INTERNATIONAL SAVA RIVER BASIN COMMISSION

Sava HIS
Final Report

Project: **Hydrological Information System of the International Sava River Basin Commission (Sava HIS)**

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ABBREVIATIONS

GML	Geography Markup Language
HIS	Hydrological Information System
WFS	Web Feature Service
JSON	Javascript Object Notation
RSS	RDF Site Summary
RDBMS	Relational Database Management System
XSD	XML Schema Definition

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EXECUTIVE SUMMARY

Hydrological Information System of the International Sava River Basin Commission (Sava HIS) will provide a tool for collecting storing, analyzing and reporting a sufficiently high quality data hydrological and meteorological data. Those data and information will be used in decision-making system in all aspects of water resources management, in the wide range of operational applications as well as in research. The exchange of quality controlled data and information is an essential element for the undertaking of basin–wide activities ranging from flood forecast and warning to the various aspects of water resources management. The legal background within the ISRBC framework is given in next subchapters.

The project implementation phase included the detail analysis, design, build, development, testing and installation activities. This Draft Final Report covers overview of all activities implemented during the project, short description of achievements, problems encountered and recommendations for further work. The Annexes cover technical documentation on database documentation, metadata specifications and training methodology.

The services and deliverables within project scope were:
- Assessment of the current hydrological and meteorological data collection
- Establishment of Sava HIS geodatabase for data storing as a part of Sava GIS database
- Establishment of Sava HIS web-based application for real time data management
- Establishment of Sava HIS web-based application for processed data and metadata management - Yearbooks (part of Sava GIS)
- Establishment of data export service via web application for further using and analysing hydrologic and meteorological data in HydroDesktop tool
- Knowledge transfer/Trainings

The project is supported by the International Commission for the Protection of the Danube River (ICPDR), the Finnish Meteorological Institute (FMI) and the International Sava River Basin Commission (ISRBC).

Project management was handled by ISRBC Secretariat and ISRBC Expert Groups and the project has been implemented by the Consortium consisting of IN2 Zagreb & IGEA Varaždin.

Duration of assignment was from July to October 2015.

Project goals and objectives

In May 2014, disastrous floods occurred in the Sava River Basin, leading to substantial damages and life losses. Such damages clearly demonstrated the need for improved flood management in the Sava River Basin, both through structural and non-structural measures. Based on experiences in all Sava countries affected by the May floods, it can be concluded that one of the main problems in active flood defence was the lack of timely information on the hydrological situation in the basin.

Sava HIS will provide a tool for collecting storing, analysing and reporting a sufficiently high quality data (precipitation and air temperature measurements, river water level recordings, discharge measurements and water temperature measurements). Those data and information will be used in decision-making system in all aspects of water resources management, especially in flood risk management.

The Sava HIS project goals and objectives are:

- To support the Sava countries, e.g. the beneficiaries (Slovenia, Croatia, Bosna and Herzegovina, Serbia and Montenegro) in sharing and disseminating of hydrologic and

meteorological data, information and knowledge about the water resources in the Sava River basin;

- To enable an effective common channel for exchanging and viewing the hydrologic and meteorological data and information in emergency situations, primarily those related to flood events.

Legal background within the ISRBC framework

Establishment of the Sava HIS is a needful step that will play an important role in facilitating of data handling and providing information flow among the ISRBC and the Parties to the Framework Agreement on the Sava River Basin (FASRB). Article 4 of the Framework Agreement on the Sava River Basin states:

> "...the Parties shall, on a regular basis, exchange information on the water regime of the Sava River Basin, the regime of navigation, legislation, organisational structures, and administrative and technical practices."

Additionally, article 10 of the Protocol on Flood Protection to the FASRB states:

1. In case of flood that induces or may induce transboundary impact, the Parties shall, without delay, inform the Parties that might be affected by this impact, through the System or any other appropriate manner in line with the agreed procedure for exchange of information important for flood defense.
2. The Parties shall, through the hydro-meteorological services and institutions responsible for flood protection, ensure timely exchange of meteorological and hydrological data, analyses and information important for flood protection, especially the timely forecast of high waters, in line with the agreed procedure.
3. The Parties shall inform each other on changes of their regulations and plans relevant to the flood protection in the Sava River Basin.

Besides main legal prerequisites that were fulfilled to start the activities on the Sava HIS project, the preliminary agreements have been made upon basic elements of a system for the exchange of hydrological and meteorological information and data within the basin. Preparation of a regulatory basis for data and information exchange, in cooperation with WMO, started back in 2012. In July 2014, the Policy on the Exchange of Hydrological and Meteorological Data and Information in the Sava River Basin, was signed by relevant organizations of the Parties to the FASRB, and Montenegro, i.e. the national/entities hydro meteorological services (6 institutions signed) and water agencies (2 agencies signed), as a framework for exchanging meteorological and hydrological data and information.

Key achievements through the project

The project implementation included assessment, design, build, development, testing and installation activities. The list of project deliverables and services achievement though the project are given here:

- Assessment of the current hydrological and meteorological data collection and storage systems in the SRB as well as current ISRBC's IT&GIS:
  - o Detail analysis of existing systems of hydrological and metrological data and information management in the beneficiary institutions;
  - o Verification if existing capacities and functionalities of the Sava GIS infrastructure are sufficient to ensure full support to the requirements of Sava HIS;

- o Proposal of technical solution that meets the functional requirements of Sava HIS, in a form of technical specifications;
- o Delivery of Inception report covering above.

- Establishment of Sava HIS geodatabase (part of Sava GIS database) that enables:
  - o Storing hourly time series from raw 24hours data for 30 days;
  - o Storing daily time series from historical data (Hydrological Year Books);
  - o Storing montly/yearly time series from discharge measurements data;
  - o Storing statistical data.

- Establishment of Sava HIS web-based application for real time data management:
  - o Procedures for loading real-time data (from institutions' files that send real time gauging stations measuring data);
  - o Hydrology real time data web application;
  - o Meteorological real time data web application.

