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USING UAV FOR THE DIGITALISATION OF PUBLIC ADMINISTRATION. A BIBLIOMETRIC ANALYSIS

Gheorghe-Gavrilă HOGNOGI[1], Ana-Maria POP[1], Alexandra-Camelia MARIAN-POTRA[2]

ABSTRACT. – Using UAV for The Digitalisation of Public Administration. A Bibliometric Analysis. The new European financial framework for 2021-2027 indicates digitalisation investments as a priority for the residential spaces, especially the urban ones. This is needed to increase the efficiency of the public administration and to optimize the relationships with the citizens (*POR 2021-2027*). In Romania, there are some recent good practice models in this regard, accelerated also by the current pandemic context. The scope of the paper consisted in highlighting the scientific production associated to the use of UAV technology in public administration by means of bibliometric analyses. Research included three stages: a). Selection of the documents in the Scopus database, b). Data extraction and visualization and c). Interpretation of bibliometric analyses conducted. The bibliometric analyses that were conducted highlighted that the interest for this topic was relatively recent (since 1988). It was strongly customized in the North-American and North-Western European research, but this type of approach is also necessary in the South-Eastern European countries.

Keywords: *UAV, Romania, VOSviewer, local administration.*

[1] *Babeş-Bolyai University, Faculty of Geography, Centre for Regional Geography, Cluj-Napoca, 5-7 Clinicilor Street, Romania, e-mails: gheorghe.hognogi@ubbcluj.ro, gheorghehognogi@yahoo.com, ana-maria.pop@ubbcluj.ro, mia21ro@gmail.com.*
[2] *West University of Timişoara, Faculty of Chemistry, Biology, Geography, Department of Geography, Timişoara, 4 Vasile Pârvan Boulevard, Romania, e-mail: alexandra.potra@e-uvt.ro*

1. INTRODUCTION

The digital territorial coverage degree becomes a priority that is taken into consideration given the importance placed on innovation and usage of various technologies capable of supporting an innovative process. According to the *Digital Economy and Society Index 2020*, Romania is in the lower quarter of the EU countries in terms of the performance of digital indicators (European Commission 2020). The phenomenon is accelerated in the current Covid-19 pandemic context. Hence, Romania's digital performances are as follows: over 49% of the houses have Internet connection; economy digitalisation is extremely low, half of the Romanians have never used the Internet and less than one quarter of the Romanian population has minimum digital skills.

The first governmental decision with impact on digitalisation at national level was that concerning the development of the National Authority for the Digitalisation of Romania. This is a structure intended for the acceleration of information/data transfer from physical to digital format (Romanian Government 2020). On the other hand, the lack of interoperability of some information systems in the Romanian public administration has been one of the problems identified over the last few years. This was generated by the lack of digital competencies, migration of IT experts from the public to the private sector, lack of an integrated vision of these digital services into the public administration (European Commission 2020).

In terms of spatial data that are used, there is a growing international interest for the use of data achieved by unmanned aerial vehicles with applications in various fields, from aviation and transport to public administration. The interest for the use of UAV/UAS (Unmanned aerial vehicles/Unmanned aerial systems) from the perspective of bibliometric analyses is recent (Greene and Roberts 2018; Zhang et al. 2018). The potential of the satellite and aerial high resolution images for the generation and update of cadastre maps is also recent (Crommelinck et al. 2017).

The scope of the paper consisted in analysing the scientific production related to the use of UAV technology in public administration, by means of bibliometric analyses. The originality of the research comes from the existing lack of compiling scientific materials on the analysed topic. The outcomes achieved by means of bibliometric analyses represent the first step for the researchers interested in the evolution of this topic.

The paper was structured into several sections: a). theoretical rationale of using the UAV technology in public administration, b). the working steps for achieving bibliometric analyses, c). the results of the bibliometric analyses that were conducted, d). discussions referring to the applicability field of the data achieved by means of the UAV technology, e). conclusions.

