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Examples of trends in water management systems under influence of modern technologies

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Subject review

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Examples of trends in water management systems under influence of modern technologies

Reliable and timely information about the current and future condition of water enables an efficient management of water management systems. Advantages and challenges of the use of modern technologies in the collection, analysis, and integration of data, are presented in this paper by means of several examples of water management systems. It is shown how advanced technologies demonstrate a pronounced efficiency in accurate monitoring of various environmental phenomena and in increasing safety of water resources and facilities, while also enabling low water and energy consumption, with simultaneous increase in water quality.

Key words:
water management, advanced technologies, Industry 4.0, information system

Pregledni rad

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Primjeri trendova u sustavima gospodarenja vodama pod utjecajem naprednih tehnologija

Dobivanje pouzdanih i pravovremenih informacija o trenutačnom i o budućem stanju voda omogućava učinkovito upravljanje vodnogospodarskim sustavima. U ovom se radu prikazuju prednosti i izazovi primjene naprednih tehnologija pri prikupljanju, obradi i integraciji podataka unutar nekoliko primjera sustava gospodarenja vodama. Pokazuje se kako napredne tehnologije imaju izraženu učinkovitost u preciznom praćenju različitih fenomena okoliša, u povećanju sigurnosti vodnih resursa i objekata te omogućavaju smanjenje potrošnje vode i energije uz povećanje kvalitete vode.

Ključne riječi:
gospodarenje vodama, napredne tehnologije, Industrija 4.0, informacijski sustav

Übersichtsarbeit

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Beispiele für Trends in Wasserwirtschaftssystemen, die von fortschrittlichen Technologien beeinflusst werden

Das Erfassen zuverlässiger und zeitnaher Informationen über den aktuellen und zukünftigen Zustand von Gewässern ermöglicht ein effizientes Management von Wasserwirtschaftssystemen. In dieser Arbeit werden die Vorteile und Herausforderungen der Anwendung fortschrittlicher Technologien für die Erfassung, Verarbeitung und Integration von Daten in mehreren Beispielen von Wassermanagementsystemen beschrieben. Es hat sich gezeigt, dass fortschrittliche Technologien bei der genauen Überwachung verschiedener Umweltphänomene, der Erhöhung der Sicherheit von Wasserressourcen und -objekten sowie der Senkung des Wasser- und Energieverbrauchs und der Erhöhung der Wasserqualität äußerst effektiv sind.

Schlüsselwörter:
Wasserwirtschaft, fortschrittliche Technologien, Industrie 4.0, Informationssystem

1. Introduction

Current global engineering and technological development in the fourth industrial revolution has been instigated by intelligent systems and process automation. The Industry 4.0 concepts is based on integration of advanced information & communication technologies with mechanical systems with a certain level of process automation (Figure 1). Terms related to the Industry 4.0 concept are the internet of things (IoT), Big Data, Internet of Services, Smart Factory, etc.

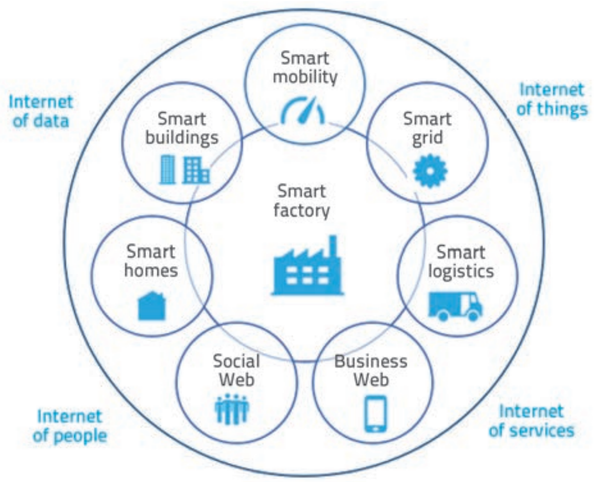

Figure 1. Environment of the Industry 4.0 concept with smart factory integrated and linked to the system, according to Smit et al. [1]

Development of a variety of technologies over the past three decades (contactless measurements, global positioning system GPS, information and communications technology ICT) enabled collection of large volume of real-time data from various sensors. Thus the IoT technology is already widely present in water management (in water supply and irrigation, in flood management systems, etc.) and a number of reviews have been published on the application of technologies in various segments of water management (measurements [2], monitoring activities [3], or applications [4]). According to the report presented in [5], recent trends in the development of technologies that are relevant for water management models can be grouped as follows:

- Reduction in size (smaller and more affordable IoT devices and sensors);
- Emergence of new mobile geospatial sensing platforms (small satellites, unmanned aerial vehicles);
- Extension of communication technologies and networks;
- Advances in computing power and speed.

