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AUTHOR'S NOTE

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Introduction

- 1 Increasingly, people who visit natural spaces, and primarily athletes (Mao & Obin, 2018), are equipping themselves, mobilising digital devices and interacting and structuring themselves in virtual communities. They thus produce digital footprints, *i.e.*, traces left behind when browsing the Internet or using a service from a digital terminal. These footprints have informational, experiential and/or spatial content, thus becoming geodigital footprints (Mericskay & Roche, 2011; Mericskay *et al.*, 2018), or Volunteered Geographic Information (VGI). The exploitation of these data opens up new perspectives for research, for example in urban mobility (Le Breton *et al.*, 2022), including sports (Musakwa & Selala, 2016; Dadashova *et al.*, 2020; Hong *et al.*, 2020; Kyuhyun & Ipek Nese, 2021; Nelson *et al.*, 2021; Venter *et al.*, 2021), or in the spatial

behaviours of tourists in urban areas (Mondo *et al.*, 2020). This collaborative web gives access to massive quantities of data documenting phenomena that are otherwise difficult to observe (Houllier & Merilhou-Goudard, 2016), particularly in the mountains due to the dispersion and low density of uses. However, knowledge of these visits is essential for the management of this area.

- 2 At the same time, the methods for assessing the visits of areas (*in situ*, using automatic devices or surveys, or remotely, using aerial photos or GPS) are now showing their limitations (Meur-Férec *et al.*, 2001), both in terms of their implementation and their effectiveness. They are largely ineffective in open areas where the topographical profile of routes frequently changes over time (Audouit *et al.*, 2016), which has led to a lack of objective knowledge of their visits. In this context, managers are turning to new solutions: mobile phone data, which has potential (Nettles *et al.*, 2022), is not very relevant in weakly equipped mountain areas due to weak mobile phone coverage; and social network data, which is more efficient and provides continuity, real-time analysis, and transferability (Hausmann *et al.*, 2018), raises methodological issues due to inequalities in its production (Tenkanen *et al.*, 2017). There is still the use of VGI, which is absent from the tools for observing mountain visits, except in two papers (Rupf & Stäuble, 2018; Davoine & Garat, 2022).
- 3 There is therefore a real interest in documenting the phenomenon of VGI more widely in the academic literature to lay the foundations for future research that will fill the gaps in the knowledge of the visits of natural areas based on geodigital footprints. Thus, our study aims to analyse the scientific production on VGI as exhaustively as possible to provide a global understanding of knowledge and identify relevant orientations (Arksey & O'Malley, 2005). In other words, the goal of our article is not to carry out a review of the literature dealing with VGI and the visits of natural areas, but to grasp the place of the subject of the visits of natural areas within the vast field of VGI research.

Materials and Methods

- 4 Bibliometric analysis quantitatively studies scientific production on a subject based on a corpus of papers. It is of interest for the purpose of doing the spadework for a specific subject. It is therefore adapted to VGI, where the literature is recent and not so large. To carry it out, we use the “scoping study” method (Arksey & O'Malley, 2005), which can be likened to the mapping of a field of research to understand its construction (Munn *et al.*, 2018). In this way, it constitutes the source of a new contribution to science. Our study proceeds in five stages (Badger *et al.*, 2000; Arksey & O'Malley, 2005).
- 5 The first is to define the research question. To provide the broadest possible overview of the scientific literature on VGI, the research question is deliberately broad. The second step is the systematic (Pahlevan-Sharif *et al.*, 2019) and transparent identification of resources. We conducted it in April 2022 by searching for the terms “*information géographique volontaire*”, “volunteered geographic information”, “volunteered geographical information” and “VGI” in the titles, keywords and/or abstracts of papers of all types in the Web of Science (WoS). We have assumed that the keyword “IGV” is at the heart of our bibliometric analysis and that the WoS is one of the leading English-language scientific literature databases for carrying out this type of analysis. The third step consists of selecting the resources. We retained no time limit

and no linguistic constraint, nor any thematic or disciplinary limit. 1,001 papers then made up our corpus. In the fourth stage, we collected the same data for all papers to ensure their comparability (Arksey & O'Malley, 2005). We analyse nine metadata available for each paper: the year of publication; the disciplinary categories defined by the Web of Science, *a posteriori* reorganised into 31 adjusted categories and grouped into five disciplinary domains; the type of document; the language of the paper; the paper journal or book or the presentation conference; the list of authors; the countries of the authors' institutions; the texts of the "Fundings" sections; and the keywords provided by the authors, *a posteriori* reorganised into adjusted keywords. The last step is the analytical presentation of the results in three points. It begins with a temporal and disciplinary overview of the scientific literature on VGI. Then comes the analysis of the context of paper production, between spaces of paper dissemination, authorship, and research funding. Finally, we propose a thematic reading of the academic literature on VGI based on a study of the analysis of the keywords in the corpus.

