PARTICIPANTS' MOTIVATIONS TO CONTRIBUTE GEOGRAPHIC INFORMATION IN AN ONLINE COMMUNITY

BY

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DISSERTATION

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ABSTRACT

This dissertation examines volunteered geographic information (VGI), a Web 2.0 phenomenon in which users contribute geographic information online and collaboratively create maps. By examining the case of www.openstreetmap.org, I clarify why people contribute geographic information to an online community and offer a framework for researching different aspects of the phenomenon. I also outline its implications for expert-oriented production and propose a hybrid model for spatial data infrastructure. I find this topic interesting particularly because it defies the traditional mode and offers a new mode of production and use of geographic information.

The dissertation uses a combination of qualitative and quantitative methods of inquiry. I analyzed about 3,000 archived text messages (user conversations called 'talk-pages' in OpenStreetMap) and contributions from about 34,000 users between 2004 and 2009. I then conducted a survey to reach globally distributed contributors and tested a set of hypotheses regarding their underlying motives for contributing to VGI.

I find that an individual's local knowledge about geospatial situations is the most significant motivation. When they see that the areas they care about are blank or erroneously mapped, this invokes the instrumentality of their local knowledge. Individuals realize that they are in possession of knowledge about the areas they live and travel, and they are better positioned to update and correct maps than remote agencies. This realization brings their self-efficacy into play and drives them into mapping. For the contributors of an online geographic information community, the map is a way to manifest their identity and a means of representation in cyberspace.

In addition to the instrumentality of local knowledge, I find that self view and monetary motivations have a positive effect on a contributor's likelihood to be a serious mapper (i.e., contribute much more than average contributors). This challenges the speculative and anecdotal claim that altruism is the primary motivation in VGI.

In addition to geographic information, the findings of this dissertation have implications for the development of other online communities, local and regional planning, and governance and citizen participation. People's desire to contribute local knowledge should not be understood in limited terms of the geometric primitives of point, line, and polygon; rather, it should be interpreted as an expression of a desire to participate in the broad processes of social, cultural,

and technological transformation. If this excitement can be tapped, it will set a new stage for participatory discourse with government and fellow citizens. The resulting collective intelligence might prove to be an asset for transforming 21st century societies.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Geographic information (GI) is a part of the everyday lives of citizens, and online maps are becoming 'next utility' (NRC, 2010). It is also a basic infrastructure underpinning a wide range of decision-making in a society (Executive Office of the President, 1994; Groot and MaLaughlin, 2000). Traditionally, production, provision, and the updating of GI and maps have required expensive equipment and specialized expertise. Therefore, it has remained within the purview of expert organizations, mainly national mapping agencies (NMAs) and commercial mapping companies. NMAs are directed by government mandates, which often result from economic considerations and political system of a society. Commercial mapping companies are driven by market signals. By their very nature, they produce and update maps with the goal of maximizing their financial benefit. Consequently, certain areas on the Earth's surface are mapped whereas others are not; even within areas that are mapped, certain features are represented on the maps, whereas others are ignored (Wood & Fels, 1992).

The belief that the world is well mapped and that maps are constantly updated for better accuracy is a *mapping myth* (Estes & Mooneyhan, 1994). In many parts of the world, even basic information such as driving directions and locations of medical services are not readily available. Haiti can be taken as an example, as the *mapping myth* was uncovered during the recent earthquake. Relief efforts in locating victims and supplying basic materials in rescue operations in Haiti were hampered due to the lack of readily available GI (Richmond, 2010). Even in places where such information is available, it is often expensive, has limited accessibility, and is associated with different use restrictions.

In addition to the two basic modes of GI production mentioned above—government hierarchy and market signals—a third mode has emerged over the last few years. In this mode, citizens take part in the production and provision of GI. The declining cost of digital devices and communication, the proliferation of GPS-enabled handheld devices, and the emergence of Web 2.0 have collectively made it possible for ordinary citizens to measure, map, and share their everyday spatial experience. Scholars have given different names to this phenomenon, for example, volunteered geographic information (VGI) (Goodchild, 2007), geoweb (Elwood, 2009),

neogeography (Turner, 2006). Although no consensus exist yet regarding the name, the term VGI is used in the remainder of this dissertation.

Six billion humans all possess knowledge about certain properties of the Earth's surface (Goodchild, 2007). If we can make appropriate tools available, even laypeople can take part in the creation and supply of GI, which forms the core information content of VGI. Indeed, there are already indications that VGI might serve as an important source of GI, both for supplementing the traditionally available information, as well as serving as a new source of information not available through other means. However, as of now, little is known about the VGI phenomenon such as the content, characteristics, and the social processes around the creation and use of information (Elwood, 2009). Before we consider VGI as a sustained source of GI, some important questions related to these issues must be addressed.

1.2 OBJECTIVES

The main objective of this dissertation is to systematically study the phenomenon of VGI with a particular emphasis on people who take part in the creation and supply of GI, and to develop theoretical foundations for its advancement. The following sub-objectives are set in order to achieve the main objective:

1. Analyze the role of the user as implicated by VGI;
2. Define and develop an overall framework for VGI;
3. Explore users' motivations to contribute geographic information in VGI;

1.3 METHODOLOGY

This research employs a combination of qualitative and quantitative methods. Qualitative methods, grounded theory in particular (Glaser & Strauss, 1967; Charmaz, 1983), are employed to analyze text conversations and trace users' motivations in OpenStreetMap (OSM); the results of the qualitative analysis are used to inform a better survey design. Quantitative surveys primarily capture information on demography and motivations of GI contributors in OSM. Additionally, OSM users' contributions are analyzed for understanding their contributory behavior. It involves an analysis of the GI contributions of about 34,000 contributors worldwide. These are computationally intensive tasks resulting about 800 million database records. The outcomes of these analyses serve two main purposes: (1) to generate a list of GI contributors of

whom to send the survey (2) to connect the survey responses to the actual contribution of the respondents, and to conduct finer analysis based on their different levels of contribution.

1.4 OUTLINE OF THE DISSERTATION

This dissertation consists of a collection of three peer-reviewed international journal papers (Chapters 2-4), which are bound together with a short introduction and conclusion. Two of the papers (Chapters 2 and 3) are already published, and the third paper will be developed and submitted from the empirical materials in Chapter 4.

