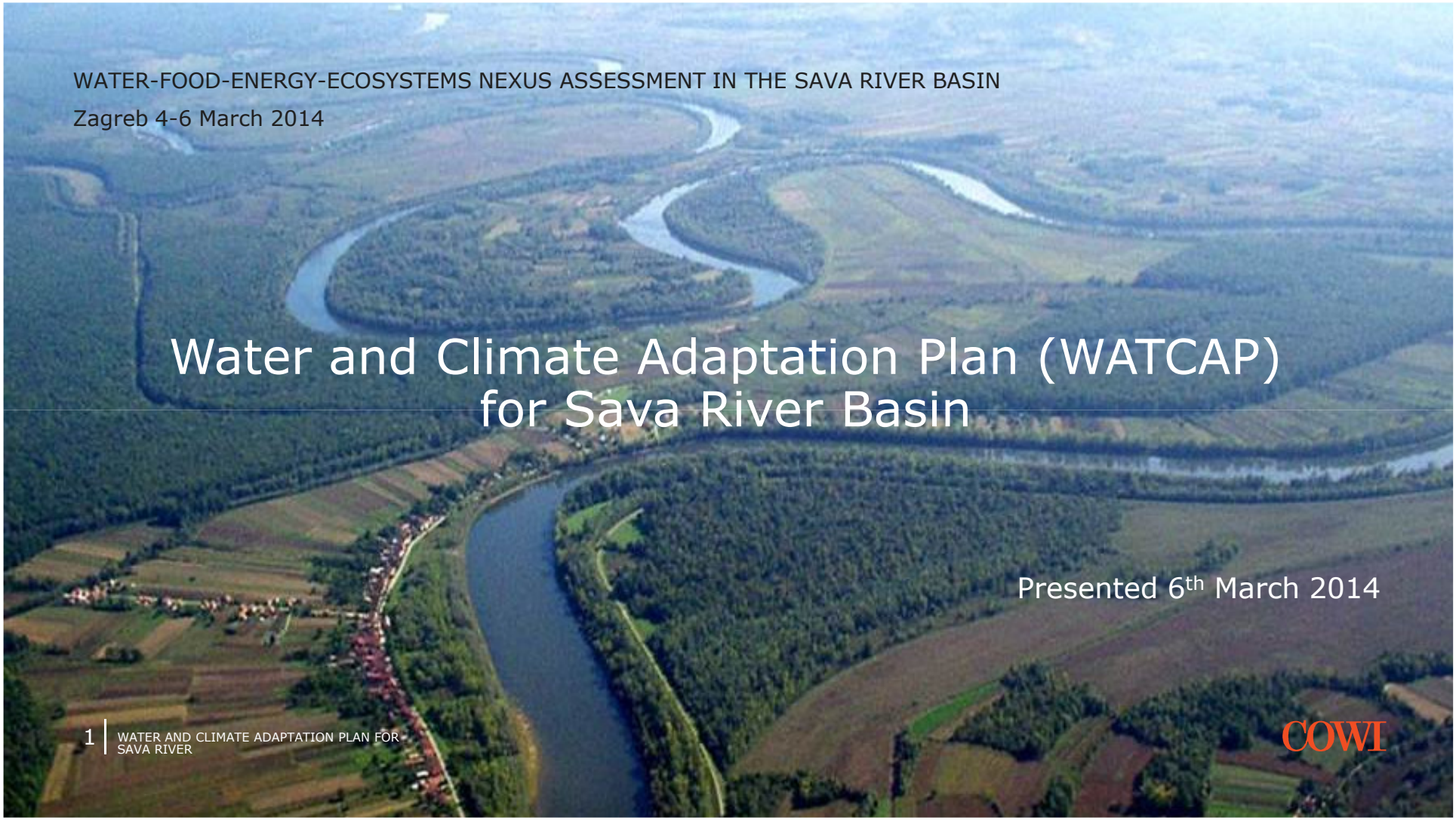

WATER-FOOD-ENERGY-ECOSYSTEMS NEXUS ASSESSMENT IN THE SAVA RIVER BASIN

Zagreb 4-6 March 2014

Water and Climate Adaptation Plan (WATCAP) for Sava River Basin

Presented 6th March 2014

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Why WATCAP?

- Intergovernmental Panel on Climate Change (IPCC) has viewed South East Europe (SEE) region as particularly sensitive to climate change.
- European Commission (EC) highlighted the SEE countries below the 40^{o} latitude at considerable risk and need to adapt to climate change.
- Governments of SEE states have acknowledged that impacts from climate change in the region are projected to get worse.

WATCAP Objectives

- To enhance climate resilience of selected water sector investments;
- To stimulate debate among key stakeholders in the water resources sector in SEE on climate-related impacts and adaptation strategies;
- To inform on approaches to adapt water resources management, planning and operations to the forecasted impact of climate change.

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Why Sava Basin for WATCAP?

- SRB is the first of these basins in South-Eastern Europe selected for this work.
- SRB is of a high priority

  Regional climate modelling suggests an overall reduction of around 15% to 30% in mean annual runoff by the middle of this century, which could be challenging for all investments undertaken in the basin.

