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BIBLIOMETRIC ANALYSIS OF WATER FOOTPRINT RESEARCH IN COUNTRIES OF FORMER YUGOSLAVIA

BIBLIOMETRIČNI PREGLED RAZISKAV VODNEGA ODTISA V DRŽAVAH NEKDANJE JUGOSLAVIJE

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Abstract

Sustainable development of water resources requires new tools and research in these fields of study. A systematic overview of water footprint research in countries of former Yugoslavia is presented through bibliometric analysis and publication review. The Scopus database was used as the data source. Among the countries of former Yugoslavia, only researchers from Slovenia, Serbia, Croatia, and Bosnia and Hercegovina published papers focused on water footprint research before March 2021. Research on water footprint in these countries was found to be insufficient in scope and intensity. The contribution of authors from the countries of former Yugoslavia is small compared to research in other countries all over the world but is not insignificant. Almost 2/3 of articles have already been cited by other authors. Two main centers of water footprint research are at the University of Maribor in Slovenia and at the University of Novi Sad in Serbia, respectively. The research is focused on the so-called volumetric water footprint, while the LCA water footprint stands outside the interest of the scientific community in countries of former Yugoslavia.

Keywords: bibliometric analysis, publication review, water footprint.

Izveček

Trajnostni razvoj vodnih virov zahteva nova orodja in raziskave na teh področjih. S pomočjo bibliometrične analize in pregleda publikacij je predstavljen sistematičen pregled raziskav vodnega odtisa v državah nekdanje Jugoslavije. Študija je bila pripravljena na osnovi baze podatkov Scopus. Iz držav nekdanje Jugoslavije so le raziskovalci iz Slovenije, Srbije, Hrvaške ter Bosne in Hercegovine do marca 2021 objavili članke, ki so se osredotočali na raziskave vodnega odtisa. Raziskave vodnega odtisa v teh državah niso pogoste. Prispevek avtorjev iz držav nekdanje Jugoslavije je sicer majhen v primerjavi z raziskavami v drugih državah po svetu, vendar ni nepomemben. Skoraj dve tretjini člankov so že citirali drugi avtorji. Dve glavni središči raziskav vodnega odtisa sta Univerza v Mariboru v Sloveniji in Univerza v Novem Sadu v Srbiji. Raziskave so osredotočene na tako imenovani volumetrični vodni odtis, z vodnim odtisom LCA pa se znanstvena skupnost v državah nekdanje Jugoslavije zaenkrat ni ukvarjala.

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Ključne besede: bibliometrična analiza, pregled člankov, vodni odtis.

1. Introduction

The sustainable development of water resource management requires modifying the status quo. New tools are indispensable to socio-economic existence and sustainable water resource management, especially in water-scarce areas.

The water footprint concept was introduced at the international conference on the virtual water trade in 2002 (Hoekstra, 2003). The water footprint concept follows the virtual water idea presented by J. A. Allen in the 1990s (Allan, 1997). The water footprint is a multidimensional indicator of direct and indirect water using, specified geographically and temporally. The Water Footprint Assessment Manual (Hoekstra et al., 2011) describes three types of water footprint indicators:

- The blue water footprint represents consumption of surface and groundwater resources.
- The green water footprint represents consumption of rainwater or soil moisture insofar as it does not become run-offs.
- The grey water footprint represents the volume of freshwater that is required to assimilate a load of pollutants, given natural background concentrations and existing ambient water quality standards.

The Life Cycle Assessment (LCA) community was also looking for ways to include water in the LCA framework (Berger and Finkbeiner, 2010; Milà and Canals et al., 2009; Pfister et al., 2009). The activities of the LCA community led to establishing the international standard for water footprint based on LCA principles (ISO, 2014). LCA focuses on assessing environmental impacts resulting from water using along with products' life cycles (Gerbens-Leenes et al., 2021). The LCA footprint distinguishes three types of water footprint as well:

- The water availability footprint describes potential environmental impacts related to pressure on water availability.
- The water scarcity footprint considers only water quantity.

- The degradative water footprint describes potential environmental impacts related to water quality.

