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ANALYSIS OF KNOWLEDGE SOURCES IN STANDARDIZED ENVIRONMENT-RELATED FIELDS USING ORIGINAL SOFTWARE APPLICATION

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Abstract

Within the International Classification of Standards (ICS), the field of Environment, Health Protection and Safety is classified as ICS1 = 13, i.e. ranking 13^{th} among 40 fields at the 1^{st} classification level. The field includes 21 subfields at the second classification level (ICS2). This research aimed to analyze the intensity of innovations in 5 of those second-level subfields (environmental protection, wastes, air quality, water quality and soil quality). The chosen fields cover the broadest and most significant environmental issues. The intensity of innovation is certainly different on local level (Serbia) and global level (the World). Thus, one of the goals of this paper was to collect and compare knowledge sources from local and global databases with reference to financial needs for acquiring those sources. Data was collected by an original software application that was developed for this purpose in Java programming language. The results show that knowledge sources within five analyzed fields vary significantly between local and global level. Continuous development of standards in the whole 13^{th} field was also noted. The number of newly developed standards every year is little more than one per work day. This fact should be enough for the policy-makers to start considering introduction of innovations into legal regulations. Financial resources necessary for obtaining the standards can be predicted based on mathematical relations provided in the paper..

Key words: Java application, ICS, environment, innovation, standard

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1. Introduction

Quality of life is always considerably influenced by the newly introduced environment-related innovations. Intensity of the innovations varies both on local and global levels, commonly depending on a number of economic, social, institutional and the related conditions. It is always encouraging when knowledge sources for innovations are standardized. Knowledge sources enable the creation of knowledge base for a specific kind of problem. Analyses of innovations and knowledge sources (KS) are valuable for further resource and system planning and development. The International Classification of Standards (ICS) implemented by the International Organization for Standardization (ISO), proposes that the field covering the sectors of Environment, Health Protection and Safety is one among 40 classification fields (ICS1). Designated with 13 (ICS1 = 13), it encompasses 21 subfields on the second (ICS2) classification level, i.e.: "13.020 (Environmental protection), 13.030 (Wastes), 13.040 (Air quality), 13.060 (Water quality), 13.080 (Soil quality), 13.100 (Occupational safety, Industrial hygiene), 13.110 (Safety of machinery), 13.120 (Domestic safety), 13.140 (Noise with respect to human beings), 13.160 (Vibration and shock with respect to human beings), 13.180 (Ergonomics), 13.200 (Accident and disaster control), 13.220 (Protection against fire), 13.230 (Explosion protection), 13.240 (Protection against

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excessive pressure), 13.260 (Protection against electric shock. Live working), 13.280 (Radiation protection), 13.300 (Protection against dangerous goods), 13.310 (Protection against crime), 13.320 (Alarm and warning systems), 13.340 (Protective equipment)".For this particular study, the authors have chosen 5 of the 21 subfields given above. Those 5 chosen ICS2 fields are Environmental protection (13.020), Wastes (13.030), Air quality (13.040), Water quality (13.060) and Soil quality (13.080). The chosen fields address the broadest and most significant environmental issues. Their significance lies in the fact that they are directly related to human health. Moreover, those domains were the subject of interest in many other studies conducted by the authors of this paper.

Knowledge sources in ICS are presented in the form of lists with some additional details and are available at several locations on the World Wide Web. Researchers can manually browse the web trying to find and analyze data but this manner requires a lot of time. In addition, it easily leads to mistakes since it depends on human factor. Thus, the authors of this paper used the software application that was previously developed. The application was developed in Java programming language by one of the authors. This Java application was originally aiming at the automation of collecting data from web servers. In this paper, it was used to obtain valuable data about knowledge sources i.e. innovations in the 5 analyzed fields at local and global levels. Serbia and Serbian standards (SRPS) were considered as local, while the whole world was considered as global level with its ISO/IEC standards.