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How will WATCAP be achieved?

Five Tasks:

1. Historic Climate Data Analysis (Task 1)
2. Future Climate Data Analysis (Task 2)
3. Hydrologic Model Development and Scenario Simulations (Task 3)
4. Guidance Notes (Task 4)
5. Water and Climate Adaptation Plan (WATCAP Main Report) (Task 5)

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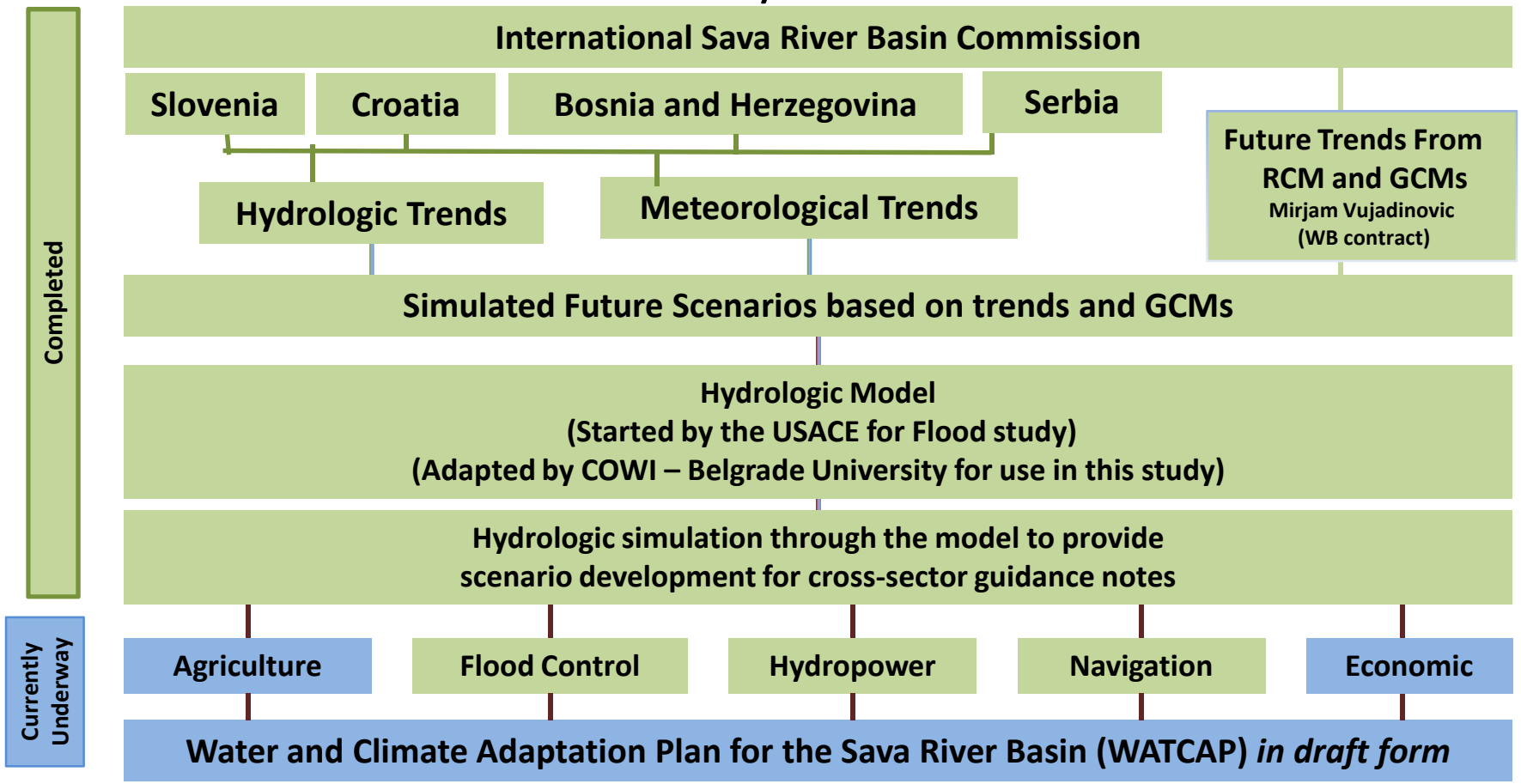
Activity Status



WATCAP funding sources

- Water Partnership Program (WPP)
- Trust Fund for Environmentally and Socially Sustainable Development (TFESSD)

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Sava Basin Hydrologic Model (Task 3)

- Covered under earlier presentation
- Model development
- Creation of forecast scenarios

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Guidance Notes

- Hydropower – COWI under existing contract and with Vrbas
- Navigation – COWI with ISRBC input
- Flood Control – Mitja Brilly – under direct contract with WB
- Agriculture – World Bank David Meerbach
- Economics – World Bank

