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HYDRO-INFORMATION SYSTEM FOR DROUGHT MONITORING *

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Abstract. *Drought is a natural hazard caused by the variability in climate, which cannot be prevented. However, its effects can be reduced through management systems incorporating drought monitoring. The main aim of this paper is the presentation of information system for monitoring drought warning based on the model with optimal set of hydro-meteorological parameters: minimal number, availability of gauge data and spatial distribution of measuring locations.*
Monitoring the relevant hydro-meteorological parameters and creation of suitable forecast tools within a hydro-information system for monitoring drought warning would serve as a platform for decision making in drought effects reduction. Significance of this idea is in the substitution of complex climatological models. It requires time and maintenance investments with a practical method for estimation of drought duration and intensity which will satisfy the users' needs and will not require considerable economic investment.

Key words: *hydro-information system, drought monitoring, hydro-meteorological parameters.*

1. INTRODUCTION

According to the UN convention to combat drought and desertification (UNCCD, 1994), drought can be defined as a natural phenomenon occurring when the rainfall significantly deviates from the normal values and causes serious changes in the hydrological balance which has harmful effect mainly on the agricultural production. The existing types of droughts (meteorological, hydrological, agricultural and socio-economic) are interrelated, but each of them is specific in its own way. Nowadays, more than 100 drought indicators are in use, developed and tested for various geographical and climatic condi-

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tions. Application of certain indicators is limited due to a large number of input data which are available only at a limited number of locations.

Taking into consideration the availability of hydro-meteorological data, it is necessary to choose the most suitable drought indicators for particular area. A simultaneous usage of several drought indicators is recommended (SPI – Standardized Precipitation Index, EDI – Effective Drought Index, RDI – Reconnaissance Drought Index, etc.), which results in more accurate prediction. Majority of these indicators are used for daily monitoring of humidity conditions, whereas others are used for research and studies. The SPI is the first indicator which meets the condition of wide spatial application and shows satisfactory results at the level of precipitation deficit determination, which is the first indicator of drought. Although it is simple and universally applicable, the SPI utilizes the precipitation exclusively as an indicator of weather status and defines periods with extreme precipitation or extreme precipitation deficiency and grades the system status between them. The problem is that the SPI does not operate with balance and does not determine the weather condition which may lead to water deficiency, even though average or usual quantities of precipitation occur. For this reason it is assumed that the introduction of the input-output relationship shall bring about a much more realistic weather condition indicator, thus defining the improved drought onset monitoring. As an output parameter evapotranspiration is proposed, not only because according to the UNESCO standards the drought index is defined as a relationship of mean annual precipitation and annual potential evapotranspiration, but also because it contains a wide range of other parameters defining the system status.

The main aim of this paper is the illustration of hydro-information system for monitoring drought warning based on the model with optimal set of hydro-meteorological parameters: minimal number, availability of gauge data, and spatial distribution of measuring locations. Monitoring the relevant hydro-meteorological parameters and creation of the suitable forecast tools within a hydro-information system of monitoring drought warning would serve as a platform for decision making in drought effects reduction.

The tasks to be carried out in the development phase will include all the aspects of establishing interoperability of the monitoring system such as: user demand analysis, metadata catalogue formation, general data model design and development, protocol, ontology and model description and implementation. Additionally, a part of the tasks is carried out in the domain of data model infrastructure development and web service implementation.

2. Drought Problem Analysis

Water deficiency represents a challenge for the environment, life quality and economy. Increase in demand for available water resources generates conflict between various water consumers. The conflicts are the most prominent during long and intensive droughts. The drought problem has been acknowledged at the global level.

Within the framework of an international project FRIEND (Flow Regimes from International Experimental and Network Data) supported by UNESCO-IHP methodologies related to drought analysis have been developed, and the EU project ARIDE (Assessment of the Regional Impact of Droughts in Europe) made a significant contribution to the project by treating drought behaviour characteristics in the area of Northeast Europe. The International Commission on Irrigation and Drainage (ICID) and the United Nations

Convention to Combat Desertification (UNCCD) founded a Drought Management Centre for South East Europe (DMCSEE) with Serbia participating as one of the 13 members. The mission of the proposed DMCSEE is “to coordinate and facilitate the development, assessment, and application of drought risk management tools and policies in South-Eastern Europe with the goal of improving drought preparedness and reducing drought impacts. Therefore, DMCSEE will focus its work on monitoring and assessing drought and assessing risks and vulnerability connected to drought.”

Drought is a natural hazard caused by the variability in climate, which cannot be prevented. Its effects can be reduced through the management systems. A timely prediction of drought has a great impact on both short-term and long-term water and agricultural resources management.