These two water footprint methodologies serve different objectives. The LCA water footprint is a product-oriented method targeting product sustainability; the water footprint according to Water Footprint Assessment Manual is a water management tool with a focus on the sustainability of water using (Ansorge, 2020; Matuščík and Kočí, 2020).

Also, other environmental footprint methodologies (Vanham et al., 2019) try to find a way to involve the water issues into their own methodology (Li et al., 2020; Wang et al., 2020). Currently, the water ecological footprint is described in the literature (Hu et al., 2008; Liu et al., 2018). On one hand, the individual environmental footprint methodologies are characterized by significant variations in methods, applications, and policy relevance (Fang et al., 2016). On the other hand, they overlap, interact, and complement each other (Galli et al., 2012).

Bibliometric analysis and systematic review are research tools that are often used to assess progress and identify research challenges in a particular field. In this study, these tools were used for the analysis of water footprint research in the countries of former Yugoslavia (Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Serbia, Kosovo, and Slovenia). The aim of the analysis is to indicate the current state of water research in these countries. Similar analyses were published for the whole water footprint sector (Mubako, 2018; Wang et al., 2018; Zhang et al., 2017) or individual countries like Spain (Aldaya et al., 2020), China (Zhu et al., 2019), the Czech Republic (Ansorge et al., 2019), or Brazil (Bodunrin et al., 2018).

2. Data acquisition and methods

The study was conducted according to the simplified PRISMA extension for scoping reviews (Tricco et al., 2018).

The bibliographic analysis was performed using the Scopus database in March 2021 with the search term “water footprint”. Other phrases, like “environmental footprint”, etc., were not involved in the analysis. This decision is based on the expectation that the lack of the phrase “water footprint” in the title, keywords, or abstract means that the paper does not focus directly on water footprint research.

In the second step, the records with affiliation to institutions in the countries of former Yugoslavia were selected. The number of selected records was low; therefore, every paper and its metadata were involved in the review analysis. Metadata was downloaded on 23 March 2021. Microsoft Excel was used for metadata analysis.

The affiliation of authors, source of the article, and international cooperation was analyzed in each paper. Review analysis focused on the article's contribution to water footprint research.

3. Results

3.1. Records in Scopus database

The Scopus database contains 19 papers by authors affiliated with institutions in Slovenia, Croatia, Serbia, and Bosnia and Herzegovina with the term “water footprint” in the title, keywords, or abstract and published before March 2021. Only 4 papers (out of 19) used the term “water footprint” in their title or keywords. At the same time, the Scopus database includes 2,407 publications with the term “water footprint” in the title, keywords, or abstract (Figure 1) published before 2021. It is interesting, that the first publication indexed in Scopus with the term “water footprint” in the title, keywords, or abstract was published in 2005.

15 papers were published in scientific journals, 2 papers in conference proceedings, and 2 papers in a book or book series. Authors from 30 countries and 53 institutions collaborated on these 19 papers (Table 1). Twelve papers were written by international teams and 8 papers have a correspondent author or the first author from a country other than Slovenia, Croatia, Serbia, or Bosnia and Herzegovina. Authors from the

University of Maribor in Slovenia and the University of Novi Sad in Serbia collaborated on 6 papers; this is the highest number of papers per institution.

As of 20 March 2021, 12 papers had been cited by other authors and 4 papers had more than 10 citations. The most-cited paper (with 64 citations to 20 March 2021) is the paper by Čuček et al. (2015). This paper was prepared in collaboration with authors from the University of Pannonia (Hungary) and the University of Maribor (Slovenia). The second most cited paper is the article by Gobin et al. (2017) with 29 citations. This article was drafted by an international team of 14 countries. However, among the countries of former Yugoslavia, only Serbia and Croatia participated. The third most often cited paper is an article by Quaglia (2014) with 23 citations. This paper was written in collaboration with authors from the Technical University of Denmark and the University of Maribor.

