Bibliometric Analysis and Science Mapping Approach in Digital Landscape Published in WoS and JoDLA from 2010 to 2021

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Abstract: Through bibliometric analysis of 732 articles in Web of Science (WoS) from 2010 to 2021, and 244 articles in the *Journal of Digital Landscape Architecture* (JoDLA) from 2016 to 2021, this study identified the most influential factors such as organizations, journals, keywords, scholars, articles, and countries in digital landscape research and came to the following conclusions: 1) Harvard University (Harvard Graduate School of Design) ranked in the top 10 highly-influential organizations in digital landscape research; 2) The most cited journals differed in the two databases. *Geomorphology* had the most citations in WoS, while *Landscape and Urban Planning* and *Journal of Digital Landscape Architecture* received the most citations in JoDLA. 3) *Landscape and Urban Planning* and *Ecological Indicators* were the two specific journals that ranked in the top 10 for citations within both WoS and JoDLA. 4) Keyword analysis identified GIS, remote sensing, visualization, etc. for both WoS and JoDLA; while in WoS, digital models (i. e. digital elevation model), digital technologies (i. e. geographic information systems and LIDAR), geography, hydrology, vegetation, and land use have become widespread concerning issues; and in JoDLA, BIM, DL architecture, visualization, computational design, simulation, remote sensing, resilience, climate change, UAV, and AR were the most recent cited keywords. 5) Germany, the UK, China, Australia, Italy, and the Netherlands ranked in the top 10 creative countries in both WoS and JoDLA; 6) The USA was recognized as the most creative country, with the most citations in both of these two databases. The research gap was the scarcity of studies on quantitative literature reviews through both bibliometric analysis and the science mapping approach in the field of the digital landscape.

Keywords: Digital Landscape (DL), bibliometric analysis, science mapping approach, comparative analysis.

1 Introduction

Owing to highly-restricted public activities and measures during COVID-19, digital technologies played a more significant role in collecting, filtering, and disseminating information, allowing for continued social and economic activities (CURKOVIC et al. 2021). According to the United Nations' Sustainable Development Goals (SDGs), the idea of a smart city emphasized the importance of improving citizens' health and well-beings via digital technology (LIU et al. 2021). Digital technologies includes multimedia (HE & CAO 2021), computer network (LIU & IEEE 2020), holographic projection (Takahashi et al. 2021), virtual reality (KOUNLAXAY et al. 2022), augmented reality (CISTERNINO et al. 2021), intelligent sensing (BALLARD et al. 2021), artificial intelligence (CLIMENT & HAFTOR 2021), etc.

Digital technology has been a vital source of innovation and a foundation for certain research fields, such as construction safety, water management, etc. (ZHAO et al. 2021). It has also been conducive for the development of landscape industry. Its application has greatly improved the accuracies and performances of landscape data collection and analysis, planning and designing simulation, digital construction and management, and quality control (PENG 2021). STEINITZ and ORLAND claimed that designers were more likely to apply these digital

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tools in designing the landscapes like the city-regional range, or some aspects of the garden scale (STEINITZ & ORLAND 2021). They combined the landscape design with digital information technology innovatively, improved the traditional philosophy of landscape design, and established a brand-new model. This technology could individualize the landscape design and provide intelligent, digital, diversified, and human-friendly services and functions (YANG 2021).

This study applied both bibliometric analysis and science mapping approach in DL research and accordingly constructed a scientific research framework (BALLESTEROS-RICAURTE et al. 2021). It categorized the thematic contents, journals, organizations, authors, countries, and other information of previous DL articles published in WoS and compared them to those in JoDLA. By comparatively analyzing DL's hotspots, this study would indicate the directions for future research. The major contributions of this study included the following: 1) it quantitatively exhibited the data results and the preliminary discoveries from WoS and JoDLA through scientific mapping in DL; 2) it qualitatively analyzed the major research topics of DL, identified the current research gaps, and proposed an effective framework to guide the future research.

2 Literature Review

2.1 Digital Landscape (DL)

DL referred to the specific type of landscape in which digital technologies were integrated (PENG 2021). In JoDLA and DLA Conferences, some scholars defined seven distinct kinds of DL: digitally-enabled representations (by computer graphics); virtual (VR) and augmented (AR) landscapes; algorithmic landscapes conceived and constructed with computational assistance; cyber-physical landscapes incorporating the physical DL features; and future artificial bionic landscapes (ERVIN 2020). To summarize, DL required effective collaborations with other disciplines. It should be referred to in various fields, such as climate, geology, hydrology, ecology, perception, etc. (STEINITZ & ORLAND 2021). It also needed collaboration in designs, whether with smaller-scale architects, medium-scale urban designers and planners, larger-scale geographers, or with engineers of all scales(STEINITZ and ORLAND 2021). For example, some scholars conceptualized a web-based 3D system for decision support, including the urban underground space to improve urban resilience; they also integrated digital information of gas, water, district heating, telecommunications, and existing transmission lines into the system (WISSEN HAYEK & GRÊT-REGAMEY 2021).

2.2 Smart Tools of DL

Smart tools used frequently in the landscape field were as follows: 1) ArcGIS with powerful capabilities of data processing, spatial analysis, and resource evaluation(ZHANG et al. 2021); 2) Landsat-8 remote sensing that could analyze the surface features through computer data or image processing and provide the digital spatial information (BELBACHIR & RAHAL 2021); 3) FRAGSTATS as a spatial pattern analysis program based on categorized images to calculate the analysis indicators of landscape ecology (RODRIGUEZ et al. 2021); 4) VR as a kind of virtual reality technology through computer simulation of the virtual environment to give users the sense of immersion (RODRIGUES et al. 2021). VR maintained the abilities of real-time (CHA et al. 2012), interactivity (ZHANG et al. 2021), and 3D (SINGLA 2021, LIU 2020);

5) Architecture's Landscape Information Model (LIM) as a technology innovated and applied in this particular discipline (YANG et al. 2019) generally by the software Revit; 6) Other widely-used types of software and technologies including BIM, Google Earth engine, laser scanning, Conefor Sensinode, Voronoi cellular automata, Grasshopper, PMSI sensor, SWAT, Google Cloud Vision API, AR, MR and Digital Twin, etc. But there remained a few examples of researches that adopted biometrics in the context of DL.