2. METHODOLOGY

The methodology was based on the bibliometric analysis of scientific materials related to the role of the UAV technology in public administration. This implied three stages (Fig. 1):

a) selecting the documents from the Scopus database. The Scopus database was used due to its high quality of the papers, to the international visibility of the studies and to the coverage of the journals publishing papers on the proposed topic. The descriptors used in the paper were "administration" AND "UAV" (based on using the Boolean logical operators). The reference time interval used was 1988-2020. Initially, 350 documents were selected in October 2020, and pursuant to applying document filtering criteria and after excluding some types of documents (conference paper, book chapter, review, conference review, book, short survey, editorial) and the languages used (Chinese, Spanish), 89 studies were selected (article type and only in English).

b) data extraction and visualization. The collected data were checked and validated for conformity of the content and their relevance to the analysed topic. Hence, 85 articles related to the analysed topic were validated. The CSV format was used in order to extract the data. Certain bibliographic data were extracted from Scopus. These included: authors, title, year of publication, title of the source, affiliation of authors, key words, and number of citations. The VOSviewer software was used for the bibliometric analyses (Eck and Waltman 2017; Briones-Bitar et al. 2020; Herrera-Franco et al. 2020; Río-Rama et al. 2020). The following bibliometric analyses were conducted: co-occurrence analysis of keywords, co-occurrence analysis of terms, co-citation analysis (by cited references, by cited sources), co-authorship analysis (by authors, organizations and countries). All the results were transposed onto bibliometric maps.

c) results analysis, by interpreting the achieved bibliometric maps, which enabled us to outline some clusters with various connections among them.

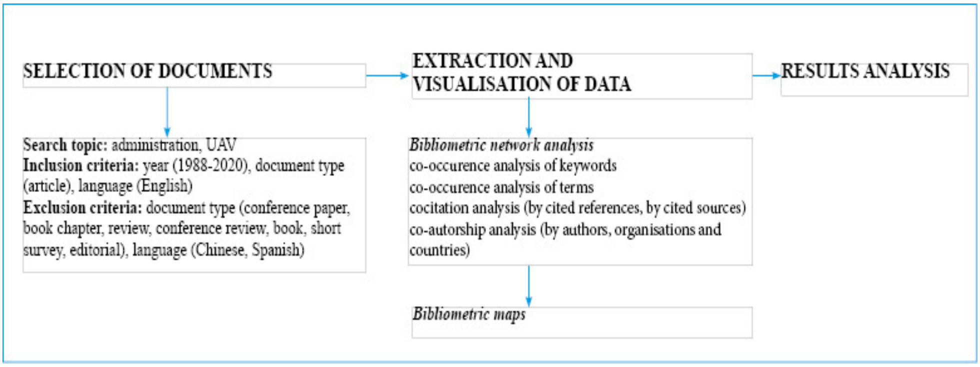

Fig. 1. Methodological flowchart. *Source: the authors*

3. RESULTS

3.1. Bibliometric features of the analysed documents

The 89 documents of the paper type associated to the use of UAV/UAS in administration highlighted some distinct aspects for the analysed interval – 1988-2020 (Fig. 2):