- 6 The WoS is a digital platform managed by Clarivate Analytics that provides access to a bibliographic database. It indexes journal articles, books, and scientific conference proceedings. It should be noted that the corpus is not exhaustive due to our choices. On the one hand, the identification of papers from the WoS is incomplete as regards the non-English literature. In addition, Scopus is a richer database in the humanities and social sciences, in "regional" journals (Frenken & Hoekman, 2014), in papers with a lower renown, and in non-English literature, but we were unable to use it because our institutions do not give us access to it. The most we know is that Scopus lists 2,009 papers meeting the same search criteria and dating from 2021 or earlier, compared with 986 on the WoS. It would therefore be relevant to carry out the following study by also considering the papers referenced on Scopus. On the other hand, the fact that the data collection was conducted in April 2022 does not allow us to consider the year 2022 (n=15) in the temporal analysis and could even exclude some papers from 2021 that were put online late, given the two-year time lag between the release of scientific papers and their registration on the WoS.

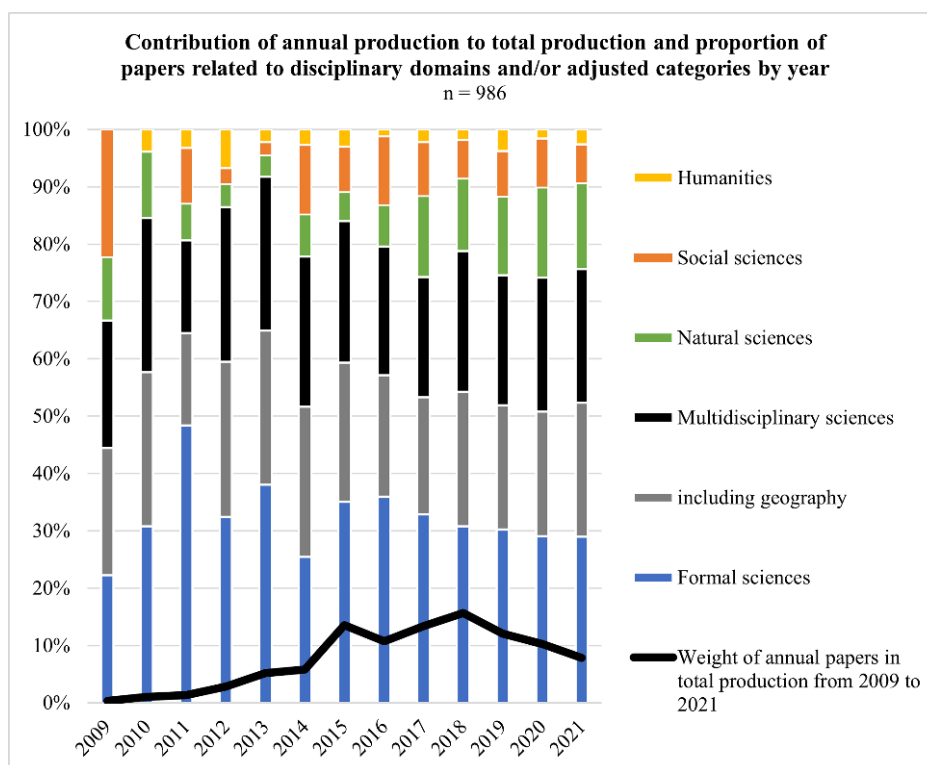
General Evolution of Scientific Production