- Establishment of Sava HIS web-based application for processed data and metadata management - Yearbooks (part of Sava GIS):
  - o Preparation of interface for uploading daily, montly/yearly statistical data and storing into HIS database;
  - o Yearbooks data overview in the web application;
  - o Searching of gauging stations via Geoportal and attributes overview.

- Establishment of data export service via web application for further using and analysing hydrologic and meteorological data in HydroDesktop tool:
  - o Implementation of WaterML 2.0 data exchange;
  - o Users will have the possibility to use hydro meteorological data with time series from Sava HIS system via WaterML 2.0 export xml data into HydroDesktop tool. The further analysis of hydro meteorological data from Sava HIS system is enabled within HydroDesktop tool (CUAHSI).

- Transfer of the knowledge:
  - o Basic user course for using of the Sava HIS
  - o Advanced administrator course for installation, management and maintenance of the Sava HIS

During Assessment phase in July 2015 the technical meetings were conducted and 9 institutions were visited and interviewed for gathering information on existing systems of hydrological and metrological data and information management in the beneficiary institutions.

In September 2015 the Sava GIS workshop was organized were the Sava HIS project was also presented with its goals and expected outputs. The next day the Ad hoc GIS EG and Ad hoc HMI EG meetings were held at ISRBC premises. During the meetings, the comprehensive discussions were held on the hydro and meteo datasets and stations to be included in Sava HIS.

At the end of October the SavaHIS web applications were implemented and this report gives detail overview of all project activities.

ACTIVITIES CARRIED OUT DURING IMPLEMENTATION PHASE

Results accomplished per components

Work package 1: Assessment phase

Introduction

The Assessment phase in Sava HIS development covered assessing the current hydrological and meteorological data collection and storage systems in the Sava Basin countries as well as current Sava Commission's IT&GIS infrastructure.

The Sava River Basin countries have different methods for collection and storing of the hydrological and meteorological data. During July the technical meetings and interviews with beneficiary institutions were held in each country. The results of the assessment phase were delivered in Inception report.

Work accomplished

The Inception report covered the analysis of data producers' systems with technical capabilities for data collection and distribution of hydrology and meteorology datasets separately. The analysis also covered the metadata availability in each institution. The next table shows the list of institutions with dates of technical meetings:

State	Name of organisation	Abbreviation	Meeting date
Bosnia and Herzegovina	Federal Hydrometeorological Service	FHMZFBIH	22.07.2015.
	Sava River Watershed Agency	AVPSAVA	22.07.2015.
	Republic Hydro-Meteorological Service of Republic of Srpska	RHMZRS	21.07.2015.
Montenegro	Institute of Hydrometeorology and Seismology	IHMS	22.07.2015.
Republic of Croatia	Meteorological and Hydrological Service	DHMZ	13.07.2015. 24.07.2015.
	Croatian Waters	HV	24.07.2015
Republic of Serbia	Republic Hydrometeorological Service of Serbia	RHMZ	08.07.2015.
	Agency for Environmental Protection		08.07.2015.
Republic of Slovenia	Slovenian Environment Agency	ARSO	10.07.2015.

Table 1. List of institutions with technical meeting dates

For each country and institution the Inception report covered information on technical capabilities for hydrology and meteorology separately, metadata availability, current data delivery method for real time hydrological and meteorological datasets and current data delivery method for processed datasets. The real time data are hourly time series from raw 24hours data (collected from gauging stations). The processed data are daily time series from historical data (Hydrological and Meteorological Year Books).

For the SavaHIS system it was also necessary to collect data of hydrological and meteorological stations (organization, type, …), spatial data (points) - locations of measuring stations, with their unique identifiers, characteristics of measuring (data type, interval, units, methods, accuracy, censoring, data quality).

During the assessment phase the conceptual data model was developed which was the baseline for the development of Sava HIS physical database for storing of all datasets.

The Inception report also covered the Sava HIS functional specification with description of the common Sava GIS and Sava HIS software and infrastructure. During the assessment phase it was agreed that the Sava HIS application components will be:

- Sava HIS web-based application for real time data management
- Sava HIS web-based application for processed data and metadata management
- Data export service via web application for further using and analysing hydrologic and meteorological data in HydroDesktop tool (CUAHSI HIS).

Work package 2: Establishment of Sava HIS database for data storing as a part of Sava GIS database

Introduction

During implementation phase the Sava HIS database was designed, built, tested and deployed. Sava HIS system will use existing and same Sava GIS database server (PostgreSQL ver. 9.3.5 with PostGIS Spatial extension ver. 2.1.7) but with particularly designed and implemented data model (compliant with OGC WaterML 2.0 part1: Timeseries model) for data storage.

The Entity-Relationship (ER) database model is included in Annex 1 Sava HIS Database Model together with database specification.

Work accomplished

Sava HIS database model for storing hydrological and meteorological real time and processed data has been designed and structured in accordance to OGC WaterML 2.0 part1:Timeseries model, INSPIRE Directive and professional requirements. WaterML 2.0 is a standard information model for the representation of water observations data, with the intent of allowing the exchange of such data sets across information systems. The core aspect of the model is in the correct and precise description of time series.

Sava HIS database contains:
- 2 schemas (hydro and meteo)
- 44 tables with indexes:
  - 24 tables in hydro schema
  - 20 tables in meteo schema
- 8 views
  - 4 views in hydro schema
  - 4 views in meteo schema
- 1 role (savahis)

Detail description of all tables and views is covered in Annex 1 Sava HIS Database Model.

As agreed and confirmed with ISRBC, the real time datasets will remain stored in the Sava HIS database for thirty (30) days. Each day, the real time data older than thirty (30) days will be deleted from the database. The processed datasets are collected and stored in the central Sava HIS database permanently.