Water management systems are increasingly being influenced by a number of pressures. On the one hand, an ever greater pressure from rapidly evolving science, technology and global communications imposes new standards for companies and organisations on the national and international levels [6], where digitisation is recognised as the main instigator of technological changes at all levels (from individual companies to national-level organisations) [1]. On the other hand, an increase in environmental pollution, climate change, and decline in biodiversity, has also resulted in the introduction of new approaches to the management of water resources and infrastructure [7]. Companies have recognised these challenges and their expectations are that the implementation of advanced technologies will be a good and sustainable solution for them [9].

The application of new technologies involves also some challenges. In fact, not all organisations have capacity for rapid and easy adaptation. In addition, experiences gained in the European Union so far [1] shows that a successful implementation of this concept is highly dependent on the standardisation of the system, platforms and processes, on the changes in company organisation and introduction of new business models, on the digital safety and, finally, on the research and investment in innovations. New guidelines of the World Meteorological Organisation (WMO) [10] also reveal that the distribution and open exchange of information, and implementation of integrated information systems, are crucial for an efficient operation of global monitoring systems and natural disaster management.

Considering the complexity of water management systems and the influence of various pressures and challenges, the question that arises is on the extent that advanced technology (collection and transfer of various types of data, informatisation) is implemented in different areas of water management, and on the level of process automation (as the main advantage of the Industry 4.0 concept) within such systems. This paper is not aimed at providing detailed and extensive overview of all advanced technologies and their implementation in the field of water management, but to try to gain insight – through a holistic approach – into the way in which the Industry 4.0 concept shapes and guides the technological and societal changes in water management systems. This objective has been addressed through presentation of recent trends in the data acquisition technology, data processing and analysis, and communication infrastructure, as well as through an overview of trends on the knowledge and skill needs within the four selected areas: water supply, agriculture, flood control, and oceanography. The comparison of trends in the selected areas has revealed advantages and challenges in the wider application of advanced technologies in water management systems. Possible future development trends are also outlined.

2. Integrated water management information system

An integrated information system is a central place that brings together and connects all elements and processes within the system. Former water management information systems had separate subsystems (data collection, database, supervision-control solutions, GIS applications, and applications in decision support) [11]. An integrated water management information system (Figure 2) upgrades the existing systems and includes, in addition to operational and monitoring subsystems, the policy-level subsystem in which rules, responsibilities and specifications are defined for all horizontal and vertical processes and activities (from data collection and processing to their exchange) [10]. The level of complexity of an integrated water management system can be seen by reviewing the WIGOS system (Integrated Global Observing System) [12].

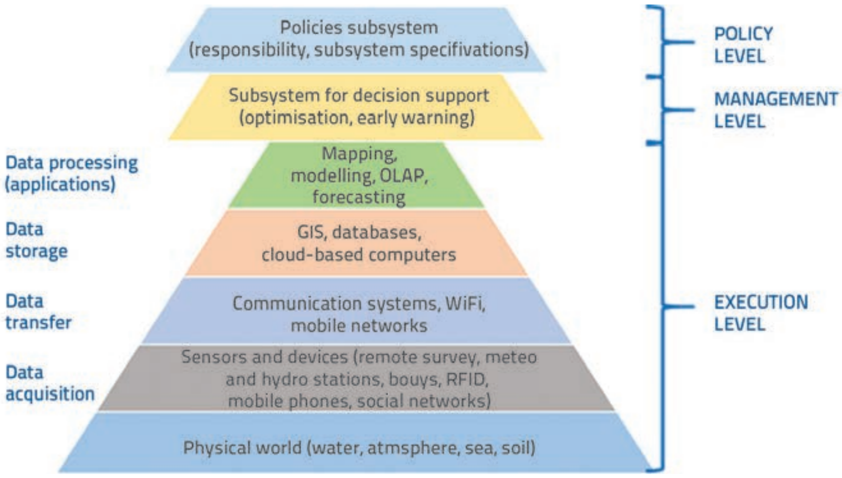

Figure 2. Functional components of an integrated water management information system

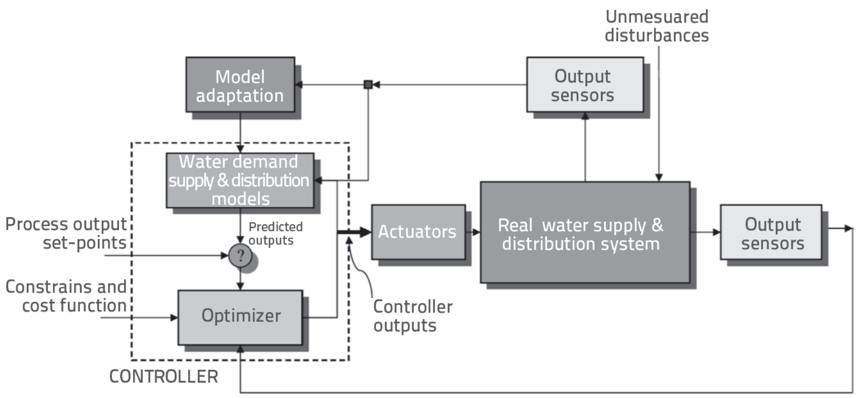

Figure 3. Architecture of an automated decision support subsystem [8]