- 7 Scientific interest in VGI is recent, with the first papers listed on the WoS being published in 2009, despite a paper published in *GeoJournal* in 2008 (Tulloch, 2008). The democratisation of the internet and mobile and/or digital tools at the beginning of the 21st century certainly explains the strong increase in the number of papers until 2015. Thereafter, this growth slows down and we observe since 2018 a decrease in scientific production.
- 8 After grouping the 86 WoS categories (a paper can be associated with several categories) into 31 adjusted categories and then into 5 disciplinary domains, two disciplinary domains dominate the study of VGI today (Figure 4). The first is the formal sciences, of which 80% of the papers are in this domain. In detail, about one third of the papers are associated with computer and/or imaging sciences and this rate is 10% for engineering sciences. The second disciplinary domain is multidisciplinary, which includes the categories of various sciences, including geography. Geography accounts for nearly 97% of papers in this multidisciplinary domain. The natural and social sciences come next. Their interest in VGI has been noted every year since 2011 and the

WoS attaches about 27% and 20% of papers to these disciplinary domains, respectively. However, it is important to note that geography is excluded from the social sciences in this analysis, which puts into perspective the fact that only 20% of the papers in the corpus belong to the social sciences. As for the humanities, they are very poorly represented in the academic production on VGI, but also in the WoS in general; this result must also be put into perspective.

- 9 Geography is the most represented adjusted category in the corpus, which seems logical given the geographical nature of VGI. The WoS attaches more than half of the papers in the corpus to geography and makes it the discipline most represented in the papers of all years except 2011. However, it has neither a monopoly on papers nor the status of precursor: more than 40% of the papers in the corpus are not related to geography, and this is true from the very first years of publication on VGI.

Figure 1. Evolution of scientific production on VGI by year and by disciplinary domain



Contextualising Academic Papers

Domination of the Geographic Information Systems (GIS) Field in the Authorship and Distribution Spaces

- 10 718 papers in the corpus are articles, from 219 scientific journals. The thirteen most represented journals gather 9 to 104 papers each. Although the spatial sciences (GIS, geography, geographic information sciences, regional and urban planning) are omnipresent in their themes, it is more precisely the GIS that dominate since they are represented by 5 journals, including the *ISPRS International Journal of Geo-Information* (n=104), the *International Journal of Geographical Information Science* (n=45) and *Transaction*

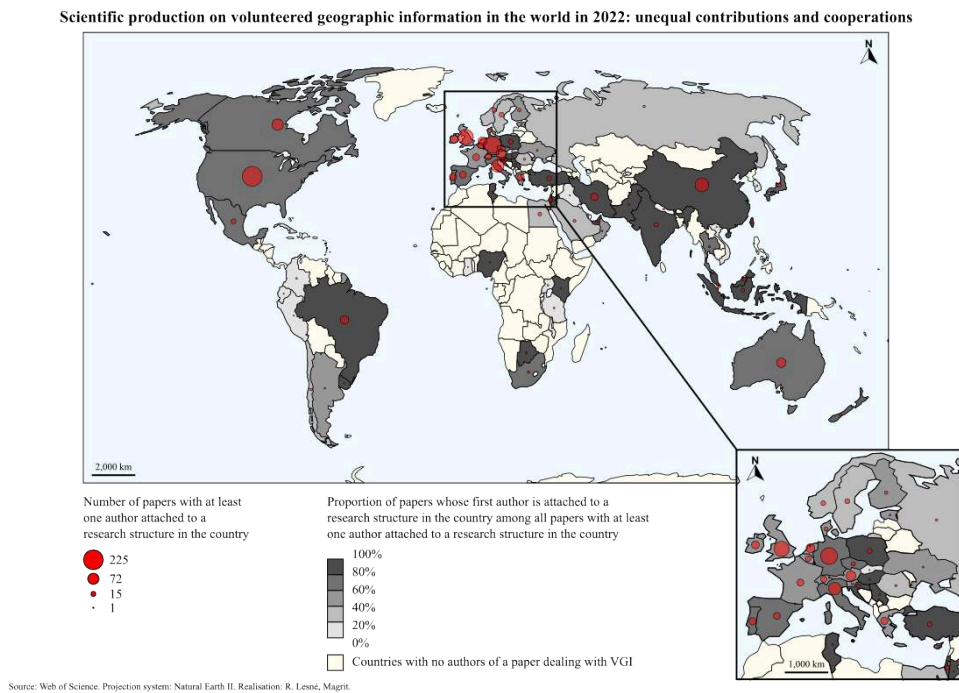
in GIS (n=40). The observation is similar for the 220 papers from scientific conference proceedings. More specifically, a few events focused on VGI play an important role in the academic production: *Volunteered Geographic Information and The Future of Geospatial Data* (n=12); *Openstreetmap in GIScience: Experiences, Research, and Applications* (n=7); *Fundamentals of Human Factors Design for Volunteered Geographic Information* (n=5) and *Mobile Information Systems Leveraging Volunteered Geographic Information for Earth Observation* (n=5).