Work package 3: Establishment of web-based application for real time data management

Introduction

To display hydrological and meteorological real time data the web-based application for real time data management is implemented. The application has unified tabular data display and map with marked locations of gauging stations. The data exchange procedures and definitions of datasets provided by each institution was challenging to setup. Each institution has different data collection, maintaining and exchange rules, formats and structure. During project implementation, the discussions were held regarding data collection, minimum exchange content, etc. The next subchapter describes work accomplished, while the detail description of data exchange procedures per each country is covered in chapter Overview of exchange of real time data.

Work accomplished

During SavaGIS workshop in September 2015, the prerequisites for development of SavaHIS, have been agreed:

- Secretariat distributed the list of stations to Ad hoc GIS and HMI EGs. The countries had task to confirm the list and fill in the required mandatory attributes by 01 October 2015;
- Hydrological data to be included in the current Sava HIS application are: water level, change of water level, discharge and water temperature;
- The data that institutions/data contributors send to SavaHIS near real time application shall be hourly recorded data. If the data is not existing the record will be empty, but all data received will be shown in the application;
- The database will store real time datasets for 30 days and this information will be also publicly available on through Sava portal;
- The web application for real time data will include a disclaimer that the data are unofficial. ISRBC will send the exact disclaimer to the consultant;
- The meteo data which is shown for real time application are: average precipitation for the previous day and the hourly temperature.

The datasets are collected via web interface or via web services. The real time data from institutions' gauging stations received in different ways are collected via middleware application. The middleware application has a task to create data conversion, migrate and store collected data into central Sava HIS database. The functionality of Middleware application:

- Periodically download real time datasets from FTP servers,
- Periodically download real time datasets from Web based services,
- Read various data formats and record types,
- Data conversion and mapping according to Sava HIS database model,
- Store data into central Sava HIS database.

The following table gives comprehensive view of all institutions real-time data exchange procedures, data type and content:

| | | | | | | Hydro data | | | Meteo data | | | | |
State	Name of organisation	Abbrev.	Data type	ID	Server URL	Discharge (m3/s)	Water level (cm)	Water temp. (°C)	Precipitation (mm)	Air temp. (°C)	Exchange type	Format	Status data exchange
Bosnia and Herzegovina	Republic Hydro-Meteorological Service of Republic of Srpska	RHMZRS	Hydro	hydro_rhmzrs_bih_rs	http://rhmzrs.com/feeds/json-poslednji-vodostaji-android.json	Hourly	Hourly	Hourly			Service exchange	json	established
			Meteo	meteo_rhmzrs_bih_rs	http://rhmzrs.com/feeds/json-trenutni-meteo-podaci.json				Daily	Hourly	Service exchange	json	established
	Sava River Watershed Agency	AVPSAVA	Hydro	hydro_avpsava_bih_fed	ftp://savacommission.org						FTP exchange	csv	not established for all stations
			Meteo	meteo_avpsava_bih_fed	ftp://savacommission.org						FTP exchange	csv	not established
	Federal Hydrometeorological Service	FHMZFBIH	Hydro	hydro_demas_bih_fed	ftp://savacommission.org		Hourly				FTP exchange	csv	not established
			Meteo	meteo_bih_fed	http://www.fhmzbih.gov.ba/RSS/FHMZBIH.xml				Daily	Hourly	Service exchange	xml	established
Montenegro	Institute of Hydrometeorology and Seismology	IHMS	Hydro	hydro_crnagora	http://www.meteo.co.me/hidrologija/sava_komisija						FTP/HTML exchange	csv	not established
			Meteo	meteo_crnagora	http://www.meteo.co.me/hidrologija/sava_komisija						FTP/HTML exchange	csv	not established
Republic of Croatia	Meteorological and Hydrological Service	DHMZ	Hydro	hydro_dhz_hrvatska	ftp://radar.dhz.hr		Hourly				FTP exchange	csv	established
			Meteo	meteo_dhz_hrvatska	ftp://radar.dhz.hr				Daily	Hourly	FTP exchange	xml	established
Republic of Serbia	Republic Hydrometeorological Service of Serbia	RHMZ	Hydro	hydro_srbija	http://www.hidmet.gov.rs/korisnici/savska_komisija	Hourly	Hourly	Hourly			FTP/HTML exchange	csv	established
			Meteo	meteo_srbija	http://www.hidmet.gov.rs/korisnici/savska_komisija				Daily (6:00)	Hourly	FTP/HTML exchange	csv	established
Republic of Slovenia	Slovenian Environment Agency	ARSO	Hydro	hydro_slovenija	http://www.arso.gov.si/xml/vode/hidro_podatki_zadnji.xml	Hourly	Hourly	Hourly			Service exchange	xml	established
			Meteo	meteo_slovenija	http://www.meteo.si/uploads/probase/www/observ/surface/text/sl/observation_si_latest.xml				Daily	Hourly	Service exchange	xml	established

Table 2. Overview of methods and formats for delivery of real time data

The web-based application interface for real time hydrological and meteorological data can be seen on Figure 1.
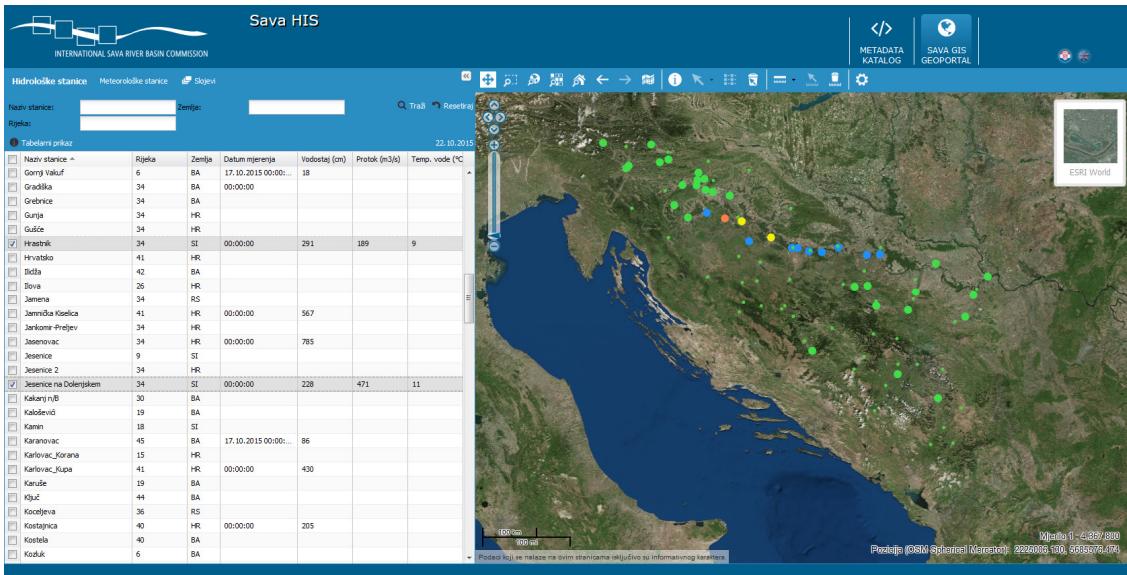

