



# A North–South Problem in Civic-Tech and Volunteered Geographic Information as Countermeasures of COVID-19: A Brief Overview

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## Abstract

The aim of this paper is to archive the situation we are witnessing regarding the application of geographic information by civic tech and volunteers, who spontaneously organised themselves to fight this newly emerging disease. Moreover, the regional bias and clarify the existence of a kind of North–South problem in the characteristics of the mapping process is aimed to be pointed out. Specific keywords were searched after which research was performed using citations and keywords in the papers. In repositories such as GitHub, the search was performed using the country name to ensure that there were no omissions. In response to CoV19, which suddenly engulfed the world, simultaneous anti-CoV19 dashboards created by citizens with computer skills were published within a month or two of the outbreak's beginning. North–South problem of our world extends to the availability and accessibility of information. Information and economic disparities also tend to cast a shadow on the response phase of society.

**Keywords** COVID-19 · Participatory GIS · Volunteered geographic information

## Introduction

The year 2020 will be considered the year when the world fought the first global pandemic to occur in over 100 years [22]. This highly infectious disease, COVID-19 (hereafter CoV19), has shown how vulnerable human society is to novel viral threats. As of September 2021, it has been about a year and a half since the world was blindsided by CoV19 [41]. The previous global pandemic was the spread of the Spanish flu from 1918 to 1919, and scholars have reported that there were three waves of infection. With regard to CoV19, we have so far experienced five waves [63]. This persuades us to reflect on our initial outlook on the pandemic and acknowledge that it was extremely optimistic.

As certain classic works suggest the spread of an infectious disease has an unquestionable relationship with the

changes and developments in transportation modes, in which humans act as vectors for virus transmission [49].

In the case of CoV19, the peak of infection within China was in early February 2020. China is believed to be where the virus originated. It is also believed that this peak is related to people moving around the country and abroad during the Chinese New Year holidays that begin on 24 January [77].

Similar to the Spanish flu, which infected one-third of the world's population, this new microscopic threat continues to pose many difficulties and challenges to humanity. However, during this pandemic, we had better modern countermeasures than people living during the Spanish flu. These countermeasures included a wide variety of things. For instance, the ability to use a digital map as a means of visualising the invisible threats has proven to be invaluable. Having an infrastructure wherein it is possible to share results regarding infections, deaths, and recoveries internationally has been central to reacting to this pandemic. Moreover, access to software and applications based on the open-source initiative, were all invaluable. Finally, the participatory act of mapping through the skills and labour of members of society has been integral to understanding the spread of the virus. As Bertolotto et al. noted:

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[W]e are experiencing [...] the importance of free open-source initiatives and platforms such as OSM that can bring together truly global and interdisciplinary efforts and expertise becomes increasingly relevant. It is in the context of supporting efforts for sustainability (including sustainable agriculture to combat poverty and emergency response) and the prevention of disease spreading (including contact tracing) that we see the biggest potential of volunteered geographic information initiatives [6].

Despite the disruption caused by the global spread of CoV19, countries have worked hard to share data on the number of deaths, serious illnesses, and infected people. Scientists have used these data to carry out a range of analyses. Due to this, in the first 2 years, we have learned a great deal about this new threat. This has allowed us to respond in a variety of ways, from social distancing to the widespread use of masks to vaccination. By wearing paper masks for vaccination, we were able to respond in a significant way. Fundamental to an effective response is the cycle of literacy. In order to obtain an effective response, we must be able to correctly analyse accurate data, share the results, and then take appropriate actions based on scientific knowledge. Much professional and scientific knowledge regarding CoV19 has been published. However, the knowledge regarding the participation of and dissemination of information to the citizens who are responsible for the bottom of this cycle has been strangely neglected.

One of the main concerns about the quality of citizen volunteer-contributed geographic data is that the underlying observation sites are inherently biased. Zhang [76] performed point pattern analysis on tens of millions of iNaturalist observations with a parallel kernel density estimation (KDE) computational tool that can run on multiple graphics processing units (GPUs) and across spatial scales. An attempt was made to visualise the geographical bias of VGI by detecting and visualising observation hotspots of volunteers. The results revealed that Western Europe and the eastern, western, and southern US are the two largest iNaturalist observation hotspots in the world; Zhang said that these results ‘could offer new evidence to consolidate findings regarding COVID-19 effects on citizen science projects and therefore contribute to forming guidelines on how to account for data anomalies caused by the pandemic’.

Zhang’s study is notable as one of the earliest and most advanced studies worldwide focussing on the location from where geographic information against CoV19 is voluntary provided. However, it is extremely difficult to automatically collect a wide variety of CoV19 control sites by citizens scattered across the world. Indeed, even in Zhang’s study, geolocations of voluntarily provided geoinformation against CoV19 was superseded by data provided by the iNaturalist

website, the world’s largest citizen science project, which includes location information of natural beings observed by citizen volunteers interested in nature observation. Therefore, this study focuses on the geographical visualisation of the state of CoV19 as an online movement that spreads spontaneously on a global scale immediately after the spread of the infection, daring to be based on manual-based methodologies. It makes sense to organise and archive results as broadly as possible, using the filter of civic participation, to examine how the world confronted CoV19 during the first 2 years of this pandemic. Through this study, I aim to examine the issues that have emerged from the participatory movement over these first 2 years.

Before proceeding to the main section, it is worth mentioning the structural organisation of this paper. First, in “[Social Participation of Citizens](#)”, the rise of citizen science as the technical or ideological basis for VGI, which is the subject of this thesis, is described. Following this assessment, the author gives an overview of the impact of the citizen science approach on participatory Geographic Information Science (Participatory GIS) in particular. In “[Archiving the First 2 Years of VGI Against Covid-19](#)”, based on a three-tier framework for VGI derived from previous research, the state of participatory GIS infrastructure development recommended before CoV19 is reviewed by region, and model cases of VGI in each region created using that infrastructure after CoV19 occurred are described. Following this, in “[Agendas of VGI Activities Visualised](#)” and “[Discussion and Conclusion](#)”, the issue of the regional maldistribution of voluntarily contributed geographic information related to CoV19 that was created in the first 2 years will be raised.

## Social Participation of Citizens

### Origins of Volunteered Geographic Information

While the twentieth century is often summed up as a century of world wars, depressions, and environmental problems, Arnold Toynbee, an English historian, well known for his *A Study of History*, once offered the following:

The twentieth century will be chiefly remembered by future generations not as an era of political conflicts or technical inventions, but as an age in which human society dared to think of the welfare of the whole human race as a practical objective [46].