2.3 Bibliometrics as a Necessity in WoS and JoDLA

Citation analysis was applied for not only evaluating the application performance of individual scholars and institutions, but also their academic publications status (PAUL et al. 2010). For example, the bibliometric method was adopted via manual searches from Landscape Journal and by citation analysis tools (PAUL et al. 2010). When assessing the U.S. landscape architectures and faculty research contributions, BROWN et al. (2020) noted that despite all of these studies measuring the quantity of publications, there had also been a certain interest in reporting their quality, which could be reflected by the total number of their citations (BROWN et al. 2020). The bibliometric analysis examined the works of literature quantitatively via the science mapping approach. This analysis method could visually highlight the institutions, keywords, journals, authors, etc., in the context of a specific research topic (ZHAO 2017). The science mapping approach could be conducted by VOSviewer, which was a smart tool that could also be applied for text analysis and network visualization (VAN ECK and WALTMAN 2010). It has been broadly applied in multiple contexts like construction safety, environmental pollution (MARCAL et al. 2021), social ecology (KARMAOUI et al. 2021), psychological health (KARAKUS et al. 2021), engineering machine (SU et al. 2021), etc. Besides, there were some bibliometric reviews in the previous landscape research, such as the spatial study for landscape changes by bibliometric analysis via VOSviewer (DANESE & GIOIA 2021). Bibliometric analysis and scientific mapping method -could effectively overcome the limitations of traditional research methods and reduce the researchers' subjective judgments or prejudice to a large extent (HOSSEINI et al. 2018).

WoS supported a broad array of scientific tasks across diverse knowledge domains and a data-set for large-scale data-intensive studies (LI et al. 2018). It was an influential database for indexing the multidisciplinary academic literature (NOROUZI et al. 2021). JoDLA addressed nearly all aspects of digital technologies, like applications, information, and knowledge bases in various researches, educations, and practices pertaining to landscape architecture and its related fields (https://gispoint.de/jodla.html, 11th December 2021). In JoDLA, there were two major parts: 1) instrumental inventions, technologies, and capabilities; 2) interconnected web of not only ideas, adoptions, applications but also social and human needs and intentions (ERVIN 2020). Both parts above deserved high attention in the contextual research of DL (ERVIN 2020). The WoS collection of journals did not cover those in the JoDLA. Therefore, this study has incorporated the analysis of 244 documents selected from JoDLA.

3 Research Methods and Samples

After entering the keywords "digital landscape" in WoS, the relevant journal articles published in English emerged. Through a bibliometric search, 4,366 articles related to DL research were selected from WoS. After the preliminary and secondary screenings by landscape professionals, articles irrelevant to the DL were eliminated, for example, some researches focused on the medical genetic landscape, digital health, digital environment, etc. Then, 732 articles in WoS were admitted as the visualization research samples. DL's another bibliometrics analysis began in November 2021 with a manual search of the JoDLA's back issues from 2016 to 2021-Issue 1 to 6-and with an online search of the Scopus databases. There were 244 documents selected from JoDLA. By using VOSviewer 1.6.17, this study visually calculated the effects of key organizations, journals, scholars, and countries as well as analyzed the hotspots and their internal relationships (JIN et al. 2019).

4 Scientometrics and Comparative Results

4.1 Research Organizations

As research became an increasingly important part to the profession of landscape architecture, it was also significant to identify the locations and individuals that were actively contributory (BROWN et al. 2020). For WoS, the results via VOSviewer 1.6.17 were shown in Figure 1 and Table 1. From Figure 1, the node and front size could intuitively reveal the number of articles issued by research organizations (MARCAL et al. 2021). Citations of a "scientific dialogue" type of methods and materials were considered "useful" by authors for their researches (TAO et al. 2021). From Table 1, it could be summarized that articles published by DL research. Table 1 and Figure 4 collaboratively exhibited that the most influential organizations were the University of Montreal and the Chinese Academy of Sciences, indicating that organizations' article productions and total citations were not necessarily correlated with each other in a positive way.

The result of JoDLA analysis, which was different from that of WoS analysis, revealed that Southeast University in China contributed the most documents in JoDLA (Figure 2). Istanbul Technical University and Penn State University also provided more documents than other organizations in JoDLA. Furthermore, Nürtingen-Geislingen University, Stuttgart University, and Harvard Graduate School of Design in the USA were found to be the top three organizations with annual citation influences (Table 2). Studies compared some organizations in WoS and JoDLA before finding that they were essentially identical to each other. For example, Havard University (Harvard Graduate School of Design) ranked in the top 10 highly-influential organizations both in WoS and in JoDLA under the context of DL research. (Table 1 and 2).

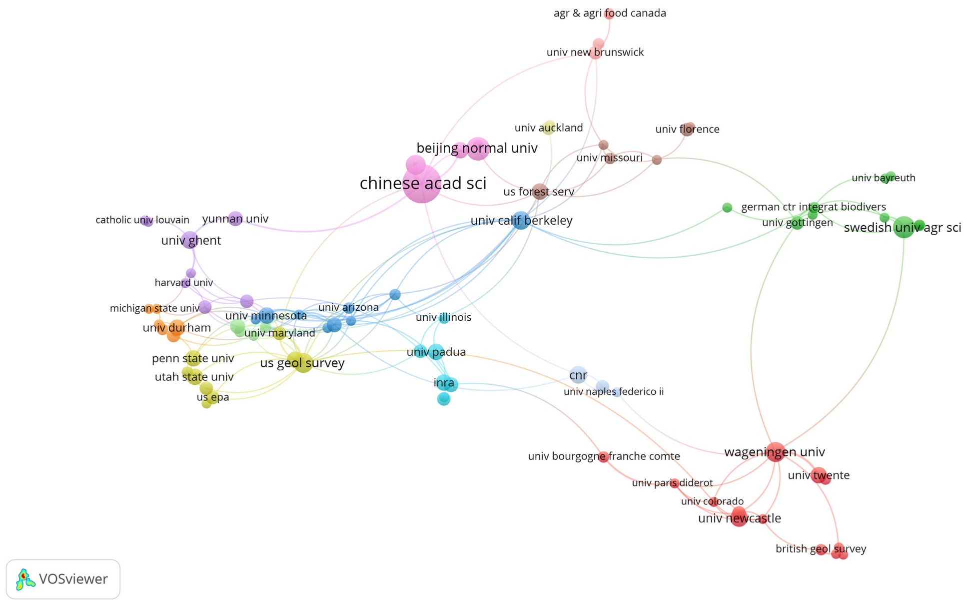

Fig. 1: Main research organizations in the context of DL research from WoS

Fig. 2: Main research organizations in the context of DL from JoDLA

4.2 Publication Sources

Figure 3 showed the mainstream DL journals in WoS. The journal *Geomorphology* published the largest number of DL articles as 32, and its total citations were also the most as 1003 times (Table 3). Corresponding to the largest node in Figure 3, *Geomorphology* was therefore the most contributory journal in DL. The other journals that published numerous articles were *Remote Sensing, Sustainability, Earth Surface Processes and Landforms, Landscape and Urban Planning*, etc. Except for *Geomorphology*, the others with top citations were *Earth Surface Processes and Landforms, Landscape and Urban Planning, Geoderma, Ecological Indicators, Agricultural and Forest Meteorology*, etc., each owning more than 300 citations