Figure 1 Real time Sava HIS web based application

Tabular data display is separated for hydrological and meteorological data (by tab change). The measurements data can be viewed in detail per station in selected time period. If several stations are selected, each station displays measurement data in own tab.

For water level measurements the chart display can be seen. The chart display is created depending if single or multiple stations were selected.

The following figures represent the data overview in tabular and graphical view:
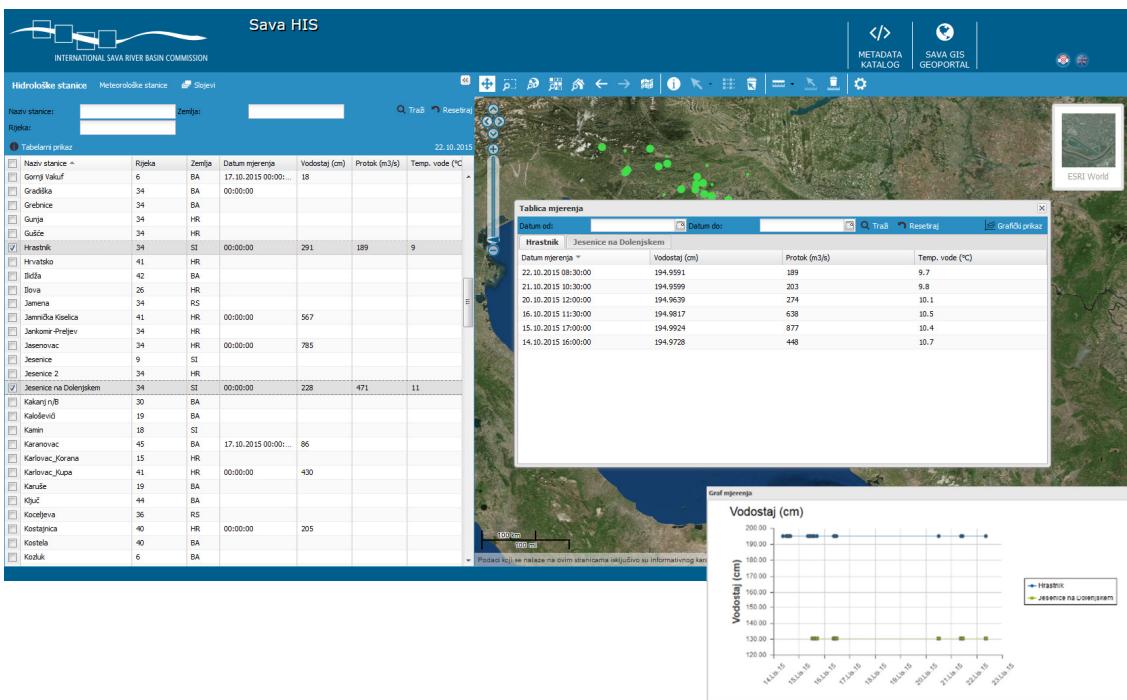
Figure 2: Tabular and graphical view of multiple selection
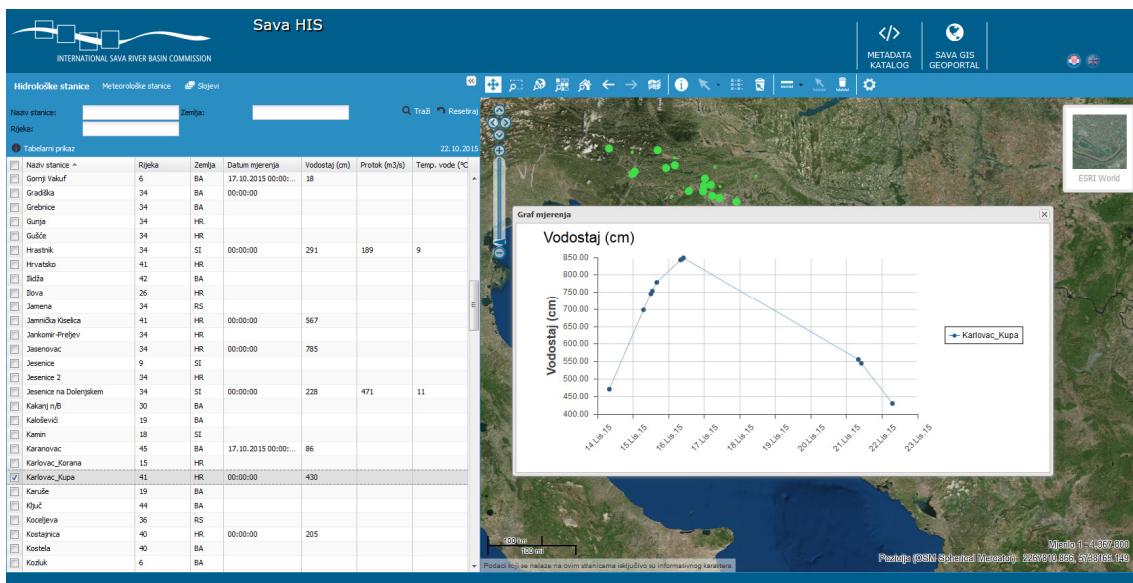
Figure 3: Tabular and graphical view of single station