Big Data and IoT are terms for the collection and processing of great quantity of digital data in real time. In advanced systems, the data are stored locally and/or in the cloud usually involving wireless transfer of data (mobile internet 2G/3G/LTE or IEEE 802.X protocol WiFi/Bluetooth/RFID). The application layer consists of platforms for the support to subsystems and platforms for in-cloud computing (Online analytical processing OLAP, etc.), and it serves for storage, processing and distribution of data and other information obtained from sensors, devices, and web services. The application layer is the top level and it constitutes the final operational task of an integrated information system.

One of advantages of integrated systems is the implementation of numerical calculation for physical systems in the present time (system simulation) or the future time (system forecast) as a support to decision making on management of physical systems. Partly or fully automated support to decision making (Figure 3) enables implementation of optimisation calculations with regard to predefined management goals and scenarios. Process automation is less complex in smaller systems and in a single organisation. However, challenges are very different in international environment where the flexibility and extensibility in data management and data exchange become basic functional elements for sustainability of information platforms [10].

3. Selected areas

3.1. Advanced technologies in water supply systems

Current growth of water-supply systems has resulted in the development of two separate subsystems: supervisory control and data acquisition subsystem (SCADA), and the business monitoring subsystem with an emphasis on monitoring water consumption bills of end users. SCADA solutions are characterized by various levels of automation (hand-operated or automatic remote control), while the communication between SCADA and water supply facilities is usually wireless (GSM or local Wi-Fi network), Figure 4. The use of the fourth industrial revolution concept in water management systems (water supply and sewer systems) has enabled a horizontal integration of physical (structures/facilities) and non-physical (computer) parts of the system, and a multicriteria optimisation of the system operation.

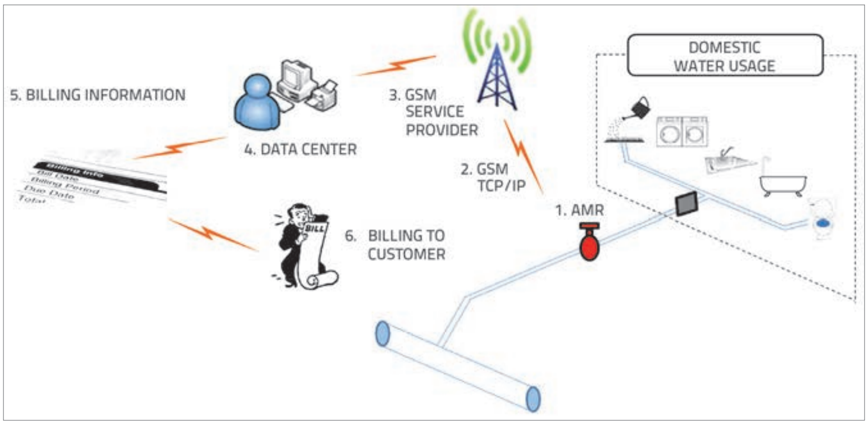

Figure 4. Modern water bill registering system using automatic remote water meter reading (AMR) device with wireless transfer of data [9]

In smart homes, the data obtained from a wide range of sensors are transferred via internet to online applications that enable, via remote control of outlet points (shower, garden sprinkler, sink, washing machine, toilet, etc.), control of the water and electric energy consumption, safe operation monitoring (in case of a malfunction or leakage), and monitoring of water quality parameters. In smart water-supply systems, the data are collected by various sensors at physical elements (facilities and equipment) of the water supply system and integrated with data obtained from remote surveying, although the infrastructure is mainly buried below the ground level. Therefore, there are:

- Water facilities subsystem (SCADA) that measures the pressure and flow rate in the network, water level in water tanks, the quality of water (water captured at intakes, water collected at connection points), status and irregularities in the operation of facilities and equipment (deviation from normal operating regime, or malfunction);
- Water quality monitoring subsystem that measures water temperature, concentration of free residual chlorine in water, and pH of water;
- Electricity consumption monitoring subsystem that collects consumption data at the facility and equipment (according to applicable tariff models), as well as the data on peak power, wattles power, and CO_{2eq} production;
- Remote surveying (thermography, multiple satellite imaging, microgravity disturbances) that collects data on pipe rupture occurrence and leakage location [13].

All the data are transferred to the main application in the information centre via a wireless or optic cable network of sufficient capacity (such as DWDM, Dense Wavelength Division Multiplexing) (Figure 5). The corresponding application is used to perform data checking and geo-positioning via GIS so that the an integrated database is formed. In addition to executing subsystem, each integrated water supply system also has a decision-support subsystem, business information subsystem (finances and billing), together with other subsystems (Figure 5).