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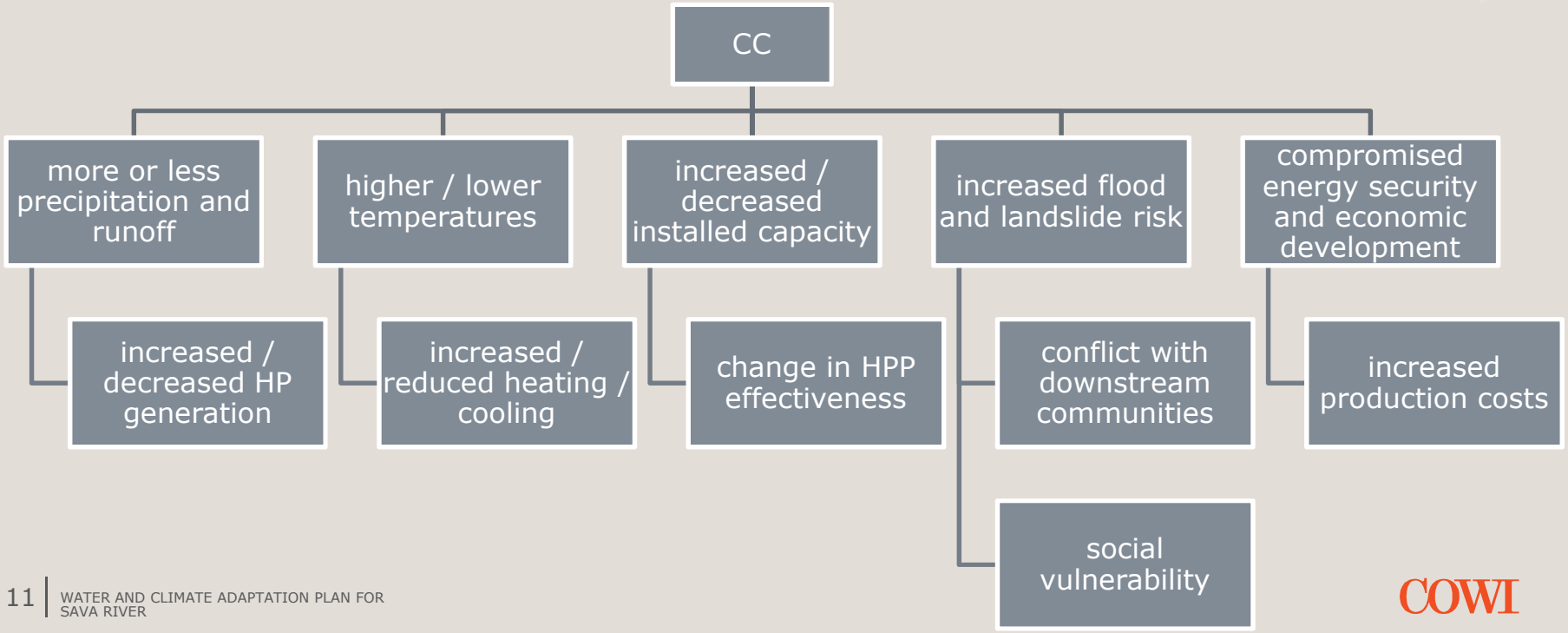
Hydropower – Guidance Notes

Hydropower: Potential impacts



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Hydropower: Indicators

- **Mean runoff** at specific dam profiles: a significant change will affect production in the same direction;
- **Intra-annual runoff variation** (duration curves) at the dam profile: a change will affect the change in total volume used for production and in the same manner production by itself;
- **Evaporation** affects volume of available water for production.

Hydropower climate change vulnerability vs HPP characteristic

Climate parameter	Climate parameter change	HPP type			Reservoir storage area:volume ratio		Reservoir size	
		Reservoir type	Run-of-river	Pumped storage	High	Low	Large	Small
Evaporation	Increase							
	Decrease							
River runoff	Increase			N/A				
	Decrease							
Temporal variability	Flood							
	Drought							
	Seasonal offset							

Legend:

- bigger decrease
- smaller decrease
- bigger increase
- smaller increase

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Hydropower: Impacts

- **Decrease in river runoff**: **reduced power production** on all facilities, particularly with run-of-river schemes;
- **Increased evaporation: power production notably reduced** on the reservoir type and pumped storage type HPPs with a high storage area/volume ratio and small reservoirs;
- Smaller effects for other types of HPP will show smaller effects, but still experience a decrease of hydropower generation;
- **Floods** in the fall/winter and **droughts** in the spring/summer will mostly affect run-of-river HPPs and HPP with small reservoirs, hence power production would likely decrease

Hydropower: Case Study

- 4 HPPs
- Daily production for selected HPPs assessed with the following assumptions:
  - Equal generator efficiency coefficient for all HPPs (0.95);
  - Assumed efficiency coefficients for turbines: Francis 0.92, Kaplan 0.9;
  - Constant useable head for energy production in each day;
  - All HPPs are the dam type and no flow and head losses in the tunnel or penstock are taken into account.