Each chapter corresponds with a sub-objective of the dissertation. Chapter 2 (objective 1) examines the phenomenon of VGI in relation to the roles of geographic information users. It uses similar phenomena, such as open source software development and Wikipedia, as lenses to make sense of users' geospatial activities in VGI. It argues for the reconceptualization of the user—from user to produser—and defines a new role for the user—from mere recipient to the creator and supplier of GI. It then establishes a connection between VGI and on-going efforts in spatial data infrastructures and shows how these two might supplement each other.

Chapter 3 (objective 2) extends the original VGI definition proposed by Goodchild (2007) and develops an overall conceptual framework for VGI. The chapter focuses the framework from the motivational perspective, drawing extensively from literatures on the sociology of volunteering, leisure studies, and social production of knowledge. The chapter provides a comprehensive list of potential motivational factors for VGI. It shows the utility of those factors for understanding users' motivations to contribute GI, and at the same time, it also demonstrates how those factors might play uniquely into the context of VGI.

Chapter 4 (objective 3) tests the motivational factors from Chapter 3 using OpenStreetMap as a case. It reports the results of the empirical investigation with particular emphasis on the characteristics and motivations of the contributors. It also reports the motivational differences between those who frequently contribute a large amount of GI and those who contribute less information more casually.

Finally, Chapter 5 concludes the dissertation with recommendations for future research.

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CHAPTER 2
RECONCEPTUALIZING THE ROLE OF THE USER OF SPATIAL DATA INFRASTRUCTURE

2.1 INTRODUCTION

Proliferation of information and communication technology—the Internet and the Web in particular—and the parallel development in geospatial technologies led to the notion of spatial data infrastructure (SDI) about two decades ago. After President Clinton's executive order 12,906 to establish a national level SDI in the United States (Executive Office of the President 1994), SDIs have diffused across the world. There were 83 SDIs at the national level by the end of 2005 (Crompvoets and Bregt 2007); this number has likely grown to more than one hundred by now. Other SDIs are being developed at regional, state, and local levels. Billions of dollars are spent worldwide on these activities each year (Rhind 2000, Onsrud et al. 2004). These infrastructures are created to facilitate the coordinated production, access, and use of geospatial data among producers and users in an electronic environment (Groot and McLaughlin 2000, Masser 2005a). SDIs use electronic media to connect distributed repositories of geospatial information (GI) and make these available to users through a single entry point often called 'geoportal'. This is a major development towards capitalizing modern technologies for wider access and sharing of GI in the societies.

With the emergence of Web 2.0, ordinary citizens have begun to produce and share GI on the Internet. The trend increased after Google, Microsoft and Yahoo! made their web mapping application programming interfaces (APIs) public (Rouse et al. 2007). Some of the common tools in use include Google Map, Google Earth, Common Census, WikiMapia, OpenStreetMap (Goodchild 2007b, Tulloch 2007), Microsoft Virtual Earth, Yahoo! Maps, and The Open Planning Project. These new tools are receiving a large response from users. For example, there were about 5.9 million place entries on WikiMapia (www.wikimampia.org) at the time of the writing, an initiative that aims to eventually describe the whole world; about 500 thousand places were submitted between mid December 2007 and mid January 2008 alone. These Web 2.0-based geospatial activities show that users are willing to engage more actively in the production and supply of GI.

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The user's potential to supply GI is promising enough that researchers are now exploring the role of citizens in augmenting the means of geospatial data collection: "the six billion humans constantly moving about the planet collectively possess an incredibly rich store of knowledge about the surface of the Earth and its properties" (Goodchild 2007b, p. 26). Others, too, have recognized the wealth of GI that individuals hold. For example, in the context of municipal activities, Carrera and Ferreira (2007) propose to capture and utilize the 'city knowledge' from those who are close to a particular phenomenon with richest geospatial knowledge. This gives rise to a new phenomenon, which has been variously named 'neo-geography' (Turner 2006), 'cybercartography' (Tulloch 2007), or 'voluntary geographic information (VGI[1])' (Goodchild 2007b).

The VGI phenomenon is intriguing for both SDI researchers and practitioners in several ways. One question concerns why millions of people participate in VGI while some SDIs are facing a major challenge to attract users. Whereas VGI participants freely contribute GI, the participants in SDIs are often reluctant to share information. What factors lead to these differences? Are SDI and VGI separate phenomena or do they have some relation? Will their harmonization be better for the society? If yes, how can this be accomplished?

Several authors have begun to explore the connection between VGI and SDI (For example: Craglia 2007, Goodchild 2007b). Others, for example Elwood (2009), have suggested that we seriously explore the utility of long-standing experiences with SDIs for understanding VGI issues. In this paper, we trace the relationship between SDI and VGI. In doing so, we look at the VGI phenomenon from the SDI standpoint and find that there are two assumptions within SDI that are problematic when it comes to handling VGI.

These assumptions are that formal organizations are the ones which produce and supply GI, and users are the passive recipients of information supplied by providers. In order to enable SDIs to accommodate VGI and derive utility from their synergy, we propose to reconceptualize the notion of the SDI user from a passive recipient to an active information actor, which we propose to call *produser*. We show that such a reconceptualization allows the user to produce and share GI, whereby the production functions are expanded from formal organizations to individuals and loosely formed groups of individuals. Further, we argue that the harmonization of SDI and VGI can, in fact, create a very rich and fertile middle ground between these two.