- 11 Ninety-nine percent of these papers are in English. 2,378 authors write them, 22% of whom participate in at least two different papers. The ten authors with at least 10 different papers each form three groups. With 34 and 30 papers respectively, Zipf and See are the two most important authors on VGI today and both are specialised in GIS. Mooney (n=19) and Fritz (n=17) follow them. While the latter is in the GIS field, the former works in a computer science department. Finally, five authors signed 14 to 10 articles each and work in spatial sciences (Antonioni), mostly in GIS (Arsanjani, Harklay, Minghini and Hochmair). Among the ten most productive authors, only de Albuquerque is not a GIS and/or computer scientist. The disciplines, themes, and specialities of this highly active authorship on scientific production corroborate the domination of the disciplinary field of geography and the world of GIS on the corpus.

Geography of the Authorship

- 12 The geographical analysis of the authorship (Figure 5) distinguishes three countries among the addresses of the institutions to which the authors of the corpus belong: the United States, Germany, and the United Kingdom. They are represented in 13% to 22% of papers and six of the ten most productive authors are attached to them. Three other countries are particularly well represented since they account for 7% to 11% of the papers: China, Italy, and Canada. France is only in 15th position. While Europe, especially Western Europe, and North America are two continents that are very much involved in the scientific production on VGI, other regions of the world also participate in a relatively significant way. These include the Middle East, with Iran (n=30) and Israel and Turkey (n=12) in the lead, but also the rest of the Asian continent since Japan, India and Singapore are each represented in at least 1% of the papers, as is Brazil. These results broadly resemble the global mapping of scientific papers (Eckert *et al.*, 2014), although some notable under-representations or absences stand out, first and foremost India and more broadly Central Asia and a large proportion of African countries, but also in South America, where Brazil is involved in 80% of scientific activity on VGI in the subcontinent.

Figure 2. Map of the corpus authorship



- 13 The study of the country of affiliation of the first author of each paper allows us to identify two dynamics. On the one hand, among the most represented countries in the corpus, some are countries where researchers are very rarely positioned elsewhere than in the first place of a paper's authorship, which may correspond to a weak international collaborative dynamic. With scores ranging from 84% to 97%, China, Brazil and Iran correspond to those countries that play an important role in the global scientific production on VGI but with very limited international collaboration. Indeed, 61% of papers with at least one author working in a Chinese structure are written only by one or more authors from Chinese structures. This score reaches 66% for Brazil and 73% for Iran. On the other hand, apart from China, the countries with the highest levels of contributions are also driving forces in the participation and/or steering of international work on VGI. For example, authors from Germany, the United Kingdom and Canada are more involved in international collaborative papers than in papers written solely by authors working in their country.

Research Funding Bodies' Support for Work on VGI

- 14 Almost half of the papers have a completed "Fundings" section. However, this is a source of information of limited reliability insofar as, on the one hand, the rules and practices regarding its filling are heterogeneous and authors who have benefited from direct or indirect funding dedicated to research by/on VGI don't systematically fill this section and, on the other hand, the binary interpretation reducing its filling to the existence of funding and the absence of filling to the absence of funding would lead to excessive methodological bias. At most, a non-exhaustive reading of the filled sections allows us to state that VGI is indeed a subject that arouses the interest of various research funding bodies, although we are unable to quantify or qualify this phenomenon to any great extent. These bodies include regional, national, and

international public research programmes and academic institutions, as well as regional and local bodies at various levels and semi-public and private bodies, particularly those involved in environmental protection.

