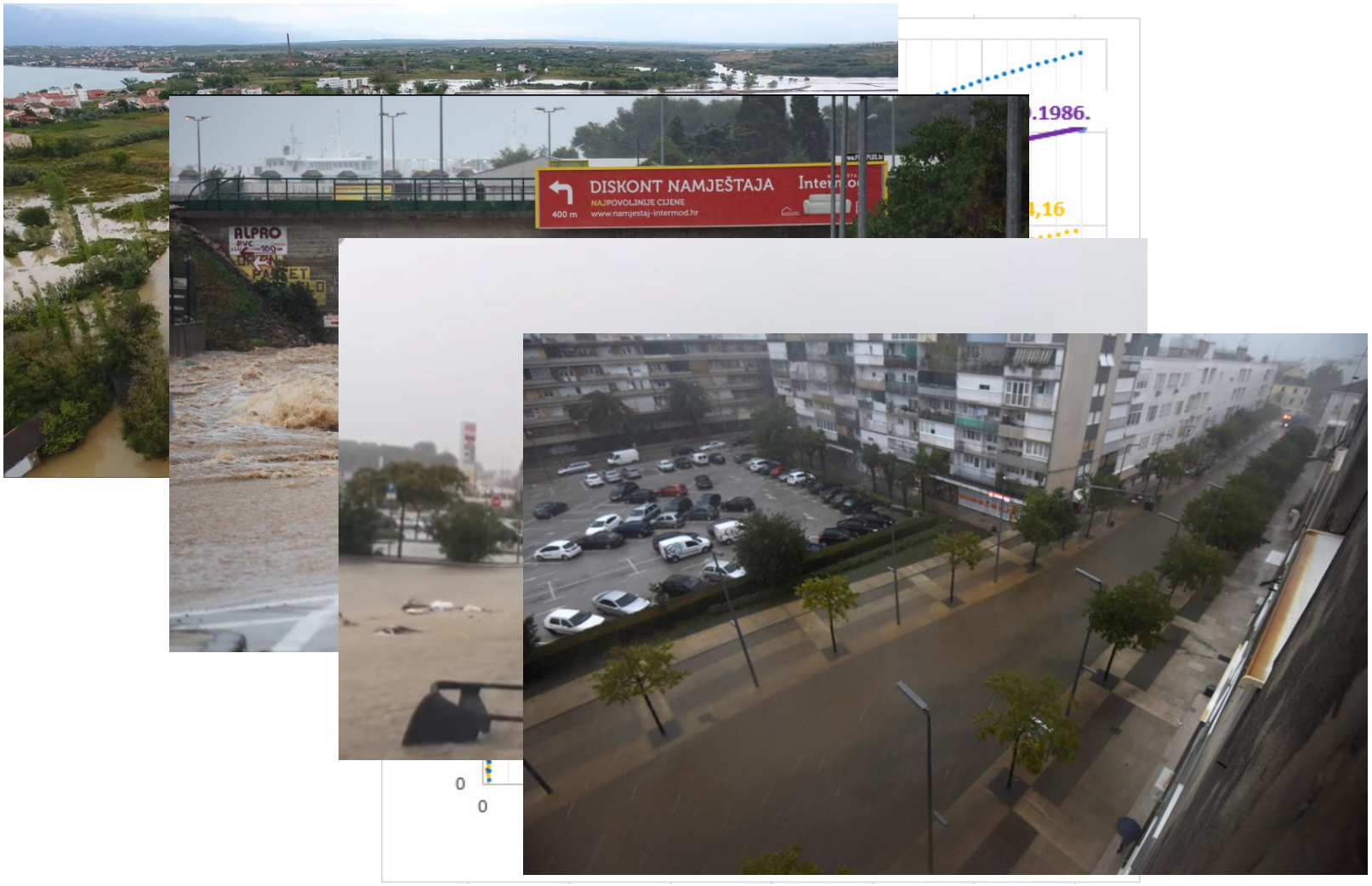
Flood in Zadar 11.9.2017.



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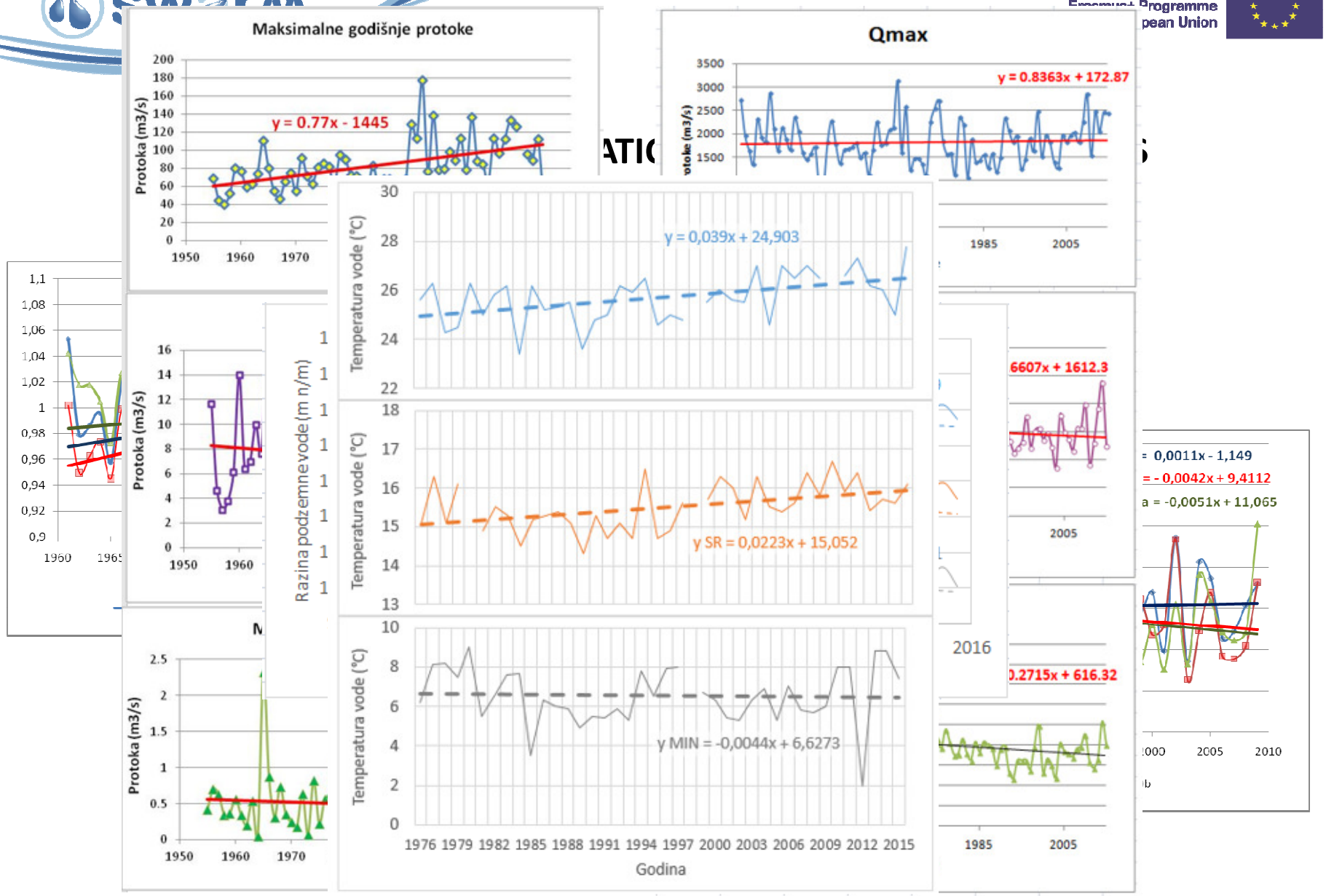