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Hydropower: Case Study

› Power plants used in the case study

Country	HPP	River	Reservoir volume (mil m^3)	Reservoir storage area:volume ratio	Installed capacity [MW]-ref. year 2005	Installed discharge (m^3/s)	Average yearly production (ref. 2005-2007) [GWh/year]	Share in average total energy production on SRB [%]	Share in installed capacity [%]
Slovenia	Blanca	Sava	9.95	0.13	43	500	144	2.2	1.8
Bosnia and Herzegovina	Bočac	Vrbas	52.1	0.045	110	240	308	4.8	4.5
Serbia	Zvornik	Drina	89.0	0.146	96	620	515	8	3.9
	Bajina Bašta	Drina	340	0.036	360	644	1691	26	14.7
Total Sava River Basin 2005					**609 of 2449 in total**		**2658/6445 total**	**41**	**24.9**

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Hydropower: Structural Adaptation Measures

- **Enhance dam structural parameters**
  - diverting upstream tributaries to decrease river runoff, new reservoir storage, modifying spillways, changing number and/or types of turbines;
- Build robust dams with **large reservoirs** that can cope with extreme events;
- **Flexible design for installed capacity**;
- Consider structural adaptation effects on **other reservoir purposes** (e.g. irrigation, drinking water supply, tourism, etc.) before reservoir construction or enlargement.

Hydropower: Non Structural Adaptation Measures (1)

- Consider **ecological aspects** (impact of structures on stream morphology, barriers to fish migration, etc.);
- **Reduce energy demand** (public awareness campaigns and training in energy efficiency);
- **Improve hydrological forecasting** to improve operational rules and utilization of HPP capacity,
- **Improve O&M practices** at power stations;
- **Incorporate future** reduced or increased generation capacity in design;
- **Consider more pumped storage** hydropower technology;

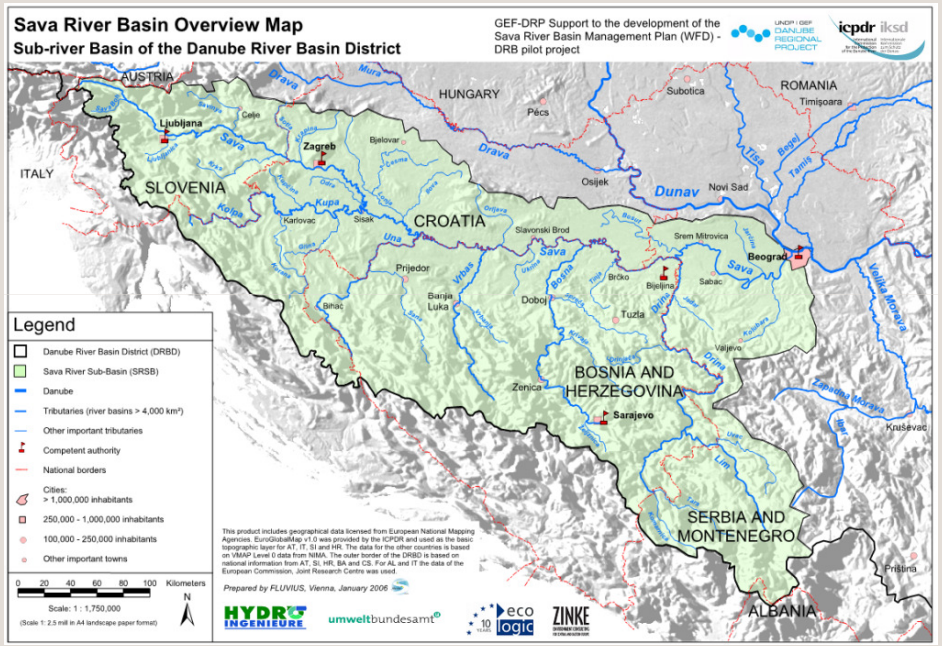
Hydropower: Non Structural Adaptation Measures (2)

- Adopt an **integrated water resources and disaster management** approach;
- Assess **other renewable energy** production facilities (wind, solar);
- Undertake regular **review of permitting and licensing of hydropower schemes** (make seasonal adjustments to ensure sufficient storage in the reservoir for spring floods and to tie this into the RBMPs);
- Establish a mandatory reporting mechanism for all hydropower companies to provide full operational details on river flow and discharge to **improve future monitoring**;
- Better development/implementation of **strict rules for water withdrawal and discharge**.

Navigation – Guidance Notes

Navigation: Navigable reaches in the SRB

River	Length (in km) from the mouth
Sava	586
Kolubara	5
Drina	15
Bosna	5
Vrbas	3
Una	15
Kupa	5



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Navigation: Standards

- Navigation standards:
  - Navigation with a *reduced* draft must be possible 95% of the time;
  - Navigation with *maximum* draft must be possible 65% of the time.