Symbology of measuring stations (in different colour) displayed on map vary depending on specific measured values such as state of flood protection water level. One of the main aims of the Sava HIS real time application is to have interactive view of all reported gauging stations in the Sava River Basin with the flood protection statuses. The figure 4 shows this interface:
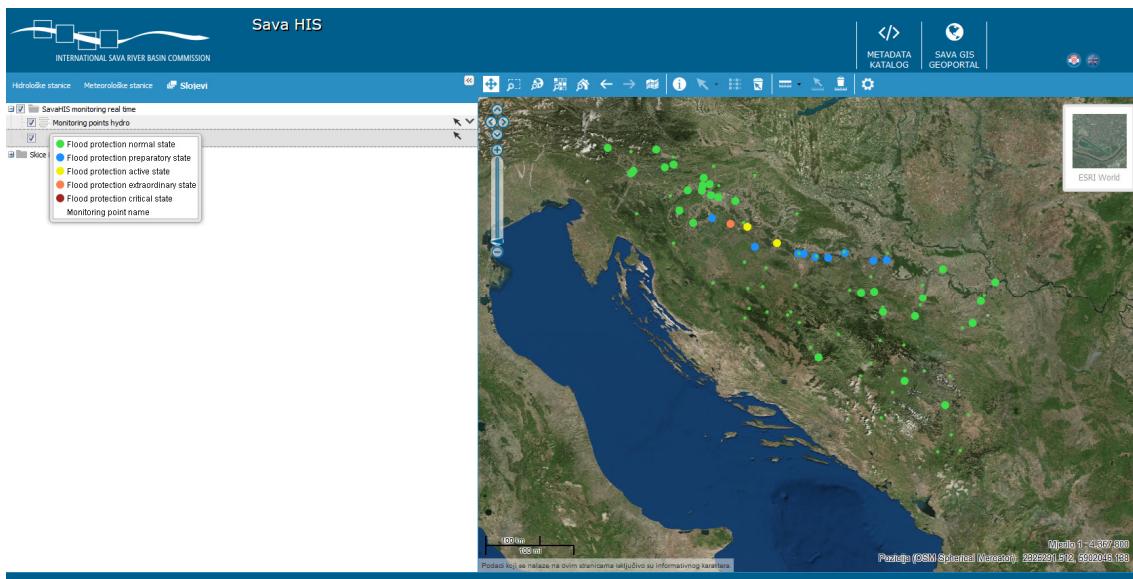
Figure 4: Flood protection statuses and GIS view on the map

Work package 4: Establishment of web-based application for processed data and metadata management

Introduction

Hydrometeorological data collected by Sava HIS system are based on and contain position of the gauging stations. Such data with spatial component can be visualized on a map as a point object with related hidrometeorological attibute data. Therefore, the SavaHIS web-based application for processed data is integrated with SavaGIS Geoportal in order to combine datasets and functionalities of SavaGIS platform. The institutions must prepare the processed datasets for upload into central SavaHIS database under authorized part of application. The processed datasets are data prepared by institutions or ISRBC which is ready for Yearbook formatting in the SavaHIS application.

The metadata management is based on GeoNetwork software which is ISO TC211 and OGC compliant. The parties shall provide metadata via editor or by web services registration. The metadata specification is included in Annex 2 Sava HIS Metadata Specification.

Work accomplished

The implementation of SavaHIS as integrated module of the SavaGIS web application gives the data management based on GeoServer software which implements OGC standards for publishing spatial data:

- Web Mapping Services (WMS),
- Web Feature Services (WFS) and
- Web Coverage Service (WCS).

Sava GIS Geoportal is expanded and enriched with new layer group called Hydrological and Meteorological data where layers are placed related to Sava HIS (see Figure 5):

- Layer for hydrological data
- Layer for meteorological data
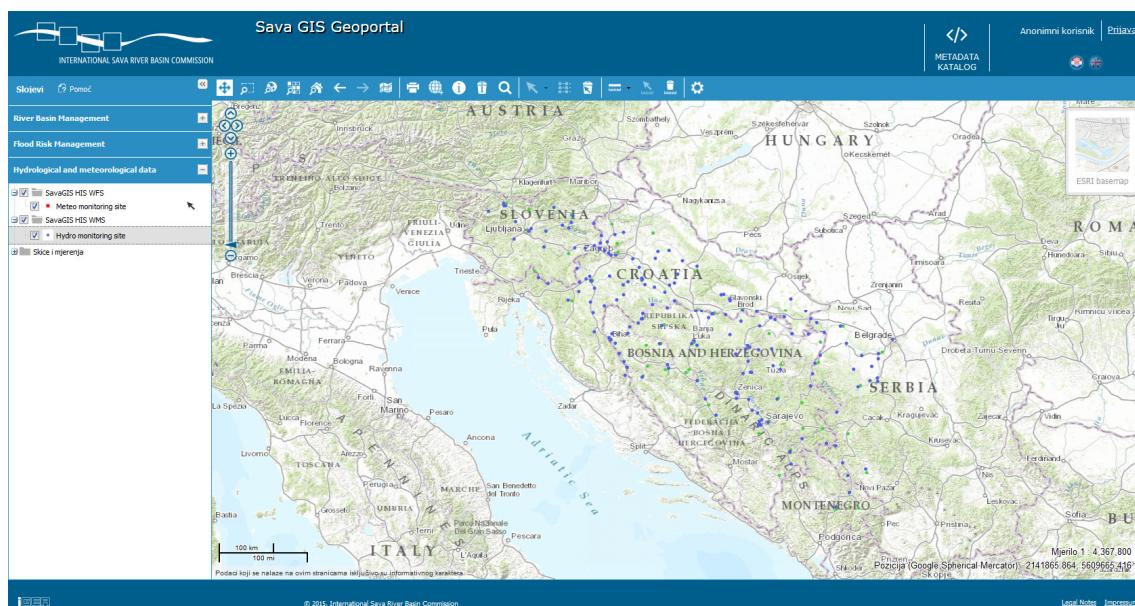
Figure 5: SavaGIS Geoportal with enriched SavaHIS layer group

Selecting individual gauging station on a map will be possible to see descriptive data about the station and get processed hydro meteorological datasets related to selected station. Most functionality of SavaGIS Geoportal can be applied to Sava HIS layers and data, but also can be

restricted according to requirements of Sava Commission or according to user right defined by administrator.

