SPATIAL DATA INFRASTRUCTURE AND VOLUNTARY GEOGRAPHIC INFORMATION

Mr. Josephat Okuku Oloo[1]
Department of Geography, Moi University, Eldoret, Kenya.
josokuku@yahoo.com

Mr. Van der krapf [2]
Centre for Geoinformation science,Wageningen University,Wageningen, Netherlands.
Van.derkrapf@wur.nl.

***Abstract*—With the development of the Web 2.0 era, new technologies and applications have emerged to make it possible for individuals to produce and share geographic information on the Internet. This development is expanding at a high rate, and has received large response from users. Spatial data infrastructure is a framework of policies, institutional arrangements, technologies, data and people that makes it possible to share and use effectively geographic information while geographic data collected through crowd-sourced movements or methods is known as Volunteered geographic information or collaborative mapping.**

This paper explores the concept of VGI and elaborates on the lack of utilization of SDI. First a short history is given on the beginnings of VGI, then an elaboration on the differences and similarities between SDI and VGI. This is followed by the difficulties faced by the SDI. Next, the motivations of people to contribute geographic information are explained, followed by the significance of VGI. The fact that SDI and VGI operate in a different environment explains the question why a high number of people participate in VGI. Furthermore, the data-centric character of SDI constrains their utilization. This can be improved by providing information to end-users.

Keywords—Voluntary Geographic Information, Spatial Data Infrastructure, Web 2.0

INTRODUCTION

The current Web technology has enabled a huge collection of geographic information by masses of volunteering individuals. The already existing online encyclopaedia, Wikipedia and the photo sharing platform like Flickr are extended with geographic information at an impressive high rate. The role of individuals as suppliers of Geographic information GI is now widely explored by researchers. Individuals can hold a wealth of GI. One of the examples is capturing and utilizing the knowledge from those who are closest to a specific phenomenon with geographic knowledge. This recognition gave rise to a new concept in the geo-information science which carries multiple names, namely ‘neo geography’, ‘cyber cartography,’ or ‘voluntary geographic information’ (VGI) (Budhathoki et al. 2008**).** This has enabled realization of complete maps and changed the traditional methods of collecting, updating, and maintaining geographic information. People distributed within an environment can voluntarily participate in collaborative online activities. While each person works on a small task, the final collective result often turns out greater than its parts. Goodchild (2007) highlighted the term Volunteered Geographic Information (VGI) as the potential use of “citizens as voluntary sensors” to create and enhance geographic data. It is also referred to as Crowd sourcing, Geographic Information or User Generated geodata in academic circles.

As a general definition, VGI encapsulates the process of collecting, maintaining, and distributing geographic information through the help of volunteers. Just about ten years ago, working with geographic information was only feasible for surveyors and professional GIS developers who had access to advanced GIS tools. VGI is also seen as “an extension of critical and participatory approaches to geographic information systems” (Elwood, 2008) and a “by-product of the so-called ‘Web 2.0’environment” (Flanagin and Metzger, 2008).

Web 2.0 has encouraged greater collaboration among internet users and other users, content providers, and enterprises. This movement has revolutionised methods of data sharing and computing by crowd sourcing movement similar to Wikipedia. In regard to the geographical data the crowd-sourced movement is known as volunteered geographic information (VGI), also referred to as collaborative mapping; a special case of web phenomenon and has been applied in many popular websites such as Wikimapia, OpenStreetMap(OSM),GoogleMap,Flickr,(Sukhjit et al.2013). Collaborative Web-based efforts like *Open Street Map, Tagzania, Wayfaring.com,* the *People’s Map,* and *Platial: The People's Atlas*,Foursquare, Trapster, UCrime.com, Google, Tom Tom and Waze now enable experts and amateur enthusiasts alike to create and share limited, theme oriented geospatial information (Castelein et al., 2010). VGI allows anyone with internet access and a computer or mobile device to generate and contribute geospatial content (Genovese & Roche, 2010).Base maps are provided through sites such as Tracks4Africa and OpenStreetMap (Cooper, 2011).