Thematic Analysis of Academic Literature

Keywords to Grasp the Themes

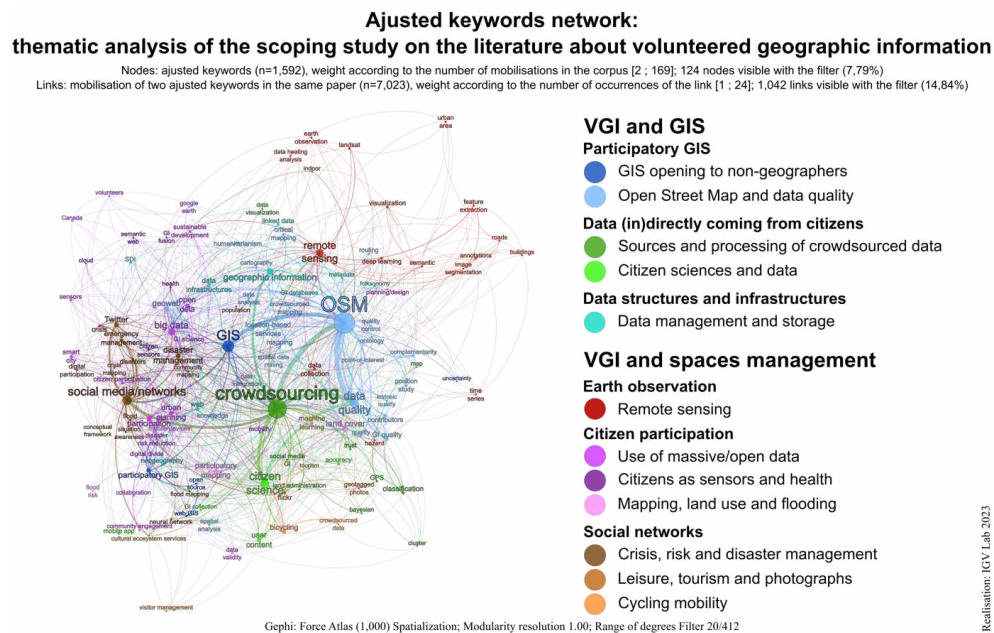
- 15 I have identified 2,326 keywords provided by the authors, which are singular in their alphanumeric composition, although sometimes identical in meaning. We therefore harmonised the different spellings and translations of the same keyword, for example "crowdsourcing", "crowd sourcing", "crowd-sourcing", "crowdthourcing", etc. Then, we gathered the singular but similar keywords under the same adjusted keyword. For example, "crowdsourcing" replaces keywords such as "crowd and community sourcing", "crowdsource", "passive crowdsourcing" and "crowdsourced". Lastly, we grouped together specific variations of the same keyword when they had very low recurrence rates. For example, "crowdsourced earth observation product", "crowdsourced platforms", "crowdsourced road view photo" and "crowdsourced air temperature" were simplified to the adjusted keyword "crowdsourcing", while we kept the ideas of crowdsourced data and mapping in separate adjusted keywords. In addition, as VGI were the focus of the bibliographic search, we excluded keywords using the term "VGI". The result is a list of 1,592 adjusted keywords.
- 16 In general, six adjusted keywords stand out. They each account for more than 1% of the total use of keywords in the corpus and are used in more than 5% of the texts: open street map (n=169); crowdsourcing (n=137); geographic information system (n=79); data quality (n=69); social media/networks (n=61); and citizen science (n=56). They give a first overview of the major thematic entries. VGI is treated in relation to the main tools with which it is closely linked, namely the collaborative mapping platform OpenStreetMap and digital social networks. Moreover, its specificity being its "voluntary" character, VGI is part of the crowdsourcing and citizen science fields. Moreover, it is a subject that raises important methodological issues, whether in terms of processing—hence the importance of GIS—or in terms of reflection on the data itself—hence the importance of the question of its quality.

Thematic Mapping of Literature

- 17 To analyse the themes of the corpus, we propose a "cartography" of the adjusted keywords carried out with the Gephi software. Each one constitutes a node of the network, represented by a circle whose size is proportional to the frequency of its use in the corpus. The fact that two adjusted keywords are used in the same paper constitutes a link between two nodes of the network. This link can be more important if the combined use of these two adjusted keywords is more frequent, which is illustrated by a greater width of the line connecting the circles. We first spatially reorganised the network using the Force Atlas spatialisation algorithm because it accentuates the complementarities between adjusted keywords solely on the basis of link strengths, and it is suitable for networks of fewer than 10,000 nodes (whereas the Yifan Hu algorithm is recommended for graphs of 100 to 100,000 nodes and seeks to simplify the graph in