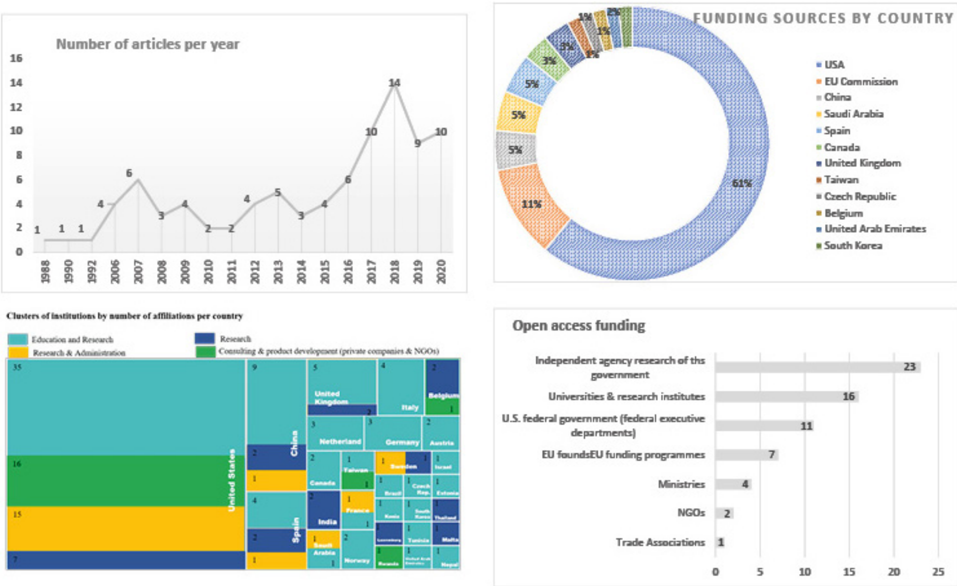

Fig. 2. Bibliometric features of the analysed documents in the Scopus database.
Source: the authors

- a field of activity developed during the last 20 years and with significant impact over the last 5 years;
- most of the authors interested in this topic come from the academic and research environment, but specialists in related fields are not excepted either (private companies and NGOs), especially from the USA;
- spatial distribution of the authors' affiliation reveals the predominance of the studies dedicated to the UAV technology in North America, some North-Western European countries, China, and India;
- of the 89 articles published, 64 benefited from the financial support of a project, with funding programs offered by governmental agencies and international programs offered by the European Commission, Horizon 2020, ministries and even by some education and research institutions.

3.2. Co-occurrence analysis of keywords

The keywords frequency analysis, totalling 1090 keywords, imprinted the research a trend of the studies on the use of the UAV technologies towards achieving data used in several fields of activity. Of the 1090 keywords, 25 terms reached a frequency of minimum 5 words, generating 5 clusters (Table 1, Fig. 3). The main term that polarizes all the research directions is UAV (*Unmanned Aerial Vehicles*) and its association with the field of data usage and with the Federal Aviation Administration and Federal Highway Administration (cluster 3, blue). Another cluster (cluster 5, purple) signals the existence of researches focusing on drone usage (Altawy and Youssef 2017; Sarghini and De Vivo 2017).

Table 1. Data associated with the frequency of keywords

No.	Cluster	Keyword	Occurrences	Total link strength
1	1	antennas	17	60
2	1	article	6	24
3	1	image enhancement	5	26
4	1	photogrammetry	5	18
5	1	priority journal	5	19
6	1	remote sensing	11	32
7	1	unmanned aerial systems	7	28
8	2	aircraft	6	25
9	2	NASA	8	28
10	2	national airspace system	6	25
11	2	sensors	6	20
12	2	unmanned aircraft system	10	38
13	2	unmanned vehicles	6	11
14	3	federal aviation administration	26	80
15	3	highway administration	5	10
16	3	small unmanned aircrafts	5	15
17	3	unmanned aerial vehicle	6	14
18	3	unmanned aerial vehicles (UAV)	57	154
19	4	aircraft accidents	5	22
20	4	national oceanic and atmospheric administration	5	21
21	4	UAV	7	17
22	4	United States	6	16
23	4	unmanned vehicle	13	42
24	5	drones	10	40
25	5	unmanned aerial vehicles	6	21