(Table 3). The total citation for *Agricultural and Forest Meteorology* was only 375, but the average citation for each publication was up to 75, which showed the crucial effect of the articles published in this particular journal. The general results demonstrated that *Geomorphology* and *Agricultural and Forest Meteorology* were the most influential journals in the context of DL research from WoS, and the latter one exerted the highest average annual influence. Other journals from WoS with high total citations, such as *Earth Surface Processes and Landforms*, and *Landscape and Urban Planning* (Table 3), also presented high influence on the DL research.

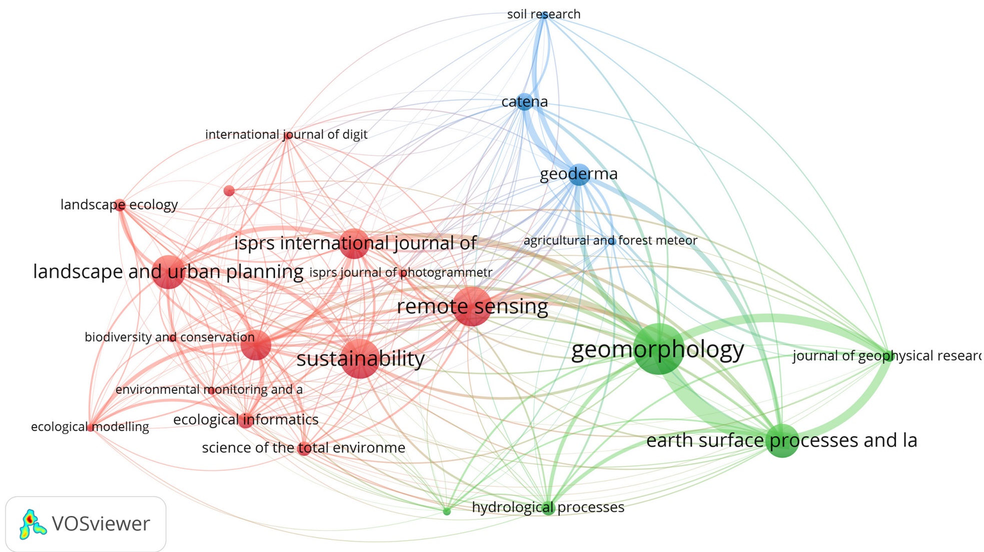

Fig. 3: Main journals of DL research from WoS

As seen from Figure 4, *Landscape and Urban Planning* was the most-cited journal in JoDLA. The *Journal of Digital Landscape Architecture* was the second most-cited. From Table 4, other journals also exerted considerable influences in JoDLA, such as *A Framework for Geodesign: Changing Geography by Design, Environment and Planning B: Planning and Design, Journal of Environmental Psychology, Computers, Environment and Urban Systems*, etc. Compared with those in WoS, 1) the most-cited journal was different. *Geomorphology* obtained the most citations in WoS, while *Landscape and Urban Planning* and *Journal of Digital Landscape Architecture* acquired the most citations in JoDLA; 2) *Landscape and Urban Planning*, and *Ecological Indicators* were ranking in the top 10 for citations in both WoS and JoDLA (Table 3 and 4).