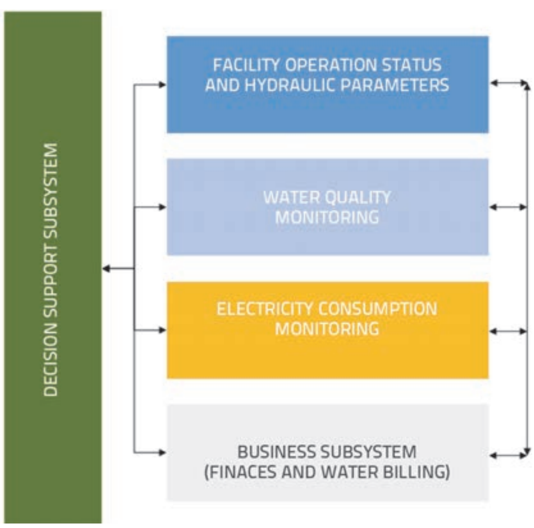

Figure 5. Schema of an integrated public water supply system

To achieve control and optimisation objectives, the decision support subsystem analyses the existing and various forecasting conditions of the system (influence of planned activities on the system) (Figure 3). An optimum solution can be obtained by simulating a set of possible water supply scenarios on a hydraulic numerical model, taking into account operational limits. The decision making support can also be provided by an expert system that is previously equipped with the database on system operation in specific conditions, as a formalized form of knowledge of real-life experts.

Some uses of IoT solutions in water supply include an automated supervision of water storage reservoir levels that involves integration of SCADA system with programmable logic controllers (PCL) based on fuzzy logic [14], supervision of illegal connections to a water supply network and a water theft [15], electricity consumption control [16], water quality monitoring with optimisation of the quantity of water available at water intake structures [17], and system optimization based on specific parameters.

3.2. Precision agriculture

The term *precision agriculture* denotes agricultural systems that use advanced technologies for the collection and analysis of various data sets, which are subsequently used for decision making and work automation. As irrigation systems are the greatest consumers of water, an efficient management of agricultural production is necessary to achieve sustainable management of water resources.

In precision agriculture, the data can be collected from numerous sources (e.g. ground sensors, GPS, remote survey) and used in operation by agricultural machines compliant with Industry 4.0. Advanced data acquisition technologies include modular sensor platforms and nanobiotechnologies. Nanobiomaterials are used to transfer chemical signal from plants into digital data which are then interpreted by conventional methods thus bypassing physical limitations of sensors [18]. Microcontrollers based on Arduino platform have proven to be a cost-efficient and adaptable solution [19] as they can use various sources of power supply, combine input from several different sensors, and locally store data with simultaneous wireless transfer to remote server [20]. For monitoring crops over a wider area, it is efficient to use cost-effective solutions combining energy efficient IoT sensors with wireless sensor networks (WSN) and remote surveying techniques. Multispectral satellite images have proven to be quite reliable for monitoring evapotranspiration, surface soil water content, estimating soil alkalinity and salinity, as well as development of diseases [21-23], while LIDAR images are used for characterisation of canopy parameters related to plant volume and density [24]. Social networks have the potential to be the source of real-time data from which information about diseases can be extracted directly from the users (plant photo, short description of disease, GPS location) [25] which, combined with geotagging can enable timely monitoring of the spread of disease.

Several examples have been published about the successful integration of the Industry 4.0 concept and agricultural IT systems. *SmartFarmNet* [26] is a globally most represented agricultural IT system enabling proper assessment of the crop performance, while also giving recommendations for crop management based on virtual laboratory environment that supports real-time interaction with users and data sharing. *mySense* environment [22] integrates various ground sensors and cloud services, supporting front-end applications utilizing Arduino and RaspberryPi low -cost solutions combined with IoT device SPWAS'18 (Solar Powered Wireless Acquisition Station). Using cloud-based application, it enables presentation, processing and distribution of data in real time and provides a real-time alert via Python script. *AgriPrediction* [27] provides warning notifications about potentially unfavourable crop condition based on data analysis acquired from the wireless sensor network using LoRa WSN-driven technology, while for estimation of crop condition the ARIMA (autoregressive integrated moving average) model is used. The *SWAMP* [28] application enables precision irrigation by controlling water distribution in real time using a set of IoT sensors. Debauche et al. [29] propose an automated operation of pivot irrigation systems which calculate water requirements based on soil moisture measurements, GIS mapping, and estimation of the potential evapotranspiration while series of photographs and sound from the camera in the centre of the pivot enable monitoring condition of crops and detection of malfunction of mechanical equipment. Subsequent processing of various data sets requires advanced algorithms and decision-making systems, such as supervised learning or neural networks, which have proven to be favourable in the analysis of complex interactions in water management [30]. *SMART-Farm Tool* [31] estimates sustainability of agricultural farms through multicriteria analyses from FAO-SAFA guidelines where input data are grouped into a set of sub-themes with the corresponding objectives and indicators, and with allocation of impact for individual indicators.