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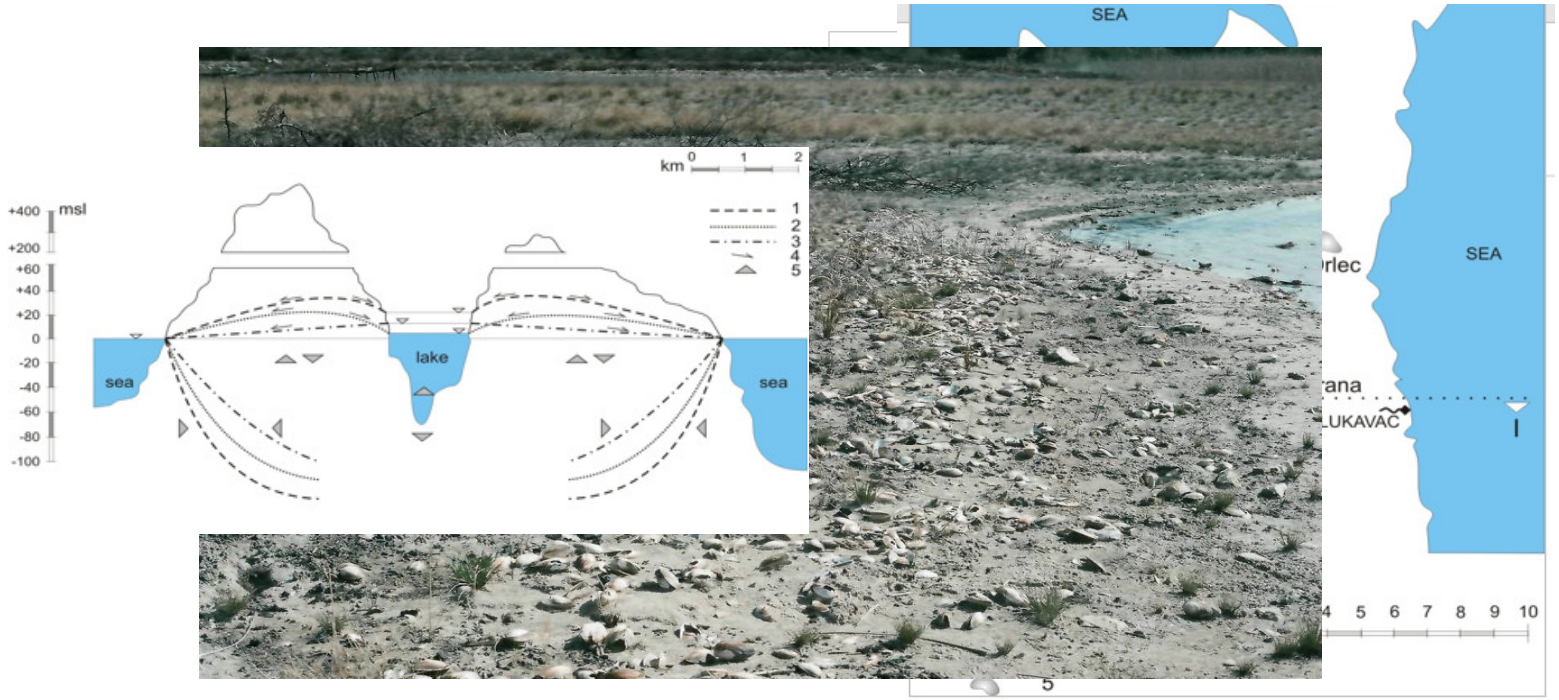
3. ASSESSMENT OF CLIMATE CHANGE EFFECT ON CROATIA AND ADAPTIVE MEASURES

- the beginnings of research in the early 1990s **/ UN project Cres – Lošinj.**
Mostly because of worrying trends on Lake Vrana on the island of Cres



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United Nations Fran NFCCC (1992, effective 1994) – accepted by

Croatia has acceptec produce and submit **every four years a n** e obligation of the Convention.

First report from 20(essing possible climate change (for the perio ulnerability assessments, definin sions CO_2 and **adapting** to CC.

The importance of C ed in the document and the **first one am ector „Hydrology, water and marine re**

REPUBLIKA HRVATSKA

MINISTARSTVO ZAŠTITE OKOLIŠA I ENERGETIKE

SEDMO NACIONALNO IZVJEŠĆE I TREĆE DVOGODIŠNJE IZVJEŠĆE REPUBLIKE HRVATSKE PREMA OKVIRNOJ KONVENCIJI UJEDINJENIH NARODA O PROMJENI KLIME (UNFCCC)

Zagreb, rujan 2018.

Public debate is e-Savjetovanja **ATE CHANGE ADAPTATION STRATEGY IN TH OD to 2040 WITH A VIEW TO 2070**

As a part of its c **trengthening the capacity of the Ministry of tion to climate change and preparation of rategy"** was implemented, financed by the ncy, and for the needs of the Ministry of Envi

JAVNO SAVJETOVANJE O NACRTU STRATEGIJE PRILAGODBE KLIMATSKIM PROMJENAMA U REPUBLICI HRVATSKOJ ZA RAZDOBLJE DO 2040. GODINE S POGLEDOM NA 2070. GODINU

Within the proj **simulations were carried out under different water resources were assessed, propo e, as well as an action plan.**

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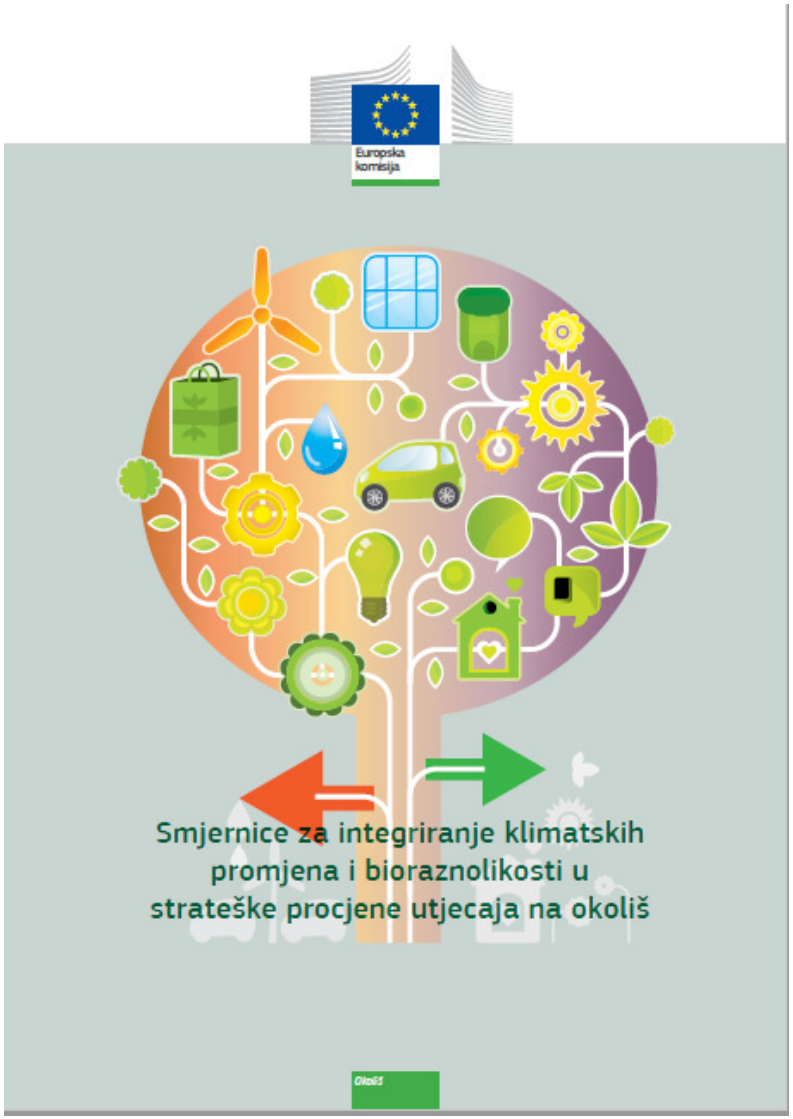
CC impact assessments on water resources **– Strategic environmental assessments and environmental impacts assessments (NN 61/2014; 3/2017).**
These water assessments are based on **European Commission`s guidelines for incorporating climate change and biodiversity into Environmental impact assessment (2013).**
They assess the impact of analyzed intervention (categorized into three levels of significance) **on the environment as well as the environment on the intervention, including the impacts of climate change.**