Mentioned layers will show only processed data (official and verified data by the competent institutions delivered to Sava HIS system) visible and available for public and registered users, but only registered user will have permission to download data. User rights and permissions will be regulated through administration module.

During the Assessment phase the analysis was done for methods and formats for delivery of processed data. The overview is done in Table 3:

	Characteristic w levels and discharges	Charact. Air temp and precipitat	Daily levels with freq. and duration	Daily disch. With flow duration	QH combined	Temperature (W / A) (daily)	Precipitation (mthly)
Bosnia and Herzegovina - Fed of B&H	Workbook, correctly structured, one sheet	Workbook, correctly structured, one sheet	Workbook with a sheet per station	Workbook with a sheet per station	N/A	Workbook with a sheet per station. Water only.	Workbook, correctly structured, one sheet
Bosnia and Herzegovina - RS	Workbook, correctly structured, one sheet	N/A	Workbook with a sheet per station	Workbook with a sheet per station	N/A	N/A	N/A
Croatia	Workbook, correctly structured, one sheet	N/A	Workbook with a sheet per station	Workbook with a sheet per station	Workbook with a sheet per station	Workbook with a sheet per station	Workbook, correctly structured, one sheet
Montenegro	N/A	N/A	A workbook per station	A workbook per station. No flow duration	N/A	N/A	Workbook, correctly formatted, one sheet
Slovenia	xls/csv export from ARSO web page	xls/csv export from ARSO web page	xls/csv export from ARSO web page	xls/csv export from ARSO web page	xls/csv export from ARSO web page	xls/csv export from ARSO web page	xls/csv export from ARSO web page
Serbia	Workbook, correctly formatted, one sheet	Workbook, correctly formatted, one sheet	Workbook with a sheet per station	Workbook with a sheet per station	N/A	Workbook with a sheet per station. Air only.	Workbook, correctly formatted, one sheet

Table 3. Overview of methods and formats for delivery of processed data

In Sava HIS system the processed datasets will be collected via web interface. The processed datasets cover daily time series from historical data (Year books), monthly/yearly time series and statistical data which shall be loaded into central Sava HIS database via web interface following the default template.

The workflow of datasets upload and validation is following:

- Each institution that delivers the processed dataset shall upload the data via web interface under login session.
- The middleware application then:
  - reads data formats,
  - makes data conversion mapping according to Sava HIS database model and
  - stores data into central Sava GIS database.

For metadata management of Sava HIS is implemented the GeoNetwork solution which is also used for Sava GIS system. GeoNetwork is an OpenSource catalogue application for spatial datasets management and can be used for metadata search and editing. GeoNetwork is powerful, OpenSource solution based on International and Open Standards for services and protocols (ISO TC211 and OGC standards).

Metadata part will contain the functionalities of metadata entry and provision by manual editing or by web services registration. The users will search registered metadata and overview the description of hydrologic and meteorological data of interest. The detail description of Metadata specification,

for metadata entry and provision as well as for xml file structure, is given in Annex 2 Sava HIS Metadata Specification.

Work package 5: Establishment of data export via web application for further using and analysing hydrologic and meteorological data in HydroDesktop tool

Introduction

The Sava HIS system is implemented for using hydrological and meteorological data for the whole Sava river basin. For the data analysis there are many expert systems for this field of work. In order to enable the analysis of hydro meteorological data gathered in Sava HIS system, the WaterML 2.0 exchange standard via service will be implemented. Accordingly, users will have possibility to import hydro meteorological data with time series from Sava HIS system via WaterML 2.0 service into HydroDesktop tool (CUAHSI) which was recommended by ISRBC. All available and implemented tools (like statistical analysis, graphs visualization etc.) within HydroDesktop software will be available for Sava HIS data.

Additionally, Sava HIS system will be WMO, WIS and WISE compliant as metadata management solution (i.e. GeoNetwork) supports OAI-PMH harvesting protocol and ISO 19115/191139 schemas. But the main prerequisite for taking the advantage of technical compliance is to have metadata loaded into catalogue. This is solely under jurisdiction of local institutions to fill in the datasets.

Work accomplished

The CUAHSI Hydrologic Information System (HIS) is an internet-based system for sharing hydrologic data. It is comprised of databases and servers, connected through web services, to client applications, allowing for the publication, discovery and access of data. Especially interesting component of CUAHSI HIS for Sava HIS system is HydroDesktop tool. HydroDesktop is a free and open source desktop application that serves as a data access client for the CUAHSI HIS. HydroDesktop has common GIS functionality and also includes data discovery, download, visualization, editing, and integration with other analysis and modelling tools. By communicating with WaterOneFlow web services, HydroDesktop gives the user access to rich hydrologic datasets that have been published using this web service standard both in the WDC catalog and independently. WaterOneFlow is a web service whereby you provide a location, a variable of interest (e.g., streamflow), and a time period, and it returns a time series of data.

