International Cartographic Association
Association Cartographique Internationale

A Holistic View on Volunteered Geographic Information

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Abstract: With the rise of web and online mapping technologies since the early 2000s, Volunteered Geographic Information (VGI) has emerged as a significant resource for generating and disseminating diverse geographic data. VGI can be characterized in multiple ways, depending on factors such as data nature, contribution purpose, collection methods, and utilization approaches. However, specific strategies may only be applicable to certain situations, emphasizing the need for a comprehensive framework to examine the diverse challenges and solutions associated with various VGI types. Although numerous conceptual frameworks exist for specific VGI applications, such as disaster or crisis management, a more inclusive framework addressing the overall VGI landscape remains lacking. This study proposes a versatile conceptual framework that captures the multifaceted nature of VGI. The framework presents parameters and criteria for evaluating similarities and differences across the VGI spectrum, ultimately identifying major VGI types and their practical implications. The framework offers a valuable tool for systematic investigation and comparison of both static and dynamic contexts, fostering a deeper understanding of the VGI and its applications.

Keywords: Volunteered Geographic Information (VGI) framework; User-generated content; Crowdsourcing

1. Introduction

“Throughout most of the history of cartography, maps have been used by elite groups, to control and administer people and places” (John Pickles 2004). Nevertheless, readily available Geo Information System(s) dispersed through the internet have marked a significant shift in the balance of power in cartographic representation. The term VGI has been commonly used to describe information with a spatial element, produced by volunteers. Tulloch, (2008) defines “VGI applications as those in which people, either individually or collectively, voluntarily collect, organize and/or disseminate geographic information (GI) and data in such a manner that the information used by many others”. Goodchild, (2007) and Elwood, (2008c) stated that VGI can be considered as a global patchwork of valuable and useful information, with space and time as its contextual glue. Goodchild, (2008b) Remarks that “the rapid growth of VGI in the past few years is one more step in a lengthy process ... It is one part of a fundamental transition as society redefines its vision of the role of public information in the early years of the 21st century”. This statement is confirmed a decade later in diverse domains such as crisis and emergency management (Tzavella et al., 2022). Yan et al., (2020) reviewed more than 300 scientific publications concerning VGI ranging from social sciences to environmental monitoring, crisis management, and location-based services.

There are several ways to describe and characterize VGI phenomenon depending upon the aspects and facets that a study wants to concentrate. These include diverse characteristics such as the nature of the volunteered data, the purpose of the contribution, mechanisms that have been used to gather data and the approach to utilize these data. For instance, many conceptual frameworks have been already developed for specific use of VGI in disaster or crisis management. However, when it comes to VGI itself not many works have been conducted and efforts of explaining and identifying the broadest landscape of VGI through a single framework has not yet reported in the literature. The problem is that, although specific strategies might be useful in some circumstances, yet may not be appropriate in various other situations. Hence, a comprehensive framework is essential to investigate different challenges and their associated remedies based on the various kinds of VGI. In this study, a generic conceptual framework for VGI is presented to model multifaceted nature of VGI. The framework considers the phenomenon of VGI holistically and offers a valuable tool for systematic investigation of static and dynamic scenarios. The framework specifies a set of criteria for evaluation of similarities and differences across the VGI panel, and ultimately determines the major sorts of VGI and crowdsourced and collaborative data.

2. Background and Related Works

Frameworks related to VGI mainly originate from Public Participatory Geographic Information System (PPGIS) and Neo-geography literature. Turner, (2006) presented a framework for Neo-geography, in which different tools and technologies for gathering and showing location are presented into a single framework called “GeoStack”. Although, the GeoStack framework provides a good summary of several different tools and technologies utilized in the process of VGI production in the context of web 2.0, the framework is based on tools and technologies, which are very rapidly evolving.