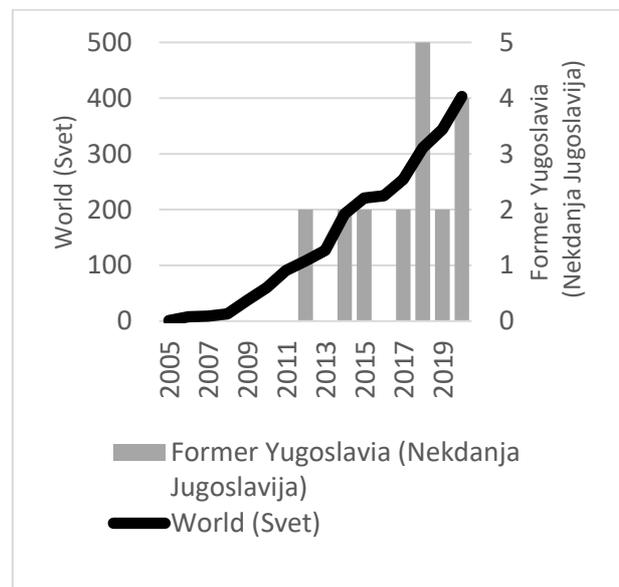


Figure 1: Number of publication with “water footprint” in title, abstract, or keywords.

Slika 1: Število publikacij z »vodnim odtisom« v naslovu, povzetku ali ključnih besedah.

The most active authors (from the countries of former Yugoslavia) are Zdravko Kravanja from the University of Maribor – the co-author of 5 papers (Čuček et al., 2015, 2012a, 2012b; Quaglia et al.,

2014; Vujanović et al., 2014), Lidija Čuček with 3 papers affiliated with the University of Maribor (Čuček et al., 2012a, 2012b; Vujanović et al., 2014) and one paper affiliated with the University of Pannonia (Čuček et al., 2015), and Branislava Lalić affiliated with the University of Novi Sad with 3 papers (Gobin et al., 2017; Lalić et al., 2018a, 2018b).

A brief review of these 19 papers is given below.

3.2. Water footprint research in the individual countries of former Yugoslavia

3.2.1. Slovenia

Among the countries of former Yugoslavia, Slovenia, with 8 papers, is the country with the highest number of papers targeting water footprint in the Scopus. The main center of water footprint research is located at the University of Maribor. The authors from this university have published 6 papers. Four papers were published by an international research team, whose core consists of researchers from the University of Maribor in Slovenia and researchers from the University of Pannonia and from Pázmány Péter Catholic University in Hungary (before 2017; and currently from the Technical University of Brno in the Czech Republic). This research group focuses on the use of indicators from environmental footprint family in general and their application in the energy sector in particular. The papers published by this research team focus on the multi-objective optimization of biomass energy supply-chains (Čuček et al., 2012b, 2012a; Vujanović et al., 2014), heat and energy production (Walmsley et al., 2018), and the importance of environmental footprint indicators for sustainable development (Čuček et al., 2015).

The last article from the University of Maribor (Quaglia et al., 2014) focuses on the mathematical optimization of industrial processes of water treatment and treated wastewater reuse, as a way for the water footprint reduction.

The authors from Agencija Republike Slovenije za Okolje published a paper focused on the application of the water footprint concept to groundwater pollution in Slovenia (Uhan and Andjelov, 2019).

The latest article with a co-author from Slovenia is a conference paper on Water-Environment-Energy-Food Nexus in Africa (Seidou et al., 2020).

Table 1: Number of articles and participating institutions by country.

Preglednica 1: Število prispevkov in sodelujočih institucij po posameznih državah.

Country/Država	Number of articles/ Število prispevkov	Number of institutions/ Število ustanov
<u>Slovenia</u>	8	4
<u>Croatia</u>	6	6
<u>Serbia</u>	6	3
<u>Bosnia and Herzegovina</u>	1	1
Austria	4	1
Hungary	4	3
Germany	3	3
Italy	3	4
Czech Republic	2	3
Finland	2	2
Netherlands	2	2
Spain	2	2
Belgium	1	1
Canada	1	1
Cyprus	1	1
Denmark	1	1
Estonia	1	1
France	1	1
Greece	1	1
Iran	1	1
Malaysia	1	1
Niger	1	1
Norway	1	1
Poland	1	1
Slovakia	1	2
South Africa	1	1
Thailand	1	1
Turkey	1	1
United States	1	1
Viet Nam	1	1

3.2.2. Croatia

Authors affiliated with Croatian institutions published 6 papers. Contrary to the situation in Slovenia, different research teams prepared each

paper. Only 2 papers are affiliated with the University of Rijeka, but the authors are from different faculties. The topic of each paper is also different.