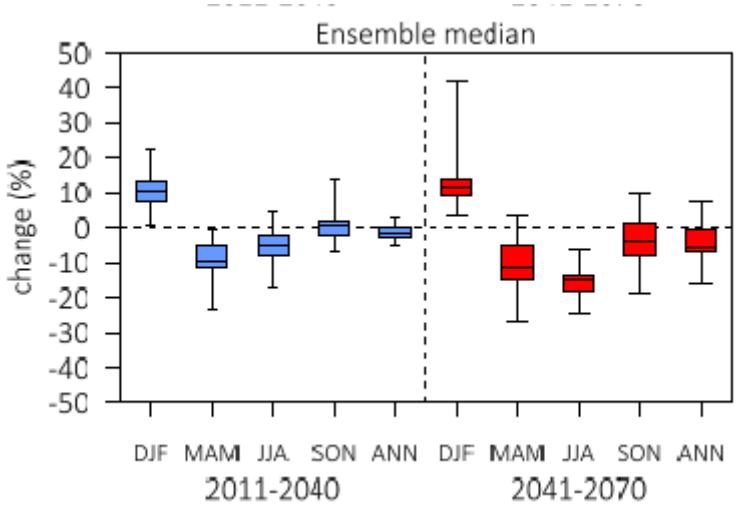
Climate change impacts are also assessed through **water management plans – e.g. in the Sava River Basin – (International Sava River Basin Commission, 2015)**

WORLD BANK GROUP
Water

Trust Fund for Environmentally & Socially Sustainable Development

WATER PARTNERSHIP PROGRAM

Water & Climate Adaptation Plan for the Sava River Basin



Changes in average seasonal and annual flow

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4. RESEARCH RESULTS FROM VARIUS UNIRIFCE PROJECTS

CCWaterS

Vransko jezero u Dalmaciji

DrinkAdria

NP Krka

Rainman

Plitvička jezera

STRATEGIJA PRILAGODBE KLIMATSKIM PROMJENAMA | *Jačanje kapaciteta Ministarstva zaštite okoliša i prirode za prilagodbu klimatskim promjenama te priprema Nacrta Strategije prilagodbe klimatskim promjenama*

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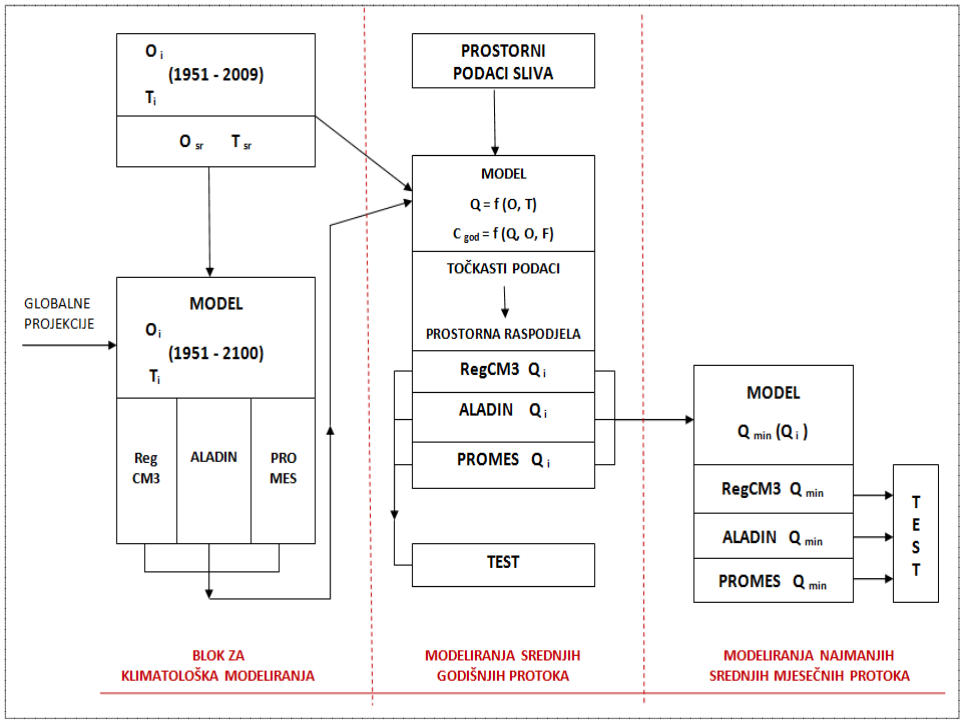
METHODOLOGY FOR THE ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES

Modelling climate changes:

- **Climatological models** (modelling monthly rainfall and temperatures for various climate scenarios and various types of global and regional models)
- **Hydrological models** (based on generated rainfall and temperatures from climate models derived flows and water temperature – application of **artificial intelligence models**)



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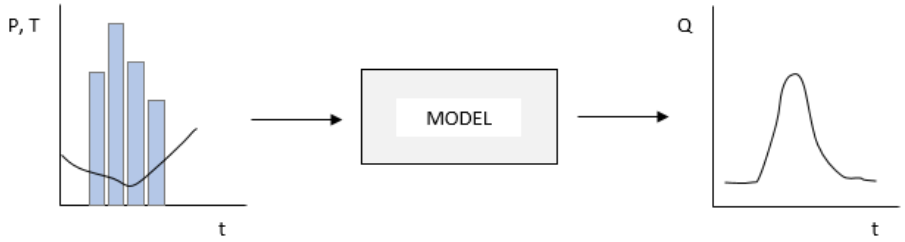
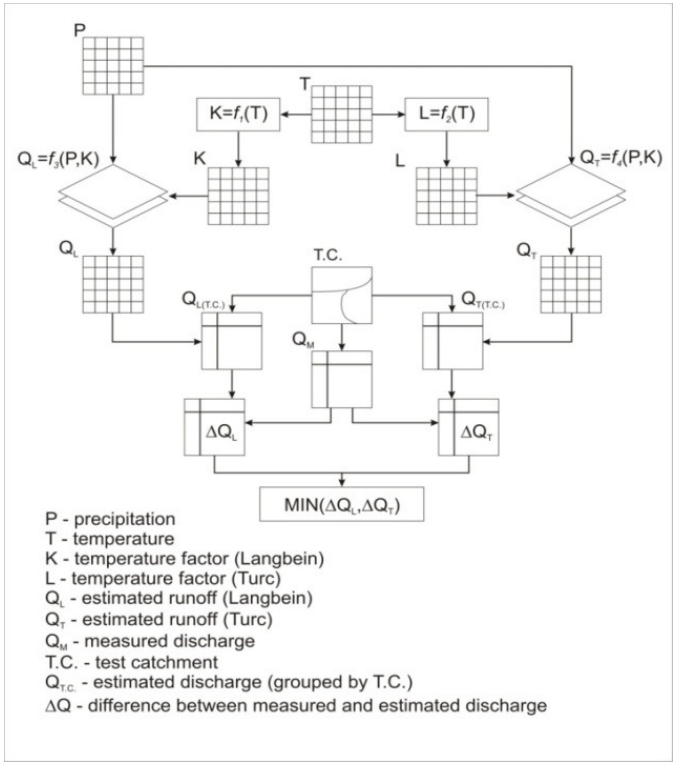
METHODOLOGY FOR THE ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES

Application of **hydrological models** with input dana – **measured and prognosed climatological data and measured hydrological data.**



Application of various types of hydrological models – depending on hydrological input data availability.

Very common application in different modelling phases from **machine learning domain – neural networks** and **decision making regression trees**.



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CC-WaterS

http://www.ccwaters.eu/

Participants from Croatia:
- Croatian Waters
- Croatian Geological Institute
- University of Rijeka, Faculty of Civil Engineering