Proceedings of the International Cartographic Association, 5, 17, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa. This contribution underwent single-blind peer review based on submitted abstracts. https://doi.org/10.5194/ica-proc-5-17-2023 |

Turkucu and Roche, (2008) proposed a framework, which describes PPGIS based on six leading characteristics listed as; public, public involvement, materials, mechanisms (equipment), and software. Considering the fact that the public, materials and mechanisms most of the time are mixed, only three axes remain (Turkucu 2008) which include software, public involvement and data. These frameworks do not focus on VGI but highlight various aspects that are important to its related fields. However, when reviewed with a perspective focused on the nature of the data and its intended use, they can bring essential blocks for the development of a VGI typology. This framework do not focus on VGI but highlights some VGI characteristics. Indeed, the framework does not allow characterization of many VGI elements in the recent VGI context, because todays VGI approaches utilize primarily web 2 technologies with a high interaction between the individuals and the tools.

Coleman et al., (2009) present a set of models that focus mainly on characterizing the spectrum of contributors, contribution motivations, characteristics of use, and institutional requirements. However, these models cannot be used as an all-encompassing framework due to the absence of connection between proposed models. Cooper et al., (2011) develop a model consists of two dimensions to assess the quality of VGI; first “the continuum of responsibility for determining the specifications for the data” ranging from a user through to an official data custodian with tightly controlled specifications. Second “classifying data as base” ranging from base data to points of interest. Building on the rating scales and evolving from the Cooper et al., (2011) approach, Parker, (2012) presents a framework to categorize neo-geographic products based on the rating criteria.

Yang (2015) developed a conceptual framework to utilize VGI, especially geo-tagged social media data to better understand the world by linking space, place and people together. Budhathoki (2010) presents the most comprehensive conceptual framework for VGI. He proposes a three-tiered conceptual framework for VGI to classify VGI-related characteristics in three arenas ‘‘Motivation’’, ‘‘Action and Interaction’’ and ‘‘Outcome’’. While the recommended arenas offer a good overall framework to analyse VGI, more comprehensive conceptual models for evaluating different sub-arenas are missing (Rehrl et al., 2013). Furthermore, the utilization of the VGI information as a crucial step to make sense of all VG information is not covered in the proposed framework. The literature highlights various classification systems that have been used to distinguish between different VGI efforts. These classifications emphasize mainly on those aspects of VGI that are critical for their presented study and do not capture the entire complexity of the VGI phenomenon in one single framework. To close these gaps, in this study a conceptual framework is proposed to investigate different aspects of VGI. It can be used to systematically explore various aspects of VGI and analyse the relationships between different elements and processes of VGI.

3. Developing a conceptual framework for VGI

To develop the conceptual framework, hence distinguish and identify the major sorts of VGI, first it is essential to specify a set of parameters and criteria that allows evaluation of similarities and differences across the VGI landscape. These parameters mainly come from the available models and frameworks in the PPGIS, neo-geography and VGI in addition to critical analysis of the VGI landscape. Parameters are organized in four categories in the framework: Enablers, Context, Mechanisms, and Utilization. Each category has various parameters to characterize and identify different VGI types. In the following sections, each arena along with its entire sub arena will be discussed.

3.1 Enablers for VGI

Enablers – unlike the other categories in the framework– are not a set of parameters or criteria for describing different characteristics of VGI. VGI inherits many of its features from scientific and technological enablers such as Geographic Information Systems (GIS), PPGIS and web 2.0. In order to fully understand the VGI, we should admit and understand the relationship of enablers to their phenomenal offspring VGI. Hence, the basis of our framework is scientific and technological enablers.

3.1.1 *Scientific background*

During the 1990s, several vigorous debates and discussions among researchers arose, addressing the ethical, political, and societal implications of GIS. These discussions were notably documented by Craig, Harris, and Weiner in 2002 and J. Pickles in 1995. A major point of contention was the exclusive nature of GIS technology, with critics arguing that it was disproportionately accessible to those who could afford the high costs of the necessary hardware, software, and geo-data, as outlined by John Pickles in 2005. The discourse further focused on the positivist assumptions underlying GIS. Critics argued that GIS, by simplifying complex societal processes into points, lines, areas, attributes, and features, could inadvertently obscure multiple nuanced geographical realities (R. E. Sieber 2006). This oversimplification could lead to the marginalization of local knowledge and perspectives, particularly when only a limited number of "official" data, which often represented a dominant viewpoint of reality, was centralized (John Pickles 2005).