Given the stated facts, the objective of this research aims towards knowledge trends analysis with trend lines and original mathematical relations for defining innovations in the chosen standardized fields. Based on those mathematical relations, financial resources necessary for obtaining the standards can be predicted.

2. Related research

There are many original research and review papers dealing with the use of software or IT tools for analyzing and/or solving environmental problems. However, there are no approaches similar to this one – no one used a web crawler for collecting and analyzing standards. Most of related papers found their place in this section because they ask and answer to research questions related to the same domains which are the subject of analysis in this particular paper. However, every one of them is based only on one domain.

13.020 (Environmental protection): The research proposed by Kezunović and Vasilić (2001) presents originally developed interactive simulation environment for protective algorithm design and evaluation. The developed environment was integrated with diverse modelling tools. They used software packages for simulation of particular segments in power systems: MATLAB's Power System Blockset (PSB), Alternative Transient Program (ATP), EUROSTAG, NETOMAC and PSS/E. The final solution provides possibility for interaction and it is specialized for particular power system operating conditions.

Dzemydiene and Maskeliunas (2011) created a decision-support system (DSS) capable of combining information gathered from all the participating data warehouses and with possible extraction of useable information. The created DSS provides the opportunity for knowledge representation and management of ecological situation in Web environment.

13.030 (Wastes): Wäger and Hilty (2000) and Patil et al. (2017) analyzed the waste management system using information technologies. The first paper presents a dynamics-based simulation system for plastics waste management and also discusses practical experiences enabled by this system. Proposed software consists of three modules: input (for definition of relevant parameters in waste management), simulation and output module (for visualizing simulation results). In the second paper, authors developed a smart system which provides the information on the filling of the bin or garbage level that automatically alerts the municipality. After the appropriate person receives the notification, they can clear the bin on time and safeguard the environment.

13.040 (Air quality): Blagojević et al. (2016; 2018) developed a web-based application for predicting the level of air pollution. The application uses artificial neural networks and its main advantage is that it is simple to use. The end user provides input parameters in form of date and place and gets the prediction value for the level of air pollution. Likewise, it was proposed a space-time prediction model of air pollutants ($PM_{2.5}$, PM_{10}, SO_2, NO_2, CO and O_3) based on artificial neural networks. Carslaw and Ropkins (2012) analyzed air pollution with the aid of R programming/statistical language. They used conditioning plots and analyzed them with many possibilities. They highlighted all significant benefits of R and openair and also confirmed that nonexistence of GUI is not a limitation for end user analysis. A model based on a multi-agent system which could be implemented in decision-making related to air pollution was designated. The model simulates the distributed monitoring process of air quality. Discussion considering laws in domain of air pollution is present in the paper.

13.060 (Water quality): Some advanced Internet of Things (IoT) techniques were used by Daigavane and Gaikwad (2017) in order to design and develop a low cost system for real time monitoring of water quality. The proposed system consists of several sensors used to measure physical and chemical parameters of water. All data which come from the sensors can be viewed via Internet. Dar et al. (2014) assessed available data from monitoring water quality of the longest river of Kashmir Valley and analyzed it using various analytical techniques. They created trend lines for easier understanding and interpretation of the results.

13.080 (Soil quality): Internet of Things was also used for monitoring soil quality by Demir (2017) in order to develop a "small and affordable sensing suite that offers farmers and gardeners a quick, convenient and effective way of monitoring pH, humidity and temperature of soil." IoT technologies provide users with real time information helping them grow more quality crops with optimal use of fertilizers and irrigation systems. Asgarzadeh et al. (2014) developed software for calculating PAW, LLWR, IWC, EI and related quantities concerning soil. The developed software also calculates the soil physical quality index (S) and the slope of the water retention curve at its inflection point. This software only requires parameters of soil water retention and soil penetration resistance models. The problem of improving land-use planning and decision-making in horticulture was solved by creating a digital map and GIS application "The benefit of this implementation is a fully integrated land information system, where information is accessed omnipresent for processing, value adding and further analysis" (Sestraş et al., 2019).