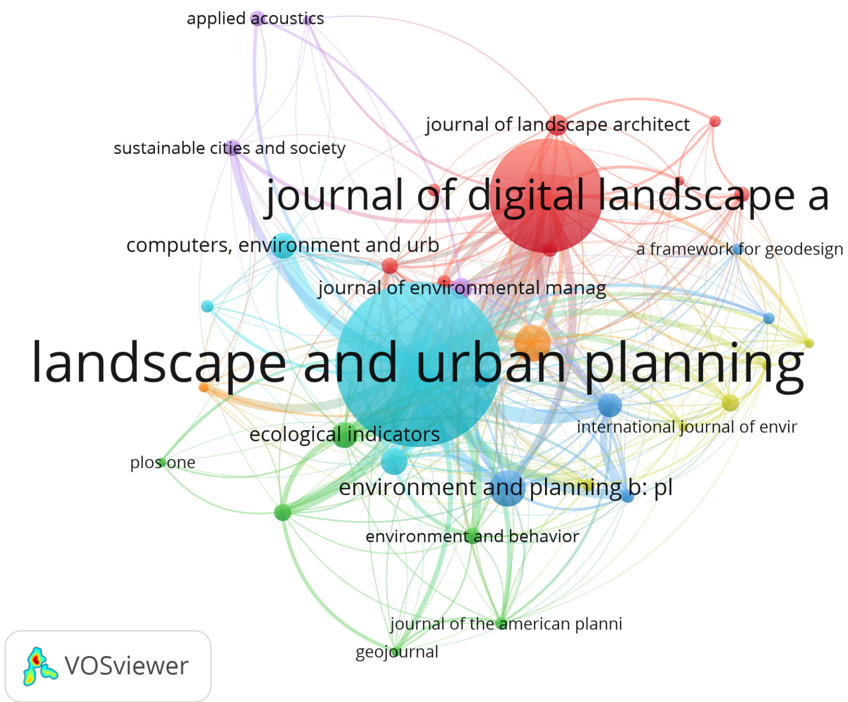

Fig. 4: Mainly-cited journals in JoDLA from 2016 to 2021

4.3 Keywords

Keywords represented the major content and described the most concerned topic in a specific research context (SHI et al. 2021; SU and LEE, 2010). The keywords network from analysis exhibited the internal relationships and connections between knowledge systems (VAN ECK and WALTMAN 2010). For WOS's keyword analysis, some common and meaningless items were excluded, such as "landscape" and "digital". Singular/plural words and synonyms have been merged, such as "model" and "models", "digital elevation model" and "digital elevation models", "metrics" and "indicators". A total of 48 keywords were retained, as shown in Figure 5. The nodes presented the most frequently-cited terms of DL, such as "digital elevation model", "model", "GIS", "classification", "area", "vegetation", "LIDAR", etc. The four different node colors implied the four different clusters. Keywords usually kept a strong connection with each other inside the same cluster, such as biodiversity, ecology, ecosystem services, and forest. Keywords from different clusters might also share strong links, such as "GIS" (cluster 1) and "remote sensing" (cluster 4). It could be summarized from the analysis that digital models (i. e., "digital elevation model"), digital technologies (i. e., "geographic information systems" and "LIDAR"), geography, hydrology, vegetation, and land use have become widespread concerning issues in the context of DL research. For average citations, each of geomorphology, sediment transport, hydrology, landscape evolution, land-use change, and variability had received a large focus. The average normalized citations indicated that landscape evaluation, land-use change, geography, China, and geographic information systems have all attracted high attention.

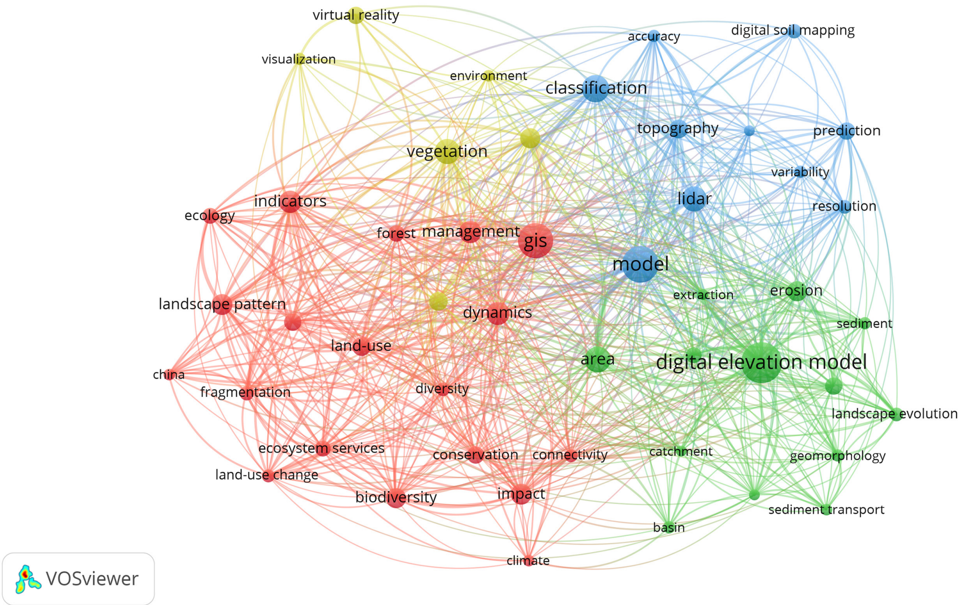

Fig. 5: Co-occurrences of keywords in DL research from WoS

As seen from Figure 6, the nodes of geodesign, GIS, simulation, landscape architecture, virtual reality, augmented reality, landscape design, BIM, education, and resilience in JoDLA were within the larger node area, which ranked in the top 10 citations of keywords. Among them, geodesign was the most cited one. Similar to the most influential journal mentioned above in the context of DL research from WoS, the keyword Geomorphology meant that the landscape architecture discipline might be strongly connected with geography or some eminent geo-physical geologists. GIS ranked in the top 3 of both WoS and JoDLA, which implied that it was a significant hotspot in the DL research. BIM, DL architecture, visualization, computational design, simulation, remote sensing, resilience, climate change, UAV, and AR were the most cited keywords recently in JoDLA, the majority of which were related to the DL research (Table 5). Thus, JoDLA was mainly concentrated on the application of digital technologies in landscape architecture. Remote sensing and visualization were the other two keywords making the top 10 both in WoS and JoDLA.