In response to these challenges, Public Participation GIS (PPGIS) was developed with the objective of democratizing access to GIS tools and technology. PPGIS aimed to empower local communities by enabling them to explore their environments and participate more actively in formal decision-making processes. This has proven useful in a variety of applications, including conflict management, neighbourhood revitalization, and land use planning, as evidenced in the works of Craig, Harris, and Weiner in 2002. However, while PPGIS has made significant strides in improving public engagement, it is not without its limitations such as concerns about data quality and privacy. Other, more complex issues have also been pointed out, such as the digital literacy divide among participants, which could potentially exclude certain individuals or communities. There is also the risk of biased representation, with the possibility that those who choose to participate may not accurately reflect the broader community, thereby skewing the data and the subsequent decision-making process.

3.1.2 *Technology*

Evolution of web technology was in the same direction as efforts in the PPGIS field to make GIS more available and suitable for public involvements. Indeed, many of the Geo-Web 2.0 core ideas are crucial for the further evolution of the GIS and PPGIS. Utilizing web 2.0 technologies can provide scientists an opportunity to produce high-quality scientific information which is enriched with experiential insights from a wide range of individuals (Metzger and Flanagin 2011). Eisnor, (2006) coined the term neo-geography; "A socially networked mapping platform which makes it easy to find, create, share, and publish maps and places".

The next evolution of web technology after Web 2.0 is commonly referred to as Web 3.0 or the "Semantic Web." While Web 2.0 was characterized by greater user-generated content, interactivity, and collaboration, Web 3.0 focuses on enhancing the understanding and processing of information by machines. As web technologies continue to develop, Web 3.0 will become more pronounced, leading to a more intelligent, and user-centric internet. Some key features of Web 3.0 include (Kautish and Singh (2022), Anwar (2022), Guha et al. (2015), Heath and Bizer (2011)): semantic data, Artificial Intelligence, decentralization, interoperability, IoT, privacy and security, and knowledge management.

Furthermore, Several standards and ISOs cater to volunteer contributors' needs. ISO 19157 assesses geospatial data quality, including VGI, while ISO 19115-1 provides metadata management guidelines, aiding VGI dataset documentation and discoverability. ISO 19138 outlines data quality measure evaluation methods, and ISO 19109 sets rules for standardizing data structure and content. ISO 19110 advises on feature cataloguing for geospatial features (ISO 2006, 2013, 2014, 2015, 2016). The Open Geospatial Consortium (OGC) creates standards like WMS, WFS, and WCS for geospatial data interoperability.

3.2 Context of VGI

The context of VGI presents different fundamental characteristics of VGI that significantly influence contribution process, nature, and quality of the gathered data. Different continuums are elaborated in this section to provide an important basis for structuring types of VGI. In the framework, the context of VGI consists of four main continuums: a) contribution continuum, which varies from scientific knowledge to personal knowledge (both local or remote), b) contribution nature that addresses different facet of contribution itself such as volunteered or unbeknownst, c) contributor continuum that ranges from professional to amateur contributors, and d) nature of volunteers' motivation that enlightens intrinsic and extrinsic motivations.