3. Material and methods

For collecting data, authors used previously developed software application described by Micić et al. (2014). This application was developed in Java programming language by one of the authors. It is a relatively simple automated program which methodically scans relevant pages to create an index of the data it is looking for. Such applications are classified as web crawlers – programs that automatically browse the Web. The application then extracts relational data from web pages and converts the unstructured text into a table style format that can be loaded into a spread sheet or a database. It must be noted that it collects data with focus on its quality and control.

In mentioned paper (Micić et al., 2014) java application was used for similar purpose but in different manner and in different field. It was used to collect standards but in the subfield of computer hardware (35.160 - Microprocessor systems; 35.180 - IT terminal and other peripheral equipment; 35.200 - Interface and interconnection equipment; 35.220 - Data storage devices). Also, data was collected only once – in January 2014. Data for this research was collected continuously through 8 years (every January from 2012-2019 for the period 2011-2018). This manner provides the possibility to analyse samples, but also changes during years which we cannot detect if we collect cumulative data only once.

In order to perform a comparative analysis of gathered data about standards (knowledge sources – KS), the following measurements (quantity indices – *Iq*) have been established:

- *Iqs* – total number of samples in considered ICS field or sub-field
- *Iqp* – standards which are published
- *Iqw* – standards withdrawn from use
- *Iqd* – deleted projects
- *Iqu* – standards in different stages of development
- *Iv* – value of standards
- *Iqi* – number of standards in current year (2019 in this specific research)

According to those indices, (Eq. 1) is formed.

$$Iqs(KS) = Iqp + Iqw + Iqd + Iqu \quad (1)$$

For the analysis of gathered data, creation and analysis of trends, authors used Spreadsheet software which is a part of OpenOffice software package.

3.1. Specific research methodology steps

Specific research tasks which were performed in this paper imply following steps:

1. Establishing the target fields of this experiment (the target field could be any standardized field, depending on specific research goal);
2. Choosing knowledge base within the field (local or global knowledge base or both, like in this research);
3. Running the original Java application which implies collecting data from local and global knowledge databases. In this research data was collected in January every year from 2012-2019;
4. Transformation of data in useful format for analysing;
5. Identifying number of samples, developed, withdrawn, deleted standards and also the price at local (SRPS) and global (ISO) level;
6. Drawing charts and adequate trend lines with equations.

3.2. Brief description of running the original java application

Java application searches the websites (SRPS and ISO/IEC) for current state of the ICS1 field and every possible ICS2, as well as ICS3, subfields. The app generates output files based on provided input parameters:

- Parameter 1 determines the group of sources for the search – 1 = SRPS, 0 = ISO/IEC, whereas 0 is the default value;
- Parameter 2 determines the ICS1 field (35 is the default value);
- Parameter 3 determines ICS2 subfield
- Parameter 4 determines ICS3 subfield

For example, running the app with parameters 0 35 110 10 provides output file for ISO/IEC sources in the subfield ICS3 = 35.110.10

Every time the app is started it adapts to changes to specified SRPS and ISO Web addresses for downloading the data. For example:

- for SRPS (https://www.iss.rs/rs/standard/advance_search.php);

• for ISO/IEC (https://www.iso.org/ics/13.060/x/).

4. Results

4.1. Comparative Analysis of the given subfields

Table 1 shows the initial results, where the indices of quantity (Iq), presented in methodology section, are given for each analyzed subfield.

The data show that knowledge sources within five fields vary significantly between local (SRPS) and global (ISO/IEC) level. In the previous year (2018), there were 84 ISO and 56 SRPS standards (*Iqi*). Total number of ISO standards since the formation of those 5 subfields is 1514, compared to 1342 SRPS standards. In January 2019, all ISO standards valued 98062 CHF, while the value of all SRPS standards in the analysed ICS2 fields was 28523 CHF. Note: CHF is designation for the currency in which ISO is selling (in Switzerland).