The development of the first Spatial Data Infrastructures (SDI) some decades ago was meant to acquire, distribute, use, and maintain geographic information. On the other side advances in geospatial positioning, Web mapping, cellular communications, and wiki-based collaboration technologies have now surpassed the original visions of the architects of spatial data infrastructures around the world (Coleman et al., 2009). These motives have become also characteristics of the VGI phenomena.

However, in practice SDI and VGI operate in a different environment. This can be a part of the answer to the question why a huge number of people participate in VGI while some SDIs are facing the challenge to attract users. New tools which need to be integrated for efficient practical uses of this future oriented technology are obtainable by Geospatial data servers, Differential Global Positioning System (DGPS) developments, and mobile GIS. The goal of this paper is to explore the concept of VGI and to discuss the lack of utilization of SDI and the popularity of VGI.

In the following section a short history is given on the beginnings of voluntary geographic information. Then an elaboration is given on the differences and similarities between SDI and VGI. The third section deals with the difficulties faced by the SDI in today's world. In the next section the motivations of people to contribute geographic information are explained, followed by a section about the significance of VGI in today's world. The paper concludes with a discussion on the lack of utilization of SDI and the popularity of VGI.

A NEW ERA OF WEB TECHNOLOGY

The production of geographic information was, in the past, mainly the responsibility of the national mapping agency through SDIs. Spatial data infrastructure is an infrastructure for sharing and use of geospatial information (Musinguzi et al.2004**)**. SDI can facilitate access to the spatial data and services through improving the existing complex and multi-stakeholder decision-making process. Moreover, it can facilitate the exchange and sharing of spatial data between stakeholders within the geo-information (GI) community (Dev et al.2011). By building an appropriate SDI, disparate spatial data can be accessed and utilized amongst different stakeholders. Many SDIs now include Web services as a key component of their architecture. Common in SDIs are Web Mapping Services, Web Feature Services and other Web services supported by standards for interoperability developed by standards consortia and geospatial technology providers (Moeller, 2010). Several technical standards defined by the Open Geospatial Consortium (OGC) and the International Organization for Standardization (ISO 19xxx series) play an important role in the dissemination and processing of spatial data. In general, they describe communication protocols between data servers, servers that provide spatial services, and client software, which request and display spatial data. In addition, they define a format for the transmission of spatial data. The ISO Standard 19115 (Geographic Information – Metadata) is also important as it defines a schema for describing spatial data, and ISO 19119 (Geographic Information- Services) defines how spatial data and services should be described so that they are able to be searched by catalogue services (such as OGC's Catalogue Service) together with their specifications developed by the World Wide Web Consortium (W3C) for data dissemination such as HTML, XML, SVG, SOAP, WSDL (GSDI, 2009, Smits, 2002 and Lupp, 2008).

The mobile GIS's architecture is very similar to that of the internet GIS. It is based on mobile computing and mobile Internet. It follows the client/ server architecture as is traditional in Internet GIS applications. It is an expansion of Web GIS to mobile Internet including wireless Internet/Intranet and mobile communication network (W. Fangxiong, 2004). The end-user hand-held devices that can display maps or provide analytical results of GIS operations are the client-side mobile GIS components. The server-side components provide comprehensive geospatial data and perform GIS operations based on requests from the client-side components. Big challenges still remain to integrate architectures, develop interoperable data models, and create a climate that enables collaboration, innovation, and sharing of geospatial data and services. New innovative and potentially disruptive technologies will continue to emerge and we will need to incorporate many of them into existing SDIs.