Today, Toynbee’s hopeful predictions are coming to fruition as political and social decision-making processes are open to more people than ever before. Decisions have begun to change from existing solely in the hands of a select few

officials and specialists to resting in the hands of the participating citizens.

Public citizen participation or engagement is not a new phenomenon. The initial sparks of public engagement can be found in the field of community planning, such as in planned planning, project-based advocacy, and transactive planning [4, 13, 15]. Although there are many opinions as to what the immediate context for the participatory approach might be, one of the key triggers was an international conference held by the UN in 1990 regarding sustainable development in Africa. From 12 to 16 February 1990, the United Nations Economic Commission for Africa (UNECA) held the International Conference on Popular Participation in the Recovery and Development Process in Africa in Arusha, the United Republic of Tanzania [68]. It was developed as a:

collaborative effort between African people's organizations, the African governments, non-governmental organizations and the United Nations agencies, in the search for a collective understanding of the role of popular participation in the development and transformation of the region [68].

Therefore, this was 'affirming the need to acknowledge the efforts and sacrifices of grassroots and people's organizations to make popular participation a reality' [68]. Then, in 1990, the International Association of Public Participation Practitioners was founded 'to promote the values and best practices associated with involving the public in government and industry decisions which affect their lives' [27].

Shortly thereafter, the participatory approach to citizenship expanded into a variety of fields. In the field of scientific research, for instance, citizen science emerged in the 1990s as a scientific concept that opens pathways and promotes understanding of science to citizens. Irwin regarded citizen science as 'a developing concept of scientific citizenship which foregrounds the necessity of opening up science and science policy processes to the public' [28]. This approach is inherently a science for the people. Wiggins and Crowston described it as a 'form of research collaboration involving members of the public in scientific research projects to address real world problems' [73]. No matter how participant driven a project may be, the overall project design is, still developed by a scientist. This is because 'citizen science projects have become a popular method for scientists to use to collect both data for their research, and communicate aspects of science to the general public', meaning that scientists are still the ones utilising the data during and after a citizen-driven project [30].

An arena of citizen science where the participatory approach has had a particular impact is geographic information science. Geographic information science is particularly relevant to this paper, as it is a working and active example. As Brabham points out:

Interdisciplinary and participatory design collaborations seem to be the best option for problem solving in a democratic society of the digital, post[-]industrial age [8].

Using Brabham's understanding, it appears that the growth of the citizen participation paradigm can be attributed to the advent of the post-industrial age. This is because it was the time when values that favoured the expansion and reproduction of powerful politicians and large corporations came to an impasse. Moreover, it can be attributed to the innovation of information and communication technologies that made citizen participation technologically feasible. Associated labels include 'e-participation' [35] and 'e-democracy' [60] emerged during this time too. Its emergence is largely owed to the implementation of digital platforms which 'offer participatory mechanisms to involve citizens in different situations and higher or lower levels of control' and 'offers self-governance and gives control to the citizens' [1]. Notably, the global transformation that has been accelerated through the use of information and communication technologies (ICT) is sometimes referred to as 'the fourth industrial revolution' [2].

The rapid technical progress of Geographic Information Technologies (GeoIT) in the 1990s made geographers aware of the magnitude of the social impacts of GISystems. Such technological advances in GIS triggered a series of debates in the 1990s on its scientific ambiguity and social implications. This, in turn, led to the establishment of a new discipline, GIScience [57, 75]. The democratisation of mapping prompted scholars to utilise GIS as a tool for social participation, public involvement, and empowerment. This trend has also been referred to as public participation GIS (PPGIS) or participatory GIS.

In an earlier ground-breaking study, Peluso [47] used collaborative sketch mapping to compare indigenous and contested occupancy rights in forest territories customarily claimed or managed by indigenous people. He used official forest mapping by government forestry planners to do so [47]. This bottom-up and collaborative-style mapping, termed counter-mapping, has contributed to the establishment of GIS as a tool for empowerment in geospatial planning and decision-making. Therefore, P(P)GIS originally conveyed nuances of community development and landscape ecology and the aspiration to empower the disadvantaged and marginalised through GIS technology [11, 51]. Despite the breadth of relevant areas, most P(P)GIS projects 'have evoked interest from researchers and practitioners' [58].

As Gilman noted, 'digital tools can help support the opportunities to reduce barriers to entry, bring new information into the public sphere' [17]. Relatedly, the bi-directionalisation of web communication (Web 2.0) advanced rapidly in the 2000s against the background of faster web

communication and higher performing computing devices. Michael Goodchild of the University of California (UCSB) coined the phrase, ‘volunteered geographic information (VGI)’ in relation to the arrival of an era in which geographic information can be mapped in both directions from anywhere in the world by anybody, provided they have certain skills and the infrastructure available to them [18]. Such movements are also described as bottom-up GIS and neogeography [62, 65].

In summary, the background to these attempts to visualise diseases through citizen participation shows the emergence of values that encourage citizens to participate in society. Moreover, we are witnessing the acceptance of citizen science, which includes citizens in the process of creating science. In geographic information science the spread of GIS has made the act of mapping on computers much more open to citizens. Similarly, the dramatic improvement in the infrastructure of the Internet’s environment has made it technologically possible to share results. This is the ideological and technical background that gives rise to VGI, bottom-up GIS, and neogeography, which are the subjects of this paper.

### VGI as a Tactic of Citizen Science in Relation to CoV19

Almost 2 years after the first outbreak, there have been a considerable number of geographical studies dealing with CoV19 from a civic science perspective.

Gorayeb et al. collected VGI directly from residents through a 12-question survey that allowed for 1 free response regarding the reasons for non-compliance or partial compliance with social distancing recommendations made by Brazil’s Ministry of Health on 12 March 2020 [20]. Liegghio and Caragata expanded their original research scope from in-person interviews to include a photovoice that could be executed online, and used these remote methods to investigate how youth and families were impacted by the pandemic [36]. They found that photovoice contributed to strengthening their personal and collective resilience [36]. Similarly, Noordegraaf et al. pointed out the emergence of a perceived inside/outside duality among the people in the cities in lockdown through qualitative analyses of two such citizen-generated collections of experiences with the CoV19 pandemic [44]. This culminated in ‘*Corona in the City*’, assembled by the Amsterdam Museum for an online exhibition. It also led to ‘*Dagboek Corona*’ (Corona Diary), assembled by a Dutch public historian and a journalist. The Corona Diary arose with the inside world, representing safety while being lonely and limited, whereas the outside world represented the danger of contagion as well as temptation. Bacon and Xu introduced a web-based participatory and immersive digital archiving initiative called ‘The CoV19 Memory Archival Project’. This project seeks to preserve individual

experiences, shared experiences, and reflections during the CoV19 outbreak using the ArcGIS StoryMaps platform in undergraduate classrooms [5].