3.2.1 *Contributions' Continuum*

The continuum of contributions in VGI can be broadly sorted into four categories. These include a) Scientific Knowledge (SK), b) Local Knowledge (LK), c) Personal Knowledge (PK), and d) Synthesized Personal Knowledge (ASK). SK refers to the data contributed by volunteers that can be quantitatively measured or is scientific in nature. It typically includes components such as mapped objects, street networks, residents' densities, and other scientific classifications. LK, encompasses data that ranges from conventional GIS to more qualitative understandings and perspectives that are unique to a particular locality or community. In contrast to SK and LK, PK is knowledge that is often shared within one's personal circles, such as friends, relatives, and co-workers. It includes geo-referenced pictures, recommendations about points of interest, and details about specific events. The fourth category, ASK, represents the knowledge produced by non-scientific volunteers through activities like analysing, evaluating, or interrogating existing datasets, which could be volunteered, official, commercial, or any other types.

Deparday (2010) classifies SK and LK as conventional GIS knowledge because they adhere to the traditional GIS knowledge structures. The remaining continuum, spanning from LK to PK is classified as unconventional knowledge. This paper proposes a distinction between the context of the contribution and the actual nature of the contributed data. Although SK is mainly objective, it can still be captured in unstructured texts. Similarly, LK and PK might be facilitated to be both structured and even objective. Regardless of the increasing education and scientific awareness among citizens, it remains crucial to maintain rigorous quality assessment measures. This caution is required due to common issues such as "proof by assertion" when using crowdsourced data.

3.2.2 *Contributions' Nature*

In the definition of VGI, the term volunteer is present, though the contribution is not always completely volunteered and various levels of willingness to contribute can be identified. We differentiate between four types of contributions: Volunteered, f-VGI, Private, and Unbeknownst. The first level of contribution is a fully volunteered work. The term facilitated VGI (f-VGI), coined by Seeger, (2008) refers to the second level of contribution willingness, when individuals are asked to participate. The third level of contribution is very usual in social media applications, when the recipients of the participation are meant to be only a limited group such as friends or relatives (Elwood 2008a; R. Sieber 2007), however sometimes the shared information will be available for everyone either due to intended software design or user's mistake in appropriately adjusting the used software (Deparday 2010). The fourth level of contribution is indeed an unaware and maybe unwanted contribution, when contributors do not know that they are contributing (Elwood 2008a; Tulloch 2008).

3.2.3 *Contributors' Continuum*

Although most of GI volunteers were categorized as amateurs (Tapscott and Williams 2008), both professionals and amateurs can be volunteers. Literature offers many polarized definitions of professional versus amateur for GI contributors. Coleman et al., (2009) summarizes and divides the contributor's continuum into five overlapping categories as 1) "Neophyte": individuals with no formal expertise but willingness to provide input. 2) "Interested Amateur": a person developing their knowledge in a subject. 3) "Expert Amateur": a passionate practitioner not reliant on their expertise for income. 4) "Expert Professional": someone whose livelihood depends on their expertise, with potential legal repercussions for misinformation. 5) "Expert Authority": a widely recognized professional who stands to lose their reputation for misinformation. Categorizing contributors through these lenses simplifies a complex issue. An individual may be an expert in one field but a beginner in another. Hence, mechanisms for training and engaging those interested in VGI are needed. This fosters a diverse volunteer community, demanding an understanding of contributors' motivations and cultural backgrounds.

3.2.4 *Motivation Nature*

Unravelling individual motivations is crucial for designing VGI procedures that maximize the number of contributions. Key questions to be addressed revolve around what triggers or hinders individuals from making contributions, how these motivations relate to different levels of contributions, and why these motivations might evolve over time. To better comprehend these motivational aspects, insights from Free or Open-Source Software (F/OSS) and Wikipedia can be gained. Coleman et al., (2009) outline a set of main motivational factors that spur individuals to make valuable contributions. These include altruism, professional or personal interest, intellectual stimulation, protection or enhancement of personal investment, social rewards, enhancement of personal reputation, an outlet for creative and independent self-expression, and pride of place. There exists a direct connection between personal motivations such as social rewards and personality types. In addition, one's inclination to perform specific activities can be tied to their position in Maslow's hierarchy of human needs. Social structures and interactions also have a direct or indirect influence on human behavior. Furthermore, the capacity and motivation of a person to contribute to VGI can be significantly influenced by their level of access to technological tools and their skill in utilizing these tools.