With the development of the Web 2.0 era, new solutions have emerged to produce and share geographic information on the Internet, and in many cases free geographic information. The rapid growth of new tools such as satellite imagery viewers, participatory mapping and mobile applications have begun to provide citizen access to geospatial tools as well, making some of the SDI core/framework data themes readily available for use by government, business and citizens. Governments in developing world are less willing to finance the creation of SDIs for geographic information dissemination as compared developed countries (Goodchild,2007). However, new initiatives have emerged to take over the responsibility to keep up with the increasing demand for geographic information. When Google and Microsoft, among others, created web mapping applications and made them available to the public, this trend increased (Budhathoki et al. 2008).

One can find many services on the Internet where GI is created and published. These applications include Google Earth, Google Maps, WikiMapia and OpenStreetMap.

These tools have received a large response from users but are prone to a number of caveats, especially in the form of vandalism (Kashian et al.,2014); Wikipedia is one of the most popular crowdsourcing projects that has been exposed to several poisoning attacks, where spammers try to disseminate fake or valueless articles in bulk.

In many cases GI is created and shared by citizens of whom a large part does not have prior experience with GI technologies (Goodchild, 2007) but the citizens have only altruistic motives, and they volunteer information to the public. An example is Google Earth for which everyone can create Web overlays and publish them. Budhathoki et al. (2008) states that the geospatial activities based on Web 2.0 show the willingness of the users to engage more in the production and supply of geographic information.

VGI VERSUS SDI

Research has found fundamental differences between VGI and SDI. According to Budhathoki et al. (2008) there are two fundamental differences between SDI and VGI. The first is that in the concept of contemporary SDI, formal and expert organizations are the producers and suppliers of geo-information. Secondly, many SDI view the users as passive recipients of geographical information and products, and for a large part belong to other expert organizations. In this way, the flow of data or information is from one organization to the other. Budhathoki et al. (2008) formulate this as "the creation for expert organizations by expert organizations." From this it can be derived that amateurs and individuals are not target user groups of contemporary SDI. In other words, the SDI and VGI both seem to exist in different environments, and behave independent from each other. In more detail, the contemporary SDI are provided by the public sector. The community on the Internet, on the other hand, provides data which is made possible by the private sector with a large business interest (Boes and Pavlova, 2008). Furthermore, the goal of a SDI to provide data created by and for GI specialists, and to make all kinds of data accessible and available, can be considered as a top down approach. An opposite approach is taken by the web community, which is a bottom up approach. Consequently, geo-referenced data is created and shared by users in the mass market by simple means. This geo-referenced data is often more advanced than the traditional paper maps, because technology makes it possible to provide videos, 3-D images, and other media content (Boes and Pavlova, 2008). Moreover, the distinction between the producer and the user becomes blurred (Budhathoki et al., 2008). Though SDIs are generally considered to follow a top down approach (while VGI a bottom up), SDIs are based on shared, interoperable standards, such as web services of OGC, so that information can flow from many distributed, independent servers to common web clients that can be tailored to the purpose and style of different end-users. On the contrary, many VGI applications are based on commercial (not open) technologies, such as those of Google and Microsoft; information providers must adhere to those technologies and the collected/distributed content is strictly coupled with the user interface provided. Table 1 gives a summary on the differences between VGI and SDI.

Even though we can list a number of dissimilarities, there are also similarities to be found between SDI and VGI. According to Craglia (2007) there are three things to say about converging concepts. The first is that although SDI are data centric, the realization of the necessity to provide information rather than raw data to reach a broader public increases.