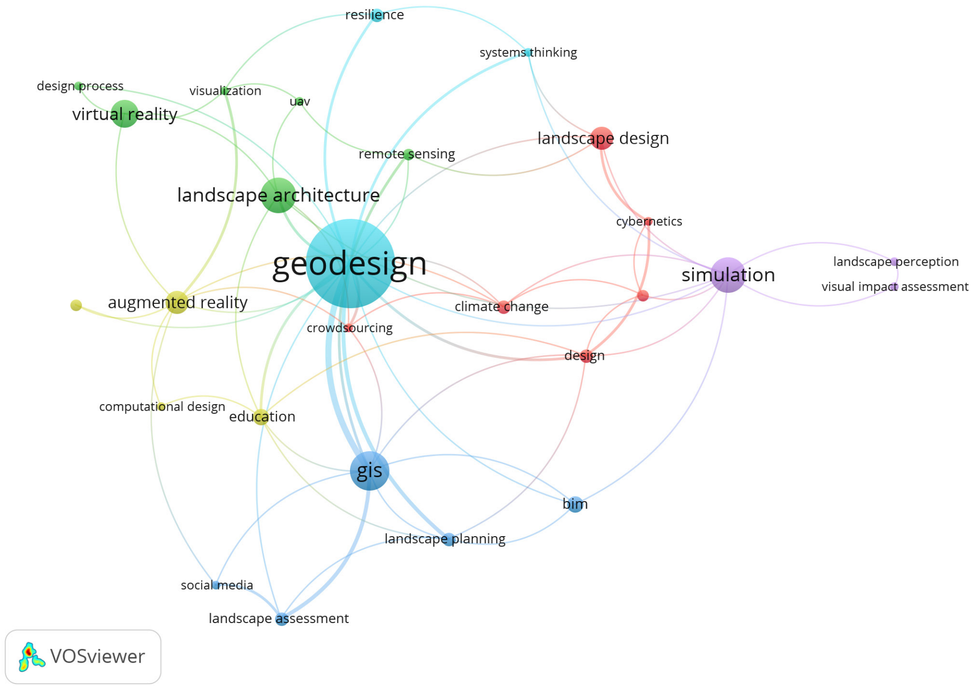

Fig. 6: Co-occurrences of keywords in JoDLA from 2016 to 2021

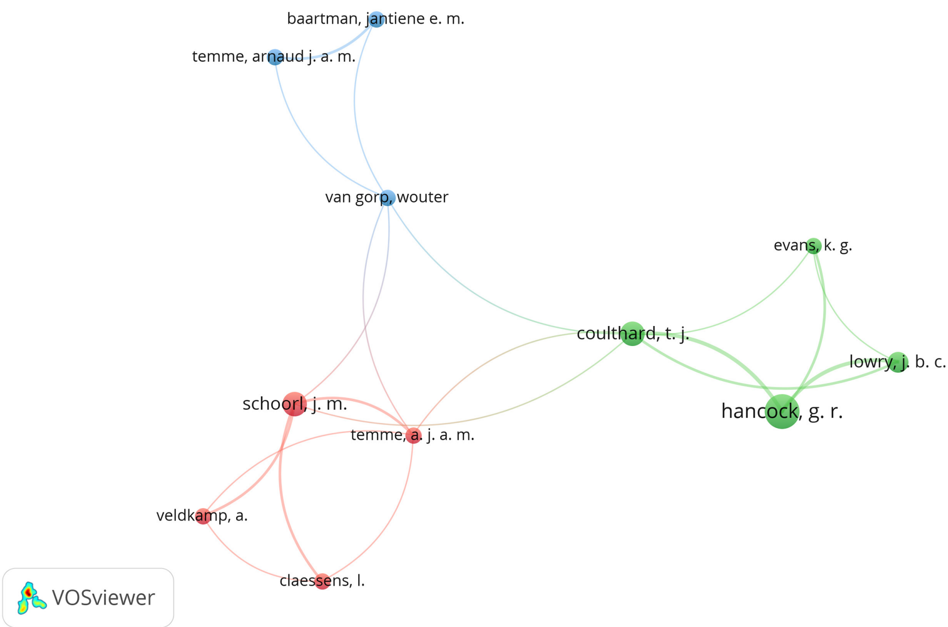

Fig. 7: Co-occurrences of authors in DL research from WoS

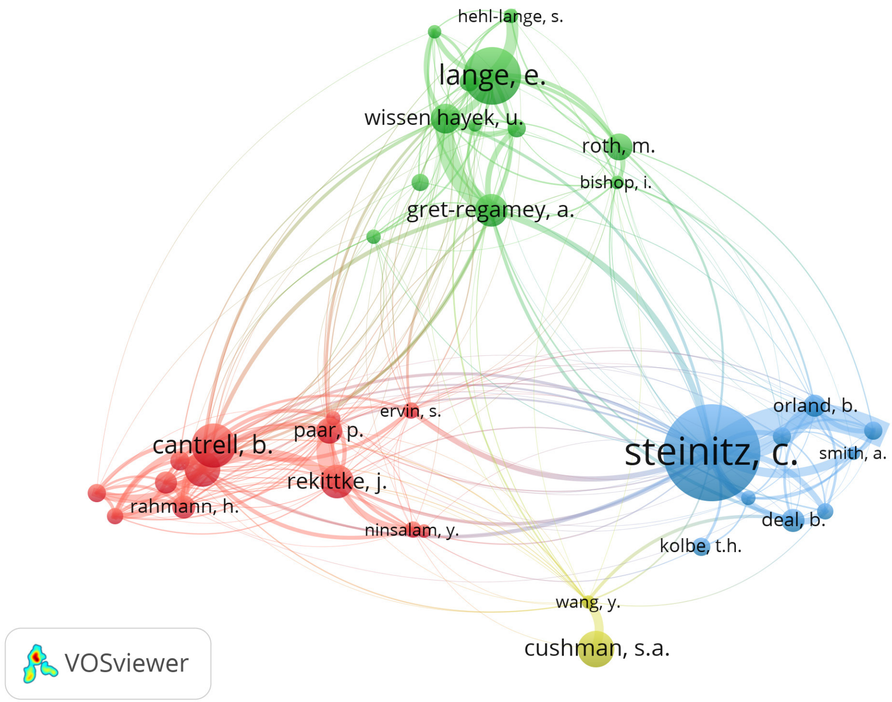

Fig. 8: Cited authors in JoDLA from 2016 to 2021

4.4 Co-Author Analysis

Co-authors of publications help readers to understand the most authoritative researchers and publications. Co-author analysis could also benefit individual researchers in seeking cooperation opportunities by providing information about research networks and theoretical directions (SU et al. 2021). For WOS, the most influential authors were shown in Figure 7, for example, BAARTMAN, HANCOCK, and TEMME. The lines connecting the researchers meant that the co-authors have collaborated before (MADSUHA et al. 2021). These authors were divided into three clusters, representing the three types of research systems adopted by the DL scholars, for example, SCHOORL, HANCOCK, and BAARTMAN. Among the authors who met the standards, the percentage of those with only one internal relationship was only 12%. This revealed that these researchers not only were relatively isolated but also lacked mutual citations and references between their existing researches on DL. Their research directions might also be quite divergent, which made it difficult for them to cooperate with each other. Thus, future researchers should look for partnerships to co-research, reduce the isolated research, and improve the efficiencies and benefits of their research(NOROUZI et al. 2021).

As shown in Figure 8, there were four clusters, representing the four types of research systems adopted by the scholars in JoDLA, for example, STEINITZ, LANGE, CANTRELL, and CUSHMAN, who were also the most influential authors in JoDLA. The connections of each scholar here were stronger than those in WOS under the context of DL.

4.5 Article Citations

From Figure 9, the results were consistent with those found in Figure 7, which further illustrated the isolation of authors in the field of DL research and the relatively small correlation between authors and/or articles. This study summarized the details of these articles, including their full titles and the total numbers of their citations. The most-cited article from 2010 to 2021 was “modelling landscape evolution” (Tucker and Hancock 2010), which also obtained the highest total citations. It reviewed the landscape theory-in the form of a numerical model of watershed evolution, as well as the current knowledge gaps and the future computational challenges. Other articles with high citations were individually researched by (Baartman et al. 2013), (Passalacqua et al. 2010) (Fisher, Bookhagen, and Amos 2013), (DiBiase et al. 2012), (Boulton and Stokes 2018), etc. The publication sources of these articles were mainly the *Earth Surface Processes and Landform*, *Water Resources Research*, *Geomorphology*, *Journal of Hydrology*, etc. This finding might also prove the DL’s interconnection with the hydro-geo discipline.

In JoDLA, VOSviewer was adopted to investigate the most influential journal publications, and the minimum number of citations was set to three. As shown in Figure 10, most of the documents were related to the topic of DL. Furthermore, Hayek (2016) explored the issues of immersive virtual landscapes for the support of participatory spatial planning, which was the most cited document in JoDLA.