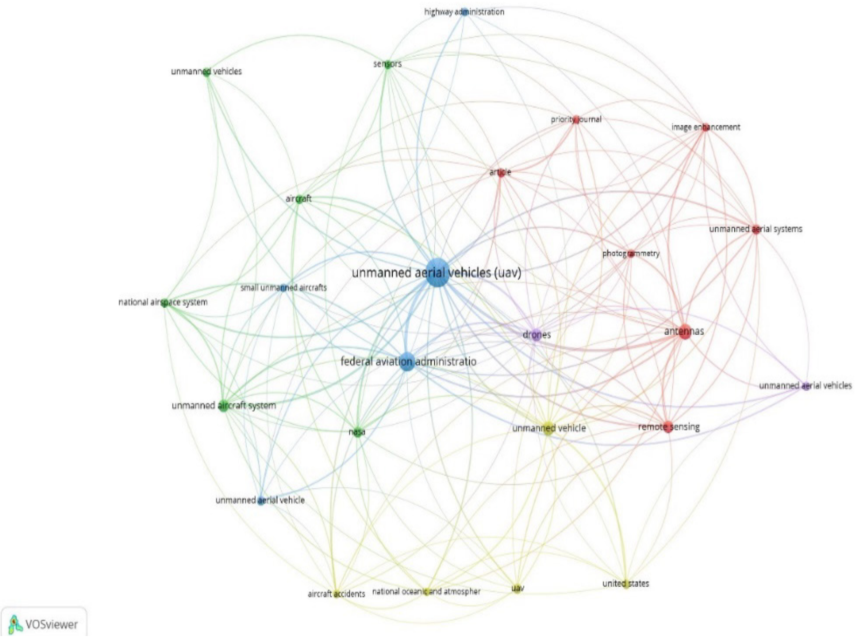

Fig. 3. Keywords co-occurrence map. *Source: the authors*

3.3. Co-occurrence analysis of term

Out of 3253 identified terms, 22 reached the threshold of minimum 10 occurrences of a term (Table 2, Fig. 4). There are two association groups of the terms: UAV - Unmanned Aerial Vehicle (cluster 1, red), used for aerial mapping and topographic modelling and UAS - Unmanned Aerial System (cluster 2, green), for various monitoring activities of some areas.

Table 2. Data associated with the frequency of the terms

No.	Cluster	Term	Occurrences	Relevance score
1	1	drone	15	0.4938
2	1	study	18	0.5905
3	1	UAV	47	16,167
4	1	UAVs	18	0.8117
5	1	unmanned aerial vehicle	40	14,971
6	1	use	22	0.4217
7	1	year	21	0.447
8	2	aircraft	28	0.4032
9	2	FAA	25	0.6828

No.	Cluster	Term	Occurrences	Relevance score
10	2	federal aviation administration	26	0.6504
11	2	system	51	0.5746
12	2	UAS	21	23,594
13	2	unmanned aircraft system	17	24,511