As these examples demonstrate, the studies utilising participatory approaches in GIScience during the pandemic mostly deal with the new tensions arising between researchers and participants. These tensions were brought about by the pandemic, and researchers attempted to overcome the limitations of social distancing by using IT. As Hall et al. adequately summarised:

[D]igital approaches such as text-based focus groups, digital ethnography, and digital creative methods may provide a valuable means of capturing participants’ experiences from afar while mitigating some of the adverse effects of the pandemic [24].

Of Course, it must be recognised that when science involving the public is explored, in the name of curbing unknown threats, there is always the possibility that the contribution of the public may lead to new exploitation as material to enhance the achievements of researchers. But we must not overlook that it is precisely this idea of citizen science that is the ideological and methodological basis for the early rise of citizens against CoV19.

### Archiving the First 2 Years of VGI Against Covid-19

#### Classification of VGI Actors

The social movement of geovisualisation is a mixture of data generated using two aspects: bottom-up geographic information and top-down geographic information. Bottom-up geographic information involves grassroots and spontaneous representations. Meanwhile, top-down geographic information involves geovisualisation as part of one’s social responsibility and technological demonstration by governments and commercial companies with international influence. The generation of primary data, which serve as the basis for all of these is largely limited to public institutions such as governments, and international organisations such as the WHO that can centrally aggregate and have jurisdiction over sensitive information. This includes information regarding the infected, seriously ill, deceased, and their social attributes. Therefore, when analysing a series of organised voluntary mapping behaviour, it is important to categorise these actors. Although the phenomenon of e-participation due to CoV19 is new, previous studies have shown some attempts to classify the actors that work against CoV19. A representative example of this is given by Graziano, who proposed classifying actors into the following four types: (1) institutional, such as national and local government representatives; (2)



academicians and professionals; (3) corporations and high-tech companies; and (4) volunteers and citizens’ committees [21].

This study adopts these classifications. However, based on the role that they play in the process of collective action, the following analysis is based on three categories that do not explicitly distinguish high-tech companies and corporations from researchers: (1) governments, which can generate at least primary data and are responsible for disclosing relevant data, including representations, under their social responsibility as public servants; (2) professionals, including experts such as academics who use the data to analyse predictive models to control the spread of the disease, and companies who try to fulfil their corporate social responsibility (CSR) by demonstrating effective visualisation tools and algorithms and designing products; and (3) civic engineers, including individuals and civic groups who voluntarily try to contribute to society to the extent they can do so on an individual level (Fig. 1).

An academic researcher is a professional who participates in this activity based on the behavioural principle of noblesse oblige and receives the reward of research achievement, and the engineers and analysts in the high-tech company also participates in the company’s business. This is based on the principle of CSR, as technical promotion through technical demonstration dictates that technicians in high-tech companies can also participate in company projects, based on CSR principles. They may also promote technology through technical demonstrations, which can be viewed as analogous activities.

As noted earlier, there are significant difficulties when using systematic methods to investigate ad hoc and spontaneous online behaviours that occurred around the world during the pandemic. In this study, illustrative and descriptive approaches are used. As will be discussed below, basic statistical data on CoV19 (e.g. primary statistics on weekly changes in the number of infected people, the number of seriously ill people, and the number of deaths) are openly

available from almost all governments, albeit in inconsistent formats. As this study is concerned with the processing and visualisation of geospatial information by the public, as noticed during the CoV19 pandemic, government data were omitted from the subsequent investigation. Snowball sampling was used to examine searchable materials such as reports, theses, and news articles as comprehensively as possible. Multiple search keywords were used in the form of COVID-19 plus country names, VGI, Participatory, and Civic-tech. After browsing the search results, research was performed using citations and keywords in the papers. In addition, for repositories such as GitHub, where the content can be searched, the search was performed using the country name to ensure that there were limited omissions.

### Development of Infrastructure: Code for, Open Knowledge and Platforms

The infrastructure needed to achieve the successful participatory CoV19 mapping includes open government platform. The participatory CoV19 mapping can work by extracting data from centralised public data holdings and be driven to contribute technology to the voluntary sector. In addition, there must be a repository for the data produced and shared through these movements.

In the UK, an important cornerstone was founded on 20 May 2004 by the creation of the Open Knowledge Foundation. The representative founder is Rufus Pollock, an activist and social entrepreneur. The Open Knowledge Foundation is a non-profit network that promotes and shares information free of charge. Of the 19 working groups, OS Geo (The Open Source Geospatial Foundation) is particularly relevant to VGI developing QGIS and annually holds international conferences called the FOSS (Free/Open Source Software) 4G.

Under these circumstances, the OpenStreetMap project was also founded by Steve Coast at the University College London (UCL) in July 2004 [23]. Using the concept of crowdsourcing, this user-generated online digital map data covers the entire earth surface to enable free access to current geographical information.

Knowing computer programming is welcomed when participating in VGI. Social participation through mapping can be achieved by people with the skills necessary to design a platform who are also willing to play a central role in the VGI project. In other words, VGI is supported by the general public (including engineers and programmers), who write programmes and codes to design the site. It is also supported by end-users, who modify and correct the wording on electronic maps and websites. This successful combination enables people to participate in solving social issues. One of the key movements was the Code for Project (CfP), which was founded in the United States in 2004 as a Code for America.

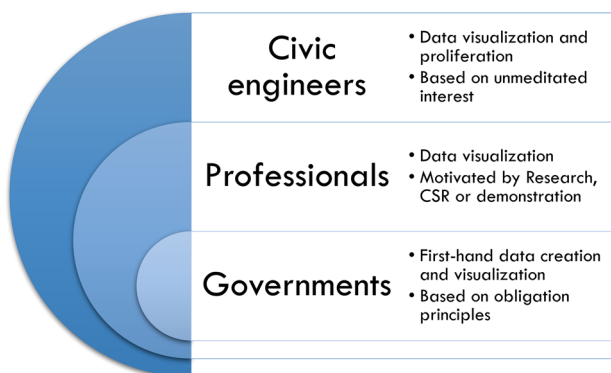


Fig. 1 Types of VGI actors

The leader of the Code for America is Jennifer Pahlka, the partner of Tim O'Reilly, who is a main advocator of Web 2.0.