Lake Vrana on Cres island

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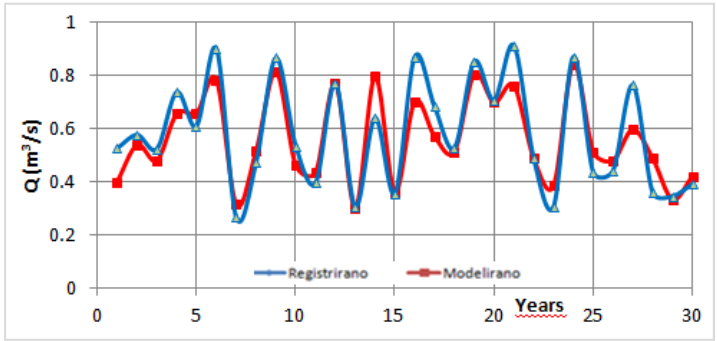
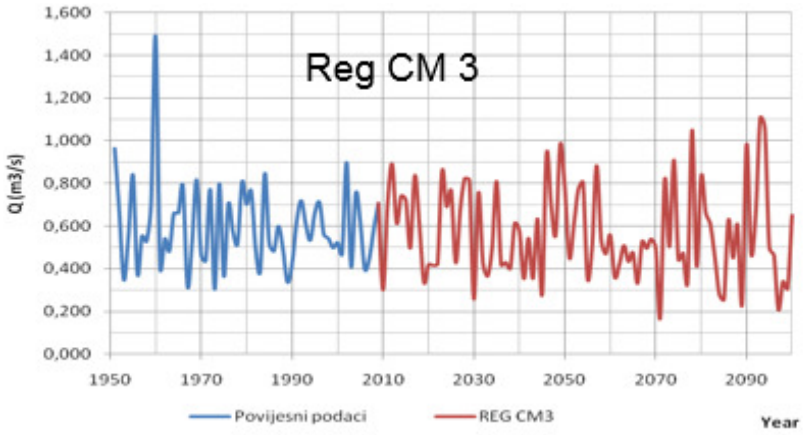
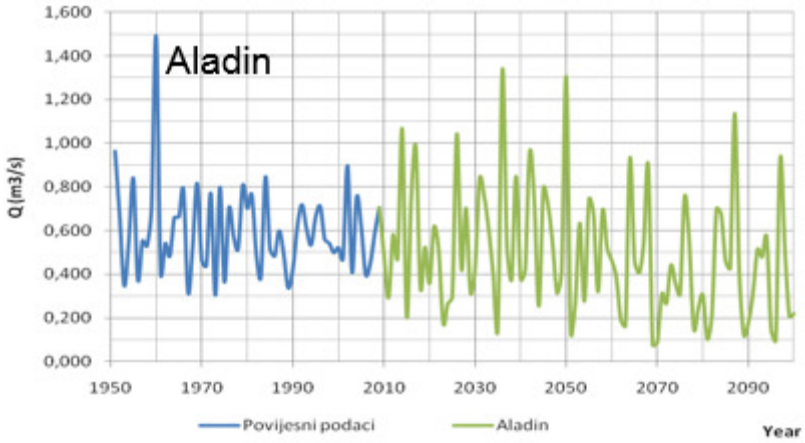
CC-WaterS

Average annual inflow assessment in Vrana lake on island of Cres according to results from climate models







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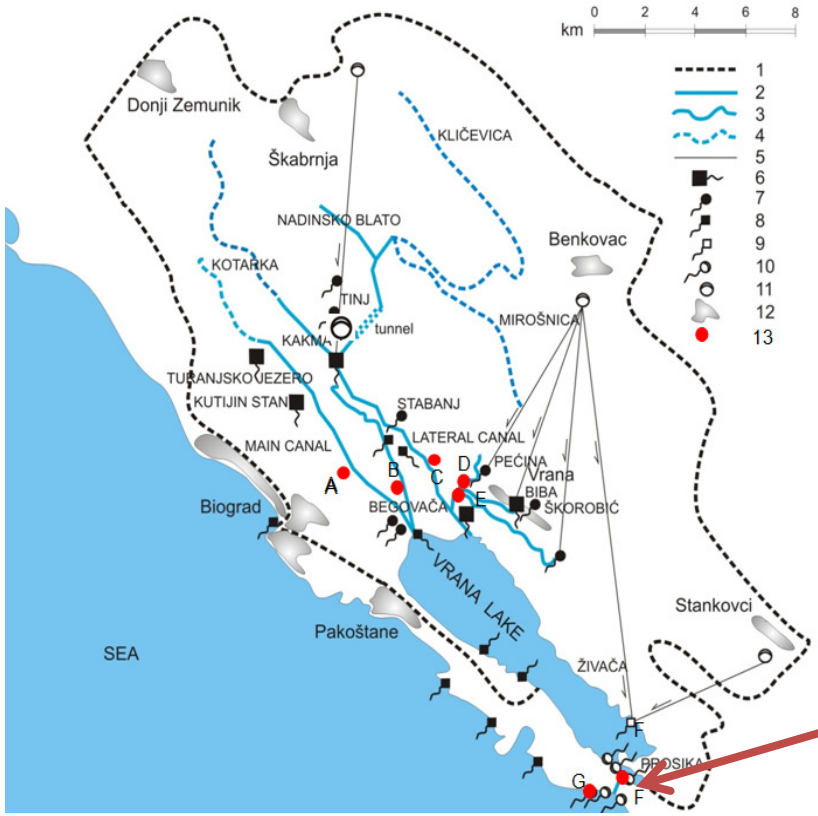
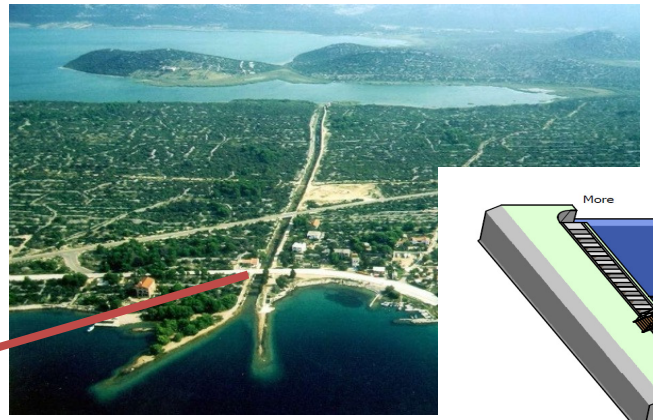
VRANSKO JEZERO
Park prirode • Nature Park

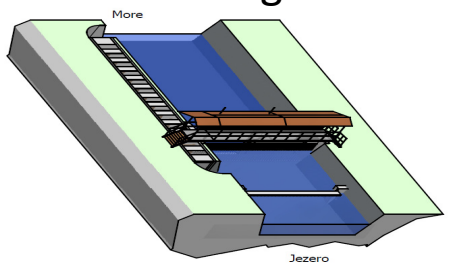
(Nature park from 1999.,

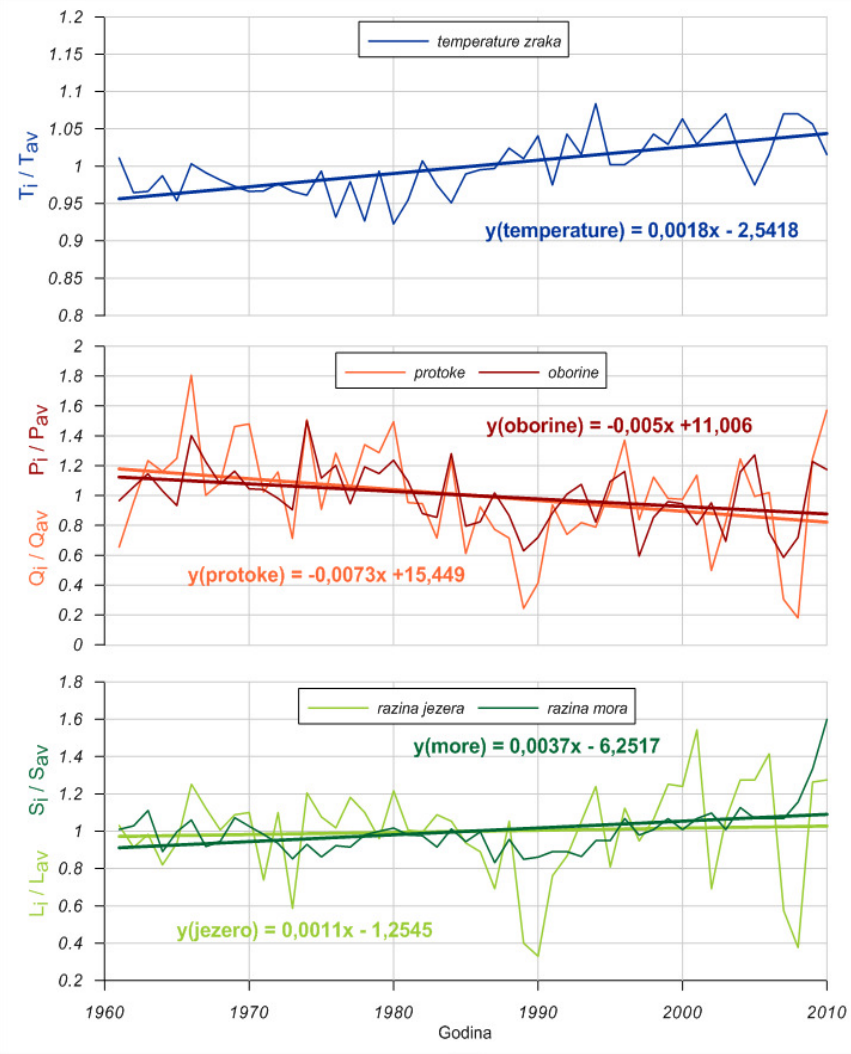
Ramsarski locality – from 2013.)