- Design requirements for an upgrade of Class IV to Class Va

Design parameter	Class IV	Class Va
95% fairway depth (m)	2.3	2.4
waterway width in bends (m)	75	90
horizontal clearance under bridges (m)	45	55

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Navigation: Actual situation

- Actual classification: class III and class IV (50%-50%); far from meeting class IV and Va requirements
- Current navigation conditions are poor:
  - limited draft over long periods
  - limited width of the fairway
  - sharp river bends limiting the size of vessels and convoys

- ISRBC aims at rehabilitation and development of the Sava waterway to minimum Class IV waterway and to Class Va on certain sectors

Navigation: Potential CC Impacts

- Climate-related restrictions of inland navigation are due to:
  - low flows (hydrologic regime)
  - high flows (hydrologic regime)
  - river ice (hydrologic regime, water temperatures)
  - visibility – fog (air humidity, air temperatures)

- Key parameter: **water level**
  - related to **flows** and **riverbed morphology**
  - impossible to predict changes in sedimentation processes and morphology

Navigation: Assessment of CC Impacts

- Climate and runoff scenarios for CM1 to CM5 model chains:
  - baseline 1961-1990
  - near future 2011-2040
  - distant future 2014-2070

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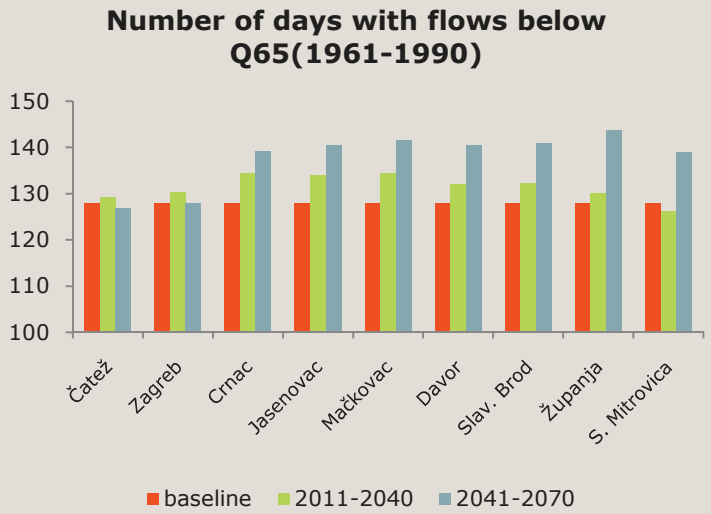
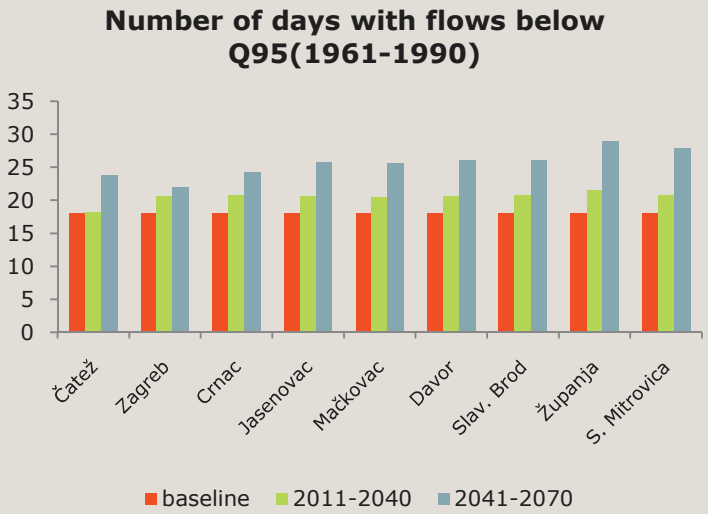
Navigation: Assessment of CC Impacts

› Low flows: increase of number of days below standard levels





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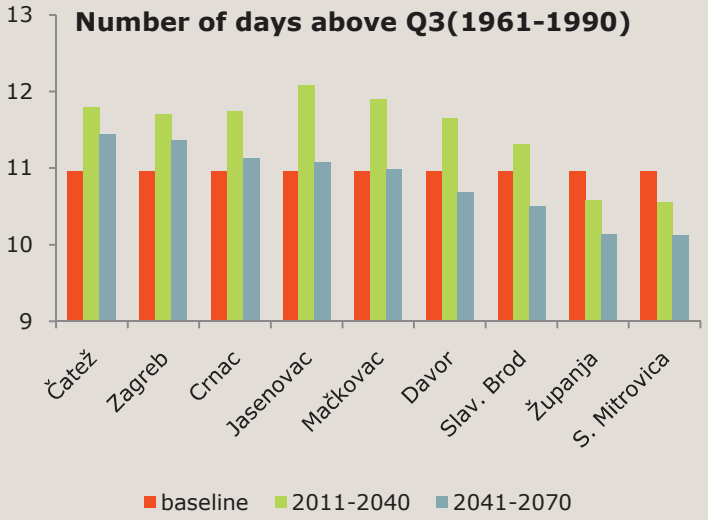
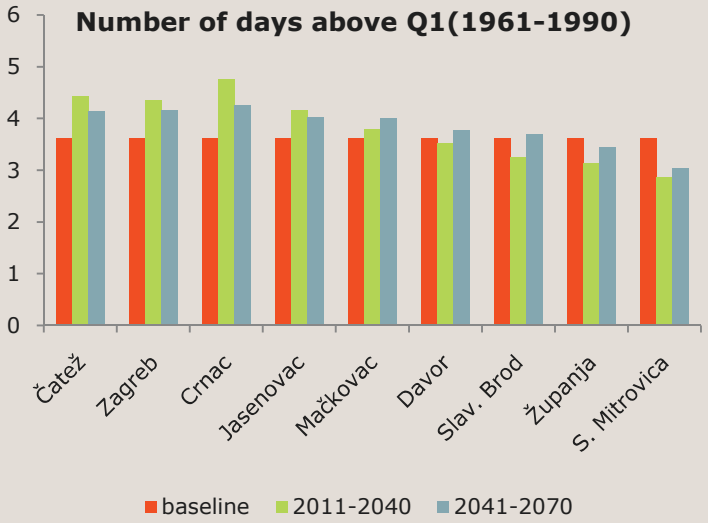
Navigation: Assessment of CC Impacts