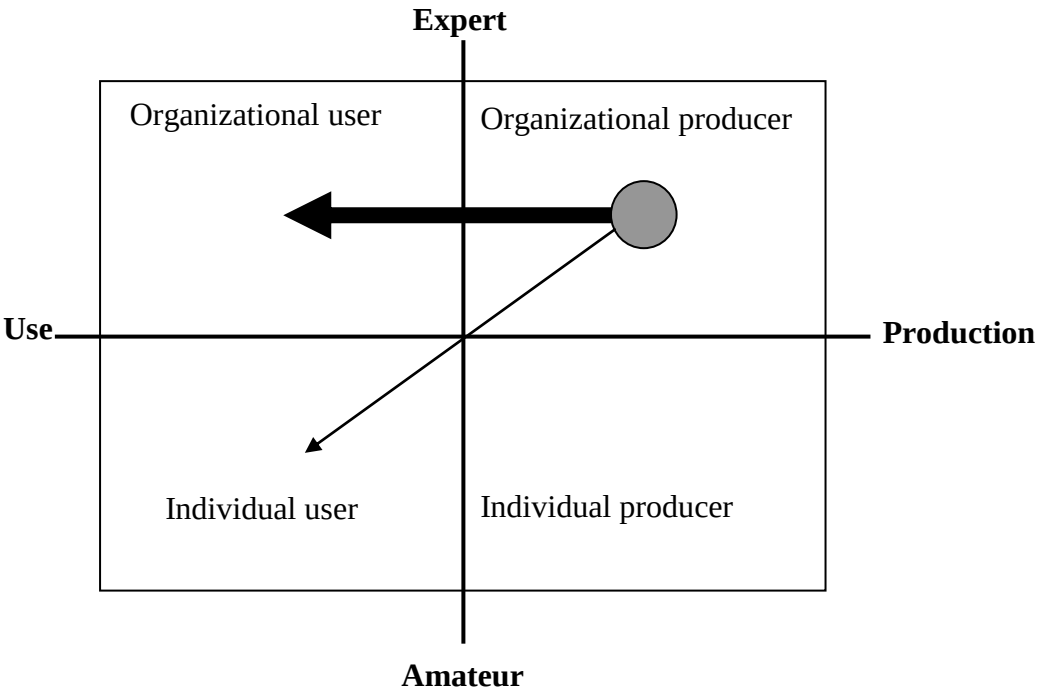
The following section examines the production and use of GI in contemporary SDIs and identifies some of the challenges for accommodating VGI. In the section "Alternative view of the user and VGI phenomenon", we propose an alternative view of the user by drawing on the information science literature, primarily on appropriation of technology, use and user studies, the open source software movement and Wikipedia. The section "Towards the hybrid SDI model: creating a middle ground between SDI and VGI", presents a hybrid SDI model, with tenets of both contemporary SDI and VGI, and discusses how it accommodates VGI. We conclude the paper with key issues and their implications for future research.

2.2 CURRENT VIEW OF SDI USER

The production of paper maps is an expensive task. Because of its capital-intensive nature, many governments have financed organizations to produce and supply geospatial information (GI) with certain mandates in order to meet the key GI needs of a society (Goodchild et al. 2007). Often, these organizations have evolved as national mapping agencies (NMAs) such as geodetic, topographic, cadastral, environmental, and agricultural mapping agencies. These NMAs have led in handling GI because of economies of scale of production and the development of expertise.

The SDI concept, which originated in the early 1990s, encompasses a framework of technology, policies, standards, and human resources required for acquiring, processing, storing, disseminating and effectively utilizing GI (Groot and McLaughlin 2000). In the early 1990s, the initial capital investment—cost of computer and other devices—required for producing digital information was still high (Benkler 2006), and the Internet and the Web were in their infancy. Therefore, large organizations continued to enjoy the economies of scale of production with the development of SDIs. Further, the expertise NMAs had developed in paper era was largely transferred over to digital GI in the SDI environment. These helped NMAs maintain their lead in the production and supply of GI in SDIs. This is illustrated in Figure 2.1, where a circle representing the GI production centers is located in the upper right quadrant in the producer-user and expert-amateur axis. Thus, the expert organizations are the producers of GI in contemporary SDIs. Often, these are government agencies, which operate in a formal and top-down environment. The more expert an organization is, farther it is from the producer-user axis in the upper right quadrant.

Figure 2.1: GI production center and conception of the user in contemporary SDIs
(Adapted from Eglash 2004)



In contemporary SDIs, users are also largely expert organizations, as shown in the upper left quadrant in Figure 2.1. The thick line connecting upper right and left quadrants depicts this. A very thin line is used in connecting upper right quadrant to lower left quadrant to signify that amateurs and individuals are not the target users in current SDIs. Contemporary SDIs are created ***for*** expert organizations ***by*** expert organizations (Craglia 2007). Furthermore, the unidirectional lines connecting the producer to users in Figure 2.1 depict the underlying assumption about the conception of the user. This assumption leads an SDI to a one-way transmission model where the user can only receive GI from an expert producer. In this model, producers make two related assumptions: first, their products/services satisfy users' needs; second, users employ these products/services in congruence with the producers' intent. Thus, users of an SDI are often referred to as ***'end-users'***—a term which itself reflects their marginalized role as mere recipients of GI.

The majority of SDIs worldwide have been led by national mapping agencies (NMAs) (Williamson et al. 2005), which traditionally view the user as a passive recipient of their

products. NMAs collect geospatial data, design maps, and then distribute these to users. SDIs have inherited this legacy view of the user, especially the first generation SDIs where the focus has been on making public geospatial data available to users (Masser 1999). At present, almost all geoportals, including the one for the United States (www.geodata.gov), are based on this conception of the user. These do not allow the user to upload GI or alter the content.

There are indications that current SDIs, which follow this top-down model, are underutilized. For example, some of the European SDIs are not fully operational (Bernard et al. 2005, Masser 2005b); data-centric implementation of the Indian SDI is not encouraging (Georgiadou et al. 2005); inadequate access infrastructure and capacity of participating agencies have impeded the uptake of the Nepalese SDI (Budhathoki and Chhatkuli 2003). The limited use has been attributed to the passive role of the users and inadequate attention to users' work practices and information behavior (Tulloch and Fuld 2001, Nedovic-Budic et al. 2004, Harvey and Tulloch 2006, Elwood 2007).

> "First-generation SDI, particularly the US NSDI, seems to have less success than desired because its concepts and policies, while technically sound and institutionally meaningful for agencies with a mandate to share and coordinate GI, failed to fully address the needs, requirements, and perspectives of local governments" (Harvey and Tulloch 2006, p. 765).

Second generation SDIs have capitalized on the advancement in information and communication technologies (ICTs) and have made substantial progress. The focus in these SDIs has shifted from the provision of data to services with web services as their key component (Bernard and Craglia 2005, Maguire and Longley 2005). However, even these new generation SDIs have not progressed beyond the view of the user as a passive recipient. The provision of services alone has made little difference in overall effective use. As Elwood (2007) finds, one of the major issues associated with use of SDIs is the difference between the provider and the user's perceptions of space. These differences are often deeply rooted in the socio-cultural reality and knowledge systems of a society in which the SDI operates. If geospatial objects have been captured and represented in databases using the supplier's priorities and perceptions, the disparity between the supplier and the user continues even with services generated from these objects. Puri (2006) finds widespread perceptual differences among different SDI stakeholders—including suppliers and users—of the Indian NSDI.