Table 1: Revised Table of Boes and Pavlova (2008): Comparison between SDI and VGI

Category	SDI	VGI
Value Chain	Public data producer -Specialist	Private data producer-End User
Major Stakeholder	Public sector	Private Sector, Internet Users
Revenue model	Cost recovery	Advertisement
Content	Spatial data	Georeferenced hypermedia
Technology	GIS, Web Portals	Web 2.0 tools
	SDIs use standards based on OGC and ISO standards	VGIs exploit private, de-facto standards such as those of Google/Microsoft
Competition	Low (natural and legal monopoly), SDIs foster interoperability,and therefore integration/comparison among different data sources.	VGIs provide a high amount of information not easy to be compared and evaluated
Strength	Existence of datasets	Uptake by industries

The second aspect is that of sensor networks and sensor webs (sensors, Sensor Web Enablement (SWE)) to monitor the real time state of, for example, smartphones. This is an initiative that offer web services aimed at including sensed data based on OGC standard into SDIs. These services are able to provide also real-time data directly from sensors of different typologies. This has complimented VGI and support for SDI, for most part based on static and dynamic data. The concept of citizens as sensors, which is in line with the VGI concept, can be a next step in the future and will bring VGI and SDI more closely together. The final similarity can be found in the technology.The production technology of SDI and VGI data has some points of contact, for example the use of GPS traces in OpenStreetMap.

DIFFICULTIES CONCERNING SDI

Now the principal differences between SDI and VGI are discussed, we continue with the difficulties which SDI face. Some of the European SDI are not fully operational like the case of Greece and Luxembourg as well as several of the former accession countries (Masser,2005), which may be an indication that they are not utilized as expected to be. One of the reasons may be the passive role of users. The arrival of the so-called second generation SDI which focuses on services and web services did not make a difference in utilization, although it views the users as passive recipients. The stages of developing national spatial data infrastructures (NSDI) in most developed countries are different. The factors behind their success can be linked to high levels of technology, availability of funds, trained personnel and political support. Examples of advanced regional SDI initiatives include the US NSDI and the Australian NSDI (ASDI). A more recent initiative launched by the European Commission and developed in collaboration with Member States and accession countries is INSPIRE. The initiative intends to trigger the creation of a European Spatial Information Infrastructure that delivers to the users integrated spatial information services (Smits, 2002).

Budhathoki et al. (2008) states that one of the issues concerning the use of SDI is the different perception the provider and the user have on space and spatial components. Consequently, when the spatial data is captured and represented in a database with the perception of the supplier as foundation, the dissimilarity between the user and supplier remains, also with the services provided based on these data. The above described characteristics on which contemporary SDI are founded, may be restrictive to the development of SDI that are used widely. A solution to overcome this difficulty and attract a higher number of users may be the involvement of users in the process of data provision. In this way their requirements can be identified and be met. This involves a shift from a system-centred approach to a user-centred approach (Mavima et al., 2001).

Furthermore, there are several discussion points to be detected among researchers that study SDI which indicate the need for change. First of all, they point out that SDI are not developed for the need to handle user generated data. They argue that the top down model of SDI supporting data access, storing and sharing is different from the bottom up model on which VGI is developed. Secondly, SDI has great practice with dealing with issues like interoperability, which could be useful for developing VGI. The third point of discussion is that new approaches may be needed, to include user generated data (Elwood, 2008). Already, we can detect a direction towards the concurrence between SDI and VGI. Google Maps, for example, uses data for the street network produced by the experts from NAVTEQ and Tele Atlas. The popularity of Google Maps, however, is considered to be the result of the contributions by individuals (Budhathoki et al. 2008).