3.3. Advanced flood risk management technologies

Flood risk is defined as a combination of the probability of a flood event and its potential negative consequences. The greatest impact have fluvial floods and urban floods, which are characterised by low frequency (stochastic nature) and high impact. Measurements made on the network of meteorological and hydrological stations constitute a reliable and almost continuous set of long term data with various variables at the measurement point (flow rate, soil moisture, precipitation, etc.). Hydrometeorological data recorded on such network of stations form the basis for calibration of remote surveying and testing of new algorithms and techniques [21], while real time recordings together with numerical weather predictions greatly increase the reliability of operational flood forecasts. In addition to national networks, there are many organisations and incentives that collect and send automated hydrometeorological measurements in real time, often with open access (such as http://pljusak.com, radioamateri).

Different sources have been recently used in flood risk management including air photographs and videos (satellites, drones), LiDAR images, IoT sensors, GPS data, on-site photographs (mobile phones, surveillance cameras) and numerical simulations [3]. Individual persons directly publish on social networks and blogs a multitude of data (photographs from mobile phones and web cameras, positions, descriptions) about a variety of phenomena, including natural disasters and floods. It was demonstrated that recent technologies have been widely applied in various phases of natural disaster management: from disaster monitoring, detection and prevention, to preparatory activities during the event, and to relief activities after a harmful event [5]. There is an increasing trend in real-time geospatial remote surveying data. The number of mini satellites orbiting the earth is increasing, mainly because they are lightweight, easy to launch, and can be easily placed in orbiting position. By using novel technologies, they are now capable of performing tasks reserved only for big size satellites. In fact, as many as 835 new satellites were launched in 2017 and 2018, and the total of 2000 small satellites are expected in earth orbit by 2030. Significant cost reduction of drones has greatly contributed to an increase in their numbers and quantity of data they generate for business and private purposes.

The integration of physical-environment data sets (originating from air or ground survey, or from social networks) with their locations has enabled an operational monitoring and accurate mapping of a variety of phenomena (meteorological disturbances, flooded areas, endangered structures, landslides, hurricanes, tsunamis, accidental pollution events) almost in real time, while such monitoring and analysis results are often publicly available (e.g. European Flood Awareness System EFAS, Global Flood Awareness System GloFAS). However, this exponential increase in the number of time-tagged geospatial data also requires new methods for processing and presenting such enormous quantities of data in real time [32]. In

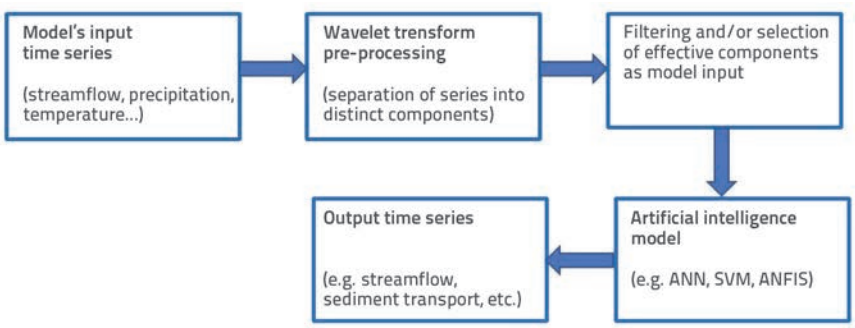

Figure 6. Flow chart of artificial intelligence (AI) model preparation, with pre-processing of input data using wavelet transform [36]

hydrological analyses, the data assimilation must be prepared and the interaction between various hydrological processes has to be estimated. Physically-based hydrological-hydraulic numerical models (such as the LISFLOOD model) have been traditionally used in operational hydrological forecasting systems, and the increasing processing power requirement has been solved through incorporation of CPU units into computer clusters.

Recent numerical modelling techniques include cloud modelling (commercial or open-code modelling) and modelling based on multiple GPU cores. Alternative approaches to hydrological forecasting involve models based on mass data, and include the use of advanced analytical techniques (deep learning, cloud-based computer analysis, integrated geostatistics [33]) and models based on artificial intelligence (AI models). AI models have proven to be successful in modelling complex correlations between hydrological variables (precipitation-runoff, sediment transport, ground water, etc.) [34]. The wavelet transform method have been used for data pre-processing in AI flow forecasting models and suspended sediment transport in watercourses [35, 36] and for satellite or radar data pre-processing [37]. Preparation of a hybrid AI model with pre-processing of input series signals using wavelet transform is presented in Figure 6.