4.2. Knowledge trends analysis

The results of knowledge trends analysis are presented graphically with trend lines and original mathematical relations. Each figure consists of two parts. Left part represents time aspects for the entire period of the existence of the subfield. Financial trend lines with regression equations are presented on the right part of each figure. Trend lines are provided only for data from the selected years in 21st century – the ones recording higher innovation intensity. In mathematical equations, i.e. trend lines, the designation Iv/y was replaced with the index *Iv* (while only the designation *y* was used in the Figures). Fig. 1 includes aggregate analyses over 2000 – 2019, as well as the trend of the planned future annual requirements, based on the data from January 2019.

The trends equations could be used for predicting future financial needs for obtaining knowledge sources in the subfield 13.020 according to (Eqs. 2-3).

$$y_{iso} = 251.13 ln(x) + 1129.4 \quad (2)$$

$$y_{srps} = 158.38 ln(x) + 184.65 \quad (3)$$

Logarithmic relations (2) and (3), for ISO and SRPS knowledge sources, respectively, show the closest trend to the linear positive trend coefficients for resource planning of innovated knowledge sources.

Fig. 2 shows aggregate analyses over 2001 – 2018 as well as the trend of the planned future annual requirements, as based on the data from January 2019. The rest of innovations from previous years are significantly greater at local than global level and this is only present in the subfield 13.030.

The trends equations could be used for predicting future financial needs for obtaining knowledge sources in the subfield according to (Eqs. 4-5). When linear trend model does not produce good results, modeling is performed by nonlinear functions. Negative coefficient can be interpreted like slightly declining trend.

$$y_{iso} = -8.527 ln(x) + 46.772 \quad (4)$$

$$y_{srps} = -9.4134 x^2 + 163.86 x - 156.2 \quad (5)$$

Fig. 3 presents aggregate analyses over 1979 – 2018 and the trend of the planned future annual requirements, based on the data from January 2019.

The trends equations could be used for predicting future financial needs for obtaining knowledge sources in the subfield according to (Eqs. 6-7).

$$y_{iso} = -26.301 x^2 + 359.96 x + 528.48 \quad (6)$$

$$y_{srps} = -10.748 x^2 + 160.42 x + 113.32 \quad (7)$$

Eqs. (6) and (7) are represented as polynomials due to the following:

- comparison of trends by relations of the same type (polynomial), comparatively ISO and SRPS
- comparing SRPS trends in this sub-area (7) with the previous (polynomial) relation (5)
- for the ISO trend according to relation (6) the polynomial relation is very close to the logarithmic representations of the ISO trends represented by relations (2) and (4).

Fig. 4 encompasses a) aggregate analyses over 1983 – 2018 and b) the trend of the planned future annual requirements, based on the data from January 2019. The number of the remaining innovations from previous years is greater at global than local level.

The trends equations could be used for future financial needs for obtaining knowledge sources in the subfield according to (Eqs. 8-9).