Users' involvement in the SDI development process has been proposed as a way to attract a greater number of potential users. There is an assumption that the users' involvement ensures identification and capture of their unmet requirements. When users, and other stakeholders, are involved in SDI development, they feel empowered to express their requirements (Craglia and Annoni 2007) and their divergent technological frames get converted into a shared understanding (Puri 2006). The call for this participatory discourse is similar to the shift from system-centered to user-centered approach to information service design in the 1980's (Dervin and Nilan 1986, Wilson 1994, 2000). The central premise behind this call is to capture the users' requirements and thereby design more useful information services.

A relatively more popular user-centered information system approach is the participatory design (PD), in which users are involved in system design exercises. PD has roots in union empowerment culture in Scandinavia as well as the socio-technical approach for information system design in Britain. Involvement of those who are affected by new computer system is important both for ethical reasons and for avoiding failures of techno-centric information systems (Mumford and Henshall 1983). However, despite its attractive rhetoric, even PD suffers from several challenges in the design and use of information systems. Byrne and Sahay (2007) cogently describe their experience in developing an information system for public health care in South Africa and argue that participatory approach in information system design adds only a little unless the capability of participants to meaningfully participate is enhanced. Spinuzzi (2005) provides a systematic analysis of participatory system design, including its limitations.

However, participation in the design of infrastructural systems such as SDIs poses additional challenges. First, since an infrastructure evolves over time (Edwards et al. 2007) , it has neither a well-defined design period nor fixed user groups. There is a lack of knowledge about who the users are, which users best represent the potential user community, and when to involve them. Even if users can be identified and involved, it is difficult for them to provide input without a sense of the SDI; they would need to use it if they are to express their requirements to producers. It is only through the process called *innovation-in-use* that users interpret and appropriate the innovation (Bruce and Rubin 1993). Further, since the user's GI needs are changing, the involvement of users cannot ensure knowledge of future needs. Thus, the users' involvement is no panacea for increasing the use and utility of SDIs.

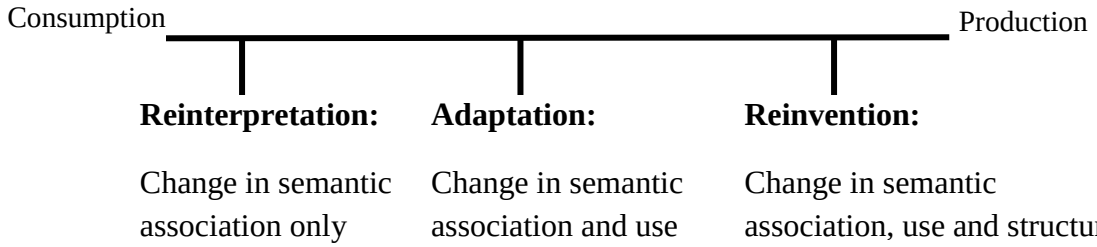
In summary, the assumptions that only formal organizations could be the producers of geospatial information and that the users are passive recipients are problematic and restrictive to the development of useful SDIs. Moreover, operating an SDI with these assumptions misses the new opportunities created by the VGI phenomenon. In the next section we look at the alternative concept of the user that draws from the literature on appropriation of technology, open source software movement, and the Wikipedia experience. We propose a reconceptualization of the existing view of the SDI user, which expands the range of GI producers from formal organizations to individuals and groups. The inclusion of users in GI production allows building upon the *funds of knowledge* (Moll et al. 1992), which users already possess or they can create.

2.3 ALTERNATIVE VIEW OF THE USER: APPROPRIATION OF TECHNOLOGY, OPEN SOURCE SOFTWARE, AND WIKIPEDIA AS PRECURSORS

2.3.1 Appropriation of Technology

Understanding of the user requires analysis of the ways in which the user's information needs arise and the process through which the user seeks, searches, and puts information in use. The gap between what the user already knows and what s/he needs to know in order to complete the task, called anomalous state of knowledge (ASK), leads the user to information seeking (Belkin et al. 1982). Dervin and Nilan (1986) similarly note that when an individual's internal sense runs out, s/he experiences information need that arises from the gap between her/his current and desired situations and leads to the use of information. Both the tasks and related information seeking, search and use are often undertaken in complex social, cultural and technological situations. Moreover, information is not something that is transmitted invariably from database(s) to users to be directly used; it acquires a specific meaning given by the user at a certain time and space. "Information mediates between objects in the natural world, as data, and the inner workings of the human mind, as knowledge and wisdom" (Poore and Chrisman 2006, p. 511). In this process, users are required to continuously act and construct information in order to bridge the gaps. Thus, users' information behavior suggests that they are the actors of information.

Figure 2.2: Categories of appropriation in the consumption-production dimension (Eglash, 2004)



Several studies in information science have investigated the notion of the user as information actor. For example, Hippel (2007) reports that up to 40% of the user population interviewed have come up with some kind of innovation to suit their own use. Similarly, Eglash et al. (2004), and Oudshoorn and Pinch (2005) present a collection of case studies of appropriation of technologies by users. Eglash et al. (2004) discuss the notion of the user as an active actor in settings as diverse as innovative uses of information technology during Tiananmen Square protests in China and learning computer skills by African-American women.

Appropriation of innovation by users occurs at several levels of increasing sophistication (Figure 2.2): *reinterpretation, adaptation, and reinvention*. Reinterpretation is the weakest case of appropriation, where the use of functional and structural properties of technology remains congruent with the designer's intent. A stronger case of appropriation is adaptation, where users discover latent functions of technology in addition to its semantic change. Reinvention is the strongest case, where users create new functions through structural change in the technology. The degree of appropriation of an innovation is influenced both by characteristics of the innovation as well as the user. For adaptation to happen, users need to violate the producers' intended purpose and technology should offer flexibility (Eglash 2004).

2.3.2 Open Source Software

The open source software (OSS) movement provides compelling examples of users' active contribution towards software development. In the OSS production, dedicated computer programmers spend several hours per week on developing software components. In OSS development, users are considered co-developers where they have access to the software source

codes, are encouraged to add to the original codes and report bugs (Raymond 1999). VGI phenomenon could draw from the OSS experience, since the users' activities in OSS and VGI are similar in nature, except that users produce software in OSS while they produce spatial data in VGI. In fact, there are indications that VGI is influenced by OSS. For example, the Open Planning Project states: "TOPP draws inspiration from the ideas, processes, and successes of the open source software movement" (http://topp.openplans.org/, June 2008).