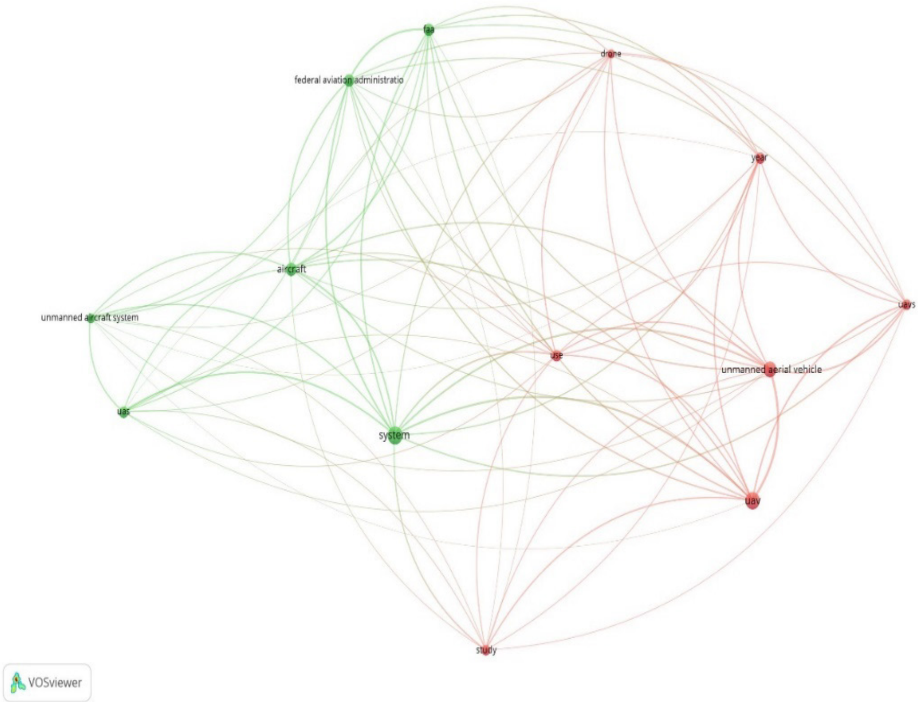

Fig. 4. Term co-occurrence map. *Source: the authors*

3.4. Co-citation analysis through cited references

The co-citation analysis revealed the intensity of the cooperation between institutions, the impact of research outcomes and the main approaches. Out of 3095 cited references, 21 meet the minimum number of two citations of a cited reference (Table 3, Fig. 5). The proximity between each node shows the networking degree of each author. Table 3 lists the most cited authors. Cluster 1 (red) refers to the basic resources for the understanding of the UAV technology, such as the role of the UAS-sourced imagery (Colomina and Molina 2014), but also their possible applications (Nex and Remondino 2014), assigning some UAS-sourced aerial images processing methodologies in order to improve the existing cadastre data (Barnes and Volkmann 2015) and land management (Zevenbergen et al. 2013), error calculation methods for image calibration (James et al. 2017).

Cluster 2 (green) includes references addressing the accurate detection of the limits of natural areas based on the features of the aerial imagery (brightness, colour, texture) (Martin et al. 2004, Ramadhani et al. 2018) and the role of the cadastre systems in the developing countries.

Table 3. Data associated with the frequency of cited references

No.	Cluster	Cited reference	Citations	Links	Total link strength
1	1	Barnes, G., Volkmann, W., *High-resolution mapping with unmanned aerial systems* (2015), Surveying and Land Information Science, 74(1): 5-13	2	6	8
2	1	Colomina, I., Molina, P., *Unmanned aerial systems for photogrammetry and remote sensing: a review* (2014), ISPRS Journal of Photogrammetry and Remote Sensing, 92: 79-97	2	6	8
3	1	James, M.R., Robson, S., D'oleire-Oltmanns, S., Niethammer, U., *Optimising UAV topographic surveys processed with structure-from-motion: ground control quality, quantity and bundle adjustment* (2017), Geomorphology, 280: 51-66	2	6	8
4	1	Nex, F., Remondino, F., *UAV for 3D mapping applications: a review* (2014), Applied Geomatics, 6: 1-15	2	6	8
5	1	Zevenbergen, J., Augustinus, C., Antonio, D., Bennett, R., *Pro-poor land administration: principles for recording the land rights of the underrepresented* (2013), Land use policy, 31: 595-604	2	5	5
6	2	Martin, D.R., Fowlkes, C.C., Malik, J., *Learning to detect natural image boundaries using local brightness, color, and texture cues* (2004), IEEE Transactions on Pattern Analysis and Machine Intelligence, 26: 530-549	2	2	2
7	2	Ramadhani, S.A., Bennett, R.M., Nex, F.C., *Exploring UAV in Indonesian cadastral boundary data acquisition* (2018), Earth Science Informatics, 11: 129-146	2	7	7
8	2	Williamson, I., *The justification of cadastral systems in developing countries* (1997), Geomatica, 51: 21-36	2	2	2