› High flows: no change





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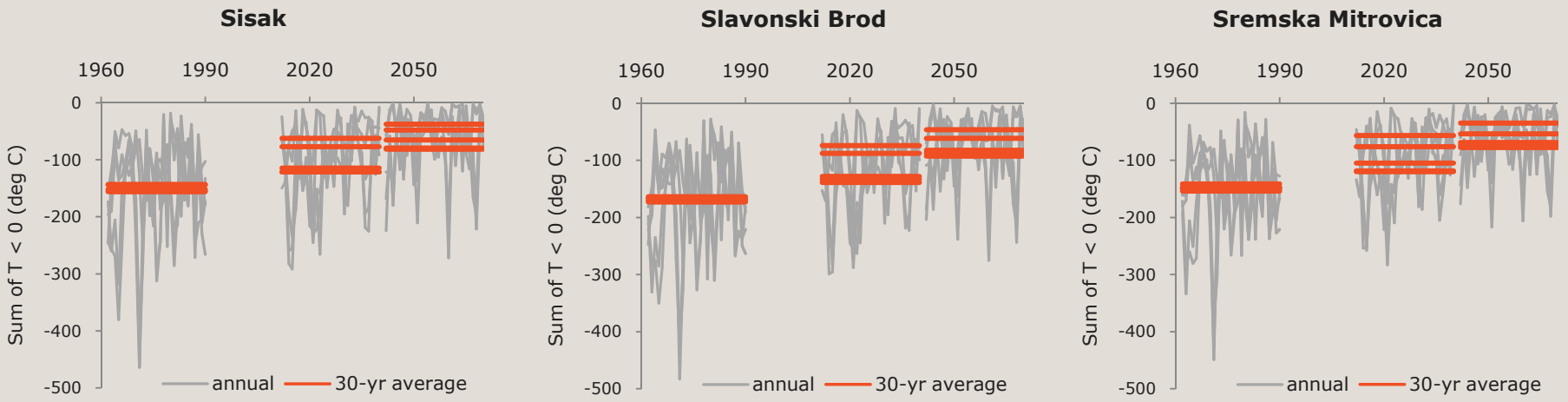
Navigation: Assessment of CC Impacts

› Ice: reduction of days with ice



sum of air temperatures below 0°C

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Navigation: Assessment of CC Impacts – Conclusions

- Low flows
  - characteristic low flows Q65 and Q95
    - near future: no change
    - distant future: decrease downstream of Sisak; the largest decrease of 6% for Q65 and 11% for Q95
  - number of days below Q65(1961-1990) and Q95(1961-1990)
    - near future: increase for 2-3 days
    - distant future: increase for 8-13 days
- High flows
  - no change in number of days in which navigation would be restricted or suspended
- River ice incidence
  - likely to be less in the future, but more studies are needed
- Visibility (fog)
  - no relevant information

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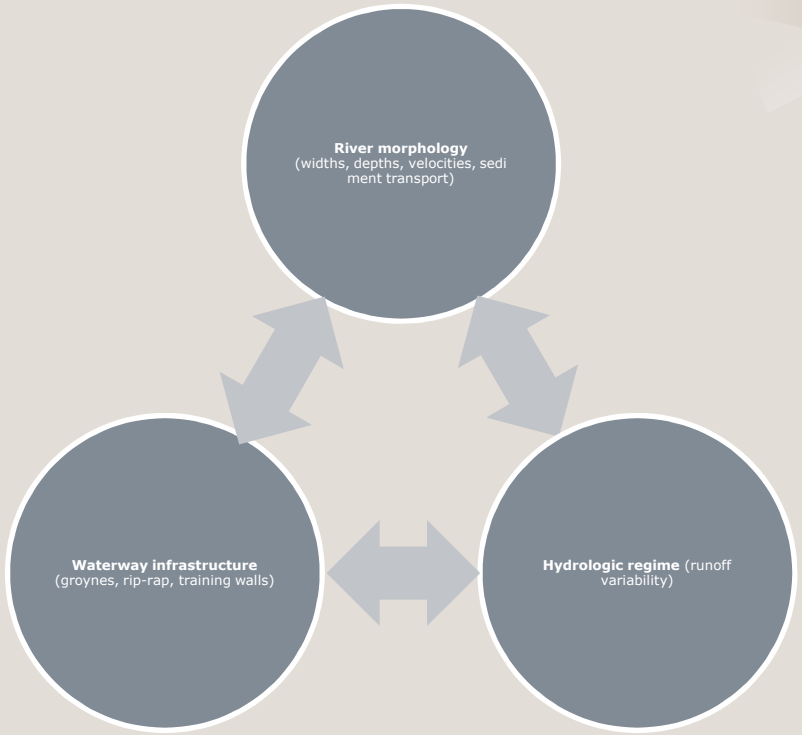
Navigation: Adaptation