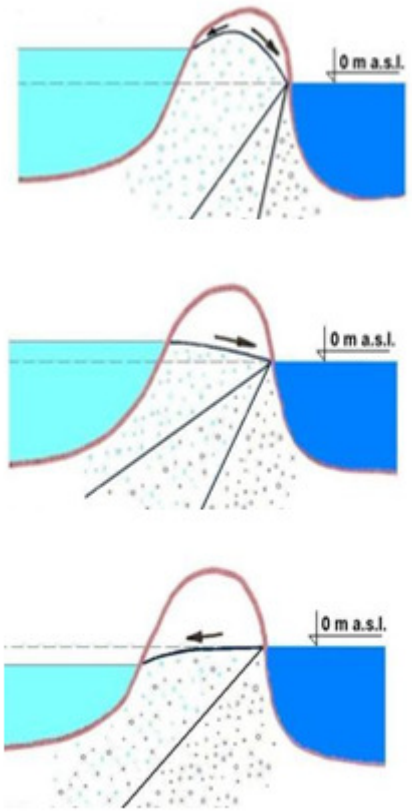




Planned gate




temperature zraka
Ti / Tav
y(temperature) = 0,0018x - 2,5418
protoke
oborine
Pi / Pav
Qi / Qav
y(oborine) = -0,005x +11,006
y(protoke) = -0,0073x +15,449
razina jezera
razina mora
Si / Sav
Li / Lav
y(more) = 0,0037x - 6,2517
y(jezero) = 0,0011x - 1,2545
1960
1970
1980
1990
2000
2010
Godina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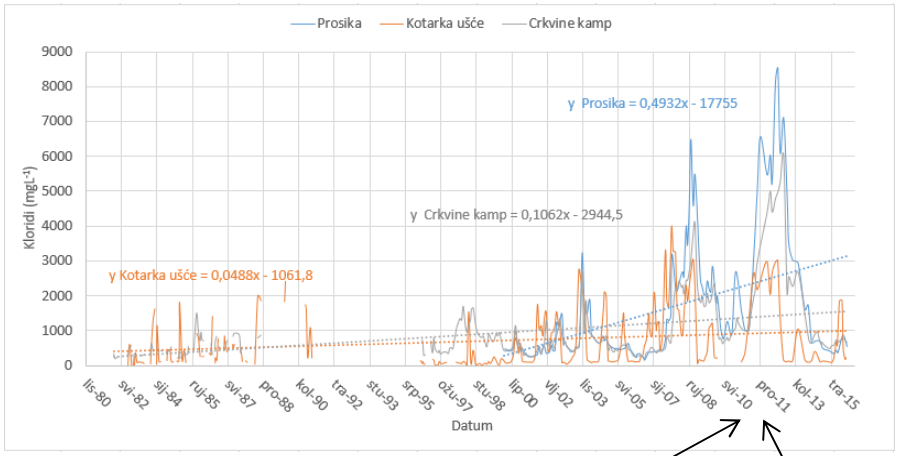
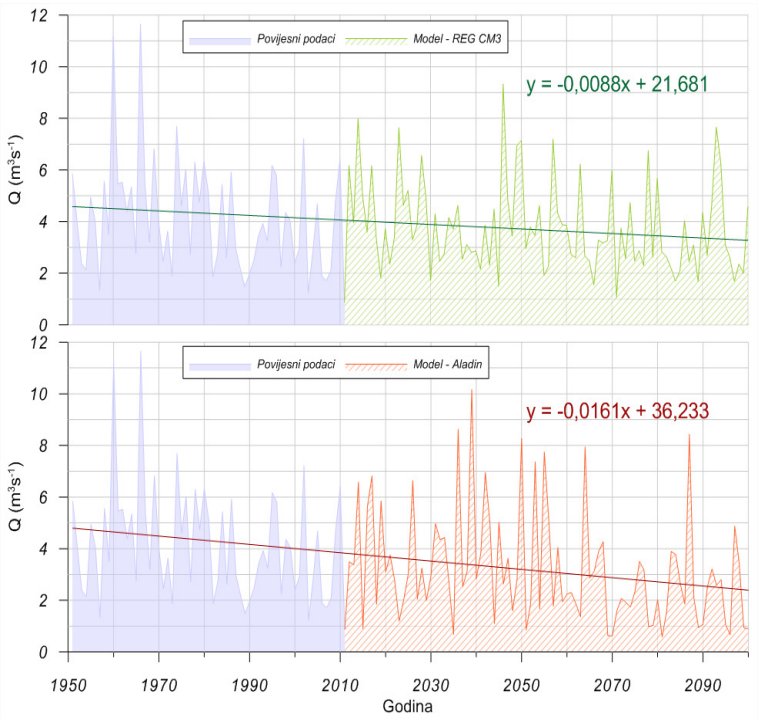
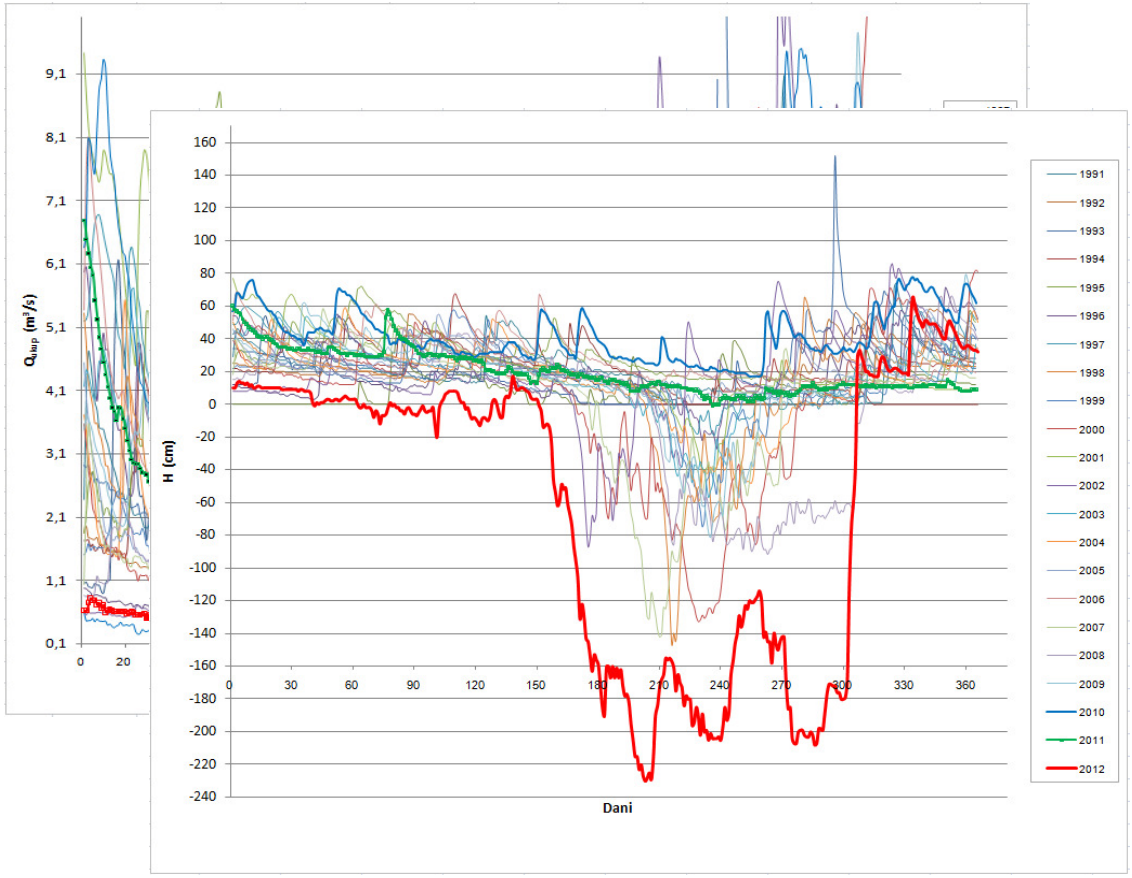