There are several motivations for users to actively contribute towards the production rather than just passively use software. One of them is the producer's failure to meet the users' requirements, which eventually stimulates the user to develop software. Users can create "precisely what they want, rather than being restricted to a set of options on offer that have been produced by others" (Hippel 2007, p. 310). Another is the free answers to queries provided by contributors in OSS development, who in turn receive valuable information (Lakhani and Hippel 2003). Additionally, some contributors are motivated by the enjoyment and reputation they gain from completing the work (Lerner and Tirole 2002). Furthermore, although the software code becomes public good, the participatory experience and learning stays with the contributor (Hippel and Krogh 2003).

Some explanations of the desire to contribute take the perspective of social movements. For instance, analyzing the survey responses of a large number of contributors to Linux kernel project, Hertel et al. (2003) suggest a parallel between the open source software movement and other social movements. They state that the "engagement for the Linux kernel community seemed to be driven by similar motives as voluntary action within social movements such as the civil rights movement, the labor movement, or the peace movement" (p. 16). Open source software allows the user to enjoy her/his freedom to express and use—the most fundamental human desire—which propriety software does not.

Proprietary and open source software also differ in their development models. By contrasting the two, Raymond (1999) calls the former 'cathedral-style' and the latter 'bazaar-style.' The 'cathedral model' is hierarchical; the 'bazaar model' is more democratic. In the 'bazaar model', everyone can watch, create, and contribute. Discussing the 'bazaar model' development of widely used operating system 'Linux', Raymond suggests that "[g]iven enough eyeballs, all bugs are shallow" (p. 29). Users' collective intelligence is the driving force behind the bazaar model. Thus, no matter what the motivations and processes are, users do not passively

use an innovation provided by the producer. Hippel (2007) concludes that users have sufficient incentive to create the 'users innovation network', and to participate in the innovation process. In a successful innovation, users are not treated as passive recipients, but as co-developers.

2.3.3 Wikipedia

The conception of the user as an actor of information is more obvious in the case of Wikipedia. Wikipedia project was created in 2001 and by 2008, it holds millions of articles that are uploaded by millions of contributors in hundreds of languages (www.wikipedia.org; May 2008). It is a collaborative knowledge production project, which allows anyone to edit, contribute, and use its content (Bryant et al. 2005, Kuznetsov 2006, Nov 2007). Most importantly, the reliability of the material is well maintained. A recent study finds that the quality of the articles in the Wikipedia is equivalent to those in the Encyclopedia Britannica (Nature 2005). Despite the difference in the nature of content—Wikipedia focuses on text information whereas VGI focuses on GI—both follow a similar process of knowledge production. Indeed, some VGI projects reveal an influence from Wikipedia, for example, the name 'Wikimapia'. Therefore, based on the phenomena discussed above and GI community's recent experiences with VGI, we can begin to reconceptualize the user of SDI in the following section.

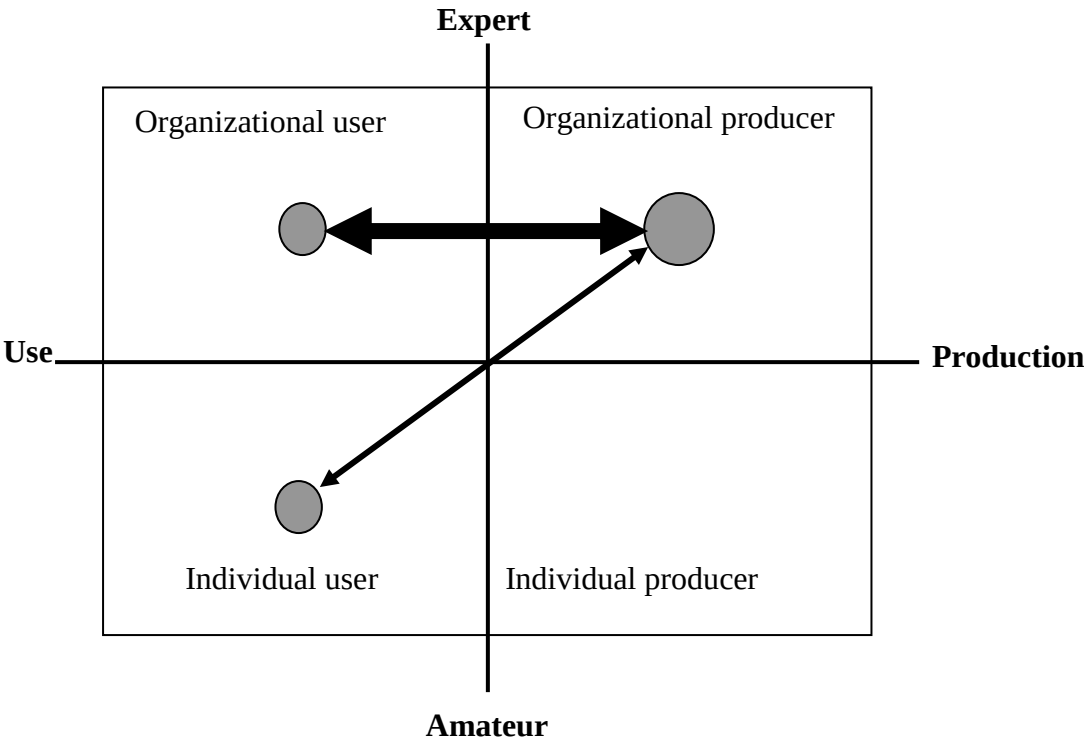
2.4 SDI USER RECONCEPTUALIZED: PRODUSER

Recently, millions of ordinary people have been actively engaging in the production, sharing, and creative use of GI (Boulos 2005, Miller 2006). While the use of geospatial knowledge held by ordinary citizens is not new in itself—we have been using citizen input for tasks such as cadastral adjudication, topographic map updating, for driving directions, and during travel in new places—the ease of use of Web 2.0 based tools and the sense of empowerment people feel from using these tools, have created a new wave of possibilities. In the aftermath of Hurricane Katrina, Google Earth images were more useful than the United States Geological Survey (USGS) maps for rescue workers attempting to locate victims and collaboratively describe the surrounding geospatial situation (Nature 2006).