3.4. Advanced technologies in oceanography

Oceanographic variables (sea waves, velocity of sea currents, temperature, sea salinity, etc.) and meteorological variables (wind speed, temperature, precipitation) are significant environmental variables that affect various aspects of sea management: safety of people and infrastructure, sea and port transport, environmental aspects (oil spills, ballast waters, nutrients from rivers and surface drainage). Sea

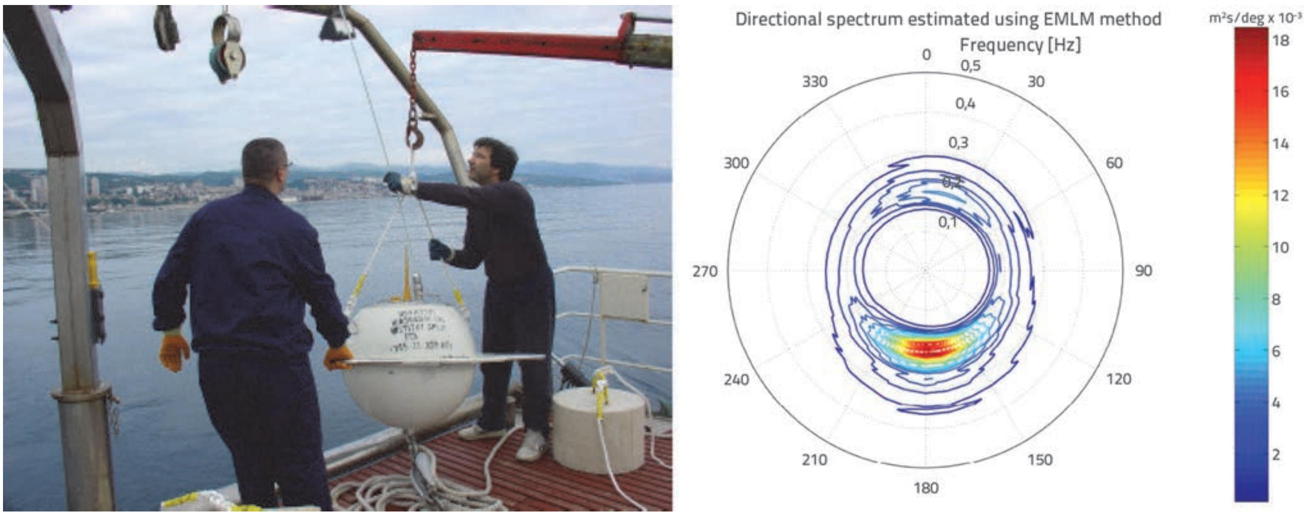

Figure 7. Wave buoy Waverider DATAWELL DWR MKIII in front of the city of Rijeka in 2009-2010, buoy installation and measured directional wave-energy spectrum (in real time)

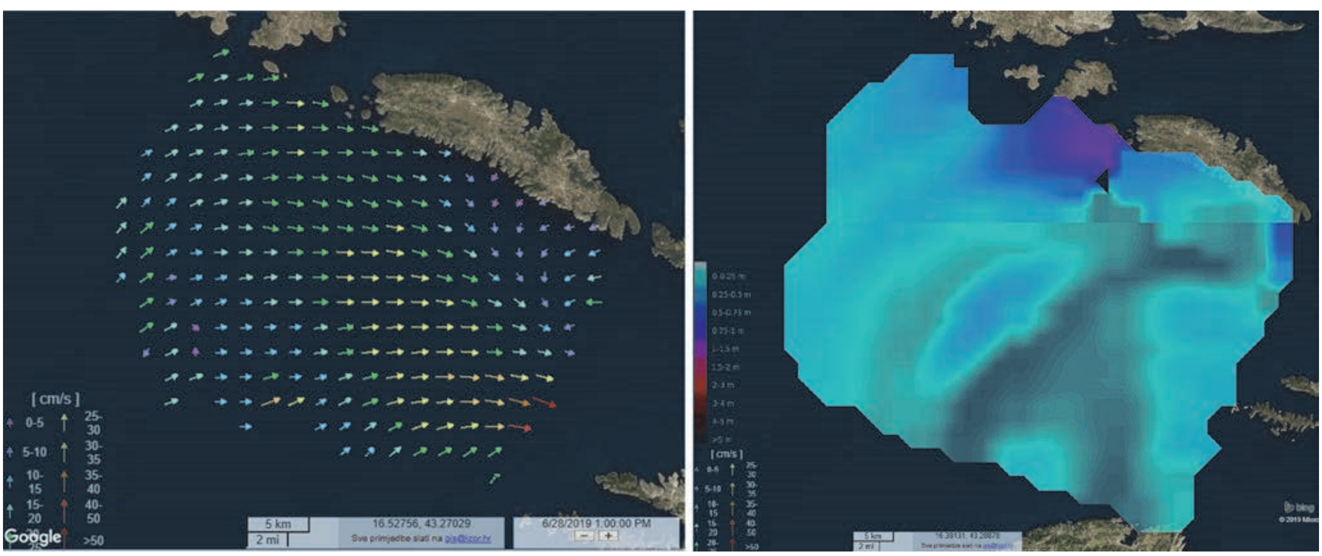

Figure 8. VF radar monitoring results on Šolta Island, field of surface sea currents (left side) and wind wave field (right side)