$$y_{iso} = 282.82 ln(x) + 1133.4 \quad (8)$$

$$y_{srps} = 746 x^{-0.285} \quad (9)$$

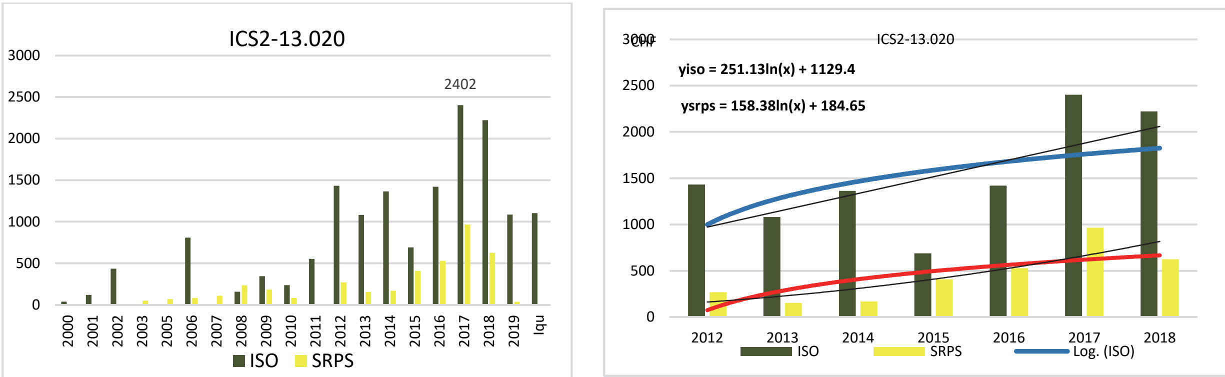
Fig. 5 includes aggregate analyses over 1993 – 2019 and the trend of the planned future annual requirements, according to the data from January 2019. The trends equations could be used for predicting future financial needs for obtaining knowledge sources in the subfield according to (Eqs. 10-11).

$$y_{iso} = -21.394 x^2 + 382.04 x - 71.188 \quad (10)$$

$$y_{srps} = -12.738 x^2 + 189.3 x - 231.37 \quad (11)$$

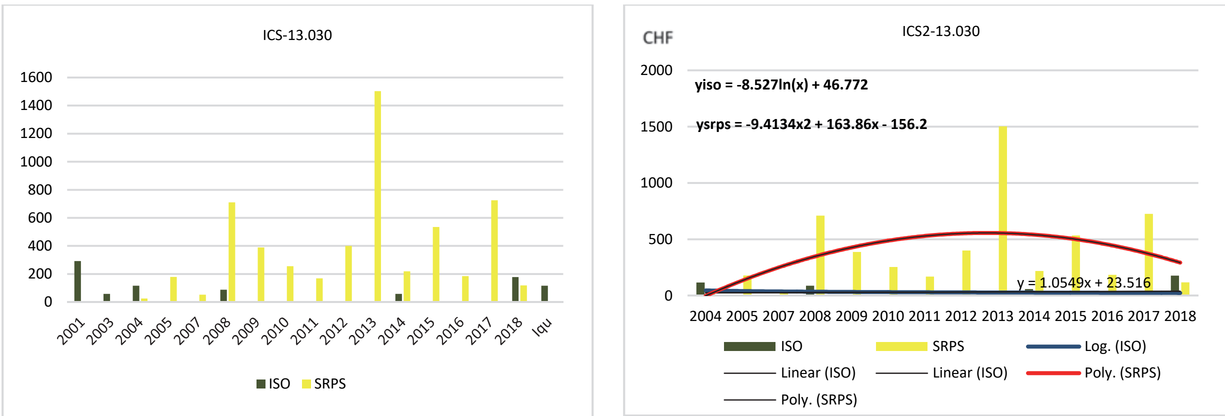
Table 1. Analysis of ISO – SRPS knowledge sources (for ICS = 13, 2019/January)

I	*Sub-field*	*Samples (Iqs) KS*		*Published (Iqp)*		*Withdrawn (Iqw)*		*Deleted (Iqd)*	*Developed (Iqu)*		*2018 (Iqi)*		*“Trend” Iv/2018*		*∑Ivalues (CHF) ∑Iv/2019.01*	
	ICS2	ISO	SRPS	ISO	SRPS	ISO	SRPS	ISO	ISO	SRPS	SRPS	ISO	SRPS	ISO	SRPS	ISO
1	13.020	**225**	161	**114**	118	**48**	38	**0**	**63**	5	18	**19**	625,69	**2222**	3966,38	**15520**
2	13.030	**44**	271	**14**	219	**13**	50	**1**	**16**	2	5	**1**	118,25	**178**	5464,12	**1228**
3	13.040	**372**	328	**239**	248	**88**	75	**0**	**45**	5	5	**11**	179,78	**1388**	7169,97	**26658**
4	13.060	**540**	399	**349**	295	**139**	102	**0**	**52**	2	9	**27**	235,75	**3306**	7847,80	**34822**
5	13.080	**333**	183	**210**	141	**85**	42	**1**	**37**	0	19	**26**	564,61	**2828**	3819,31	**19834**
∑	21	**1514**	1342	**926**	1021	**373**	307	**2**	**213**	14	56	**84**	2029	**9922**	28523	**98062**