Clearly, these VGI activities conflict with the traditional view of the user as a passive recipient. In order to explain and accommodate these activities, we propose to reconceptualize

the user of SDI as an actor of GI. This is illustrated by changing unidirectional lines connecting producers to users in Figure 2.1 to bidirectional as shown in Figure 2.3. As the notion of the user is reconceptualized, small circles that were not present in the upper and lower left quadrants in Figure 2.1 appear in Figure 2.3. This means that the production functions are now expanded from expert organizations to user organizations and individuals. Accordingly, the user's roles transcend from recipient to producer, and therefore we call them *produser*. The produser may choose to receive, appropriate, creatively use, share, and/or produce GI independently or in collaboration with others. Furthermore, the produser need not be limited to the organization; individuals and groups can also take part in the production and supply of GI.

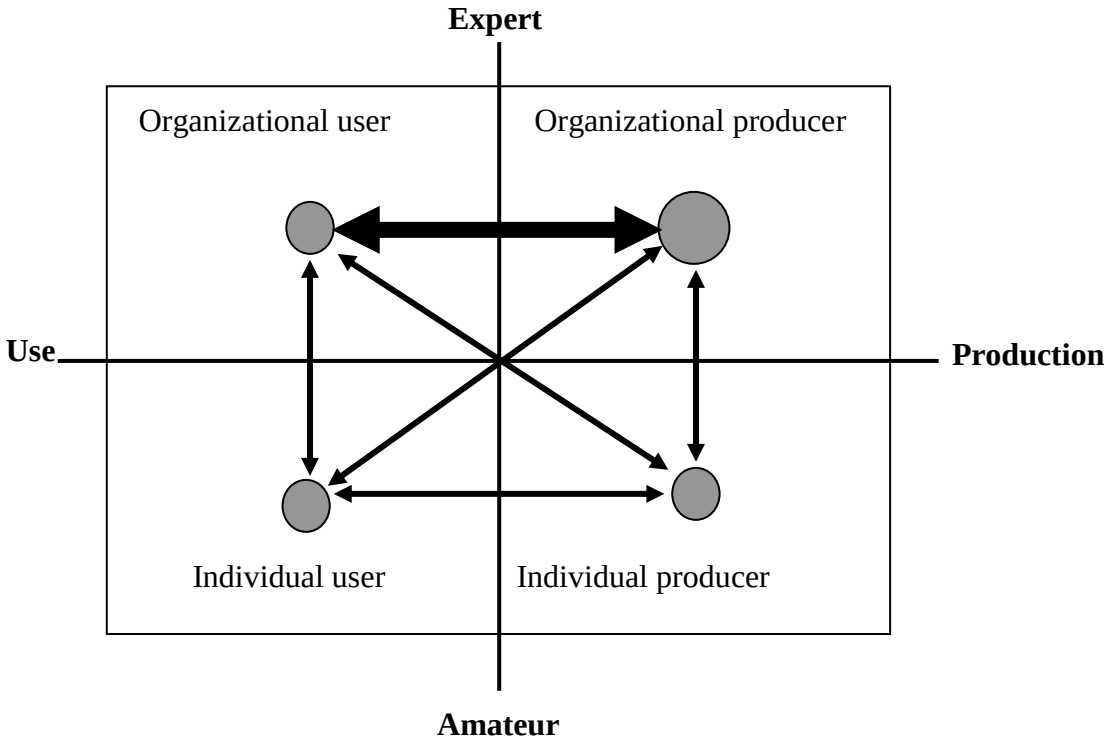
Figure 2.3: Reconceptualized notion of the user



Thus, the reconceptualization of the user establishes a two-way interaction between the producer and the user, which blurs the boundary between them. However, some individuals produce more than others. Therefore, we can place them in the lower right quadrant as in Figure 2.4. This distributes the production centers in all the quadrants. Because organizations or

individuals in any quadrant can produce and share GI with others located in any other quadrant, all the circles in Figure 2.4 are connected with each other.

Figure 2.4: Production-Use dynamic resulting from the VGI phenomenon



In the reconceptualized notion of the user, an SDI provider may ask the produser: 'what situation has brought you to access and use SDI?', rather than asking: 'what do you want from SDI?' This helps to understand the produser's information seeking and potential uses. The provider may also ask: 'how can this infrastructure enable your easy production, sharing, access, and use of information?', rather than asking: 'how can I provide information to you that best satisfies your needs?' One who considers the user as a passive recipient is likely to ask the second type of questions, whereas one who considers the user as a produser is likely to ask the first type. These seemingly small shifts in the way questions are framed may bring potentially large change in the conceptualization, design, and implementation of an SDI.

2.5 TOWARDS A HYBRID SDI MODEL: CREATING THE MIDDLE GROUND BETWEEN SDI AND VGI

Reconceptualization of the SDI user has led us to a framework with multiple GI production centers that are connected with each other forming complex networks of produsers (Figure 2.4). This framework suggests that produsers contribute as well as derive from others' contributions. Individuals can supplement organizational GI production and at the same time they can use the expert organizations' products; this is illustrated by the bidirectional lines connecting the upper and lower right quadrants. Produsers may point out the official producers' erroneous or missing data, as in the case of USGS's National Map Corps program (Bearden 2007).

There can be variations among VGI participants depending on the level of contribution and the degree of expertise. This could be expressed as the placement along the producer-user and expert-amateur continuum in Figure 2.4. For example, those individuals who choose to free ride (i.e. those who contribute little) are placed farther from the expert-amateur axis in the lower left quadrant; those whose contributions far outweigh their use are placed farther from this axis in the lower right quadrant; and those whose contribution and use levels are similar are placed near the axis. Similarly, individual producers with more GI expertise are placed closer to the producer-user axis in the lower right quadrant than those with relatively less expertise. Participants may also vary across VGI projects depending on the nature and goal of the project. For example, contributors to the Open Street Map are likely to have more expertise than contributors to the Degree Confluence project. In Open Street Mapping, produsers contribute geometry and description of streets (www.openstreetmap.org, May 2008). In the Degree Confluence project, produsers just take pictures at the locations where the integer degrees of geographic latitude and longitude intersect (http://confluence.org/, May 2008).

The multiple bidirectional lines among produsers in Figure 2.4 suggest that VGI and SDI are related phenomena. We argue that SDI can accommodate VGI with the reconceptualized notion of the user. Users' contributions of information in VGI fits quite well as patchworks to SDI (Goodchild 2007a). However, at present, it is unclear how the lines in Figure 2.4 will influence and shape each other, and in which direction. Some have called this current state 'a stage of anarchy' (Carrera and Ferreira 2007), as little is known about how amateurs and experts are interacting in the production and use of GI.