The largest Git repository hosting service, GitHub, was launched on 10 April 2008 built by Chris Wanstrath, Tom Preston-Werner, and P. J. Hyett [12, 74]. GitHub opens the source code of the user's programme so that volunteers can request, point out, and respond to bugs in real time. As a result, the error revision statuses of the sections and the content of the conversation during the revisions are also visible. Although GitHub played a prominent role, several other data repositories such as carto.com (established in 2012 in Madrid, Spain) and tableau.com (founded in 2003, Seattle, USA) also provide open platforms for such mapping web tools.

The US, which was a leading GIS country with the global giant ESRI (Environmental Systems Research Institute, Inc.), was one of the first countries to release several useful dashboard applications based on participatory GIS methods. This occurred at the very early stage of the pandemic. The US predominantly used ArcGIS online, a cloud-based software that allows users to create and share interactive web maps. Many of the maps were created by professionals with expertise in GISCorps, a sub-organisation of the URISA (Urban and Regional Information Systems Association) [33].

For example, Jeremiah Lindemann, of URISA, has several applications. One of them, an application named *Coronavirus Lost Loved Ones* went live on 28 March 2020. It was created to share the memory of the lives lost due to the pandemic. Another application, *Coronavirus Stories of Recovery*, released on 1 April 2020, enables people to share how many people affected have recovered from CoV19. In addition, on 7 January 2021, a programme called *I Got Vaccinated* was released to share people's vaccination stories. Likewise, Holly Torpey, also of URISA, published *A COVID-19 vaccination provider* on 13 March 2021. This programme helps people find the nearest CoV19 vaccine providers using the GISCorps CoV19 vaccination site data. Then *COVID-19 testing and vaccination centre locations* also opened to encourage citizens to suggest a CoV19 testing or vaccination location that is not already on the map.

In the US, where the world leading GIS company is located, there is an efficient and orderly system constructed by non-profit organisations and global enterprises to release relevant applications using ArcGISOnline as a platform. This shows that there are other examples of activities in which technicians and voluntary individual engineers belonging to companies can make use of the platforms released free of charge. These platforms are released by companies involved in the visualisation and analysis of geospatial information, to carry out various analyses of CoV19 and create and release applications and tools. For instance, Álvarez and Rushton presented vaccine distribution optimisation using a data

clustering algorithm to maximise the effectiveness of vaccine distribution logistics through their company's web spatial intelligence platform, *CARTOfames* [3].

Just as described above, the significance of the fact that the ideological and technical infrastructure necessary for the democratisation of mapping on the web was in place before the spread of CoV19 should be noted.

## Visualising Infectious Diseases with VGI

### Contributions from the US and European Countries

The most famous visualisation site globally as of September 2021 is the website 'Covid-19 Dashboard (DB)' created by The Center for Systems Science and Engineering, Johns Hopkins (JH) University.

A DB is a set of visualisation tools on the web that look like an administration screen. It allows users to adjust values and output results by clicking or pressing buttons relating to data, figures, and charts. A DB does not analyse anything from a professional perspective. It is a public instrument that can be used to effectively visualise and understand the current situation as accurately as possible.

Facebook and Google also partnered with Carnegie Mellon University and the University of Maryland to call people to participate in a survey about symptoms and risk factors for CoV19 infections. This allowed them to use the data from that survey to upgrade their *Symptoms Map and Dashboard*, which was initially developed for seasonal flu forecast surveys since 2012 [19]. Google also launched *community mobility reports* in multilingualised platforms aiming:

to provide insights into what has changed in response to policies aimed at combating COVID-19. The reports chart movement trends over time by geography, across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential [19].

*Influzanet Analytics* is a Europe-wide network DB that monitors the activity of influenza-like-illness (ILI), including CoV19, with the aid of volunteers via the Internet. Originally, it was launched in the Netherlands in the 2003–2004 influenza season to validate the representativeness of the GIS population and compare the GIS data with the official ILI data obtained by Dutch GPs participating in the Dutch Sentinel Practice Network [38]. It consists of nine countries: Portugal, Italy, the UK, Sweden, France, Spain, Ireland, Switzerland, Denmark, Belgium, and the Netherlands.

Some smaller American companies and even individual civic engineers also launched dashboard applications such as the *COVID-19 Support App* by Ilys, a Texas based company. *Worldometer* was created in 2004 by Andrey Alimetov, a 20-year-old immigrant from Russia as an individual business

for web-hosting fees [39]. It also accesses and visualises governmental data by reported cases and deaths by country or territory pages.

Subsequently, Navid Mamoon and Gabriel Rasskin, two students at Carnegie Mellon University, published a virtual globe named *Coronavizualizer*. It is a simple and interactive visualisation of the Worldometer's real-time updates, with the website pulling new data every 2 min.

While these US visualizers are primarily depicted on a global or national level, there are tools that focus on the state level for more local use. The *OK COVID Vaccine Scheduler Assistant* is a Google Chrome extension using GitHub as its repository. It works as a location map and was uploaded on 25 February 2021 by a local programmer who lives in Oklahoma.

Aside from the US, contributions from the UK have been among the most remarkable. For example, in England citizens participated in the monitoring webtool *Flusurvey*, which serves as the UK's data contributor to *Influenzanet*. It is a web-based application, originally set up during the swine flu pandemic in 2009 by researchers at the London School of Hygiene and Tropical Medicine. It was intended to monitor the disease trends of influenza-like illness (ILI) activity, which includes CoV19. *Flusurvey* has now become a part of the *Influenzanet* international network. Any of 8000 members from the UK public can register on the platform to report any symptoms they may experience. Based on the concept of citizen science, the *ZOE COVID Symptom Study Application*, developed by a professor at King's College London named Tim Spector, calculates the participants' daily records with software algorithms to predict who has the virus and thus track CoV19 infections across the UK and other countries. Some of the most recent epidemiological studies within the European Union have been published using data from this application as their evidential basis [40, 43, 61].

There are many examples mainly focussed on the status quo in Great Britain. *Rapid COVID-19 virology—Public* created by Public Health Wales NHS Trust, is a good example of a professionally created dashboard that effectively visualises official statistics data in Wales using tableau.com as its data repository.

The Scottish Collaboration for Public Health Research and Policy (SCPHRP) and the University of Edinburgh also developed SPOTTERON and the OSM-based web mapping platform *CoronaReport*. This was administrated in a citizen science manner, so that mainly English-speaking citizens are likely to submit it, as you can see the ongoing product as of 16 September 2021.