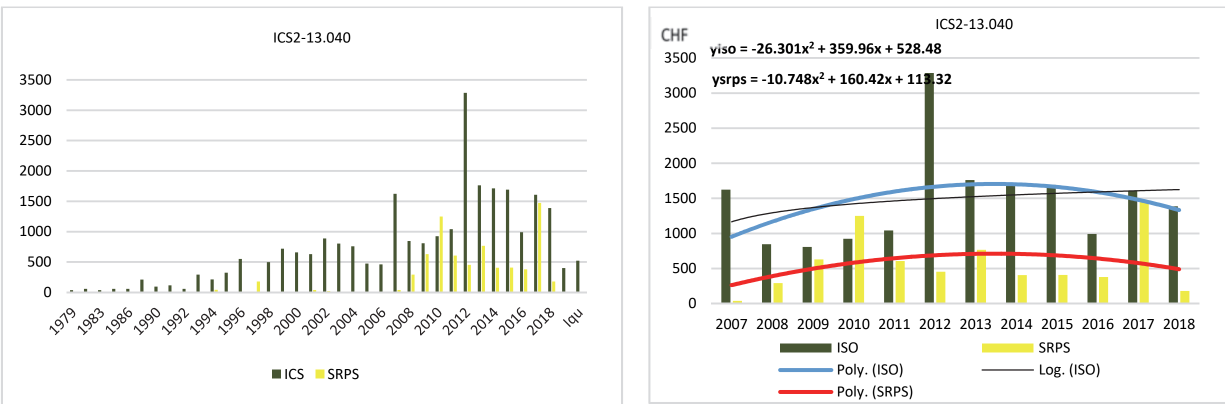
(a) (b)

Fig. 1. Results for ICS_2 = 13.020: Environmental protection:
(a) aggregate analyses over 2000-2019, (b) trend of the planned future annual requirements



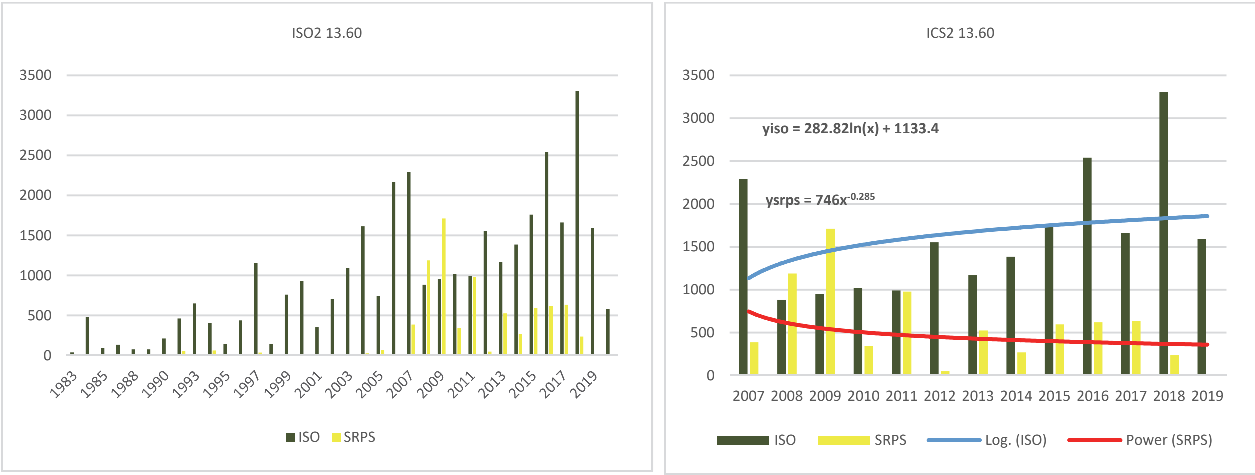
(a) (b)