addition to basing itself on link strengths)¹. We then partitioned the network into several communities using the “modularity” tool in the Gephi software, which applies the Louvain algorithm for partitioning. The method was used by varying the resolutions to identify the ideal resolution between obtaining a quantity of communities large enough to reflect the diversity of the papers in the corpus, but also small enough to summarise this diversity. With a resolution of 1, the partitioning proposes a breakdown of the network into 15 communities, but we exclude the isolated micro-networks from the analysis, which leads to the final classification of 1,592 adjusted keywords into 12 communities. To make it easier to read, we also applied a range of degrees filter: only adjusted keywords with twenty links or more are displayed (Figure 6). Of course, approaching the themes of a corpus of 1,001 papers from the authors’ keywords has its biases, particularly their synthetic and polysemous nature: keywords do not provide detailed access to the ideas of a paper, and the same keyword may have different meanings from one paper to another. We have therefore adopted this approach as an initial overview of the themes in the corpus albeit with its limitations.

Figure 3. Thematic analysis of the corpus using the keywords network



- 18 The “OSM and data quality” community is the largest due to the dominant weight of one of its adjusted keywords in the network, “OpenStreetMap” (OSM), and the space it covers within the network. This result highlights the centrality of the OSM participatory platform in scientific work on VGI today. In addition, the high weights of the adjusted keywords “data quality” and “geoweb” highlight the central place occupied by the question of the quality of the data making up VGI, particularly through this collaborative cartographic tool, in the research carried out on VGI. Moreover, this community is graphically spread out, showing a significant connection with the other adjusted keyword communities.
- 19 The “Sources and processing of crowdsourced data” community appears important due to the dominant weight of one of its adjusted keywords in the network, which is “crowdsourcing”. This trend highlights the fact that scientific work on VGI is part of

the broader theme of mass data produced directly or indirectly and voluntarily or involuntarily by citizens and which does not necessarily include geolocation information. The other important adjusted keywords in this community, which are complementary to the notion of a participatory approach, are the methods of participation (using GPS terminals, for example) and the methods of processing the data collected in this way. This is particularly representative of the methodological issues that run through the field of crowdsourced data following their production during scientific or institutional projects. This community is grouped together in only one part of the network, but it is strongly connected to the rest of the communities via the adjusted keyword “crowdsourcing”.

- 20 Mainly structured around the adjusted keyword “remote sensing”, the main theme of the “Remote sensing” community is that of the observation of the globe from a distance. This community is important according to the surface it occupies within the network. This trend highlights the epistemic link between the mobilisation of VGI in scientific work and remote sensing. The keywords present in this community point to research, especially relating to planning, infrastructure, and cities. This community is grouped together in one part of the network, but is nevertheless present, by only a few elements, across the entire surface of the network. This seems to reflect a weakened, and ad hoc only, interrelationship with the other communities. More precisely, there seems to be more of an area of research using remote sensing that mobilises VGI than an area of research using or on VGI that also mobilises remote sensing. In fact, this community appears to be very poorly connected to the other communities using VGI via work applied to crisis management, citizen participation or even leisure activities.
- 21 The “Use of massive/open data” community can be identified firstly by its presence across the board and in the background of the other communities, and secondly by the weight of four of its adjusted keywords in the network. These revolve around the concepts of massive data and open data on the one hand, and urban planning and participation on the other. In so doing, this community highlights a whole field of work involving VGI, which deals with issues of spatial planning in an urban environment using methods of citizen participation and via data massively produced by citizens. It covers a large area of the network and is close to other communities. Several of the adjusted keywords that make up this community (portable devices, in particular) are close to adjusted keywords that characterise other communities (participation), which indicates a strong interrelationship with the other communities.
- 22 The “GIS opening to non-geographers” community is overwhelmingly important due to the high weight of the adjusted keyword “GIS”. This result highlights the central aspect of GIS in scientific work on VGI today, which seems quite logical from a disciplinary point of view in geography. Combined with the notions of web and/or participatory GIS, and even “open source”, this community illustrates the close link between scientific work on VGI and the issue of opening GIS to data produced by citizens, and to its manipulation by citizens themselves. The positioning of this community within the network reflects this reality, since apart from “GIS” in a central position, its keywords are spatially close to other communities reflecting the fields of application of research using VGI, such as participative planning, risk management and leisure.
- 23 The “Data management and storage” community is not very large, in terms of intensity and therefore the number of adjusted keywords, but it is nevertheless made up of themes that are important from a methodological and disciplinary point of view in