The climate change is a global problem. One of the most important consequences, apart from the increase of air temperature and sea level rising, is a higher incidence of extreme events such as droughts, floods and storms. Even though this project is not directly related to the climate changes, its significance lies in the treatment of a very important manifestation of climate change (drought).

Figure 1 illustrates two examples of the contrasting average monthly temperature and precipitation regimes of various regions (Sacramento Valley and Nis). The weather data were obtained from CIMIS for Davis weather station located in Sacramento Valley Region Yolo County (Central District) and from Republic Hydro-meteorological Service of Serbia for 2010 year. Drought occurs in each of these locations, but characteristics such as frequency and duration vary appreciably. Sacramento Valley's has maximum precipitation in December with minimal concentration from Jun to September. Niš's precipitation distribution is distinctly continental with minimum precipitation from July to September.

Intensification of drought study in the last twenty years resulted in a large number of drought indicators, primarily in the areas of meteorological and agricultural droughts. Study of hydrological drought is sparse, particularly in the methods for its prevention.

In Serbia, research was performed mostly for the large watersheds. On the other hand, the agricultural drought monitoring is performed by the Republic Hydro-meteorological Service of Serbia (RHMSS), which issues evapotranspiration forecasts based on operative data from the main meteorological stations and the forecasts for ten-day period for the same locations. The forecast is based on deterministic forecast of daily maximum and minimum air temperatures.

The main goal of the development of hydro-information system for monitoring drought warning is in substitution of complicated climatologic models which require time and significant maintenance investments by a practical method for estimation of drought duration and intensity which will be able to satisfy the user demands without major economical investment. This gives a good basis for a complex analysis of drought onset, evaluation of its intensity and spatial coverage. Contemporary achievements related to the development of hydro-information system can contribute to the improvement of monitoring drought warning, which is important for increase and stabilization of farming production in significantly changed climate conditions expected in the future.

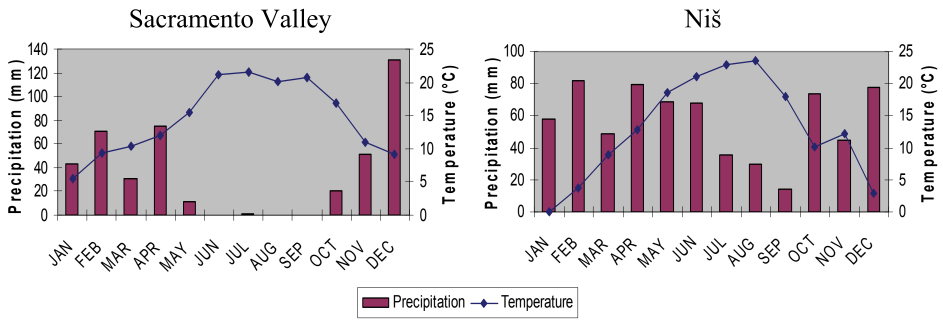

Fig. 1. Climographs illustrating average monthly temperature and precipitation regimes for Sacramento Valley and Nis

3. Architecture of Hydro-Information System for Drought Monitoring

Water deficiency represents a challenge for the environment, life quality and economy. Increase in demand for available water resources generates conflict between various water consumers. The conflicts are the most prominent during long and intensive droughts. The drought problem has been acknowledged at the global level.

Development of hydro-information system for drought monitoring is a complex process that aims to provide abstraction of processes from the real world that surrounds us. In addition, it uses formalisms and collection of techniques which are from the general system theory, hydrology and information systems. In order to reconcile the complexity of real-world, the system includes certain assumptions about the phenomena it describes (drought). That is why during the development of the system pursued simplification and modularization process. Also, because of frequent presence of the need to integrate information from different scientific disciplines, we are faced with the problem of integrating models, which is not an easy or simple process.

Figure 2 shows the architecture of the hydro-information system for drought monitoring which is based on Web services and ontology. The proposed system consists of the following modules:

- Data Acquisition Module (DAM) – whose function is to collect data from hydrological measuring stations,
- Drought Module (DM) – whose function is to use object-oriented model for the calculation of hydro-meteorological parameters such as evapotranspiration (Gocic and Trajkovic, 2010a; Trajkovic and Gocic, 2010; Gocic and Trajkovic, 2011),
- Knowledge Management Module (KMM) – whose function is to collect knowledge from the literature using the software for the acquisition of knowledge and services for integration and information extraction,
- Ontology-Based Module (OBM) – whose function is to use ontologies in the field of drought (drought ontology),
- User Interface – whose function is to access the data processed through the information system.

The data are transferred to the end user via a web interface and OWL (Web Ontology Language) (Smith et al., 2004). The user can efficiently browse all the measured data with appropriate explanations obtained on the basis of experts from this domain.