Spetič et al. (2015) described a survey of individuals' water footprint in a group of 200 participants. The water footprint was used as a sustainability indicator. As the most important result of their study, they highlighted the value of an individual's average total water footprint (about 6000 liters per day) belonging to the category of intermediate-sustainable water footprint (from 4000 to 20 000 liters per day). The current level of the individual's average water footprint is still within parameters that do not create a cause for concern.

The paper by Grofelnik (2017) presents a pilot study of sustainability assessment of water use of tourism on the islands of Cres and Lošinj via the local blue water footprint. The study shows unsustainable water use during the summer months.

The paper by Racz et al. (2018) is an example of a situation where bibliometric analysis is not effective. This article uses the term "water footprint" in the abstract, but the whole paper is focused on food waste, and the water footprint is mentioned once in the paper.

The water extended input-output model of the Croatian economy was developed in the paper by Čegar (2020). Input-output analysis is one of the popular analyses of structural interlinkages among the individual economic sectors. It represents a top-down approach in the water footprint assessment (Feng et al., 2011). Čegar (2020) concluded that the power, oil-processing, and chemical sectors are the most significant cumulative water users in the Croatian economy.

The last 2 papers are representatives of the results of broad international cooperation. The paper by Gobin et al. (2017) aims at assessing the variability of the water footprint in agriculture across Europe. The study shows that variability in the water footprint of arable crops across different regions in Europe is mainly due to variability in crop yields and to a lesser extent to variability in the water used to grow crops. The water footprint variability

among countries is lower than the variability between seasons and among crops.

Authors from 12 countries collaborated on a paper by Bodini et al. (2020), again including authors from Croatia and Serbia. The paper describes a study aimed at comparing non-conventional certified products with the same products obtained by conventional production schemes. The study uses the water footprint as an indicator of pressure on water resources. The results emphasize that the potential benefits associated with non-conventional production are usually apparent when attention is focused on water use intensity, which represents the water requirement per unit area.

3.2.3. Serbia

Like the Croatian authors, Serbian authors also participated in 6 papers. The main center of research on water footprint in Serbia is at the University of Novi Sad. Authors affiliated with this university collaborated on all 6 papers published by Serbian authors. Another center of water footprint research in Serbia is the University of Belgrade. Authors from the University of Belgrade published 4 articles. Authors from the Republic Hydrometeorological Service of Serbia collaborated on 2 papers.

All articles co-authored by authors affiliated with Serbian institutions are focused on agriculture or food production. The first 2 articles by Gobin et al. (2017) and Bodini et al. (2020) were described in the previous section.

The article by García-Caparrós et al. (2018) describes a study on the possibilities of using a blending of drainage with water of low electrical conductivity and the sequential reuse and sequential irrigation in a sequential production – horticultural and ornamental plants under greenhouse conditions. This irrigation technique would reduce the water footprint of crop under greenhouse conditions.

Two articles by Lalić et al. (2018a, 2018b) describe a probabilistic crop and green water footprint forecast based on ensembles of crop model output estimates for winter wheat (Lalić et al., 2018a) and summer crops (Lalić et al., 2018b).

The water footprint study of Sjenica sheep cheese production is described in the chapter by Filipović et al. (2019). The study was aimed at assessing the sustainability of sheep cheese production and the water footprint is one of the indicators used in the study. There is a chapter in the same book describing a study on the sustainability of organic raspberry production (Stojanović et al., 2019). The same methodology was used in this study. However, this chapter is not included in the analysis because it does not use the term ‘water footprint’ in the title, keyword, or abstract.