PARTICIPATION AND MOTIVATION

If the contribution by individuals plays a major role in the success of VGI, then the question arises why people want to contribute to the collection of GI. One of the clearest examples of users being producers of information is Wikipedia, a free online dictionary with content which is entirely based on voluntary contributions and is the largest collaborative collection of information in the world. Anyone is allowed to contribute, edit, and use the contents of this online encyclopedia, and consequently the reliability of its contents is greatly sustained. Wikimapia is one of the VGI phenomenon which is based on the idea of Wikipedia, and where geo-information is produced by non-professionals (Budhathoki et al.,2008). Kuznetsov (2006) explains in her article why people are motivated to contribute voluntarily to the Wikipedia project. With the facts that the work of contributors is often anonymous, their edits not permanent, and they receive no money for their time spend, raises the question what motivates these people to spend effort and time in Wikipedia. Kuznetsov (2006) concludes that the values of reputation, sense of community, reciprocity (cooperation), altruism (good will), and autonomy underlie the motivations of Wikipedians. In detail, this means that they feel they are rewarded for their work and acquire a reputation within the community. And by discussing articles with other Wikipedians they feel to belong to a community. Furthermore, by adding to an article, and participating in debates and discussions, users expand their knowledge. Thus the sharing of information is based on reciprocity. Also a majority of Wikipedians invest time and effort without the need for compensation (except satisfaction), which is an act of altruism. Finally, the freedom of independent decision making leads people to contribute to the content of Wikipedia. These values together create a virtual atmosphere in which citizens collaborate and learn together on a voluntary basis. However, vandalism in Wikipedia can be categorized; generating non-existing features or fictional objects, deleting existing features randomly (could happen in bulk), modifying the geometry of a feature in a non-regular format and assigning incorrect or non-common attributes to a feature. This can be controlled by instituting an automatic method for the detection of vandalism with a special focus on the insertion of non-existing Points of Interest (POI) and the modification of attributes and positions of current point features (Kashian A ,2014).

The users activities in Open Source Software (OSS) production are quite similar to that of VGI, except that users produce spatial information in VGI. Budhathoki et al. (2008) connects the motivation of people to the lack of adequate applications elsewhere. One of the reasons why users are actively contributing towards OSS, is that users can create exactly what they want instead of being restrained by the producers pre-set options. Consequently, the situation in which the producer fails to meet the user requirements is not longer applicable (Budhathoki et al., 2008).

THE SIGNIFICANCE OF VGI

There is one important question that arises from the VGI framework concerning the quality of the contributed information. By examining the quality, the utility of VGI activities and the value of their outputs for a range of applications (e.g. simple navigation) will become clearer. Haklay (2008) performed an analysis of the quality of the OpenStreetMap (OSM) dataset in comparison to the Ordnance Survey (OS) dataset, for the city of London. OSM is a geographical application within the framework of Web 2.0 that aims at creating a free digital map of the world and implemented through the concept of collaboration. The analysis is based on positional and attribute accuracy, consistency and completeness which reflect the quality of the geographical information. Haklay (2008) argues that the quality can be good if the participants are committed and attentive. Reasonable positional accuracy of about 6 metres is reached. However, only the centres of the major cities are well covered and complete. The quality of the coverage decreases from the centres to the periphery.

Furthermore, there is inconsistency of information between areas which are digitised by different participant groups. Some areas are handled with more care than others. And the fact that most area was digitised by a small group of participants, infers that little quality assurance is carried out. Haklay (2008) concludes that OSM can be relevant for mapping products of city centres. However, it is not suitable for more advanced applications which require more detailed and completeness of information.

Research VGI technologies discuss how decision makers, researchers and citizens will use voluntary geographic information. The lists of applications include emergency response, monitoring environmental change, identifying problems in urban neighborhoods, and filling the blanks in existing databases. These applications require integration of data provided by many different sources, citizens in this case, into larger data collections. Also to retrieve, to query, and to analyze these data is required for such purposes (Elwood 2009). However, according to Elwood (2009) the integration and handling of the spatial information created by citizens with the new technologies poses difficult challenges in geo-information science. The reason for this is the heterogeneous, dynamic, and qualitative nature of such data provided by large groups of citizens. Heterogeneity arises when different attributes are used for similar entities, or when one attribute is used to describe different conditions. Furthermore, the integration of data representing qualitative spatial expressions (e.g. the use of expression such as "near," and "close"), is complicated in a digital environment (Elwood 2009). Diaz et al.(2013) arques that interoperability of the various Web 2.0 platforms is key to spatial data interaction mechanisms from different information systems. SDI networks provides several technology prerequisites, which include: provide interoperable services, consuming interoperable services, structuring geospatial data according to determined models and publishing/displaying the geospatial data. Thus the actual use of voluntary geographic information on higher levels than on individual level is still finding its way.