Fig. 2. Results for ICS_2 = 13.030: Wastes: (a) aggregate analyses over 2001–2018,
(b) trend of the planned future annual requirements



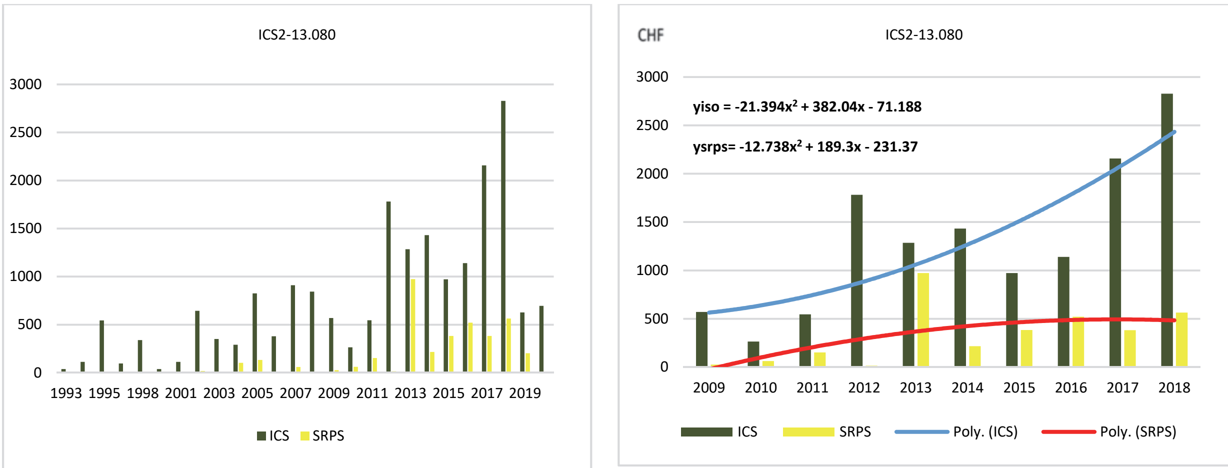
(a) (b)

Fig. 3. Results for ICS_2 = 13.040: Air quality: (a) aggregate analyses over 1979–2018, (b) trend of the planned
future annual requirements



(a) (b)

Fig. 4. Results for ICS_2 = 13.060: Water quality: (a) aggregate analyses over 1983–2018, (b) trend of the planned future annual requirements



(a) (b)

Fig. 5. Results for ICS_2 = 13.080: Soil quality: (a) aggregate analyses over 1993–2019, (b) trend of the planned future annual requirements

5. Discussions

Proposed research provides an innovative approach for analysing innovations in the fields which address the broadest and most significant environmental issues.

Some of the related papers also provide trend lines, but without analyzing innovations in the field. Moreover, every related paper analyzed environmental data in only one field. Bearing in mind the presented results the main advantages of the created Java application and proposed approach are underlined:

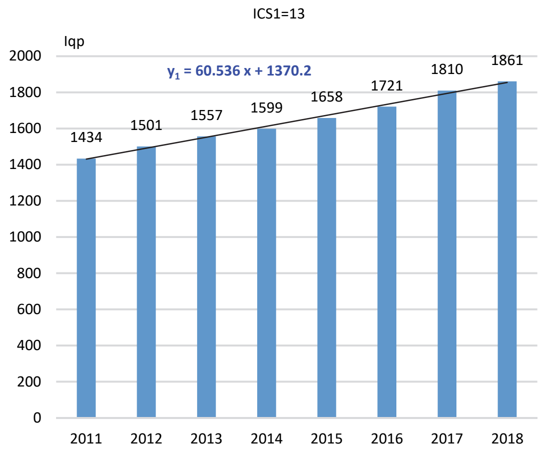
- Simple use;
- Automatized process of collecting data;
- Numerous possibilities with database which the application provides (analyzing and visualizing).