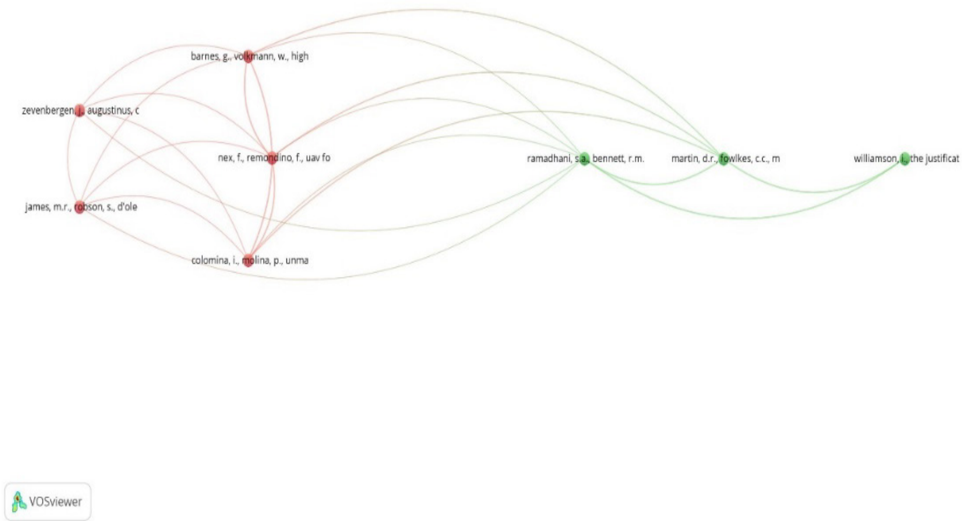

Fig. 5. Co-citation analysis map by taking into account cited references.
Source: the authors

Co-citation analysis through cited sources highlighted 1923 cited sources approved by researchers, of which three have the minimum number of 15 citations of a source. Remote Sensing has the highest impact.

3.5. Co-authorship analysis

This co-authorship analysis by authors provides information on the existing cooperation relationships between the authors in certain fields of research. If we consider the analysis of cooperation starting from the "Author" category, of the 281 authors who published papers on the analysed topic, only 4 exceeded the minimum number of 3 documents of an author (Table 4, Fig. 6). Cluster 1 (red) includes 4 authors: "Bennett", "Koeva", "Stocker", "Zevenbergen". The highest influence was manifested by Bennett, with topics focusing on the cadastral mapping based on the UAV technology and on the users' perceptions of data processed by aerial imagery.

Table 4. Data associated with the frequency of the co-authors

No.	Cluster	Author	Documents	Citations	Total link strength
1	1	Bennett R.	3	29	6
2	1	Koeva M.	3	16	6
3	1	Stöcker C.	3	8	7
4	1	Zevenbergen J.	3	8	7