The goals of using ontology and Web services in hydro-information systems would be:

- Integration with other information systems in terms of environment resources management,
- Monitoring and learning about the drought parameters, because drought can be effectively monitor only through simultaneous measurement of hydro-meteorological parameters,
- Education of users in the field of drought which would result in:
  - Accessibility for applications based on the semantic Web (Gocic and Trajkovic, 2010b),
  - Explicit and clear nature of presented data,

Homogeneity of data without the necessity to additionally finance manual data processing.

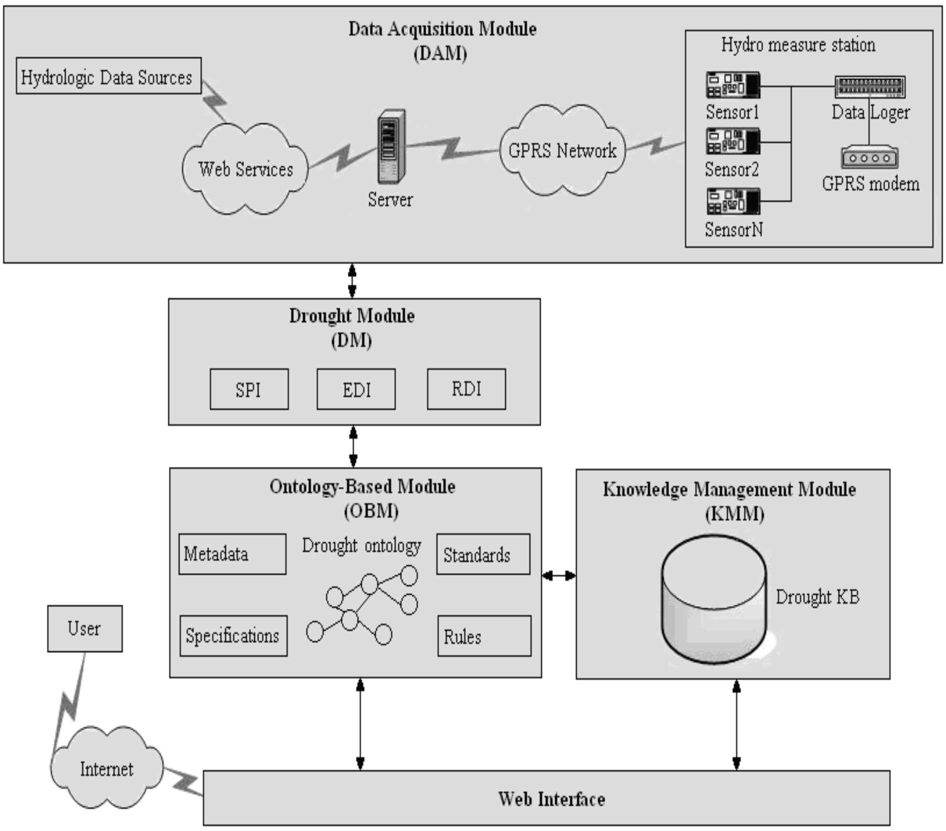

Fig. 2. Detailed overview of the architecture of hydro-information system for drought monitoring

4. Conclusions

This paper presents a possibility to use hydro-information system for drought monitoring. Also, a part of architectural design of an information system is presented. The system will be tested by using the collected data for the identification of the risk zones related to drought and priority areas for development of irrigation.

Naturally, the proposition is aimed at enhancement of interoperability and consistency with the existing information system through application of ontologies and Web services.

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HIDROINFORMACIONI SISTEM ZA PRAĆENJE SUŠE

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Suša je prirodni hazard uzrokovan varijabilnošću klime, koji se ne može sprečiti. Međutim, njeni se uticaji mogu redukovati kroz sisteme upravljanja koji u sebe uključuju praćenje suše. Osnovni cilj ovog rada je predstavljanje informacionog sistema za pouzdano praćenje suše korišćenjem optimalnog skupa hidrometeoroloških parametara po kriterijumima: minimalnog broja, dostupnosti podataka i rasprostranjenosti mernih mesta.

Praćenje relevantnih hidrometeoroloških parametara i izrada odgovarajućih prognostičkih alata u okviru hidroinformacionog sistema za praćenje suše, koji bi služili kao osnova za donošenje odluka u cilju ublažavanja posledica suše. Značaj ove ideje ogleda se u zameni složenih klimatoloških modela koji zahtevaju vreme i velika ulaganja za njihovo održavanje, praktičnom metodom procene trajanja i intenziteta suše koja će moći da zadovolji potrebe korisnika i neće zahtevati velika ekonomska ulaganja.

Ključne reči: *hidroinformacioni sistem, praćenje suše, hidrometeorološki parametri*