DRINK ADRIA



Extreme drought 2011-2012 – reduction in water supply in Istria – an example of the largest water source Gradole

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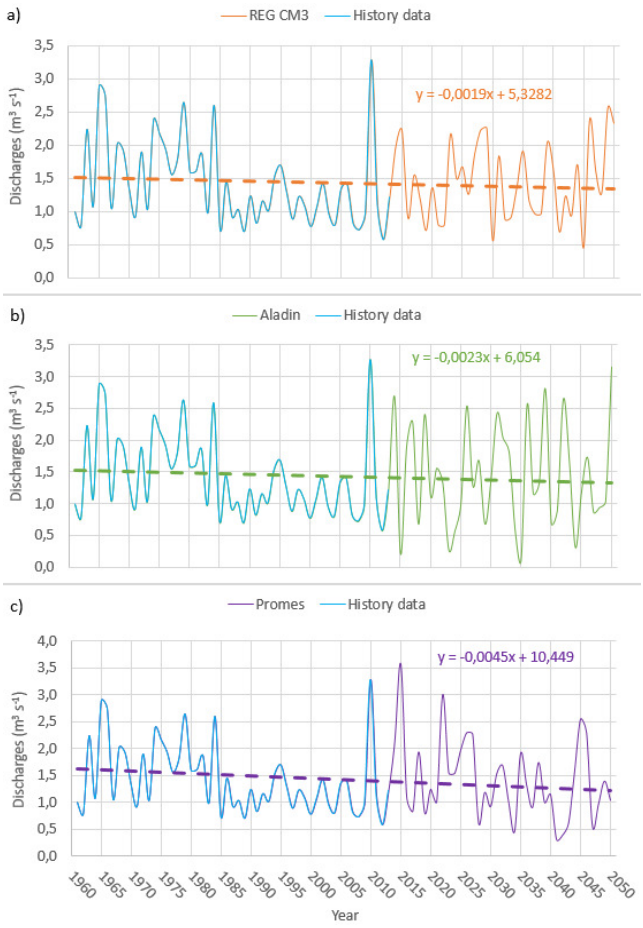

	Avg	Min	Max
	(m^3s^{-1})	(m^3s^{-1})	(m^3s^{-1})
1961-1990	1.60	0.70	2.88
1961-2013	1.41	0.57	3.28
2021-2050/1961-1990	(%)	(%)	(%)
REGCM3	-8.6	-35.4	-11.3
ALADIN	-11.6	-82.1	9.6
PROMES	-15.6	-57.4	4.1

An overview of historical and different climatic models of synthetic series of mean annual flows – karst springs in the Mirna basin (1961-2050) and trends by models:
a) REG CM3 b) Promes c) Aladin

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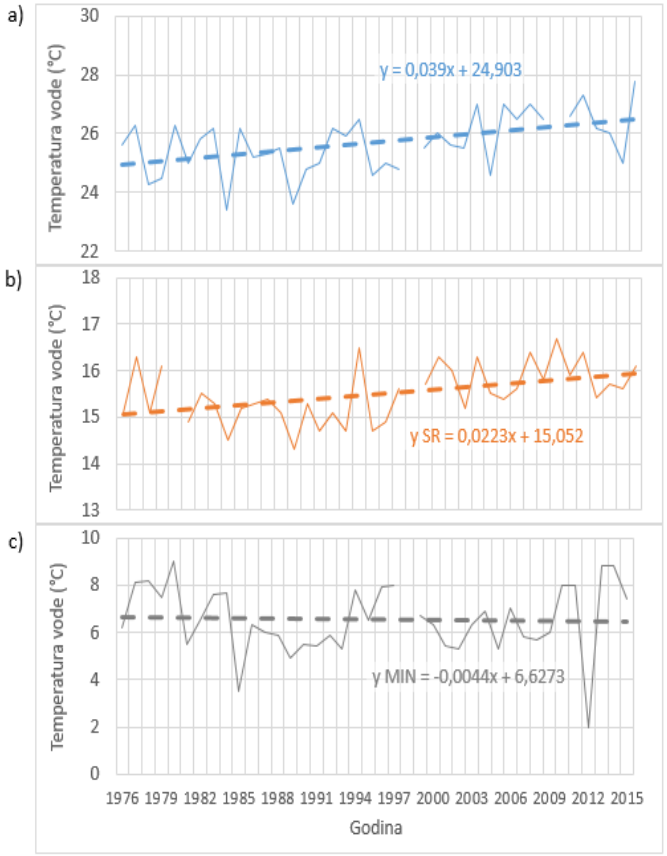
KRKA
Nacionalni park
National Park

Water temperatures



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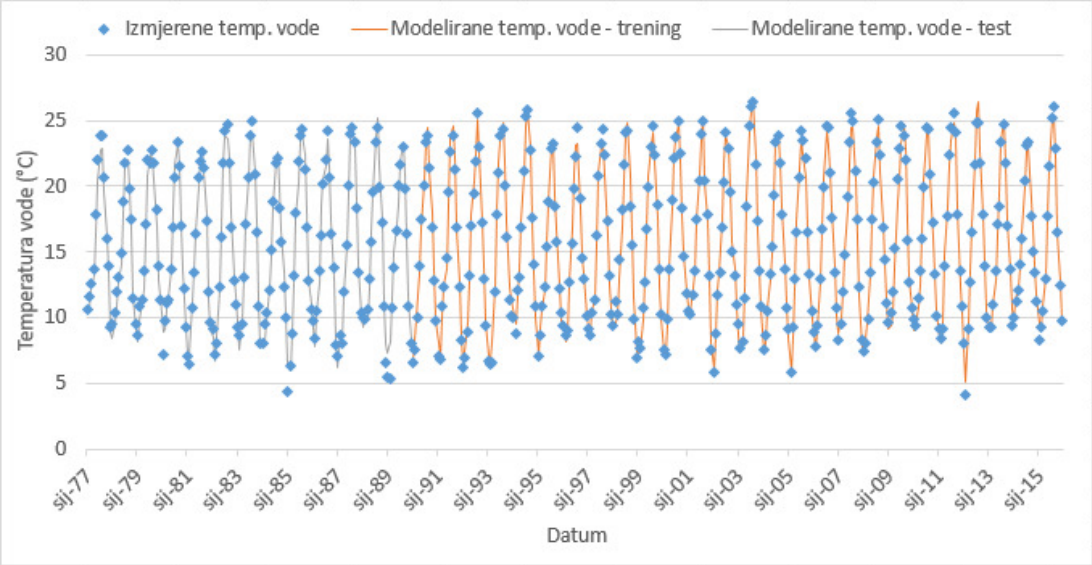

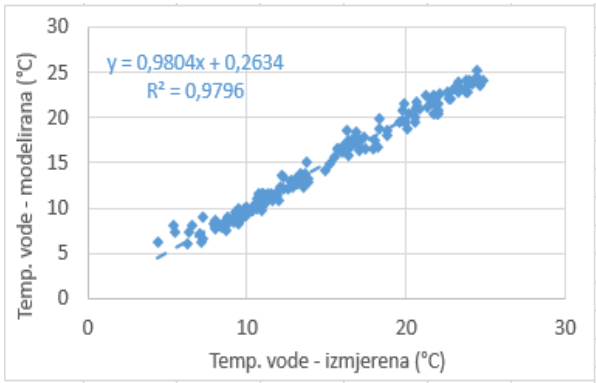

Grapical overview of measured and derived average annual water temperature from decision making regression trees (Trees M5P) for trained (1990.-2015.) and tested period (1977.-1989.)