The last stable version of HydroDesktop tool (v. 1.7.3.) enables data import from services or XML files based on WaterML 2.0 standard (see Figure 28).
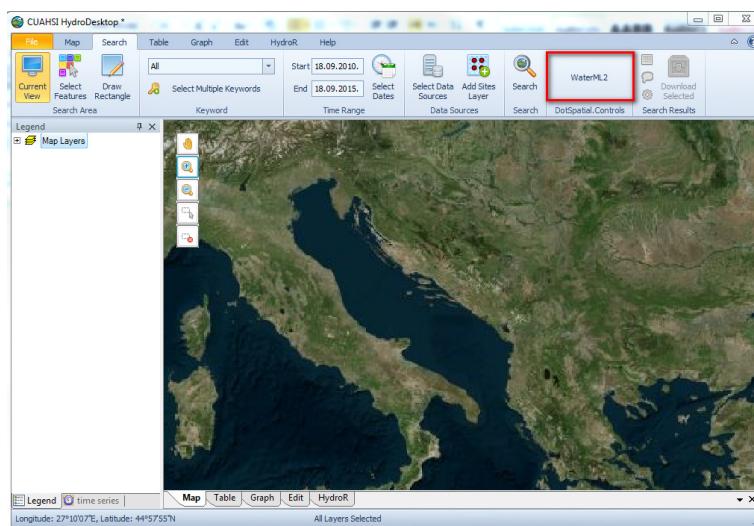

Figure 6: HydroDesktop software (v 1.7.3.) with WaterML 2.0 support

Establishment of data export via web application for further using and analysing hydrologic and meteorological data in HydroDesktop tool will be implemented via the WFS 2.0 (GML 3.2.1) structured in accordance to the WaterML 2.0 format and SavaHIS application.

Introduction

Knowledge transfer is delivered though training courses:
- basic user course for using of the Sava HIS;
- advanced administrator course for installation, management and maintenance of the Sava HIS.

Work accomplished

The training courses for Sava HIS cover the knowledge transfer of the following:
- Basic user course cover the following topics:
  - Sava HIS web application for real-time data overview
  - Sava GIS Geoportal with Sava HIS data segment for stations viewing and searching
  - Sava HIS web application for update of stations' attribute data
  - Sava HIS web application for processed data overview
  - Sava HIS web application for upload of processed data into Sava HIS system
  - SavaHIS web application for metadata management
  - Sava HIS export service in WaterML2.0 structure for further usage
- Advanced administrator course cover the following topics:
  - Sava HIS admin module functionalities for roles
  - Sava HIS architecture
  - Sava HIS stations management and maintenance
  - Creation of web services of SavaHIS datasets via GeoServer and GeoNetwork.

Training participants and logistics is organized by ISRBC.

Project work plan

The work plan presented in the Inception report was adjusted during project implementation according to availability of institutions' data, readiness for data exchange procedures setup, beneficiaries' feedback and project resources availability.

Duration of assignment: from July 2015 to October 2015.

Work package	Planned delivery	Real delivery
Assessment phase	14.08.2015	14.08.2015.
Inception report	14.08.2015-21.08.2015	21.08.2015.
Development phase - Sava HIS geodatabase	31.08.2015	18.09.2015.
Development and support phase - web-based application for data and metadata management	15.09.2015	23.10.2015.
Development and support phase - web-based application for using and analysing hydrologic and meteorological data	30.09.2015	23.10.2015.
Draft final report	10.10.2015	23.10.2015.
Training courses	10.10.2015	30.10.2015.
Final report	20.10.2015	30.10.2015.

Table 4. Sava HIS project work plan

Project schedule deviations and corrective actions

SavaHIS system is aimed to be comprehensive system for sharing and disseminating of hydrologic and meteorological data in the Sava River basin. Due to system complexity, especially in the area of data collection and real time data exchange procedures, the project implementation timetable with initial deadlines had to be extended.

The 8 beneficiary institutions in 5 countries have different data formats and exchange procedures. Additionally, institutions have different levels of technical knowledge for data exchange formats preparation, or lack of resources to be engaged to prepare the datasets and procedures for data exchange. The assessment phase showed a wide diversity in the institutions regarding data availability, formats, exchange procedures, resources and the reporting took longer time than initially planned. The corrective action taken because of schedule deviation was to engage additional resources at Consultant's side.

The implementation of web applications was made in accordance to project task. However, the system datasets for processed data will be empty as long as the institutions start the processed data loading.

Real time application was implemented to show the real time data for water level, discharge, water temperature, and precipitation and air temperature according to specifications described above. For the Sava HIS application development the ISRBC provided the whole list of stations that shall be included in the system. For certain number of stations the real time data values in the application will be empty as long as the relevant institutions don't enable data exchange procedure in the same way as for other stations.

OVERVIEW OF EXCHANGE OF REAL TIME DATA

This chapter gives overview of established exchange of real time data, while the specification of each exchange procedure per each institution is given in [Annex 3 Sava HIS specification of real time data exchange per each institution.](#)

Bosnia and Herzegovina – RHMZRS

Republic Hydro-Meteorological Service of Republic of Srpska Institution established service exchange of hydrological and meteorological real time data.

Hydrology

Hydrological real time data are available in JSON format from service: http://rhmzrs.com/feeds/json-poslednji-vodostaji-android.json. Service can deliver required information's for Sava HIS system: water level, discharge and water temperature, but availability and schedule of measured data varies and depends on particular gauging station. Data for all necessary and expected gauging stations are in response per one service call.

Meteorology

Meteorological real time data are available in JSON format from service: http://rhmzrs.com/feeds/json-trenutni-meteo-podaci.json?lokacija=14545
Parameter "lokacija=14545" is gauging station ID and per one service call in response are only data for one particular gauging station. For required gauging stations is received a list of IDs.

Bosnia and Herzegovina – AVPSAVA

Sava River Watershed Agency will deliver hydrological and meteorological data via FTP by uploading data in CSV format to FTP server: savacommission.org in property of Sava Commission. Access to data on FTP location is secured with username and password.   Until now is established delivery only for few hydrological gauging stations. It was agreed that they will deliver all available data for all requested measuring stations.