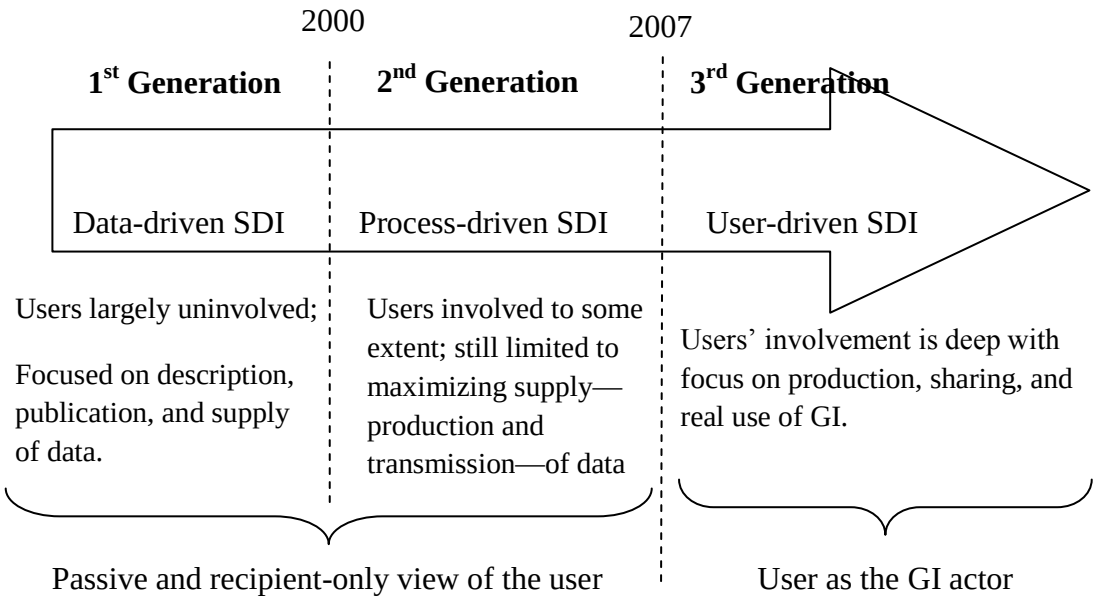
At the conceptual level, the emergence of SDIs is in itself a manifestation of the expansion of GI production centers from NMAs to a large number of other organizations. For example, the United States National SDI encompasses a network of hundreds of organizations (Goodchild et al. 2007) that acknowledges the distributed production of GI among these organizations. This distribution now needs to be widened from organizations to individuals to accommodate VGI. We argue that the conceptual foundation SDIs have developed over the last two decades can be useful in VGI context as well. Conceptual apparatuses such as metadata, standards, interoperability, policy, and organization have been evolving in SDI research (Budhathoki and Nedovic-Budic 2007). The concept of metadata, for example, could be applied to VGI, perhaps with reduced mandatory elements of metadata standards for amateurs or for certain GI types. In fact, the metadata is even more important for VGI than SDI, given that GI is supplied by a large number of produsers which is more difficult to discover. The long-standing experience in the contemporary SDI combined with the produsers' excitement in VGI can create a richer GI infrastructure, which we refer to as the hybrid SDI model.

In fact, the synergy between SDI and VGI has already begun to happen. For example, Google and Environmental System Research Inc. (ESRI) recently announced an intention to integrate ESRI's professional GIS product with Google's VGI product (http://radar.oreilly.com/, June 2008). The recent decision by Yahoo! to provide its high resolution aerial imagery to the Open Street Map (See http://www.opengeodata.org/, May 2008) is another evidence of the complementary nature of various approaches to SDI. Thus, VGI is forcing the expert producers to rethink their traditional approaches of GI production. Further, Google Map, which is considered as one of the most popular VGI tools, relies on a hybrid model. It is the synergy between the street networks produced by NAVTEQ and Tele Atlas (the expert producers) that Google uses (http://maps.google.com/, June 2008), as well as its produsers' contributions that has popularized the Google map. However, it is unlikely that VGI will completely replace SDIs. For example, amateurs would not be able to create maps, had Google Map not provided the streets as the basic frames. Along the same line, OSS and proprietary software have influenced each other and resulted in new models. For example, IBM is not only providing financial support to popular OSS products like Linux and Apache, but also adopting a different business model by selling products for which an increased demand is created by the OSS products (Benkler 2005).

Also, VGI is unlikely to satisfy a vast majority of institutional and professional GI produsers whose requirements in terms of data quality, timeliness, and completeness are not flexible.

SDI researchers have called for a user-driven SDI model (Williamson 2003, Masser 2005a, Budhathoki and Nedovic-Budic 2007), which relates to the hybrid SDI that incorporates VGI. The synergy between SDI and VGI has a potential to lead to a third generation SDI in its development continuum proposed by Rajabifard et al (2006). This model of SDI could tap numerous VGI participants similar to Google map, Google Earth, and similar other products. It would enable SDIs to obtain and provide fine-grained GI produced by spatially-aware individuals. In such an SDI, produsers' collective intelligence and local knowledge are harnessed. Further, produsers are deeply involved and empowered, and a more bottom-up, incremental and evolutionary approach is adopted.

Figure 2.5: Next generation SDI emerging from VGI (Adapted from Rajabifard et al.2006)



2.6 CONCLUSIONS

In this paper, we argue that SDI and VGI are not separate, but complementary phenomena. Indeed, these can be brought within a single framework when the role of the user of SDI is reconceptualized to *produser* and VGI is included in the SDI-related processes. We show

that such a reconceptualization distributes the production of GI among organizations, individuals, and groups of individuals. Such a reconceptualization creates a hybrid SDI model that draws on the synergy between the conceptual foundation of SDI and an extensive user base of VGI.

The emergence of the hybrid SDI suggests several new research directions. Instead of being focused either on SDI or VGI, we now require research that focuses on the boundary phenomenon. Some questions might be: how should traditional GI producers now redefine their roles? Which of the GI production tasks are to be distributed to individuals or groups of individuals, and which are to be retained by traditional producers? Which aspects of SDI and VGI neatly synergize, and which of them conflict? Which SDI conceptual tools need to be extended or even redefined in the context of emerging VGI phenomenon? Such questions require a careful consideration of several issues: access to technology (penetration of the Internet in particular), cultural values, skills, and education, among others.