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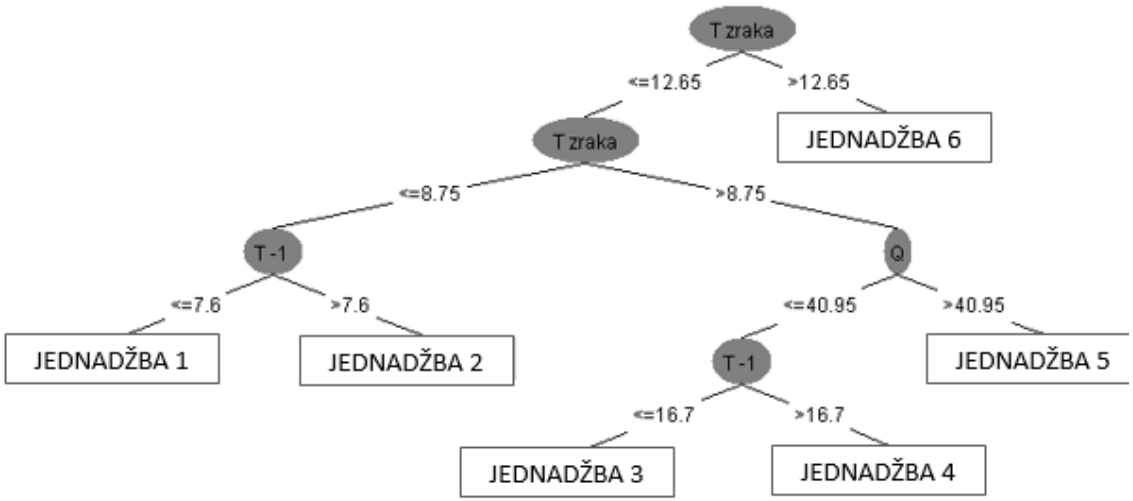
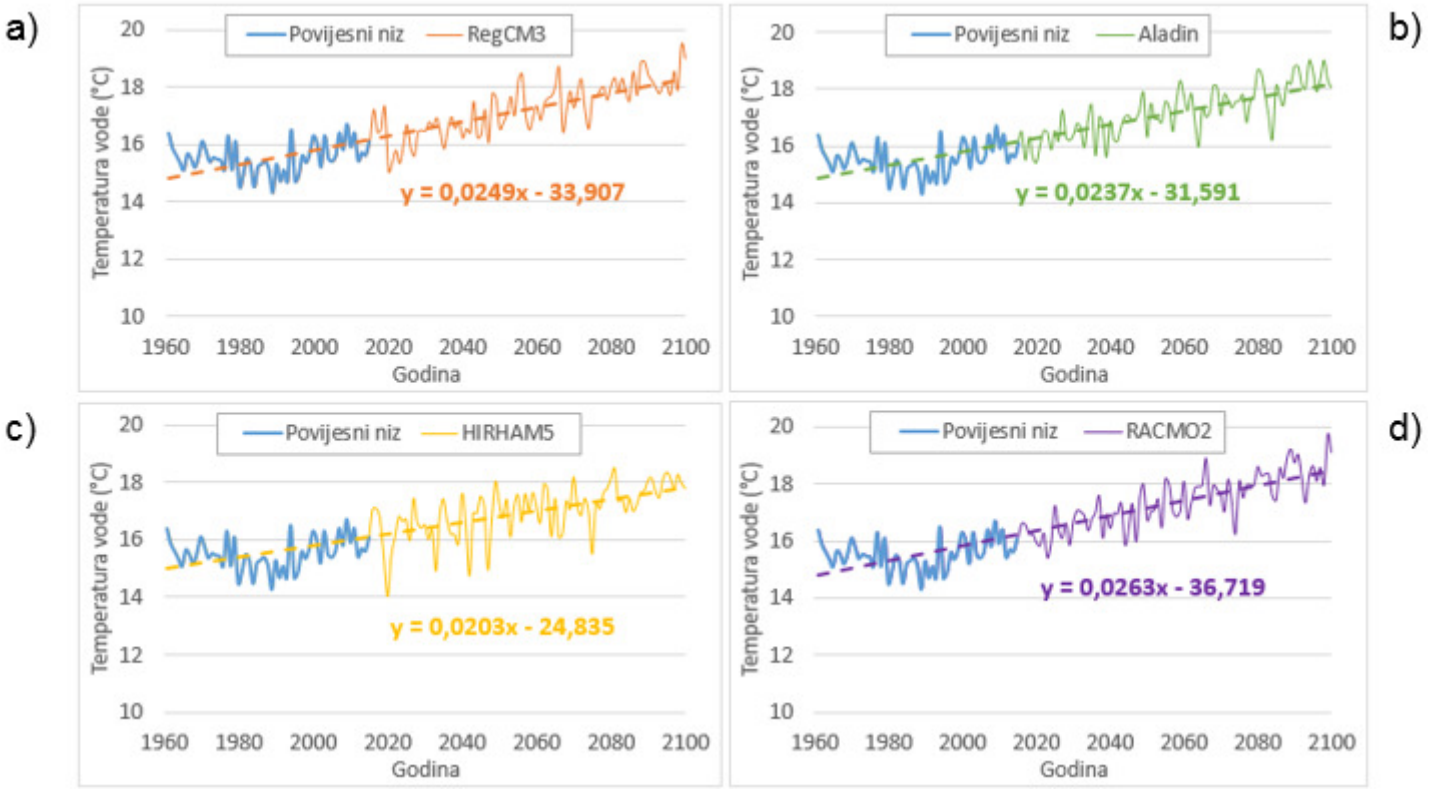
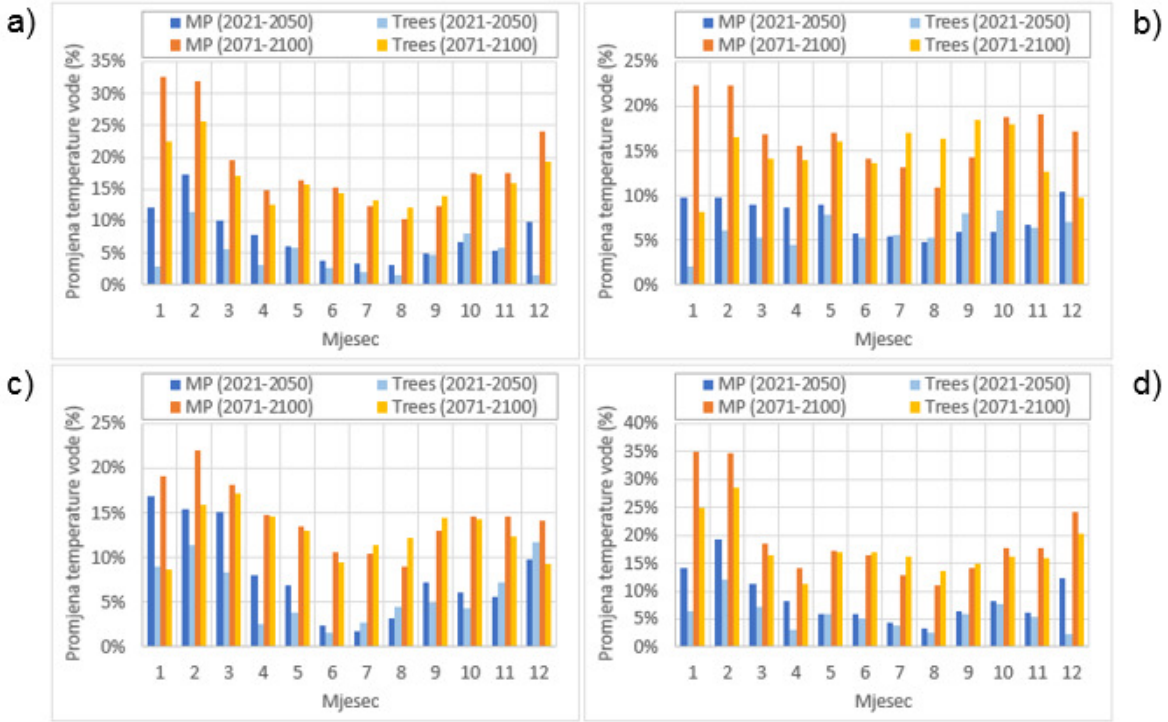


Decision making regresion tree for average monthly water temperature assessment

Redni br.	Rangiranje utjecajnosti varijabli
1	Temperatura zraka
2	Temperatura zraka – prethodni mjesec
3	Redni broj mjeseci u godini
4	Temperatura zraka – srednja između 2-5 mjeseci prije
5	Temperatura zraka – srednja između 6-12 mjeseci prije
6	Protoka
7	Oborine
8	Oborine – srednje između 2-5 mjeseci prije
9	Protoka – prethodni mjesec
10	Oborine – prethodni mjesec
11	Oborine – srednje između 6-12 mjeseci prije
12	Protoka – srednja između 2-5 mjeseci prije
13	Protoka – srednja između 6-12 mjeseci prije



An overview of the historical and according to different climate models generated synthetic series of mean annual water temperature from Skradinski buk gornji (1961.-2100.) with associated trends according to models REGCM3, Aladin, HIRHAM5 i RACMO2 (MP)



Distribution of change in water temperature within a year (in %) generated mean monthly water temperature for time period 2021.-2050. and 2071.-2100. (Multilayer Perceptron i TreesM5P) in comparison to meas monthly water temperature historical series (1976.-2015.) according to model a) REGCM3, b) Aladin, c) HIRHAM5 i d) RACMO2

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Interreg CENTRAL EUROPE
RAINMAN

INTEGRATED HEAVY RAIN RISK MANAGEMENT

I phase - Analysis of intensive rainfall occurence

- **Analysis of HTP i ITP curves and its regionalization**

- Defining the shape „design storm".