There has been a movement towards using GitHub as a free data repository to visualise the spread of infection on an individual basis. On 10 March 2020 Emma Doughty, who claimed a post-doctoral researcher at the University of

Birmingham, released a tool called '*Daily\_COVID-19*' that uses official UK CoV19 data to perform daily collation and visualisation.

In these two headquarter countries and regions, same sort of participatory CoV19 countermeasure mapping projects came out from other western European countries.

Vogel et al. reported that in Germany, online neighbourhood social networks (ONSNs) named *MyNeighbors* became a platform for strengthening the social resilience of local residential ties [72].

On 12 March 2020, *Covid19italia.help* was launched in Italy. This is a collection of selected useful information to the location information of a variety of available services with the location map via Google map API [79]. German-based NPO, Freunde LiberiaseV, developed a free smart-phone application for epidemic containment *EBOLAPP*. Although it was originally made for the Ebola epidemic in West Africa in 2014/2015, the application was upgraded in March 2020 to be compatible with CoV19 [25]. Similarly, immediately after the first global wave of pandemic, there are also many Bluetooth-based virus exposure notification applications published in the recent past, such as *Ranking C-19* in Iceland (since 1 April), *Virus Radar* in Hungary (13 May), *Immuni* in Italy (1 June), *Swisscovid* in Switzerland (8 June), *Radar COVID* in Spain (6 July), *COVID Tracker* in Ireland (7 July), *Smittestop* in Norway and Denmark (17 June), *TousAntiCovid* in France (10 October), and so on [66]. There are also several similar self-health checkers or tracker applications for non-English speakers, such as *Cuidarnos* (Argentina) and *Andrija* (Croatia). In addition to *COCOA*, the Japanese contact verification application released on 19 June 2020 is based on *COVID-19 Radar*. It is a volunteer-led open-source project created by Kazumi Hirose, a Microsoft Japan employee.

### Other Advanced Activities in Japan and Taiwan

As an example of the activities of citizen hackers against CoV19 outside of the Western world, we would like to compare the cases of Japan and Taiwan.

Based on the bitter lessons learned from the Great Hanshin–Awaji Earthquake in 1995, Japan has promoted the digitisation of land information [54, 55]. Today, various statistical data and numerical maps, such as prefectural boundaries, railways, roads, rivers, and elevations, can all be accessed free of charge on the websites like the National Geographic Institute and the Statistics Bureau of the Ministry of Internal Affairs and Communications. This makes them easy to access on personal computers and mobile devices [53].

In 2011, 16 years after the Great Hanshin–Awaji Earthquake, crisis mapping was conducted during the first restoration stage immediately following the Great East Japan Earthquake. When it was not possible to determine what

was happening in the immediate aftermath of the disaster, the only clues were obtained from the photos taken by satellites and aerial photographs taken by aircraft, both in real time. It was thus essential to read and digitise these to understand the information relating to roads in coastal areas and associate it with digital maps on the web, and then enable its sharing so that Self-Defence Forces and rescue teams could access entrance routes as quickly as possible. This platform was then built and used during the Great East Japan Earthquake [54, 55]. Following the bitter lessons learned from the Great Hanshin–Awaji Earthquake, these were the measures put into practice.

CfP was also introduced in Japan. The code for Japan was established in 2013 based on achievements made through the Japanese version of the crisis mapping method mentioned earlier. The founder of the Code for Japan was Hiroyuki Seki. At this time, the Japanese version of crisis mapping was developed on a website, *sinsai.info*, using GeoAPI to operate the OSM. It is no coincidence that it was Seki who also built *sinsai.info*. All these were created by the general public in a collaborative spirit, and not by government officials or researchers. Although participatory GIS has been rapidly accepted since the beginning of the twenty-first century, it was the first instance in Japan where social participation from citizens allowed for mapping, namely participatory GIS, that achieved concrete and remarkable results for the first time and resulted in the democratisation of mapping [54]. In summary, an open data trend was developed in Japan after the Great Hanshin–Awaji Earthquake, and the trend of civic-tech citizens actively participating in society through programs and data editing was established prior to the emergence of the current social peril, CoV19.

In Japan, four Chinese people who visited Japan from 16 to 26 January developed the disease sequentially. The first Japanese person was infected on 28 January 2020 [56]. This occurred just prior to the docking of the Diamond Princess (a luxury cruise ship suspected of carrying many positive patients) in Yokohama Port on 3 February [16]. To establish a better understanding of the Japanese situation in the context of this paper, please recall that at this time Japan believed that the CoV19 outbreak would not have direct repercussions for Japan. Understanding this belief allows us to understand the context of Japanese VGI activities.

The earliest example of a visualisation website was launched by a Japanese newspaper company, Nihon Keizai Shimbun Co., Ltd. on 7 February, who aimed to visualise the CoV19 spread using graphic charts. Subsequently, Takuma Ohamazaki, a representative of an election consulting firm, launched the DB entitled ‘Map of the Number of Infected People’ on 16 February. In this respect, the company aimed to visualise the disease by adding its own expressions, such as a kernel density map. They planned to do so with

technical support from the ArcGIS dashboard while referring to the DB design of Johns Hopkins University.

On 27 February, another newspaper company, Toyo Keizai Shimbun, published a DB that visualises the progress of domestic infection. There are two notable points relating to this DB: the author (Kazuki Ogihara) worked for the company’s editorial department and had individually planned and created the DB. He used an online data vault, GitHub, to build the visualisation site. This DB subsequently received a good design award in October 2020.

This trend became firmly established when the Tokyo metropolitan government, under the technical support of the Code for Japan, released the official ‘New Coronavirus Countermeasure Site’ on GitHub on 4 March and took further measures to enable perfecting it using collective knowledge by applying an open-source code under a common licence that permits its reproduction and distribution for non-commercial purposes. It was also selected for the Good Design Best 100 award in 2020. Hokkaido, which was suffering from the spread of infection, employed a Hokkaido version of the Tokyo metropolitan government site created under the name of ‘#JUSTDoIT’, and a similar movement spread to Kanagawa and other prefectures. In addition, large information technology corporations, such as ESRI Japan and Yahoo, also created CoV19 visualisation websites using open data.

A participant in a VGI makes a social contribution based on their time limits and abilities, without expecting anything in return. In 2020 in Japan, the VGI movement occurred at the individual level, based on this conviction.