geography. The main themes are represented by the adjusted keywords “geographic information”, “data infrastructures” and “metadata”. These categories are all fundamental to the development of objective geographic reasoning through VGI. In terms of the overall organisation of the network, this community is located in a similar way to that of OSM and therefore seems to indicate a thematic proximity, but also a complementarity with themes such as this collaborative mapping platform or other ways of exploiting data.

- 24 The “Crisis, risk and disaster management” community has a modest presence, mainly on keywords such as “social media/networks”, “Twitter” and “emergency”. This community therefore revolves around issues of disaster, emergency and crisis management, using data retrieved from social networking platforms, with Twitter in the lead. This organisation illustrates the structuring of a research community in which VGI are tools for managing crises, particularly natural disasters. According to the analysis of the location of keywords in the network and among its major communities, this one is singular in its location at the centre of the “Use of massive/open data” community. The orientation of the scientific mobilisation of VGI that it outlines therefore seems to constitute a specific subject closely connected to the field of work dealing with issues of spatial planning using massive citizen data or citizen participation, to the point of appearing to constitute a subfield.
- 25 The “Citizen sciences and data” community is grouped around adjusted keywords such as “citizen science” and “user content”, but also “accuracy”. Their co-presence in this community places it in the field of methodological issues linked to crowdsourced data, mainly represented by the “Sources and processing of crowdsourced data” community. The methodological issues identified here therefore seem to be the corollary of the thematic work based on crowdsourced data, and the proximity of the two communities is a good indication of the dynamics of fixing methodological issues, particularly through the application to different areas of geography.
- 26 Structured around three adjusted keywords located on the network, the “Cycling mobility” community appears to be extensive on the scale of the network. It mainly includes the keywords “bicycling” and “machine learning”. In so doing, this community reflects the existence of a field of research limited in size and mobilising the VGI generated during cycling movements, particularly from the Strava platform (adjusted keyword not displayed due to the filter), data then enhanced by large dataset management and machine learning systems. This thematic field corresponds to that of urban planning. Its position close to the area occupied by the “Sources and processing of crowdsourced data” community seems to indicate that it too constitutes a subfield, in this case collected during leisure or mobility activities and then used in another field. However, as with the previous community, its location within the network also reflects its interrelationship with the “Citizen sciences and data” community, which illustrates the need to address the methodological issues associated with citizen data at the same time.
- 27 Structured around four adjusted keywords displayed on the network, the “Mapping, land use and flooding” community is mainly organised around the keywords “land cover” and “participatory mapping”. This community reflects the existence of a field of research in which VGI are used for participatory mapping and to identify land cover and prevent natural hazards (floods, landslides, etc.). Its position within the network logically makes it a community connected to several other communities, mainly those

dealing with the methodological challenges of crowdsourced data and the participatory aspect of work using GIS from a planning perspective.

- 28 Structured around just a few keywords, the “Leisure, tourism and photographs” community appears minor. However, its logic is very distinct, since this community reflects the existence of a field of research, admittedly marginal in terms of the number of occurrences of the keywords, dealing with a specific category of VGI, namely geolocated photos. In so doing, the grouping of these keywords indicates a concern for data produced in a leisure context, but also their integration into studies on the visits of tourist areas. However, the modest size of this community illustrates the minor place it currently occupies within the scientific research associated with VGI. Its location within the network shows its connection with other communities, especially those dealing with the methodological challenges of crowdsourced and citizen data, as well as those on spatial planning and cycling mobility.
- 29 The “Citizens as sensors and health” community appears to be minor and difficult to define in terms of thematic coherence. However, with its keywords “citizen sensors” and “health”, it seems to reflect the existence of a marginal field of research dealing with VGI and focusing on health and the mobilisation of citizens as public health sensors. Its position within the network and close to the “Use of massive/open data” community seems to indicate that it is a sub-field of the field of spatial planning using participatory data. Its position within the network also reflects an interrelationship with the communities dealing with data management and storage and dealing with crisis management using social network data.