3.3 Mechanisms of VGI

The mechanisms of VGI framework facilitate contributions of contributors with appropriate tools to produce GI content. Additionally, it addresses common problems faced in the production of content such as conflict, congestion, overuse, and quality. The mechanisms address the process of contribution such as how people interact and cooperate to produce content, what norms and rules are in place, what the data features are and how they are captured, what are the supporting processes and structures, and which evaluation mechanisms are possible. Careful analysis and evaluation of these mechanisms are necessary to understand strategies and techniques for contributions gathering and implementing and executing VGI initiatives.

3.3.1 *Contributory Mechanisms*

Contributory mechanisms in the context of VGI serve as guiding structures that define the boundaries of contributions such as regulations, norms, or infrastructural limitations to maintain the quality of information and enhance the contribution rate. Common norms in VGI platforms might include avoiding the upload of copyrighted GI. Such norms, as they're widely adopted and respected, gradually solidify into structures. These structures emerge from the interplay between individuals and the technology, subsequently shaping the behaviors of both community members and non-members. One such pivotal structure revolves around copyright issues. Copyright rules act as a double-edged sword. A variety of licenses have been developed for VGI projects. These licenses aim to balance the protection of intellectual property rights and the necessity for collaboration. Notable examples include CC0, CC BY, CC BY-SA, CC BY-NC, and CC BY-NC-SA. The chosen license can greatly impact the collaborative capacity. Licenses that are more permissive, like CC0 and CC BY, promote broader participation and data sharing, fostering the creation of richer and more diverse datasets.

3.3.2 *Data Capturing*

Different capturing means, methods and approaches have essential influences on different characteristic of the generated data such as format, quality and accuracy. Some of the most common approaches used by amateurs and professionals are GNSS, WiFi, cell or IP loggers, and geocoding. With rapid advances in sensor technology and emergence of IoT, VGI content will witness a radical shift. In many cases there won't be a need to collect data by volunteers anymore because sensors will be able to provide us accurate and up to date data constantly. Data such as environmental, traffic and meteorological information are first to be fully captured by sensors. Nevertheless, cultural issues and features are more difficult to capture. Additionally, processes such as feature recognition through artificial intelligence (like OSM's Rapid platform), although currently assisted by human validation can play as fundamental a role as sensors. This raises again the question, what will be the role of volunteers in the IoT era, which data collection methods will be cheaper and more accurate than ever before. However, the more data is collected the more challenging will be the task of data mining and knowledge discovery. Volunteers as intelligent agents might be best fit to develop mechanisms to synthesize the data. However, to achieve this goal significant educational investments in VG communities is required.

3.3.3 *Spatial Data Features*

Spatial data features are greatly influenced and defined by the data capturing approaches and the variety of features that applications support. Some applications solely allow the insertion of spatial features like points, while others enable contributors with basic geo-processing capabilities such as measuring and merging. Contributions in raster format have become possible with the rise of drone imagery, satellite photos, and other remote sensing technologies, expanding the range of spatial data features beyond points, lines, and polygons. The richness of spatial data features has essential effects on the information collected, as it enables diverse and detailed insights. Examples of data collection methods for VGI and crowdsourcing efforts include mobile phone-based GPS tracking, geotagged social media posts, user-contributed photos with location information, and georeferenced sensor data from IoT devices. The increasing variety of data formats and features also pose challenges and difficulties for further analysis, interpretation, and integration as well as incorporating various data formats and features into geospatial datasets.