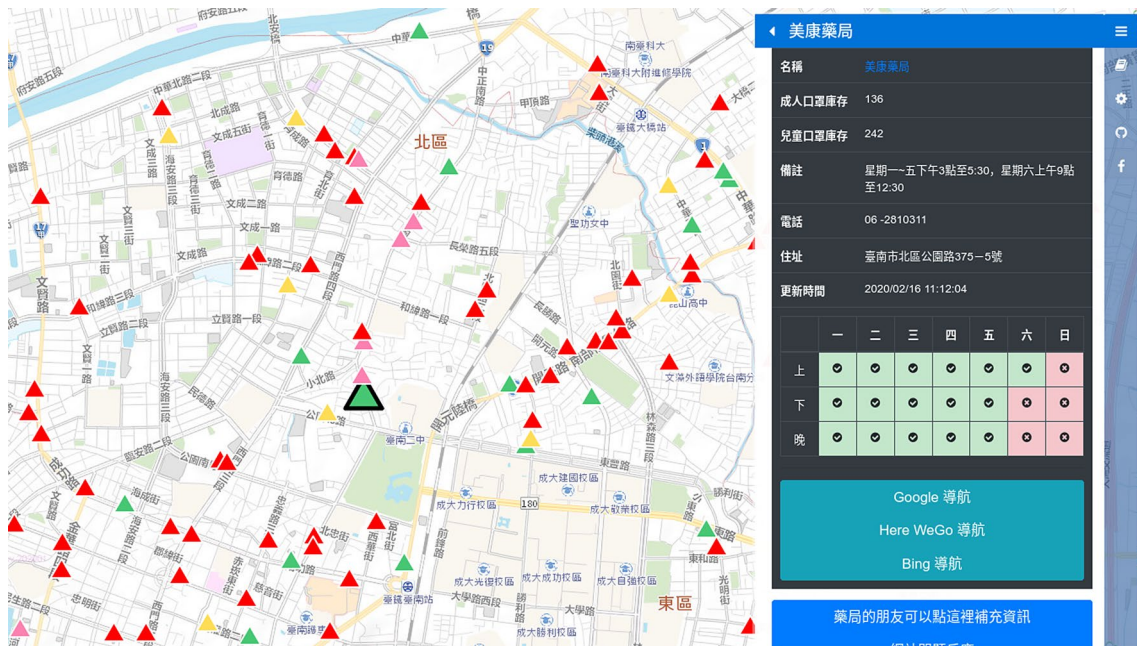
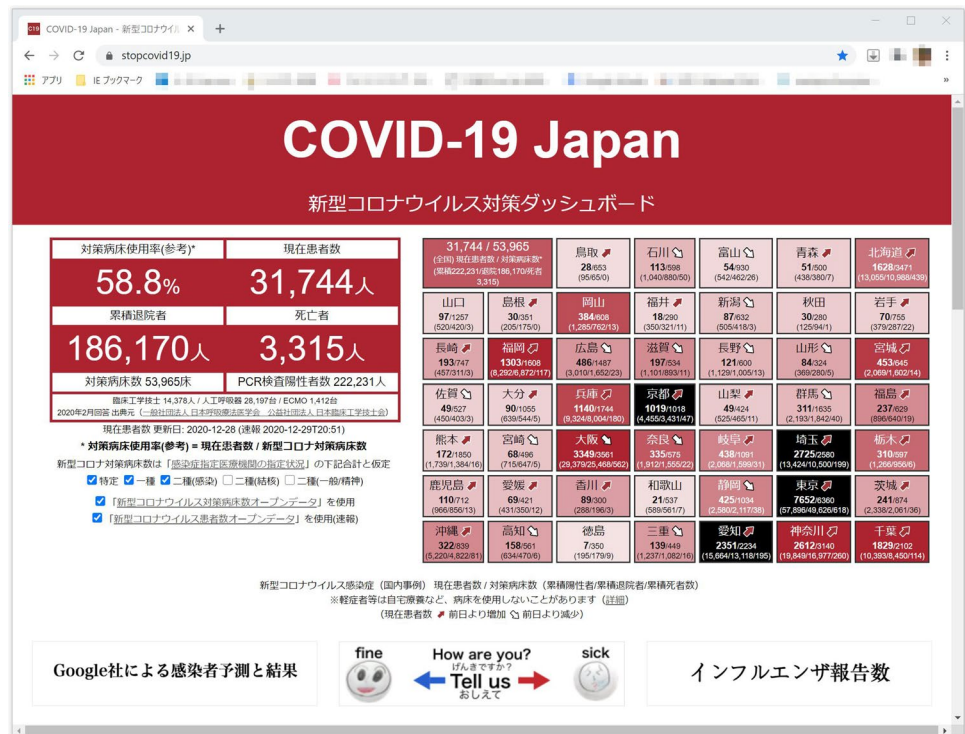
The first DB related to CoV19 was created on 8 March by an anonymous person known as ‘Kenmonezumi’. As the data formats and methods of publication for each prefecture were not uniform and the number of PCR tests and the positive test rates were published in PDF format, he manually converted these to CSV via text and published them using Google’s data portal. Although it is not a visualisation site using a map, his DB is an example of an individual’s first attempt to visualise data related to CoV19.

Taisuke Fukuno is a representative of the Code for Sabae and president of a venture company based in Sabae City, Fukui Prefecture. Fukuno also charted the occupancy rates of hospital beds by prefecture in late March, which enabled the visualisation of the risk of the health system collapsing (Fig. 2). This website was viewed more than a million times in 1 month from beginning in March *Mainichi Shimbun* [37].

Another noteworthy aspect of VGI that came to light is that during the pandemic, foreigners living in Japan, who are considered socially vulnerable made social contributions through VGI. On 23 February, Dong-Yeon Lee, a student from South Korea studying at Kyushu University, created the ‘Novel Coronavirus Case Map’, which shows infected



**Fig. 2** Dashboard screenshot of COVID-19 Japan (Retrieved on 30 December 2020 from; <https://www.stopcovid19.jp/>)



**Fig. 3** The mask map screenshot. Reference: <https://camo.githubusercontent.com/c8ffca832526b28b14dfcc0a47bca124d996cd0b81340ca840b2976954d766f6/68747470733a2f2f6b69616e672e6769746875622e696f2f706861726d61636965732f6f675f696d6167652e706e67>

people in red, people whose migration history is known in blue, and people who have been treated in green, as well as a streamlined map of migration history by city, ward, and town (the map has not been updated since 30 October 2020). In addition, covid19.live was launched on 3 March

by Wei\_Su, a Chinese international student, and this visualises transitions between the infection density and status by prefecture (Fig. 3). Such a movement is in accordance with the Sustainable Development Goals (SDGs) philosophy of “ensure responsive, inclusive, participatory, and

representative decision-making at all levels (Goal 16–7)’ and ‘ensure public access to information and protect fundamental freedom, in accordance with national legislation and international agreements.