4.6 Countries Actively Participating in DL Research

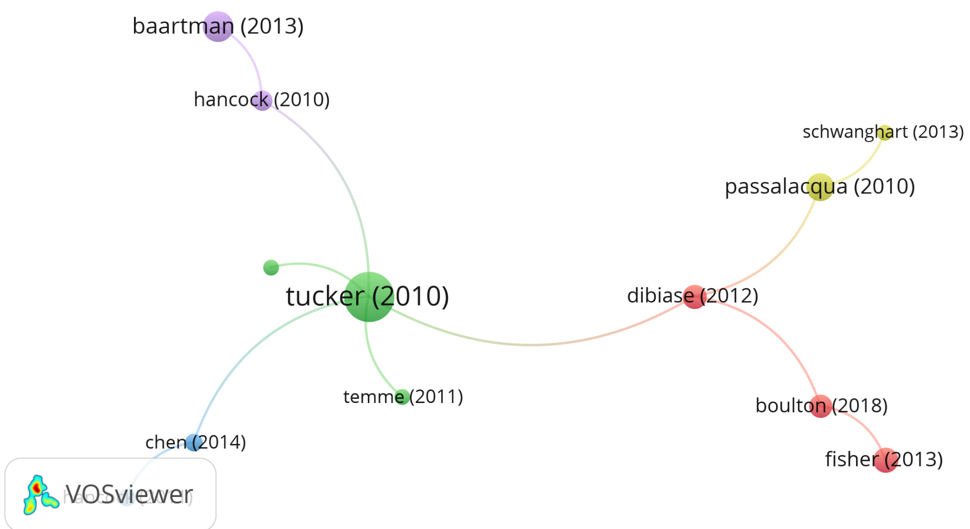

Fig. 9: Scientific mapping of the most influential articles on DL research from WoS

The above keyword analysis also showed that China was one of the countries actively participating in DL research. Figure 11 and Table 6 jointly exhibited the countries that had actively participated in DL research since 2010. In Figure 11, the lines represented the mutual reference relationships between different countries, and the thickness of the lines indicated the strengths of these mutual references. According to the nodes and connections, the USA, China, the United Kingdom, France, Germany, Australia, and Italy have all actively participated in DL research. China and the USA presented the strongest citing relationship, followed by that between the United Kingdom and the USA, and then that between France and the USA.

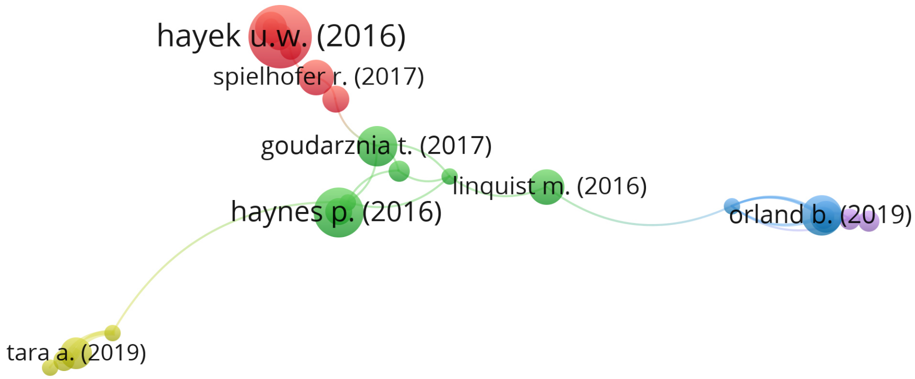

Fig. 10: Scientific mapping of the most influential articles from JoDLA

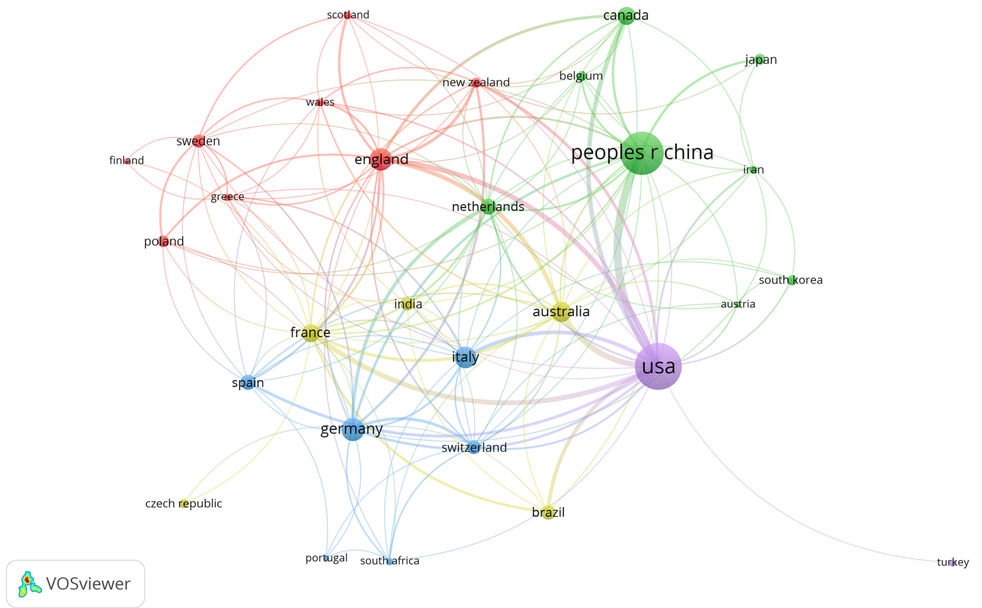

Fig. 11: Scientific mapping of countries active in DL research

As shown in Figure 12 and Table 7, the USA, Germany, the United Kingdom, Australia, and China were the top five active countries in JoDLA. Moreover, the USA, Germany, the UK, China, Australia, Italy, and the Netherlands entered the top 10 in both WoS and JoDLA.

Among all of them, the USA was the most creative country with the highest citations in both of these two databases (Table 6 and 7). Moreover, universities across the USA have been offering professional programs on Landscape Architecture (LA) for more than a century (BROWN et al. 2020). Traditionally, these programs have taught landscape architectural knowledge, skills, and values to numerous students so that they could become successful professionals (BROWN et al. 2020). However, many of the U.S. professional organizations of landscape architecture nowadays also considered conducting LA research when evaluating and/or supporting the LA faculty (BROWN et al. 2020).