Bosnia and Herzegovina – FHMZFBIH

Hydrology

Delivery of hydrological data from Federal Hydrometeorological Service of Bosnia and Hercegovina is still not established. They were asked via email about possibilities of delivery but we have not received and answer yet.

Meteorology

Meteorological real time data are available via service exchange in XML format: http://www.fhmzbih.gov.ba/RSS/FHMZBIH.xml . However specified service does not provide information for all needed gauging stations. They were asked via email about possibility to expand service with all necessary gauging station and about precipitation value in service. XML contains information for precipitation but it is unknown for which period applies. The reply is still pending.

Montenegro – IHMS

Delivery of hydrological and meteorological real time date from Institute of Hydrometeorology and Seismology of Montenegro is still not established, but exchange is agreed both for hydro and meteorological data via FTP and CSV format. They will establish FTP exchange location on their own

servers and let the public address: http://www.meteo.co.me/hidrologija/sava_komisija from where will be possible to download data in CSV format. They agreed to provide all available hydrological and meteorological data for all expected gauging stations.

Republic of Croatia – DHMZ

Delivery of hydrological and meteorological real time data from Meteorological and Hydrological Service of Croatia is established via FTP protocol. They have own FTP location "radar.dhz.hr" where frequently put data and Sava HIS system via FTP protocol copies data in exchange formats. Access to FTP location is secured.

Hydrology

Hydrology data are available in CSV format for all expected gauging stations. One CSV file per gauging station, but only with water level information. There is missing information for discharge and water temperature.

Meteorology

Meteorological data are available in XML format for all expected gauging stations. Value "precipitation_mm" within XML format is unknown. Apropos we are not sure if this value presents daily average precipitation for the past day. We are waiting for the answer to that question.

Republic of Serbia – RHMZ

Delivery of hydrological and meteorological real time data from Republic Hydrometeorological Service of Serbia is established via FTP protocol. They have own FTP location http://www.hidmet.gov.rs/korisnici/savska_komisija where frequently put updated data and Sava HIS system downloads them. Exchange format for hydrological and meteorological data is CSV. They agreed to provide all available hydrological and meteorological data for all expected gauging stations.

Republic of Slovenia – ARSO

Slovenian Environment Agency has established service exchange of hydrological and meteorological real time data.

Hydrology

Hydrological real time data are available in XML format from service: http://www.arso.gov.si/xml/vode/hidro_podatki_zadnji.xml.
Service can deliver required information's for Sava HIS system: water level, discharge and water temperature. Data for all necessary and expected gauging stations are in response per one service call.

Meteorology

Meteorological real time data are available in XML format from service: http://www.meteo.si/uploads/probase/www/observ/surface/text/sl/observation_si_latest.xml
Service can deliver required information's for Sava HIS system: air temperature, average precipitation for past day. Data for all necessary and expected gauging stations are in response per one service call.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions on implementation

The Sava HIS development was divided in two phases. The first Assessment phase covered analysing and assessing the current hydrological and meteorological data collection and storage systems in the Sava Basin countries. The second Development phase covered implementation of technical solutions of Sava HIS. The delivered applications will be accessed via savahis.org and savagis.org.
Regarding reporting, the three reports were requested to deliver: Inception report, Draft Final Report and Final report. Those documents cover all information and specification on implemented system and data collection procedures.

Very good engagement of ISRBC was crucial during project implementation. The communication with all stakeholders was good but the aggravating circumstance was that each institution has different data availability, structure, formats, infrastructure and resources to participate in data exchange process.

The project deadlines were very short and therefore after the web applications development the continuous and further work on data collection must be done. This will be under ISRBC jurisdiction to coordinate and communicate the data collection for attributes of station datasets and processed data with every participating institution.
Especial attention must be put on the institutions that did not establish real time data exchange procedures. At the time of writing this report those institutions are Institute of Hydrometeorology and Seismology of Montenegro and Sava River Watershed Agency from B&H (AVPSAVA sends data for just few stations).

The most important benefit of the Sava HIS system is integrated platform for data collection and visualization of all institutions datasets in the Sava Basin. This will be the central place for overview of data in the whole Sava Basin. The real time web based application shall significantly contribute to the flood protection activities as the water level statuses will be showed in graphical on the map and tabular form. This will help in the overview and planning the flood risk management.

The results of the project will have positive impact to the hydrometeorogical data management in the beneficiary countries. It shall help the beneficiaries to enhance the process of collecting, processing and exchange the data. With SavaHIS project the beneficiary countries and the ISRBC will have great platform for much easier Yearbook creation and management of historical Yearbooks. Full participation of all relevant stakeholders involved with the project implementation is widely recognised as a crucial issue for securing successful implementation and sustainability of the project lifecycle.

Recommendations for further work

The Sava HIS system will support storage of water observations data and spatial information in central database, data publication via web services on the Internet, presentation of water observations data published by related institutions and search across various uploaded datasets.

After project implementation it is necessary to plan the system maintenance covering infrastructure and application maintenance. It would be recommended to plan the budget for contracting the maintenance in the next period.

The implemented system must be used and managed primary by the ISRBC and beneficiary institutions. However, the lack of human resources in ISRBC is recognized and it is recommended to focus on that question. Very important issue that influences project success is also the activity of beneficiary institutions in data exchange process and system usage. The awareness of Sava HIS importance must be continuously communicated and the good cooperation is of vital importance.

ANNEX 1 SAVA HIS DATABASE MODEL

Annex 1 Sava HIS Database Model can be found as separate document attached to this Draft Final Report.

ANNEX 2 SAVA HIS METADATA SPECIFICATION

Annex 2 Sava HIS Metadata Specification can be found as separate document attached to this Draft Final Report.

ANNEX 3 SAVA HIS SPECIFICATION OF REAL TIME DATA EXCHANGE PER EACH INSTITUTION

Annex 3 Sava HIS specification of real time data exchange per each institution can be found as separate document attached to this Draft Final Report.