3.3.4 *Attributive Data Features*

Attributive data features in GIS pertain to the textual and semantic elements of the data. This form of accuracy, the "closeness of attribute values to their true value," is crucial when evaluating data (Chrisman and McGranaghan 1990; Lo and Yeung 2007). Unlike location data, attribute data can change more frequently. Depending on the aim of data collection, the collected data may be structured or unstructured and objective or subjective. Objective data presents facts, while subjective data offers opinions (Tulloch, 2008). However, the way individuals present facts may vary, making semantic analysis of attributive data challenging. Therefore, standard terminologies, like the OSM tagging system, can help improve data quality and prevent future difficulties in data utilization. Structured attributive data are attributes linked to spatial features that conform to nominal, ordinal, interval, or ratio scales. These organized data are collected according to a specific plan. Conversely, unstructured attributive GI data refers to free-text comments and opinions linked to various spatial features. The issue of metadata structure arises from the fact that vast amounts of data are generated by a multitude of authors. One remedy for managing the quality problems is the use of data standards and structures like OSM tagging standards and metadata. However, quality control in VGI requires additional measures to ensure accuracy and reliability beyond just tagging standards. A viable strategy to address this issue is to leverage the power of contributors to categorize and classify data, involving them directly in the development of metadata. This "folksonomy" approach creates metadata that balances structure and freedom.

3.3.5 *Action and Interaction*

The mechanism of action and interaction delineates the degree of a contributor's involvement. This concept, inherited from PPGIS frameworks (Schlossberg and Shuford 2005), has been described in a multitude of ways. Rowe and Frewer (2005) identify three types of engagements based on the flow of information: public communication, public consultation, and public participation. In public communication, information flows from the sponsor to the public without seeking public input. Public consultation involves information flowing from the public to the initiative's sponsors. Public participation involves an exchange of information between participants and sponsors. Facilitators can interact with the public and allow interactions among the public members themselves (Hall and Leahy 2011). This level of interaction is crucial for VGI initiatives, since contributors often also act as users (Goodchild, 2008b) and facilitator, which is increasingly important as the number of participants and the volume of content grow.

3.3.6 *Evaluation mechanisms*

Data quality and credibility remain primary concerns in VGI due to variables like the volunteer's demographics, motivations, and abilities (Flanagin and Metzger 2008). Maintaining data accuracy and reliability is essential, requiring careful evaluation of data and the implementation of mechanisms to guide volunteers in their data collection. Providing guidelines and standards can help maintain high-quality data (Newman et al. 2010; Dickinson, Zuckerberg, and Bonter 2010). Cross-verifying volunteer-contributed information with researcher-collected data or authoritative datasets can ensure data complementarity (Clark and Aide 2011).

Contributors not only add data but also correct others' contributions, significantly enhancing data quality. This aligns with Linus' Law from computer science: "Given enough eyeballs, all bugs are shallow," meaning enough capable individuals can solve any problem (M Haklay et al. 2010; Raymond 1999). In VGI, this law can be applied to the number of collected geographic features, such as points, lines, polygons, or attributes. Over time, as contributions increase, data credibility, accuracy, and quality are expected to improve (M Haklay et al. 2010). However, studies on OSM reveal that the relationship between number of contributions and quality isn't linear.

3.4 Utilization of VGI information

The results of individuals' contributions constitute a public good that lies at a different point of the public-private continuum. Public goods are distinguished by two features: indivisibility, indicating that a person 's consumption of the good does not lower the quantity available to others; and non-exclusiveness, indicating that it is difficult or even impossible to exclude people from benefiting the public good (Kollock 1999). According to these criteria, VGI is a public good setting the sky as the limit for its utilization. The utilization of the VGI framework consists of two phases: a) data aggregation, filtering, and quality check (pre-processing), and b) information visualization, synthesis and developing innovative services (post processing). Quality control and aggregation of gathered data from different data sources are of vital importance for almost any VGI initiative, without which the developed services cannot successfully provide a basis for decision making. Numerous studies have focused on the utilization of the VGI and analysed different aspects of the gathered data such as trust and credibility (Bishr and Mantelas 2008; Flanagin and Metzger 2008); quality and coverage (Clark and Aide, 2011; Haklay et al., 2010); privacy and control (Harvey 2007); access and empowerment (Tulloch 2008); and effect on social and political procedures (Elwood 2008a).