monitoring traditionally involves local measurements (CTD probes, ADCP devices) with subsequent data processing, thus remote collection of oceanographic data in real time is of great importance. The autonomous buoy Waverider DATAWELL DWR MKIII sends wave data to an on-shore computer by transferring data using antenna (HF antenna – RX-C receiver) thus enabling presentation and analysis of measurement results in real time from any location at open sea (Figure 7). The Croatian Hydrographic Institute (CHI) has in a short-time plan deployment of seven such buoys in the near-shore zone, and the coverage is to be additionally extended in a recent future.

More recent remote sea and wave measuring methods focus on the application of shore-based radars and on satellite measurements. New coastal VF radars enable spatial monitoring of sea surface velocities and wind wave parameters in real time (Figure 8) within the area of 40 x 40 km with the spatial and temporal resolution of 1.5 km and 1 h, respectively [38]. Initial steps in the implementation of this technology are carried out at the Adriatic Sea in the scope of HZADR and NASCUM projects.

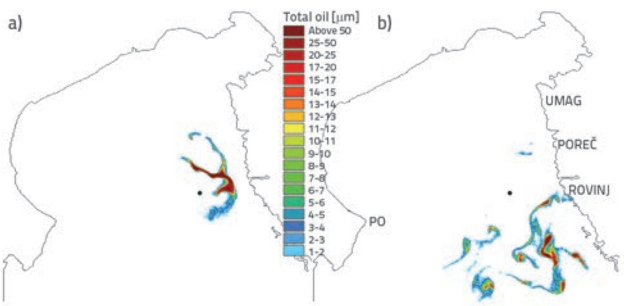

Figure 9. Oil pollution zone 240 h (a) and 480 h (b) after an accidental oil spill (6 February 2008 at 6 a.m.) [39]

Considering the complexity of sea management activities, an international platform Maritime Situation Awareness (MSA) [40] has been developed in order to integrate measurement and processing of oceanographic data, and to disseminate data to various decision support systems. If there is no permanent oceanic monitoring network for obtaining the dynamics of sea current and waves [41], the dynamics of contaminant transport [39] or the dynamics of chlorophyll transport [42], then appropriate numerical models are used, but only for specific locations and for the needs of individual projects (Figure 9). The application of numerical models using historic wind data can provide a long-term database (10 to 15 years) about sea currents and water, with temporal resolution of 1 to 3 hours. The efficiency of machine learning has proven to be quite high in case of short-tem predictions of wave heights based on measured and/or numerically modelled wind data [43, 44], which reduces the computation time when compared to numerical models (such predictions are useful in the scope of the MSA concept).

4. Discussion

The overview of recent trends in selected areas clearly shows the advantages of their implementation. Advanced technologies have enabled a significantly detailed and accurate spatio-temporal monitoring of all water systems and related structures, as well as their safety supervision (e.g. infrastructure failure, preventive measures, accidental pollution, sea transport, etc.). Visualisation of geospatial data has enabled clear identification of changes and migrations of regional environmental phenomena, often within open platforms (EFAS, GloFas). Adjustable real-time cloud-based integrated information platforms (commercial or open code) with almost automated management-related applications (decision support, system optimisation), and with end-user support, have enabled an increase in the system's efficiency (reduced water and energy consumption within water supply and irrigation, higher yield) as well as an increase of water quality.

After accession to the European Union, various individual and integrated high-level ICT solutions have been widely applied in a number of water management systems in the Republic of Croatia. The implementation of ICT technology has resulted in the development of supervisory control (SCADA) subsystems within the water supply [45] and hydropower plant management [46] systems. Precision agriculture approach is implemented in vineyard irrigation systems [47], in automated fertilisation systems with integrated navigation, and in real-time computation of vegetation indices [48]. Information systems (such as Field Watcher) offer support to farmers by providing geo-tagged photos by using integrated DroneDeploy platform for drone mapping, while SmartRain systems are used for irrigation timing and monitoring based on analysis of relevant data. Flood risk management systems are successfully implemented through operational flood forecasting systems (such as FRISCO1 Geoportal [49]), by modernisation of hydrologic stations (VEPAR project), and via modernisation of meteorological monitoring system (METMONIC project).