- Interconnection of factors relevant for navigation and fairway parameters



adapted from Simoner et al., 2012

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Navigation: Possible adaptation approaches

Area of Intervention	Response (measure)	Additional Information
Waterway design and maintenance	• Creation of water storage • Deepening of channels instead of widening	• (Upstream) reservoirs needed for flood mitigation can also be used to improve navigation
Waterway operation	• Managing water flow • Improving forecast of water level • Improved queuing procedures • Implement River Info System (RIS) • Provide up to date electronic charts	• Store water in times of high water flow and release in times of low flow • Better information and decision support systems and automation of queuing will help overcome capacity restriction • RIS in general support safe and efficient navigation • Better information to optimise use of vessels
Transport management	• Chartering additional vessels • Increasing daily operation times • Cooperation with other transport modes • Increasing storage of goods	• Contractual arrangements with road and rail transport companies can be made for time of reduce navigability
Vessel operation	• Using state of the art electronic chart display and info system (ECDIS)	• Provide always up to date information
Vessel design	• Reduction of weight • Increasing width	• Using alternative design/material of install lighter equipment • Wider vessels need less draught

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Navigation: Priority Adaptation Measures (1)

(selected from measures proposed by ICPDR)

- Preparing for adaptation
  - Better monitoring of water levels
  - Improved hydrological forecasting
- General measures
  - Promoting river transport on Sava will enhance the competitiveness of river transport relative to other modes of transportation.
  - Providing sufficient water depth in times of low water flow
- Ecological measures
  - Definition of navigation fairway conditions according to ecological needs.
  - Combining any increased water storage to support navigation infrastructure with habitat creation initiatives

Navigation: Priority Adaptation Measures (2)

(selected from measures proposed by ICPDR)

- Management measures
  - Low flows augmentation by better reservoir management
  - Increasing the share of river transport in total transport of goods
  - Look to changes in industrial production leading to lower transport requirements, or shifting transport towards the season with higher river levels
- Technological measures
  - Adaptation / creation / modernisation of waterways and ports
  - Support container shipping with shallow draft vessels
  - Fleet modernisation

Flood Control – Guidance Notes

Flood – Guidance Notes – Main Components

Flood Guidance Note has been prepared from three reports from the University of Ljubljana:

- Part 1: Report on meteorological part of development of climate projections for the SRB,
- Part 2: Climate change impact on flood discharge of the Sava River, hydrology report,
- Part 3: Assessment whether additional modelling of climate change impact on flood vulnerability is needed, preliminary identification and description of possible adaptation measures, selection of a package of prevention, preparedness, resilience, response and recovery measures

Flood – Guidance Notes – Findings

- The most vulnerable flood prone zones are those areas that coincide with big settlements with high population density and economic activities. e.g. between Zagreb and Slavonski Brod, as well as some eastern parts of the Basin that are vulnerable due to protected natural habitats.
- Almost 50% of flood area is classified as "moderate vulnerability" and the remainder is equally distributed between high and low vulnerability.
- Areas with high vulnerability are mainly those around Zagreb, Belgrade and areas at the confluence with the Drina River into the Sava River.
- Sensitivity analysis was performed only within the 100 year return flood zone, but not beyond.
- Historical events like the 1896 Drina River, the most Probable Maximum Flood event with extremely high water downstream on the Sava River, need some special treatment.
- The question on how will vulnerability change in the future and what will be the change in population density is also important.
- The process of reforestation has a strong impact on the water balance and decrease in discharge. In Slovenia, the area covered by forest is increasing by almost 1% each year, however in Bosnia and Herzegovina, the reverse is taking place.

Flood – Guidance Notes – Conclusions

- In general on flood studies in the SRB indicate that future flood events will increase,
- The E-OBS data set is useful for hydrological climate change forecasts of flood peak discharges in the SRB but needs further improvement
- Climate change will increase the peak discharges mainly in the head part of the Sava River Basin watershed. Peak discharges will increase at the end of the 21st century for the 100-year return period i.e. from 3 % at water station Sremska Mitrovica up to 55 % at water station Čatež.
- The impact of climate change on the water level forecasts with 100-year return period floods is quite high in the head part of the watershed, i.e. more than 2 m. Downstream it initially strongly decreases then it gradually increases up to 1,81 m and finally it drops to 0,10 m at the water station Sremska Mitrovica.
- The Central Posavina region is an extremely important flood retention basin which needs to be protected from further development (building of flood protection structures, levees etc.).
- There is clear evidence that reforestation has decreased the mean discharges in Slovenia by up to 35 % and consequently such actions will decrease flood discharges and mitigate the impact of climate change on floods in the SRB. Further research on reforesting should be undertaken on other areas of the SRB.

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Flood – Guidance Notes – Short Term Mitigation Measures

To be undertaken over the next 3 years at cost of Euro 50 million, including:

- development of flood warning system based on institutional strengthening;
- Determination and survey of permanent geodetic monitoring points (river bed cross sections); surveys to be repeated ideally every 2 years;
- Hydrologic modelling for predicting flood flows;
- Hydraulic modelling for calculating water levels; and
- Maintenance and reconstruction of existing flood protection structures and its mechanical equipment (gates and pumping stations).