3.4.1 *Data aggregation, filtering, and quality check*

Contributions in VGI "are the aggregate repository of user-contributed geo-referenced information." (Budhathoki, Nedović-Budić, and Bruce 2010). Contributed spatial data are often cluttered and overlapped and free texts with mainly different semantic information and no language standards make the whole information utilization phase more tedious. Senaratne et al. (2017) present reviews on various quality measures, indicators and assessment methods for selected VGI projects and classify them according to utilized methods quality assessment. Automatic processing techniques aim to simplify and categorize data while ensuring access to original information, maintaining transparency (Deparday 2010). Filtering systems can reduce information overload, allowing retrieval of relevant data (Roberts 2008).

The quality of crowdsourced geographic data like OSM can be challenging to assess due to a lack of traditional quality assurance (Goodchild and Li 2012). Usually, assessments rely on comparing OSM data to 'ground truth' reference datasets (Minghini and Frassinelli, 2019). However, because of inherent differences between OSM and these datasets, methods that assess OSM quality internally, by examining its temporal evolution, have been developed (Minghini and Frassinelli, 2019; Muttaqien et al., 2018). For instance, Novack et al., (2022) explored temporal dynamics of OSM data in 20 cities, using time series analysis and forecasting models like ARIMA, proving effective.

3.4.2 *Information visualization, synthesis and innovative services*

VGI's complex nature presents challenges but also unique opportunities due to its heterogeneous, qualitative, and subjective characteristics. These features allow data to disclose relationships, patterns, and insights when analyzed collectively. Robinson et al., (2017) propose using these traits to create meaningful maps and emphasizes the importance of interdisciplinary connections. VGI's potential is evident in diverse fields with many successful initiatives ranging from wildlife preservation to emergency management and land management (Silvertown 2009; Me Haklay et al. 2014). Pioneering examples include the Christmas Bird Count project and the eBird project. The latter has revolutionized how birding communities access and report information. Tools like VIEW-IT, Geo-Wiki, and Ushahidi, have contributed to remote sensing and disaster management (Clark and Aide, 2011). de Albuquerque et al., (2015) successfully combined social media and authoritative data for disaster management. Yang, Ye, and Sui (2016) used social media to enrich geographical context, while Mozas-Calvache, (2016) leveraged VGI data to analyze vehicle behavior for traffic safety.

VGI can update outdated information and datasets, as shown by the Canada-OSM Synergy Project (D. Sui, Elwood, and Goodchild 2013; Me Haklay et al. 2014). Polous, (2016) proposed a model for handling real-world dynamics using VGI, and Silvertown, (2009) stresses VGI's role in knowledge dissemination and public education. Polous (2016) recommends transitioning the public's role from mere sensors to data analysers to fully realize the potential of VGI Understanding.

4. Conclusion

The escalating use of VGI underscores the need for a robust understanding and definition of this phenomenon. Existing classifications in literature focus on aspects crucial to specific studies and don't capture VGI's full complexity, underscoring the need for a comprehensive framework. This framework would consider various aspects, such as the data's nature, contribution purpose, data gathering mechanisms, and utilization approaches. A clear understanding of these elements and their interrelationships is vital for VGI practitioners and scholars. While frameworks have been developed for specific VGI uses like disaster management, fewer efforts have addressed VGI as a whole. This study introduces a conceptual framework to model VGI's multifaceted nature, laying groundwork for future explorations. This framework outlines parameters for evaluating VGI's different facets and classifying VGI types, under four categories: enablers, context, mechanisms, and utilization and consume. The proposed framework takes a holistic approach to VGI, facilitating systematic investigation of static and dynamic scenarios for a sustainable VGI ecosystem across diverse projects. It emphasizes the interconnection between various VGI entities, situating VGI at the intersection of multiple disciplines. Future research will delve deeper into the mechanisms category, given its complexity and breadth. To establish a comprehensive list of approaches for each mechanism like contributory and evaluation methods, a thorough literature review is needed.

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