Organizations active in the selected water management areas may have different needs, objectives and stakeholders. However, it is evident that the implementation of advanced information systems, albeit useful for organisations, is not possible without increase of the ICT infrastructure and knowledge [50]. Furthermore, published examples show that larger organisations (farmers) implement advanced technologies to a greater extent and that most of them already use digital technology (and an upgrade to the IoT connected system is a logical development). On the other hand, smaller organisations (farmers) do not often obtain adequate return on capital investment (e.g. on IoT sensors, software applications, technical support). Malicious overtaking and manipulation of data causes major negative financial and functional effects, so the data safety presents an important aspect in various processes within information system and organisations. Almost on a daily basis, water engineers are faced with the need for investment in the maintenance of existing infrastructure in the advancement of their own technical and professional capabilities, which is often not sufficiently recognised in national strategies and policies.

There are several challenges that limit wider application of new technologies in the field of water engineering. The number of weather stations and hydrological stations is continuously decreasing in a number of countries [51]. There is a need to make additional harmonization in the water quality monitoring between the global and local levels [52]. Challenges hindering satellite techniques include sky covered with clouds and night flights (for sensors in visible spectrum), and the algorithms that are insufficiently developed for conversion of some signals into variables. In addition, satellite overpass cycles (between 1 and 15 days) are a limitation for monitoring rapidly-forming phenomena. Insufficient capacities (bandwidth) and density of telecommunications networks is a limiting factor impeding development of advanced systems in developing countries. Standardisation is currently a great challenge for process automation on the international scale [1, 52], and a harmonized data exchange is a key segment in systems (hydrologic and oceanographic models) covering several countries (*Manual on the Global Data-processing and Forecasting System* by WMO [53], *INSPIRE Directive by the EU*, *Open Geospatial Consortium* OGC platform). Inadequate development of information systems is a frequent problem in developing countries where data are usually collected and processed in a decentralised manner (in several agencies and ministries), which is totally inappropriate for making operational management decision (such as decisions related to flood risk management) [6].

An increasing presence of various sensors on the ground and in the air is noted in all segments of water management, as well as in the volume of data coming from social networks. The trend toward further reduction of sensor size (inexpensive IoT devices, mini-satellites) is expected to continue in the future. Rapid development of algorithms and AI models for efficient processing and presentation of an ever increasing number of data from satellite images is also expected. A considerable advance is expected in monitoring of remote and still ungauged areas through integration of data from new air-bounded sensors with affordable IoT ground-based sensors. It is expected that various elements of advanced systems will be connected in agricultural production [4] (integration of spot data, spatial data and big data), but a wider application of advanced technologies is anticipated mainly among larger farmers. As to flood risk management systems, it is expected that the data from social networks will be integrated in real time with the measured data (on the ground and in the air), and that models based on statistics (deep learning, AI models) and cloud-based models will be take up an increasingly greater space compared to the models based on process physics. As an insufficient number of sensors is currently located along Croatian coastline, it is reasonable to expect an increase in the number of monitoring stations, and that various sources of data will be connected with the numerical oceanographic models. Recent advances have been initiated and supported by a considerable development of communication technologies, and a rapid transfer of great quantity of data will be certainly progress in parallel with the development of wireless ICT infrastructure and cloud computing. A wider application of blockchain solutions as an advanced computing technology is anticipated for the resolution of information security and data integrity issues. To enable an efficient use of full potential of advanced technologies, the strategy for information system development and specifications of all individual subsystems (open code applications, models, data locations, etc.) are essential. Considering the uncertainty of future technological developments, and in the context of system sustainability needs, the modular and adjustable information platforms may have their advantages compared to closed systems.

5. Conclusion

Advantages and challenges in the collection, processing, analysis, and integration of data via advanced technologies in water supply and agricultural systems, and in flood risk management and oceanography, are presented in this paper. The number of measured data from small sensors installed on the ground, on structures, and in the air, has been increasing exponentially in recent times. These data, together with the data from social networks, are being geospatially integrated, analysed and visualised in very short time intervals. An exceptional increase in the number and sources of data drives existing desktop and cluster physically based models towards cloud-based and machine learning models. Information systems have enabled a more detailed and accurate spatiotemporal monitoring of all water systems, supervision of system safety and an efficient implementation of preparatory and protection measures on the ground and at sea, while optimisation algorithms and almost automated operation have reduced consumption of water and energy with a simultaneous increase in revenues and water quality. Considerable advances are expected in the monitoring of remote and still ungauged areas through integration of data from new air-bound sensors with affordable IoT ground-based sensors. However, in parallel to such technological advances , the water management and infrastructure facilities are aging and climate change and extreme weather conditions impact is growing, and companies that continuously invest in their development and capacity building have more success in such new conditions . It can be concluded that advanced technologies and integrated information systems can offer efficient response to climate change and to sustainability concept issues in the areas of water use, preservation and management, but only with properly structured systems and permanent investment in development capacities of companies.

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