Flood – Guidance Notes – Medium Term Mitigation Measures

To be undertaken over the next 15 years with cost of Euro 1 billion, including:

- Institutional strengthening of the organizations responsible for the collection and exchange of hydrological data.
- Purchase of new state-of-the-art equipment as: meteorological radars, measurement of snow cover water content and soil moisture.
- Increase of the level of protection of major cities along the Sava River: Belgrade, Zagreb and Ljubljana. Similar protection should be developed for critical infrastructures: highways, railroads, industrial and health care buildings.
- The protection of other cities and populated areas along the Sava River depending on long-term spatial planning and future development. Zoning of areas should be integrated with spatial planning.

Flood – Guidance Notes – Long Term Mitigation Measures

To be undertaken over the next 50 years with a cost of Euro 2 billion, including:

- Continuation and completion of works in the all of segments.
- The protection of cities and populated areas along the Sava River depending on long-term spatial planning and future development. Zoning should be integrated with spatial planning.
- Giving more space to rivers, by deepening and widening of the river channel; increasing the floodplains (flood retention areas) by lowering the surface and the movement of dams; removal of structures that impede water flow; and similar with special attention to river front development.

Agriculture – Adaptation Measures

Agriculture – Preparing for Adaptation

1. Improved monitoring of all parameters covering agriculture;
2. Research on new plant species resistant to climate change;
3. More research on pesticides;
4. More research on the impact of climate change and droughts on the quantity and quality of water resources used in irrigated agriculture;
5. Further development and improvement of models for climate and vegetation;
6. Detailed assessment of vulnerability of agriculture to climate change;
7. Establish/enhance early warning systems for droughts and other extreme climate episodes of importance to agriculture;
8. Improve short-term weather forecasts by setting up comprehensive and efficient forecasting systems; and
9. Assessment of the energy demand of irrigation systems.

Agriculture – General Adaptation Measures

1. Development / adaptation of the agricultural infrastructure by improving protection to irrigation schemes,
2. Promoting water retention in the agricultural landscape especially in drought prone areas and consider provision of pipelines for long distance water transportation.
3. Application and expansion of irrigation for agriculture: choose the most suitable irrigation method considering type of crop, soil type, technology, costs and benefits.

Agriculture – Ecological Adaptation Measures

1. Encouraging farming methods that are compatible with environmental protection, conservation of biodiversity, improved quality of water, soil and natural landscape in order to preserve and improve the condition of natural resources habitats.
2. Development and application of new, sustainable and environment -friendly technologies, e.g. for plant protection and priority development of nonchemical methods against crop diseases and pests.
3. Promotion of less intensive land management techniques in sensitive areas and elsewhere in order to reduce environmental pressures.

Agriculture – Management Adaptation Measures

1. Maintaining soil-fertility and soil-water-saving techniques;
2. Consider changes in agricultural practices;
3. Adaptation of the sowing / harvest dates and the field work calendar;
4. Changing cropping patterns e.g. avoiding monoculture, going for longer rotations, etc;
5. Development /adaptation of pesticides /fertilization and the pest system/management;
6. Better education, awareness raising, knowledge transfer and cooperation between authorities responsible for agriculture and improvement of the way in which experts are informed about climate change impacts and possible ways of adaptation.

Agriculture – Technological Adaptation Measures

1. Building of buffer zones in the vicinity of sensitive areas to reduce water run-off;
2. Implementation of novel crop production technologies and breeding;
3. Develop and apply new, water-use efficiency related techniques i.e. drip irrigation;
4. Develop and construction of new systems for irrigation based on BAT;
5. Elaboration of the present irrigation technologies and equipment, aimed at compliance with new needs and increasing their efficiency;
6. Development / adaptation of irrigation infrastructure through:
7. Implementation of more efficient and water saving irrigation technologies such as drip or switching from gravity fed to sprinkler fed systems. Application of proper moisture preserving technologies and techniques for soil treatment in irrigated lands
8. Development and application of technologies and systems for regulation and control of technological processes for the distribution and use of water for irrigation
9. Development of deficit irrigation techniques in identifying the optimum balance between crop-production and irrigation requirements

Agriculture – Policy Issues

1. Review the WFD RBMPs by the SRB riparian states including their technical, financial and social dimension,
2. Increase the coordination between water and agricultural policies,
3. Use water pricing according to consumption as an effective economic instrument,
4. Adaptation of insurance systems such as introduction of mechanism like "multiple risk insurance", or to improve the existing agricultural insurance system to assist farmers to cover costs of bad weather insurance policies,
5. Implementation of Best Agricultural Practices (BAP),
6. Adaptation of water conservation technology policies through implementing and enforcing water saving regulations,
7. Adaptation of the instruments of licensing, control and funding in order to mitigate negative impacts of irrigation measures on the water table and ecosystems,
8. Changing legislation and regulation in the irrigation sector, and
9. Determination of an irrigation control programme.

Thank you for your attention!