Conclusion

- 30 Research on VGI, although recent, is now well established in the international scientific landscape. The progress made, both thematically and methodologically, means that we now have a knowledge base that favours the setting up of larger-scale scientific projects. In addition, the geographically rooted identity of work on VGI and its participatory and involving work in information technology dimensions underpin the centrality of multidisciplinary research on this subject today. While geographers are the key researchers on this subject, particularly those in GIS, specialists in citizen sciences and computer sciences also play a particularly important role. Among these contributors to research on VGI, we note that France is currently lagging, particularly regarding the investment of researchers in neighbouring countries. The dominance of the English language in the corpus studied, however, suggests that this point should be put into perspective, as this shortcoming may only be apparent insofar as several French-language journals host papers dealing with VGI. Finally, we note from the analysis of the keywords that four major themes dominate the mobilisation of VGI in the framework of scientific research, namely OpenStreetMap, the use of crowdsourced data, citizen participation, and the study of the globe. Faced with these themes, those of leisure activities and/or the visits of natural areas appear to be largely in the minority, including within the issue of spatial planning and management. Thus, at the end of our bibliometric analysis, we have selected only 45 of the 1,001 papers in the corpus as being directly concerned with the issue of the visits of natural areas. This selection is the result of the following process: extraction of the 144 adjusted keywords related to the “Leisure, tourism and photographs” and “Cycling mobility” communities;

identification of the 43 keywords in this list corresponding to the theme of observing the visits of natural areas; extraction of the 82 papers in the corpus containing at least one of these keywords; and reading of the titles and abstracts to identify the 45 papers. We must put into perspective these results because of the biases associated with the fact that we gathered the data from the WoS. This main limitation leads us to consider carrying out the same study on the corpus of over 2,0000 papers listed in Scopus on the same subject, and to cross-check the results with those presented in this paper.

- 31 Finally, while the work on VGI is now collectively a well-established field, there is still work to be done on observing the visits of natural areas in depth. Several initiatives undertaken by institutions responsible for sport show that VGI, in this case in the form of geo-digital footprints, are becoming legitimate tools for public action. In France, for example, there is the Outdoorvision system run by the Ministry of Sport and the Olympic and Paralympic Games, and in several Central European countries, the OutdoorActive application plays an important role in the promotion and management of sports tourism. In this context, although their heuristic scope has yet to be precisely defined, they have their place in observing the use of areas that are difficult to map in the traditional way (Norman & Pickering, 2017, 2019; Norman et al., 2019) following the continual evolution of itineraries or the high spatial distribution of users. This is a sub-field of the work being done on VGI, as illustrated by the exploratory and often concomitant work being done in France (publication of a special issue of the *Revue de Géographie Alpine*, organisation of seminars) and in Europe (dedicated session at the Monitoring and Management of Visitors—MMV—conferences).

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NOTES

1. <https://github.com/gephi/gephi/wiki/Spatialisations-%28FR%29>

ABSTRACTS

A growing and massive digitalisation of society marks the visits of natural areas. This leads to the production and sharing of digital footprints which, as soon as they contain data allowing them to be spatialised, become Volunteered Geographic Information (VGI). By making it possible to understand phenomena that are difficult to observe, their use opens new research perspectives, even more for mountain areas marked by the need to understand these visits and by the lack of efficiency of other systems. Documenting the phenomenon of VGI within scientific production can therefore help to lay the foundations for future research. Our aim is to provide a comprehensive understanding of the academic literature on VGI. We conduct a bibliometric analysis based on a scoping study of the 1,001 papers listed on the Web of Science dealing with VGI. Firstly, we identify the evolution of their production since 2009 and their particularly important attachment to geography and formal sciences. Secondly, we highlight trends in their production context, including the influence of Geographic Information Sciences in the authorship and dissemination spaces of the work, and the dominance of a few countries in the production of this literature. Thirdly, we identify themes that are prevalent in the corpus through an analysis of keywords, and the lacunar nature of the issue of recreational use of natural areas. Thus, our paper highlights the maturity of the field of studies of VGI, but also the opportunity that is emerging in terms of mobilising this tool in scientific work dealing with the visits and management of natural areas.

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Keywords: volunteered geographic information, visits of natural areas, scoping study, bibliometric analysis

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