Legal regulations at the local level are appropriately adapted to the international level. In Serbia, legal regulations are adopted for each of the analysed subfields:

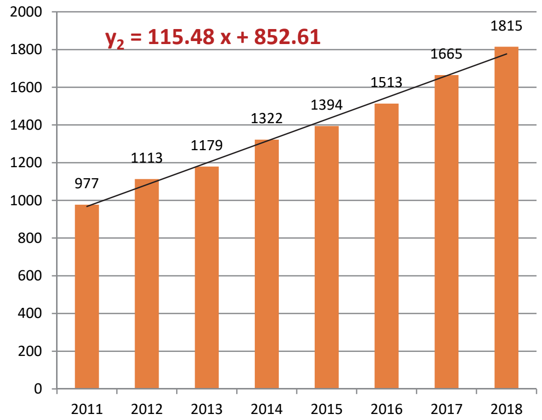
1. Law on Environmental Protection (GD, (2018));
2. Law on Air Protection (GD, (2013));
3. Law on Waters (GD, (2018a));
4. Law on Agricultural Land (GD, (2018b));
5. Law on Waste Management (GD, (2016)).

However, law adoption and adaptation should always rely on and reflect the state of innovations in the domain. This paper made first steps towards implementing innovations into legal regulations. Now policy-makers have the word. It also addresses the policy-makers stating that they should develop strategies, programs and policies which are more effective in the field of environmental management.

Bearing in mind that the 13th ICS field contains more subfields than it is presented in this research, we made a cumulative analysis of the whole field at the end in order to support previous assertions. Fig. 6 shows the standards published over 2011-2018 for all the subfields at global level. Continuous growth in the number of published standards in every analyzed year for every ICS = 13 field on global (ISO) level is obvious. Left part of the figure presents data collected continuously through 8 years (2011-2018), while the right part presents cumulative data collected only in January 2019. Differences of trend coefficients in two figures present the number of withdrawn or deleted standards.



(a)



(b)

Fig. 6. Published standards in ICS1 = 13 during the period 2011-2018 (y_1 – archived data collected at the end of every year; y_2 – current state with cumulative data collected only in January 2019)

6. Conclusions

The presented results and the methodology proposed may lead to several conclusions all of which can be related to continuous improvement, financial needs, and future expectations.

Continuous improvement in ICS1=13 has been proven by reviewing the standards published over the period of last eight years (Fig. 6). The analysis of the field during several years leads to the conclusion that further development of the field at global and, consequently, local level is expected.

The analyses like this one and similar previous analyses of knowledge sources innovation have been a significant explanation for the distributed reorganization and access to knowledge sources (KS) in Serbia. As of 2019 it is possible to access all standardized knowledge sources from 6 more locations (e.g. Chamber of Commerce in Kragujevac), compared to the only one previously possible access from Belgrade (from the Institute for Standardization of Serbia). Researchers can now access the standards to review its contents, as well as to integrate themselves with the economy, legal regulations, practice or environment. For further (more detailed) usage of the standardized knowledge sources (in the form of ISO or SRPS standards) individuals need to provide the values shown in the paper (in the form of Value index).

According to the trends in ISO/IEC and SRPS levels and also based on the mathematical relations (presented trend lines), the financial needs of each subfield or whole field ICS1 = 13 could be predicted. The results show continuous development of standards in the field No. 13 which should be followed by the introduction of some innovations in legal regulations. Some regulations in Serbia have not been innovated since 2013 (Law on Air Protection), and 2016 (Law on Waste Management) which should be done in line with the standards.

All the results point to the necessity of continuous improvement of standardized knowledge. In the analyzed field the number of newly developed standards every year is little more than one per work day (daily intensity of innovation) which demands urgent inspection of current legal regulations.

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