DISCUSSION

Advances in positioning, Web mapping, cellular communications and wiki technologies have surpassed the original vision of GSDI programs around the world for SDI (Coleman,2010). It's from this viewpoint that individuals are willing to volunteer geographic information that a large part of the information they provide is of useful quality for simple mapping applications, it can be assumed that humans are now acting as sensors. Once mapping organizations appreciate and motivate potential volunteer contributors, they will require a more in-depth understanding of the potential accuracy of the contributions. A close look at Ordnance Survey, OpenStreetMap, and Google Maps suggests that their focus is different but when, considered alongside each other they can be categorized together. However, OpenStreetMap is very distant from Wikimedia, since OpenStreetMap aims at map of features (e.g. roads, buildings, post boxes, etc.) while Wikimapia produces a subjective layer of descriptions on top of an existing map. This means these two ventures should be categorized as different forms of neogeographic products; despite both products being VGI based (Parker, 2014).

In order to enable SDIs to accommodate VGI and derive utility from their synergy, it's important to reconceptualize the notion of the SDI user from a passive recipient to an active information actor, which is call produser (Budhathoki et al., 2008).

In the field of ornithology the concept of citizen science is already widely recognized because a large part of the observations and measurements is done by amateur bird-watchers. This can be considered as a huge source of observations which is the means of technology integration, a new way of surveying. This provides a solution to the problem of lower production and update rates of mapping (Goodchild 2007). In this way the VGI concept can complement SDI. Moreover, both SDI and VGI have their own contributions to the world of geo-information, and cannot be replaced with each other. They operate in a different environment which makes them serve different applications. Consequently, the quality of data cannot be compared with each other. However, in VGI, data quality control is difficult to achieve due to the "heterogeneous and dynamic nature as well as the volume of the VGI" but some mechanisms for quality control can be applied such as "automated methods and thorough peer reviews by specialists" (Maué and Schade, 2008).

Goodchild (2007) argues justly that VGI lacks the certainty of quality, and a sufficient level of trust that governmental and other professional agencies enjoy today.The extension of a GIS from the office into the field is Mobile GIS. It allows to access, capture, store, and update, manipulate, analyze, and display geographic information directly in the field. More technologies, such as: mobile devices, GPS technology, wireless communications for Internet GIS access, and GIS software for mobile platforms are evolved with Mobile GIS (Maruto, 2008)

More important, however, is the fact that SDI are still predominantly data-centric and VGI information-centric. Because end-users, or individuals, attach more value to information than data, their requirements are met with information from a VGI application rather than with some data from a spatial data infrastructure point of view. Thus, the fact that SDI and VGI operate in a different environment can indeed explain the question why a high number of people participate in VGI and its popularity. And probably the data-centric character of

SDI constrains their utilization in a world where the value of information becomes more and more important. By extending the value chain of SDI, and to make their spatial data better available to the end-users, maybe their utilization can be improved. In this way the concurrence of both concepts becomes larger and perhaps collaboration is achieved. Geospatial metadata is commonly referred to as data about data. Metadata describes the content, quality, and origins of a geospatial data set. According to the US Federal Geographic Data Committee (FGDC), which pioneered geospatial metadata standards in the 1990s, metadata was critical for the online delivery of data, allowing users to find, understand, and reuse data sets produced by others (FGDC 2000). Metadata allowed organizations to better manage their investments in geospatial data and provide information to online catalogs and clearinghouses (FGDC 2000). Within an NSDI context metadata allow use, accessibility, and sharing of geospatial data. M*etadata*, or 'information about information resources', involving the documentation necessary for a user to discover whether an information resource exists, who has it, where it is located, what the conditions for accessing it are, and whether it is fit for the purpose that the user intends. Metadata plays an important role in all efforts to develop spatial data infrastructures and VGI initiatives.