An alternative to traditional drainage systems is the **integrated approach** - tzv. **Low Impact Development (LID)** ili **Best Management Practice (BMP)**

For dimension of such modern systems it is neccesary to know not only critical rainfall intensity , but also the **overall hietograph of the rainfall**, **the distribution of its volume during the rain event**.

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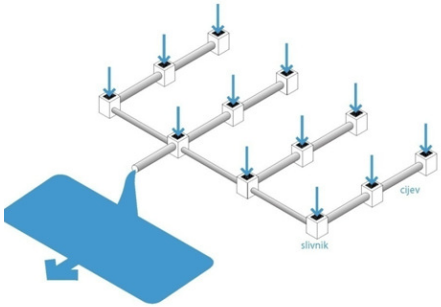
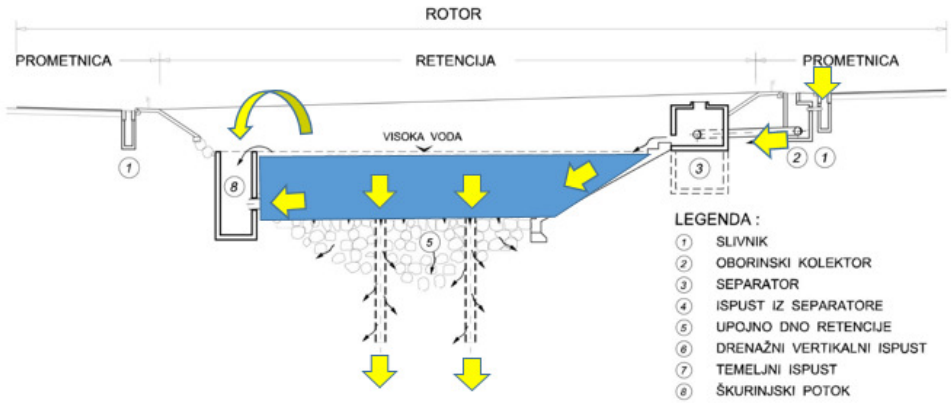
tradicionalni pristup
.... cijevima odvodi zagađenje
s jednog mjesta na drugo

integralni pristup
.... pročišćava oborinsku
vodu zelenim površinama
na izvoru - parkovima, ne cijevima !



tradicionalno upravljanje oborinske odvodnje:
" oborinska odvodnja = cijev" - što dalje što brže

integralno upravljanje oborinama: slivni pristup
uspori, rastereti, infiltriraj



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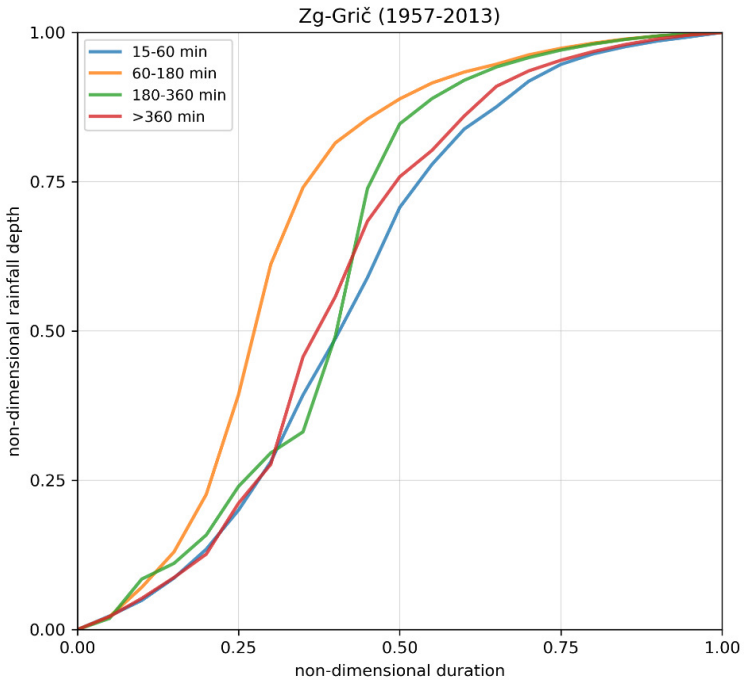
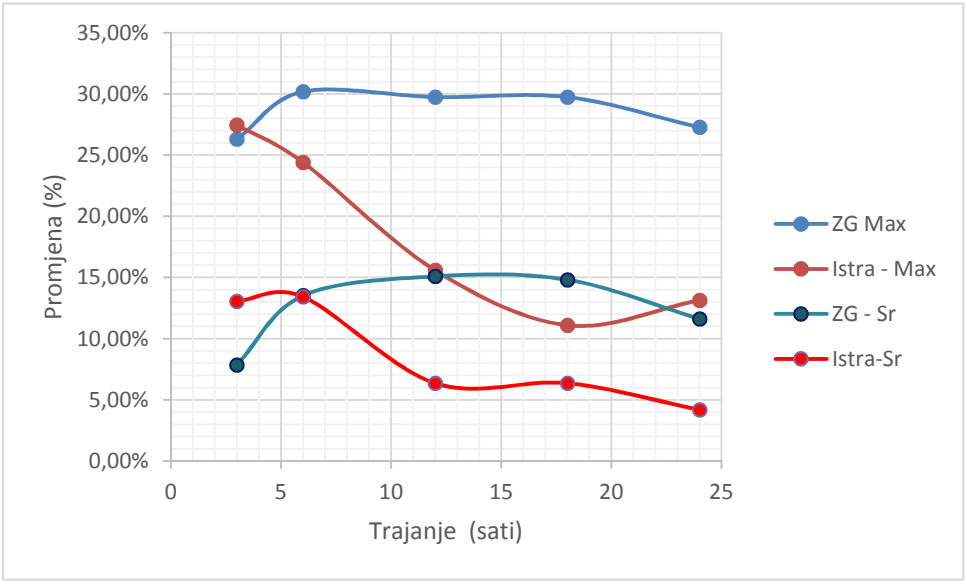


Comparison of four duration class of nondimensional cumulative curves for

Zagreb-Grič (1957. – 2013.)



CC assessment - Comparison of average and anvelope calculated maximum changes in the probability of occurrence of short-term heavy rainfall over a 100-year return period for Zagreb / Rijeka stations / localities

5. CHALLENGES AND NEW SOLUTIONS IN WATER MANAGEMENT IN CROATIA

STRATEGIJA PRILAGODBE KLIMATSKIM PROMJENAMA

Jačanje kapaciteta Ministarstva zaštite okoliša i prirode za prilagodbu klimatskim promjenama te priprema Nacrta Strategije prilagodbe klimatskim promjenama

Estimation of the expected changes in the hydrological parameters of water resources caused by climate change indicate possible:

- **reduction in total available water supplies**,
- **intensifying** the occurrence of prolonged **extreme droughts and high water**,
- **increase in water temperature,**
- **increase in sea level** and **intrusion of salt water in aquifers and surface water systems**

In this conditions **the growth of anthropogenic pressures** on water quantity and quality is noted, which can additional **endanger natural water systems and its ecosystems**

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Climate change require **appropriate responses**:

- Management measures:

- Rationalization of water consumption and its reuse
- Favouring the use of alternative water sources
- Spatial-planning measures in the function of reducing the risk and harmful consequences of floods in endangered areas
- Monitoring and modelling of projections of possible changes
- Adoption of legal legislation in the domain of adjustment insurance climate change…

- Structural solutions:

- Reduction of losses from the water supply system
- Construction and revitalization of water reservoirs for spatial and time water redistribution
- The use of alternative water sources
- Artificial aquifer recharge
- Providing natural spaces and objects with retention capacity
- Control of runoff in urban areas…

Starting measure - **it is necessary to minimalize existing negative anthropogenic pressures**

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