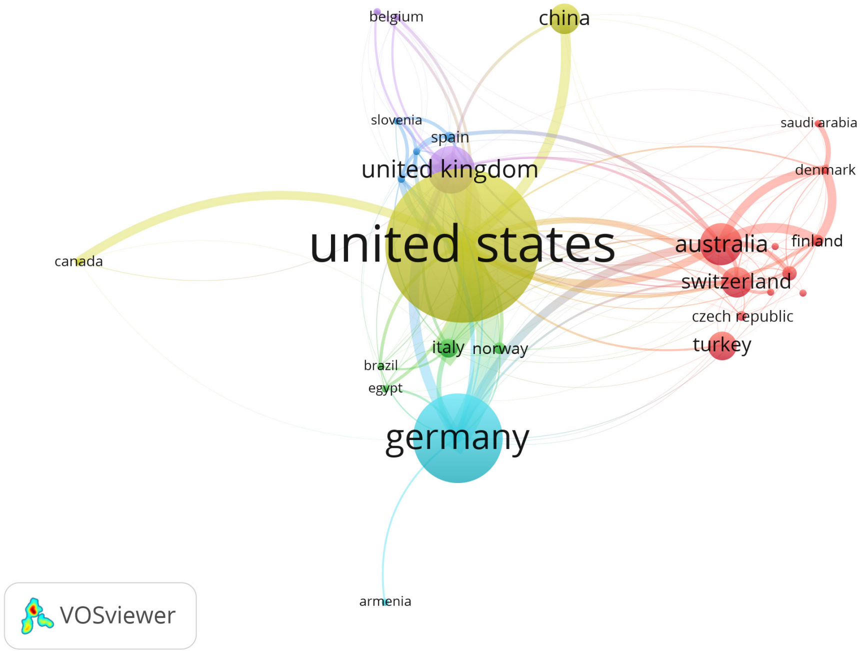

Fig. 12: Scientific mapping of countries active in JoDLA

According to the average publication year, in WoS, Belgium and Portugal began their researches on DL earlier than the others. In 2017, developed countries such as the USA, Germany, and the United Kingdom also started to play a leading role in DL research. Since 2018, developing countries such as Brazil, China, India, and South Africa have also successively invested in this field of research. Furthermore, developing countries like Brazil, Egypt, Greece, etc., were active in JoDLA earlier. Developed countries were active in JoDLA later, such as Ireland, Canada, Netherlands, Denmark, Czech Republic, Finland, Australia, Singapore, Norway, Germany, and Switzerland (Table 8 and 9).

5 Qualitative Discussion

Landscape site characteristics corresponded to the previous keyword researches, such as hydrology, vegetation, digital elevation model, LIDAR, land-use change, geomorphology, etc. In terms of terrain, pioneer researchers applied LIDAR to automatically extract the features of complex mountain landscapes. They adopted digital technology to test the method of landscape spatial scale (PASSALACQUA et al. 2010). For the hydrological landscapes, scholars applied the digital elevation models to collect information and specifically investigated the mesoscale watershed landscapes in Central Europe, based on the method of hydrological landscape classification and the dominant runoff mechanism (GHARARI et al. 2011). In terms of soil, scholars employed the approach of Digital Soil Surveying and Mapping (DSM) to quantitatively predict the spatial distribution of soil taxonomy and to accordingly draw a spatial distribution map of the soil classification, thereby guiding the landscape soil applications and management decisions (BRUNGARD et al. 2015). For vegetation, researchers studied the influences of plant status (flowering, leaf shape, and autumn color) on the preference and Recovery Potential (RP) of the designed DL model (KUPER 2020).

Based on public needs, it was vital to apply digital spatial information to create digital planning for the urban landscape, to build an urban ecological network system, and to promote a smart and healthy city's construction and development (YANG 2021). For example, scholars simulated the urban blue-green space's planning based on the thermal environment. Taking Shanghai as a case study, scholars formulated the distribution strategy for its blue-green space in urban planning and proposed various design methods to optimize both its green space and water landscape (DU et al. 2019). Furthermore, relevant research adopted computer simulation analysis, FPGA, and neural network design to simulate the landscape of urban gardens and to reduce urban floods through the effective use of urban rainwater (YANG 2021).

6 Conclusion

The WoS journal list did not include JoDLA, so quite a lot of relevant literature might be missing from the studied sample. The authors not only wrote with knowledge of the JoDLA corpus from 2016 to 2021, but also compared and contrasted these corpus-based findings with those WoS-based findings from 2010 to 2021. In recent years, there have been more tools(such as VOSviewer and CiteSpace) helpful to draw the scientific knowledge map, but in the field of DL, scarce research has been made on quantitative literature reviews by scientometric analysis. The science mapping approach was also a tool applicable to track the frontline technologies (WANG et al. 2021), promote knowledge management, and assist in technical decision-making (HUANG et al. 2021). Those influential organizations, publications, hotspots, scholars, documents and countries active in DL were all analyzed by this approach. However, after the keyword visualizations of WoS and JoDLA, the results showed that interdisciplinary collaboration was important to landscape architecture. They also reflected more hard-science disciplines being published in the WoS journal collection. At the *21st annual DLA conference*, some scholars argued that landscape designing must collaborate more with other disciplines' professionals, such as architects, urban designers and planners, geographers, engineers, lawyers, bankers, government officials, stakeholders, etc. (STEINITZ and ORLAND 2021). These conclusions were significant for governments, managers, researchers, and designers in DL.

Moreover, this study acknowledged the limitations of adopted approaches. Google Scholar, Publish or Perish (Harzing.com), SCOPUS, WoS, and Mendeley covered a wide variety of peer-reviewed major landscape journals on not only natural and social sciences but also landscape design issues (BROWN et al. 2020). But in this study, these kinds of findings were only from WoS and JoDLA in Scopus under the context of DL research. Thus, these methods were just useful for DL research, and whether they would be suitable for other research contexts needed further investigation.

The future research directions of DL are proposed as follows: 1) Low-carbon plant communities and models are to be researched via comprehensive digital technologies. (HANNA and COMIN 2021). Faced with the increasingly severe changes of global climate, all walks of life should contribute to the "carbon neutrality" and "carbon peak". Scholars can keep striving to promote the construction of low-carbon cities, the saving of energy and the reduction of emissions all in a sustainable way (KUMAR et al. 2022). 2) Digital technology should realize the service function of a landscape ecosystem more effectively. Ecosystem service should be one of the most important keywords that appeared in the keyword analysis. Mankind needs to systematically apply DL technologies to achieve the ecosystem service functions, such as climate regulation, flood and drought relief, and biodiversity maintenance. 3) New digital media technologies are to be also applied in landscape designs. There should be more interactive and sensory landscapes with artistic expressions to fulfil the increasing public needs.