The metadata standards were developed when the Internet was in its infancy, but since then, the use of the Internet as a medium of communication and exchange among data producers and users has burgeoned. Metadata has taken on a more vital role in locating and managing the enormous amounts of geospatial data now available in the GeoWeb (Scharl and Tochterman 2007; Tsou 2002).

In my opinion both VGI and SDI can improve by learning from each other's developments. The rapid growth of new tools such as satellite imagery viewers, participatory mapping and mobile applications have begun to provide citizen access to geospatial tools as well, making some of the SDI core/framework data themes readily available for use by government, business and citizens.

REFERENCES

1. Boes U. and Pavlova R. (2008). *Is there a future for Spatial Data Infrastructures? Conference material GI-Days*, Münster, Germany from 16 to 17June 2008. Retrieved January 27, 2014, from http://www.gi-days.de/.
2. Budhathoki N.R. Bruce B.C. and Nedovic-Budic Z. (2008). *Reconceptualising the role of the user of spatial data infrastructure*. GeoJournal 72:149 - 160.
3. Castelein, W., Grus, L., Crompvoets, J., and Bregt, A. (2010). "A characterization of Volunteered Geographic Information." *13th AGILE International Conference on Geographic Information Science,*pp.1-10.
4. Coleman,D.J.(2010). The Potential and Early Limitations of Volunteered Geographic Information. In Geomatica Vol. 64, No. 2, 2010 Pp. 209 – 219. Accessed on 5th sept,2014.http://www.cigacsg.ca/english/geomatica/geomatica_files/geomatica_sample/64-2/Coleman.pdf.
5. Coleman D.J,Georgiadou Y.and Labonte J.(2009). Volunteered Geographic Information: The Nature and Motivation of Produsers.In International Journal of Spatial Data Infrastructures Research, 2009, Vol. 4, 332-358.
6. Cooper A. (2011).*Volunteered geographical information and standards for metadata*. Proceedings of *Third Conference On Free and Open Source Software for Geoinformatics* Wrocław, Poland, 12-13 May 2011.
7. Craglia M.(2007).Volunteered *geographic information and spatial data infrastructures:When do parallel lines converge*? Retrieved Sept,,14, 2014, from http://www.ncgia.ucsb.edu/projects/vgi/participants.html.
8. Díaz L., Manuela Núñez-Redó M., González D. , José Gil J., Pau Aragó P., Pultar E. and Huerta J.(2012).Interoperable Search Mechanisms for Web 2.0 Resources. In International Journal of Spatial Data Infrastructures Research, 2012, Vol.7, 277-299.
9. Elwood S. (2008). *Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS*. GeoJournal 72: 173 -183.
10. Elwood S. (2009). *Geographic Information Science: new geovisualization technologies emerging questions and linkages with GIScience research*. Progress in Human Geography 33: 256 - 263.
11. Fangxiong, W. (2004): "Research on a distributed architecture of mobile gis based on wap. , Vol.,", XXXV 2004.
12. Federal Geographic Data Committee. (2000). *Content standard for digital geospatial metadata workbook, Version 2.0* . Reston: Federal Geographic Data Committee.
13. Flanagin, A. J., and Metzger, M. J. (2008). "The credibility of volunteered geographic information." *GeoJournal,* Vol. 72(3-4), pp.137-148.
14. Genovese, E. & S. Roche (2010). Potential of VGI as a Resource for SDIs in te North/South Context. Geomatica vol. 64, no. 4, pp. 439-450.
15. GSDI (2009). Spatial Data Infrastructure Cookbook. Global Spatial Data Infrastructure Association. Available from: www.gsdi.org/gsdicookbookindex.
16. Goodchild M.F. (2007). *Citizens as sensors: web 2.0 and the volunteering of geographic information*. GeoFocus (Editorial) 7: 8 -10.
17. Haklay M. (2008). *How good is OpenStreetMap information? A comparative study of OpenStreetMap and Ordnance Survey datasets for London and the rest of Engeland. Environment & Planning B: Planning and Design, 2010 volume 37: 682-703.*