(Goal 16–10)’ [67]. It is remarkable that the active participation of people who are in a socially vulnerable position during an emergency occurred via mapping.

For those responsible for civic tech and participatory GIS in Japan, Taiwan’s civic activists have been a model, much like their European counterparts. G0v (gov zero) is the largest group of civic hackers in Taiwan, stemming from the open government movement in 2012 that encouraged people’s understanding of the official budget of the government [34].

Just before Japanese citizens started to create web-based visualisation of the actual state of the CoV19 spread, Taiwan’s *mask map* provided a role model of a collaborative effort to create electronic maps (Fig. 3). Having suffered from epidemics more than once, including SARS, avian influenza, and influenza A virus, in the past without shared resources, information, and guidelines by the WHO, Taiwan has established its own disease control measures, including quarantines. For the sake of the Taiwanese government’s disease control measures, facemasks were rationed with the implementation of the real name system for facemask purchases in Taiwan on 6 February 2020. A mask map was also published to provide near real-time information about where to purchase masks. To make the map, relevant government agencies assisted in providing mask and pharmacy information in an open data format and reduced data update frequency from hours to minutes. However, all iterations of the map and its variations have been coordinated and maintained by a longstanding civic hacking organisation, g0v, and project members of each variation [48]. In addition, the Taiwanese government strongly recommended wearing facemasks, maintaining good hand hygiene, disinfecting one’s environment, and continued social distancing. Since these measures were put in place in February 2020, there has been a marked decline in invasive pneumococcal disease as compared to the number of cases in the past 5 years [64]. As a consequence, about half of the Taiwanese population, approximately 10 million people, installed the application by July 2020 [59].

## Agendas of VGI Activities Visualised

On 2 February, the WHO declared the new coronavirus ‘a massive “infodemic”’. Hao and Basu [26] pointed out that ‘fears around the coronavirus have been especially amplified by social media [26]. It allowed misinformation to spread and flourish at unprecedented speeds, creating an environment of heightened uncertainty that fuelled anxiety and

racism in person and online’. The human struggle against the spread of the new coronavirus infection was also the first global information war via the Internet over the authenticity of all related information in human history. In this context, a set of dashboards and applications that relied as much as possible on primary sources and tried to disseminate reliable geographical information in real time proved to be one of the keys to winning this new information warfare.

As described in the previous chapter, regarding the front-line of CoV19, VGI was able to achieve remarkable results in some regions. However, there is a regional bias in the descriptions covered so far.

Vaidyanathan reported that the current situation in India relies on labour-intensive methods. Health workers must obtain phone records to investigate the contact histories of people with CoV19 that might otherwise be evasive. It also involves going door-to-door daily to monitor and test potential patients [70]. Many non-profit organisations employ a participatory approach in Africa. Many less developed and non-English-speaking countries, while equally affected by CoV19, have experienced concentrated impacts from the virus. This concentration tends to be among those who are socially and economically disadvantaged. Although civic participation via the Web is progressing in these countries, the reality is quite different from that of the West and other, more developed countries.

According to Zisengwe [78], there are more than 140 civic-tech organisations in Africa, but they mostly consist of focussed groups [78]. Their coverage is focussed on more pressing issues that predate the expansion of CoV19. Moreover, their deployment is unevenly distributed across countries. This is with the exception of the Code for Africa, which is an international network covering all of Africa. For instance, the *BudgIT* foundation in Nigeria, an affiliated organisation of *Civichive*, initially started tracking the implementation of government projects in July 2014 to ensure the equity and transparency of their public service delivery. This effort can be characterised as participatory budgeting [10]. For CoV19, their portal COVIDFUND Tracka enables the monitoring of CoV19-related donations given to the federal and states of Nigeria. This allows the government to be held accountable, and means that they also use the budgeting method in response to CoV19 [45]. Likewise, in South Africa, an association for community advocacy, *Amandla.mobi* has collected signatures, using web petitions, for CoV19-related social problems. These problems include asking the Ministry of Basic Education to disclose its plans to reopen schools to ensure the safety of all affected people. *U-Report* in Uganda also conducted an online opinion poll for solution initiatives.

In the Latin American region, several countries such as Ecuador in 2008, Brazil in 2010, Bolivia, Uruguay, and Venezuela in 2013 amended their state laws to mandate the use

of free and open-source software (FOSS) for state business. Most countries possess a governmental map viewer maintained by the agency responsible for the country's geography, mapping, or spatial data infrastructure activities [50].

Since the FOSS licence permits modification and redistribution of the code, the implementing country or municipality can modify, enhance, and standardise the software without having to wait for updates from the vendors. This allows host countries in Latin America to consider that they have developed an infrastructure for participatory GIS. The first citizen-led network, *Geoinquietos Argentina*, was formed as the first Latin American branch of *Geoinquietos* in 2013. Currently, there are three more *Geoinquietos* in Brazil (Fortaleza, Brasilia) and Bolivia (Santa Cruz). This is despite the fact that CoV19-related citizen activities that are organised online cannot be found in the region. In addition, Franco et al. investigated the repertoires and interests of 205 collective action initiatives in Middle and South America as of May 2020, and pointed out that citizen participation is one of the crucial areas in which 'local organisations lack the capacity or resources to establish initiatives' (Id. 538) [14].

Likewise, while the status of digital countermeasures of CoV19 by citizens in the Middle East region in terms of GIScience is largely unclear, Vahidi et al. [69] provided a detailed status report on the relationship between CoV19 and citizen science projects using Iran as a case study. According to them, there are 'five significant domestic online projects with citizen science characteristics, including the "Ministry of Health and Medical Education" (MOHME) of Iran's project for COVID-19 self-assessment and self-reporting (hereinafter referred to as the CSASR project), the AC19 project, the Mask project, Gharbargar the COVID-19 project, and the project of "China-Iran Cooperation Group against COVID-19 Disease"' (p. 7). Despite their existence, 'no organisation exists in Iran to serve as a central reference point for various stakeholders of citizen science, nor to bring various stakeholders of citizen science together and create a network, to co-ordinate and support the citizen science landscape, and to encourage and accelerate the growth of the citizen science movement in the country. Furthermore, it is noteworthy that citizen science is not currently consolidated in national research programmes in Iran' (pp. 4–5).