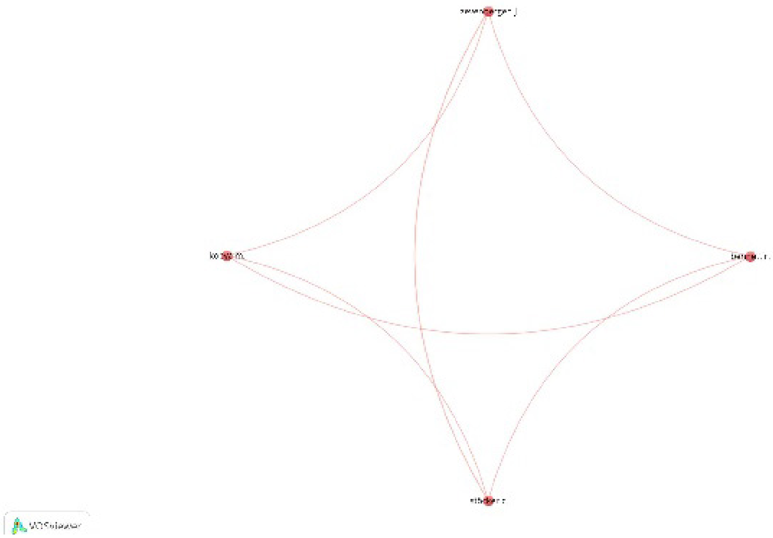

Fig. 6. Co-authorship map by authors.
Source: the authors

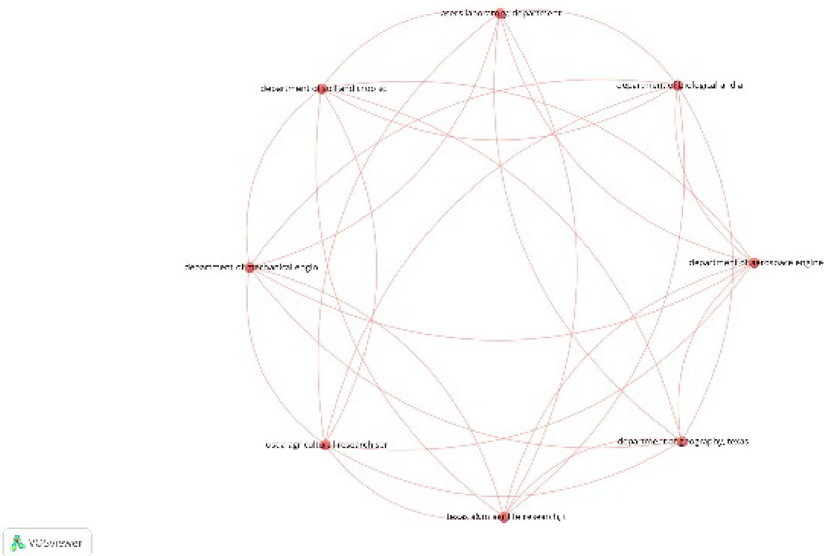

Fig. 7. Co-authorship map by organizations.
Source: the authors

If we consider the cooperation relationships in terms of the institutions where the authors work or cooperate with, i.e. co-authorship analysis by organizations, out of the existing 186 organizations, 101 have the minimum number of 5 citations per organization (Fig. 7). The first 8 units in terms of impact (with 132 citations) reveal again the predominance of the Americans regarding the interest in using the UAV technology (Texas A&M University, USDA).

Of the 26 countries with studies on the role of the databases (with the minimum threshold of 5 documents and 5 citations) (Table 5), two research schools stand up. On the one hand, there is the North European research (Faculty of Geo-Information Science and Earth Observation – ITC, KU Leuven, Kadaster, University of Twente), with 10 papers, and on the other hand, the USA, with a number of 44 papers (NASA Flight Research Center, NOAA National Oceanic and Atmospheric Administration, USDA Agricultural Research Service, Washington DC etc.).

Table 5. Data associated with the frequency of the authors at country level

No.	Cluster	Country	Documents	Citations	Total link strength
1	1	Belgium	5	32	4
2	1	Netherlands	5	39	3
3	2	United States	44	843	1

Source: the authors

4. DISCUSSIONS

The significance of the data achieved after certain UAV flights is also highlighted by the need of using them for other purposes, in various fields of activity (Table 6).

Table 6. The applicability of the UAV technology

No.	Purpose	Applicability	Author(s), year
1	Identification and registration of land and land use classes	Land administration	Crommelinck et al., 2017; Stöcker et al., 2019; Xia et al., 2019; Casiano Flores et al., 2020; Koeva et al., 2020
2	Assessment of road traffic analyses, accidents and damages for the building of bridges	Transportation	Skoglar et al., 2012; Sharma et al., 2017; Dorafshan and Maguire, 2018; Dorafshan et al., 2018; Inzerillo et al., 2018; Yoon et al., 2018; Julge et al., 2019; McCormack and Vaa, 2019; Congress et al., 2020; Outay et al., 2020

No.	Purpose	Applicability	Author(s), year
3	Avoiding collisions, UAV-, UAS-, and drone-type flight systems security assessments, flight route planning	Aviation	Lopez, 2007; Dalamagkidis et al., 2008; Newcome, 2009; Reitz and Crouse, 2013; Liu and Foina, 2016; Papa et al., 2017; De and Sahu, 2018; Fouda, 2018; Mahjri et Ayhan et al., 2019; Ghubaish et al., 2019; Lin et al., 2020; Xu et al., 2020; Vu et al., 2020; Woo et al., 2020
4	Management of the gas deposits	Petroleum administration	Xie, 2020
5	Management of the agricultural areas	Agriculture	Shi et al., 2016; Chávez et al., 2020
6	Monitoring, management and rehabilitation of brownfields	Extractive activities	Padró et al., 2019
7	Assessment of archaeological remains	Archaeology	Carvajal-Ramírez et al., 2019
8	Meteorological prediction models and behaviour simulation experiments	Meteorology	Berman et al., 2012; Thomas et al., 2012; Privé et al., 2014; Aurell et al., 2017; Wick et al., 2018
9	Supervising field interventions	Counter-terrorism, cyber attacks	Boyle, 2013; Rani et al., 2016; Birdsall, 2018
10	Resource management	Natural resources management	Rango and Laliberte, 2010