3.2.4. Bosnia and Hercegovina

The sole article co-authored by an author from Bosnia and Herzegovina (Capone et al., 2020) deals with food loss and waste, and the impact on ecosystems, such as disruption, deforestation, biodiversity loss, as well as water pollution and land degradation due to useless intensification of production through high application of fertilizers and pesticides. Considering the water footprint, a conservative percentage of 30% of water waste occurs when Mediterranean people waste food. This article is a result of the research of an international team, gathering five countries.

4. Discussion

This study seeks to answer the question of how intensive or important is research on water footprint in the countries of former Yugoslavia. These countries are located in the Mediterranean region, which is commonly referred to as a water-scarce region, although Slovenia with an average annual precipitation of 1600 mm can hardly be considered as such. However, research into the water footprint in these countries is not intensive in scope. On the other hand, researchers from these countries are members of international teams trying to find solutions to water scarcity in this region.

Similar to the research in the world, most papers (8 papers) are focused on agriculture and food production. The second-highest group (6 papers) deals with the water footprint in the energy sector. This is also correlated with the intensity of water footprint research in the world. Three papers are

focused on the general application of water footprint methodology. Two papers are focused on water management and one paper is focused on tourism.

Only the papers by Lidia Čuček et al. deal with the LCA approach to the water footprinting; other authors use the volumetric approach.

The first study's limitation is based on using the Scopus database as a data source. The Scopus database covers more scientific sources than the Web of Science. Nineteen papers that meet the selection criteria have been identified in the Scopus database. Only 16 articles meeting the selection criteria were found in the Web of Science database. Yet the Web of Science database contains 2 articles that are not in the Scopus database and meet the selection criteria. The first is the paper by Berisha et al. (2017) from Kosovo. This paper uses the term of “water footprint” in the abstract but the article itself does not describe research on the subject. The second one is a paper by Jovanovic and Stikic (2018) from the University of Belgrade. Their article is a review of irrigation practices and water footprint is used as an argument for the application of the partial root-zone drying strategy.

The use of the Scopus database as a source for analysis may introduce biases because English-language sources are overrepresented at the expense of other languages (Mongeon and Paul-Hus, 2016). Future research as a systematic review of the water footprint in the countries of former Yugoslavia should focus on various data sources, such as Google Scholar, the Cooperative On-line Bibliographic System and Services – COBISS (Seljak and Seljak, 2000) implemented in Slovenia, Serbia, Bosnia and Herzegovina, Montenegro, and Macedonia (Župan, 2018), or the Croatian HRČAK (Stojanovski et al., 2009), etc., which covers non-English scientific literature in more detail.

The study's other limitation is based on selection criteria. This is shown by the example of the paper by Racz et al. (2018), where a document was included in the selection that does not deal with research on the water footprint. Papers by Filipović et al. (2019) and by Stojanović et al. (2019) provide another limitation example of this study. The same methodology was used in these 2 papers; while the

first mentioned publication meets the selection criteria, the other does not.

The next limitation based on selection criteria is the focus on the authors affiliated with institutions in the countries of former Yugoslavia. Thus, articles dealing with the water footprint in the countries of former Yugoslavia, which are written only by foreign authors, are not included in the study (e.g. Van Leeuwen et al., 2016).

5. Conclusions

Research on water footprint in countries of former Yugoslavia is lacking in scope. Only 19 documents were found in the Scopus database that were written or co-written by authors from countries of former Yugoslavia and use the term "water footprint" in their title, abstract, or keyword. The authors from 30 countries collaborated on these 19 articles, but only from 4 countries of former Yugoslavia. Two institutions only (the University of Maribor and the University of Novi Sad) have published more papers in this area of research. The papers address a wide range of research themes of water footprint research. At the University of Maribor, water footprint is being researched as a part of the environmental footprint family. Most papers are focused on the water footprint of agriculture and food production, especially by authors from Serbia and Croatia. Marginally addressed are issues of the water footprint in industry, the water footprint of tourism, the Water-Energy-Food nexus, and the application of Input-Output analysis in water footprint research.

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