In their study, Vannoni et al. used the mobility index of a wayfinding app called *Citymapper* and the study period lasted from 2 to 26 March 2020. They examined how user mobility might be reduced by social changes associated with the spread of the infection. China, India, and Africa were excluded from the analysis [71]. The South American continent was represented only by São Paulo; the Middle East was represented only by Istanbul; and Asia was represented by only four sites: Tokyo, Seoul, Singapore, and Hong Kong. Although Vannoni et al.'s study did not address

the North–South issue in VGI, it unexpectedly had the effect of making the issue symbolically visible. In many African countries, most resources are devoted to more pressing issues, such as violence against women and poverty, and CoV19 Solutions initiatives do not account for a high percentage of activities. Such activities are carried out by NGOs and NPOs as representatives of citizens, with citizens often participating mainly as evaluators. There are some research contributions from India in the form of a data visualisation methodology of CoV19-related numbers of cases and deaths in linear, parabolic, or exponential graphical representation, which helps compare different stages and countries [7].

Compared to the situation in developed countries such as Europe and the United States, online citizen participation in the VGI form is still developing. However, the population in such areas:

[...] are more vulnerable due to the pre-existing precariousness that reflects on the health of residents and on the access to services and resources for fighting against the disease [9].

In other words, the North–South problem of our world extends to the availability and accessibility of information. Consequently, information and economic disparities will also cast a shadow on the response phase of society [32].

## Discussion and Conclusion

To interpret the results, it is necessary to view the subject in at least four quadrants. The first axis is the evaluation of the extent to which the object world is drawn at the global or national level, and the second is the evaluation of the extent to which the object is drawn by the public administration (tree type) or by the citizens (rhizome type).

The first quadrant is a tree type, and the second is a rhizome type. The first quadrant is where large international companies in Europe and the US (Google, Esri, and so on) belong, in a top-down organisation structure, depicting the world globally. In the case of Western Europe and the US, there is also a portion of citizens who participate in a global visualisation (Quadrant 2). All groups, from professionals to citizens, are included in the most mature group that are likely to represent maps from a global perspective.

On the other hand, the third quadrant is a group whose depiction is confined to a single country. It has a tree-like organisational structure, and most of the primary sources provided by non-Western governments belong to this type. However, even the countries in the category were bifurcated into two groups: those countries where citizens were actively involved in the mapping process, such as Japan and Taiwan, and those where citizens' participation could not be confirmed. There are two types of countries where citizens'



participation cannot be confirmed: those in Africa, South America, the Middle East, and parts of Southeast Asia, where citizens' participation is still at an immature stage due to pre-CoV19 problems such as poverty and inadequate infrastructure, and those in China, where there are certain restrictions on the dissemination of information by citizens, for political reasons.

In addition to basic domestic data published by home governments, internationally circulated data are published in English. If one does not understand both English and computer languages, one's involvement in this collective act is greatly constrained. Moreover, the access speed to infrastructures such as open sources and repositories such as GitHub must be fast enough. This may be a premature conclusion due to the limited scope of this research, but so far, it appears that the more non-English speaking and less developed a country is, the more the level of infection control through information disclosure tends to remain at the government level. This trend may be attributed to the fact that countries with social problems as serious or more serious than the pandemic response are unable to devote their limited resources to infection control. There may also be an educational problem as there are not enough civic-tech leaders with programming skills being trained in these countries. For example, Jeremy Philemon, the central figure of *Covid19india.org*, one of the most compelling dashboards in the Indian region, is an international student from India who studied at Brown University and is enrolled at the Rhode Island School of Design in the US. In some respects, the CoV19 disaster may have made the North–South knowledge problem more visible.

Today, even the poorest countries in Africa have websites. For example, Burundi is the world's poorest country in terms of GDP per capita, according to the IMF 2021 announcement. While Burundi does not have a separate webpage with statistics on CoV19, the Ministry of Public Health and the Fight against AIDS has weekly published press releases in the form of a scanned document declaring the new cases, tested cases, suspected cases, number of contact persons, patients, and former patients. The problem is that the civic participatory movement, which uses and visualises primary data provided by governments to provide feedback, has hardly developed in these regions and is mainly used by organisations and individuals from countries in the first quadrant, with the poorest countries being the ones being visualised. As the limited examples of the present study show, it was unexpectedly the people of the US and Western European countries who were visualising the rest of the world, while Africa and Asian regions remained being portrayed by them. This is a vivid reminder of the discussion related to the asymmetry often pointed out in gender studies.

Namely, the idea that throughout history, men have depicted objects and women have been the depicted objects [31].

In response to CoV19, which suddenly engulfed the world, simultaneous anti-CoV19 dashboards created by citizens with computer skills were published within a month or two of the outbreak's beginning. In other words, human communication on the Web, unconstrained by distance, reaches people faster than infectious diseases. In one respect, the pandemic has made the virtues and disadvantages of this fast-moving digital revolution even more visible. Of course, it goes without saying that a dashboard made from limited open data, processed by ordinary citizens with limited capabilities, naturally contains various restrictions and limitations. As Rosenkrantz et al. [52] summarised, such shortcomings of the CoV19 dashboards include (1) messy and inconsistent health data as there is a paucity of high-resolution spatial data to monitor health outcomes, and (2) securing geo-located health data at a high enough spatial resolution to detect meaningful patterns is difficult due to privacy constraints. However, these shortcomings due to a lack of data do not completely nullify the potential for citizens to take action against CoV19.

This study aims to organise and archive the first 2 years of this historic event, however, that the scope of the event was vast and it was only possible to capture the whole picture in a limited way. Since the object of this analysis was largely limited to the tools described by any media in English, it is possible that web tools published in countries or regions with other language systems may have been omitted from our search network. This is especially true if they were published and shared without including search terms such as 'COVID-19' or 'pandemic' in the summary, or if they do not appear in repositories such as GitHub, which is used worldwide.

Even if the challenges mentioned in this paper remain, the significance of archiving, for the first time in an academic context, the grassroots and spontaneous mapping of CoV19 by unknown volunteers that emerged around the world, pointing out the existence of certain North–South issues in the context of CoV19, is unassailable. When people 100 years from now study the CoV19 pandemic, they will understand the historical significance of the fact that for the first time in human history ordinary citizens collaborated across borders to visualise geographical information and prevent the spread of disease. This will be made more obvious to them if it is archived.

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## Declarations

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**Consent to Participate** Not relevant.

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