18. Lupp M (2008). *Degree Free Software.* In: Shekhar S, Xiong (eds) Encyclopedia of GIS. New York: Springer, pp. 235-239.
19. Kashian A., Rajabifard A., Richter K.,(2014). "RoadPlex*: A mobile VGI game to collect and validate data for POIs"*, ISPRS Archives, 2014.
20. Kashian A., (2014)."*Smart VGI Platforms: Methods for Automatic Vandalism Detection",* Spatial Data Infrastructure Asia & the Pacific Newsletter, Volume 11, Number 3, March 2014.
21. Kuznetsov S.(2006). *Motivations of contributors to Wikipedia.* ACM SIGCAS Computers and Society 36: 1 - 7.
22. Maruto M.S.(2008). "Quadtree Spatial Indexing Use to Make Faster Showing Geographical Map in Mobile Geographical Information System Technology Using an Oracle 10g Application Server and MapViewer Applications,",IJCSNS International Journal of Computer Science and Network Security, 2008.
23. Masser Ian(2005). The Future Of Spatial Data Infrastructures in *Proceedings Of The Isprs Hangzhou Of Oct.14-16, 2005 Workshop Service and Application of Spatial Data Infrastructure* ISPRS Archives – Volume XXXVI-4/W6, 2005 WG
24. Moeller J. (2010). Spatial Data Infrastructures - Challenges and Opportunities *Directions Magazine, July 28th ,2010.*
25. Maué, P., and Schade, S. (2008). Quality Of Geographic Information Patchworks. Paper presented at the *11thAGILE International Conference on Geographic Information Science,* University of Girona, Spain , pp.1-8. IV/1-8, ICWG II/IV pg 7-16.
26. Mavima R.,. Michael Barry M. and Rivett Ulrike,(2001). Systems Thinking: An Approach Towards The Development Of Spatial Data Infrastructures: The Case Of Zimbabwe, *in proceedings of International Conference on Spatial Information for Sustainable Development Nairobi, Kenya 2–5 October 2001.*
27. Musinguzi M., Bax G., And Tickodri-Togboa S.S.(2004). Opportunities and Challenges For Sdi Development In Developing Countries - A Case Study of Uganda**.** *Geoinformatics 2004 Proc. 12th Int. Conf. on Geoinformatics − Geospatial Information Research: Bridging the Pacific and Atlantic University of Gävle, Sweden, 7-9 June 2004.*
28. Parker,C.J.,(2014).The *Fundamentals of human factors design for Volunteered Geographic Information 2014,X,138p.16 in color softcover* IBN 978-3-319-03502-4. Acessed on 1st Sept,2014*.* *http://www.springer.com/978-3-319-03502-4*.
29. Scharl, A., & Tochterman, K. (2007).*The geospatial web*. London: Springer. Schuurman, N. (2008). Database ethnographies using social science methodologies to enhance data analysis and interpretation. *Geography Compass, 2* (5), 1529–1548.
30. Smits,P.(2002).*INSPIRE Architecture and Standards Position Paper.*European Commission.http://inspire.jrc.ec.europa.eu/index.cfm/pageid/241/documentid/809
31. Sukhjit S. S.,Singh J., and Rai H. S. (2013). *Assessment of OpenStreetMap Data - A Review*.In International Journal of Computer Applications (0975 - 8887) Vol. 76 - No. 16, August 2013.
32. Tsou M.(2002). *An operational metadata framework for searching, indexing, and retrieving geographic information services on the Internet*. In M. Egenhofer & D. Mark (Eds.), *GIScience 2002: Lecture notes in computer science* (Vol. 2478, pp. 313–332). Berlin: Springer.