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Supplementary Materials

Table 1: Quantitative measurement of the top 10 cited organizations under the context of DL research in WoS

Organizations	**Weight (Citations)**	**Score (Avg. pub. Year)**	**Score (Avg. citations)**	**Score (Avg. norm. citations)**
University of Montreal	501	2015	167	7.2
Harvard University	488	2015	163	6.2
Ghent University	475	2014	59	2.0
Wageningen University & Research	398	2015	40	1.5
University of Newcastle	393	2015	49	1.6
United States Geological Survey	306	2017	31	1.6
Swedish University of Agricultural Sciences	303	2017	25	1.4
University of Colorado Boulder	283	2016	94	2.7

Table 2: Quantitative measurement of the top 10 cited organizations in JoDLA

Organizations	**Weight (Citations)**	**Score (Avg. pub. Year)**	**Score (Avg. citations)**	**Score (Avg. norm. citations)**
Chinese Academy of Sciences	252	2017	8	0.7
Nürtingen-Geislingen University	53	2018.9	10	10.9
Planning of Landscape and Urban Systems Eth Zurich	24	2018.3	4	1.8
University of Sheffield	23	2015.5833	4	1.8
Cukurova University	22	2018	7	4.7
Stuttgart University	16	2018	16	7.8
Royal Melbourne Institute of Technology	13	2019.2	2	2.1
University of Georgia	11	2017.7	4	2.0
Anhalt University of Applied Sciences	11	2018	4	1.7
Harvard Graduate School of Design	8	2019	8	4.8
University College-London	8	2019	8	4.8

Table 3: Top 10 journals with the highest citations in WoS

Journal	**Docu-ments**	**Cita-tions**	**Avg. pub. Year**	**Avg. citations**	**Avg. norm. citations**
Geomorphology	32	1003	2016	31	1.5
Earth Surface Processes and Landforms	21	647	2017	31	1.2
Landscape and Urban Planning	21	561	2016	27	1.9
Geoderma	14	499	2017	36	1.7
Ecological Indicators	19	471	2017	25	2.8
Agricultural and Forest Meteorology	5	375	2017	75	3
Remote Sensing	25	175	2019	7	1
Biodiversity and Conservation	5	138	2015	28	1
Soil Research	5	133	2016	27	1.5
Isprs Journal of Photogrammetry and Remote Sensing	5	131	2018	26	1.4

Table 4: Top 10 journals with the highest citations in JoDLA

Journal	**Clus-ter**	**Weight (Links)**	**Weight (Total link strength)**	**Weight (Cita-tions)**
Landscape and Urban Planning	6	34	623	164
Journal of Digital Landscape Architecture	1	29	279	108
A Framework for Geodesign: Changing Geography By Design	7	26	91	30
Environment and Planning B: Planning and Design	3	20	104	30
Journal of Environmental Psychology	6	22	107	21
Computers, Environment and Urban Systems	6	16	72	20
Ecological Indicators	2	25	116	20
Sustainability	3	24	127	19
Journal of Environmental Management	5	26	102	16
Journal of Landscape Architecture	1	17	43	16

Table 5: Top 10 the most recent co-occurrence keywords in WoS and JoDLA

Digital landscape research from WOS		All research from JoDLA	
Keywords	**Score (Avg. pub. Year)**	**Keywords**	**Score (Avg. pub. Year)**
Random Forest	2019.6	BIM	2020.429
Virtual Reality	2019.179	Digital Landscape Architecture	2020.2
Ecosystem Services	2018.522	Visualization	2019.75
Digital Soil Mapping	2018.333	Computational Design	2019.75
Resolution	2017.95	Simulation	2019.467
Basin	2017.944	Remote Sensing	2019.4
Remote Sensing	2017.849	Resilience	2019.333
Climate	2017.75	Climate Change	2019.333
Accuracy	2017.667	UAY	2019.25
Visualization	2017.647	Augmented Reality	2019.2

Table 6: Top 10 countries producing the most documents in WoS or JoDLA

	WOS		JoDLA
Country	**Weight (Documents)**	**Country**	**Weight (Documents)**
USA	185	USA	87
China	159	Germany	47
Germany	55	UK	23
UK	52	Australia	20
Italy	49	China	14
Australia	45	Switzerland	14
France	37	Turkey	13
Canada	36	Italy	8
Netherlands	31	Netherlands	6
Spain	28	Finland	5

Table 7: Top 10 countries with the highest citations in WoS or JoDLA

	WOS		JoDLA
Country	**Weight (Documents)**	**Country**	**Weight (Documents)**
USA	3073	USA	99
Australia	1007	Germany	58
Germany	1000	UK	44
UK	992	Switzerland	35
China	870	Turkey	34
Italy	857	Australia	18
Canada	855	Italy	12
Netherlands	798	Norway	10
France	692	Finland	7
Belgium	541	Spain	7

Table 8: Top 10 the earliest countries active in WoS or JoDLA

	WoS		JoDLA
Country	**Weight (Documents)**	**Country**	**Weight (Documents)**
Belgium	2015	Brazil	2016
Portugal	2015	Egypt	2016
Netherlands	2016	Greece	2017
New Zealand	2016	Poland	2017
Scotland	2016	Slovenia	2017
Czech Republic	2016	Belgium	2017.333
USA	2017	Turkey	2017.539
Australia	2017	Ireland	2017.667
Germany	2017	Spain	2018.25
England	2017	Canada	2018.5

Table 9: Top 10 the latest countries active in WoS or JoDLA

	WoS		JoDLA
Country	**Weight (Documents)**	**Country**	**Weight (Documents)**
People’s Republic of China	2019	Netherlands	2020.3333
India	2019	Denmark	2020
Wales	2018	Saudi Arabia	2020
Japan	2018	Czech republic	2019.75
Brazil	2018	Finland	2019.6
South Korea	2018	Australia	2019.55
Iran	2018	Singapore	2019.5
Finland	2018	Norway	2019.2
USA	2017	Germany	2019.0426
Australia	2017	Switzerland	2019