Source: the authors

The first field of activity where the use of the UAV technology was considered necessary was the aviation sector. The role of the UAV, UAS or drones in aviation was particularly highlighted by the studies conducted by the Federal Aviation Administration and NASA on the rethinking of the flight routes in order to avoid collisions by developing mathematical models (Reitz and Crouse 2013; Liu and Foina 2016; De and Sahu 2018; Mahjri et al. 2018; Ghubaish et al. 2019; Lin et al. 2020; Xu et al. 2020; Vu et al. 2020; Woo et al. 2020), pre-flight contingency planning (Ayhan et al. 2019), reporting incidents related to the UAS safety (Fouda 2018) or assessing the acoustical emissions generated by drones (Papa et al. 2017).

When speaking about the public administration, the use of the UAV technology is associated with achieving the spatial data related to the development of land cadastre and land use categories (Crommelinck et al. 2017; Stöcker et al. 2019; Xia et al. 2019; Casiano Flores et al. 2020; Koeva et al. 2020).

Drones are useful also in the transportation sector by the development of algorithms for data extraction (Yoon et al. 2018; Outay et al. 2020), identification of obstacles on crossroad sectors (Congress et al. 2020), avalanche monitoring area (McCormack and Vaa 2019), testing of elevation models accuracy (Julge et al. 2019), analysis of the road pavings (Inzerillo et al. 2018), bridge inspections (Dorafshan and Maguire 2018), traffic management (Sharma et al. 2017).

The UAS are used for the detection and quantification of the waste dumps and monitoring of brownfield rehabilitation (Padró et al. 2019), investigation of the archaeological sites conservation status (Carvajal-Ramírez et al. 2019), management of agricultural crops and improvement of agricultural techniques (Shi et al. 2017; Chávez et al. 2020), supervising the gas deposits (Xie 2020). The data achieved after drone flights, by associating them with specific sensors, may be found also in the forecasts of meteorological models (Wick et al. 2018), for the determination of atmospheric pollutants (Aurell et al. 2017) or simulation of observation experiments (Privé et al. 2014). Regarding drone usage, the Obama administration campaigned for their application in counter-terrorism (Boyle 2013; Birdsall 2018) and cyber-attacks interventions (Rani et al. 2016).

5. CONCLUSIONS

The aim of the paper consisted in conducting complex bibliometric analyses on the use of the UAV technology during the 1988-2020 interval, based on the papers published in the Scopus database. Although the topic is relatively new, the need of introducing these types of aircrafts in various fields of activity has a growing impact over the last five years and an upward trend for the interest in this topic. The data obtained by means of drones and other unmanned flight devices provides accuracy and new categories of information, etc. The high number of citations from American studies on this topic highlights, including through the conducted bibliometric analyses, the significance of the papers published by various education, research and administration institutions in the USA.

The spatial distribution of the researches focused on the role of the UAV has revealed an interest in this topic also among the European education and research institutions, many of them funded by various programs of the European Union, with northern and western countries head of the list. Although there are recent initiatives for the processing of data by drones also in the South-Eastern European countries, including Romania, the international visibility of the published studies is modest, found only in certain databases.

In the context of yet unfinished process of systematic recording of real estates in Romania, the need of using some spatial data obtained pursuant to flights (the digital elevation model, land use, conservation status of certain resources in the territory) would accelerate these efforts, all the more so since there are already studies on the role of UAVs in land management and the use of this data by local public administrations.

Limitations of the study

The bibliometric analyses conducted in this research used only the Scopus database, which, together with WOS, represent the most relevant scientific databases. Therefore, the analysis of the documents is not exhaustive. Some materials were found also in other scientific databases. In addition, only papers related to the analysed topic were considered, not all the possible document categories (scientific reports, reviews, etc.).

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