While the informational aspect has received greater attention, the infrastructural aspects need equal consideration in VGI research. How do backend infrastructures—which are often invisible (Star and Ruhleder 1996)—emerge and evolve to support VGI activities? How can a large number of participants, without being coordinated by any formal organization, collaboratively produce something when there is no obvious monetary reward? What motivates them? What organizing principles do they follow? Are these principles transferable to the settings of formal organizations? In addition to accommodating VGI, addressing these issues could illuminate a wide range of organizational and institutional problems that limit the effective development and use of SDIs.

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CHAPTER 3
AN INTERDISCIPLINARY FRAME FOR UNDERSTANDING VOLUNTEERED GEOGRAPHIC INFORMATION

3.1 INTRODUCTION

The term ‘volunteered geographic information' (VGI) has drawn increasing attention in academia, business, and government alike. In academia, this is evident from special journal issues (GeoJournal, 2008; Geomatica, this issue) and dedicated sessions on the topic in major conferences such as the Association of American Geographers and Global Spatial Data Infrastructure. In business, companies are seeking to integrate user-contributed geographic information (GI) to their business model. For example, Google has opened its map for users from more than 100 countries to edit (Google, 2009); TeleAtlas sees users’ contribution as a valuable means of keeping its maps current (See 'Report map changes' at http://www.teleatlas.com); and CloudMade uses OpenStreetMap (OSM) data to provide value-added services (CloudMade, 2009). VGI content also has implications to governments. It creates a synergy between authoritative and volunteered sources of GI, enabling the distribution of government-centric production of GI to individuals and groups of individuals (Budhathoki et al. 2008).

VGI is driven by contributors’ collective efforts. The efforts to contribute GI without an apparent or direct monetary reward or someone's direction suggest that VGI departs significantly from the traditional mode of GI production. This new mode of GI production resembles the creation of open source software and production of knowledge such as Wikipedia. Benkler (2005, 2006) describes these phenomena as ‘puzzling’. Understanding why individuals scattered around the globe—many of whom are unlikely to meet each other—would invest themselves in such an effort would help resolve the puzzle. Only a few years ago, it was difficult to imagine that people would collaboratively produce online maps as detailed as in OSM.

A closer look at the phenomenon reveals further complexities. For instance, in OSM, one of the well-developed VGI projects, we find that less than 10% of the users contribute more than 80% of GI content, and about 40% of the users do not return to the site after their first contributions. This is intriguing and prompts us to question: Why do some individuals contribute

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large amounts of information whereas others do not? How do the contributors' motivations change as they engage in VGI activities? While some researchers speculate that altruism is the primary motivation (Goodchild, 2007a), others suggest that the underlying motives are more complex (Elwood, 2008; Tulloch, 2008).

Furthermore, the nature, process, and outcome of contributions vary among VGI projects. The nature of contribution includes place descriptions, insertion of push-pins, as well as substantial data development (e.g., a street network in the case of OSM). Regarding the process, some projects such as Google Map Maker moderate contributions using dedicated staff, whereas others such as OSM simply follow the norms established by its volunteer community.
The outcomes of users' contributions constitute a public good that lies at different points of the public-private continuum. Public goods are characterized by two characteristics: indivisibility, meaning that one person's consumption of the good does not reduce the amount available to another; and non-exclusiveness, meaning that it is difficult or impossible to exclude individuals from benefiting from the good (Kollock 1999). For example, while both OSM and Google Map might appear similar at the surface from the perspective of public good, their underlying copyright laws are markedly different.

Researchers recognize that understanding users' motivations is necessary to advance the VGI process (Elwood, 2008; Flanagin & Metzger, 2008; Haklay & Weber, 2008; Tulloch, 2008). For example, Goodchild (2007a) considers VGI as a serious source of GI and emphasizes motivation as an essential condition for capitalizing this source. Budhathoki et al. (2008) develop these arguments further and ask: "How can a large number of participants, without being coordinated by any formal organization, collaboratively produce something when there is no obvious monetary reward? What motivates them? What organizing principles do they follow?" (p.10).

Research on VGI motivation has not progressed beyond initial discussions (Coleman et al. 2009). Currently, there is insufficient understanding on what drives people to contribute, what impedes their contributions, how motivations relate to different levels of contribution, and how motivations change as users engage in VGI. A deeper understanding of motivations is essential for designing systems that garner greater contributions. In addition to the amount of information, motivation has potential implications regarding the overall value of geographic information, the mapped coverage of the earth's surface, the credibility of the source, and the protection of

privacy. However, to date, there is no theoretical framework to guide the study of VGI motivations. In order to fill this gap, we first propose a VGI conceptual framework (VGI-CF) and then use it to begin deeper investigation of participants' motivations to contribute GI. We hope that, in addition to studying motivations, the framework provides a resource for researchers to systematically examine other aspects of VGI.

In section 3.2, we construct a conceptual framework depicting the relationships among various elements and processes affecting VGI. In section 3.3, we review relevant literature on volunteering, leisure study and social production of knowledge (which can also be considered as user-generated content) to identify factors that are potentially useful for examining contributors' underlying motives in VGI. The factors identified in section 3 are categorized into intrinsic and extrinsic motivations in section 3.4. In section 3.5, we analyze OSM to illustrate how the motivational factors identified in section 3.3 could play out in VGI. We conclude in section 3.6 by summarizing the key elements of the proposed framework and discussing potential research venues.

3.2 VGI CONCEPTUAL FRAMEWORK

A framework is an analytical scaffold that contains a set of logical building blocks and their interconnections (Ostrom & Hess, 2007). By providing a big picture, it helps us to analyze the problem in a more holistic way and provides a useful tool for systematic investigation of both static and dynamic situations. One such situation is the study of online knowledge communities including VGI, which continuously evolves in terms of membership, norms, rules and outcomes. Bruce (2009) refers to this study as community inquiry. *Community* emphasizes support for collaborative activity and for creating knowledge, which is connected to people's values, history, and lived experiences. *Inquiry* points to support for open-ended, democratic, participatory engagement. *Community inquiry* is thus a learning process that brings theory and action together in an experimental and critical manner (Bruce & Bishop, 2008).

The VGI framework presented here adapts ideas from Nedović-Budić and Pinto (1999) and Ostrom and Hess (2007). Nedović-Budić and Pinto (1999) provide four constructs—context, motivation, coordination mechanism, and outcomes—to facilitate understanding of the development and sharing of geographic information systems (GIS) in inter-organizational settings. Organizational and inter-organizational contextual factors influence decisions and

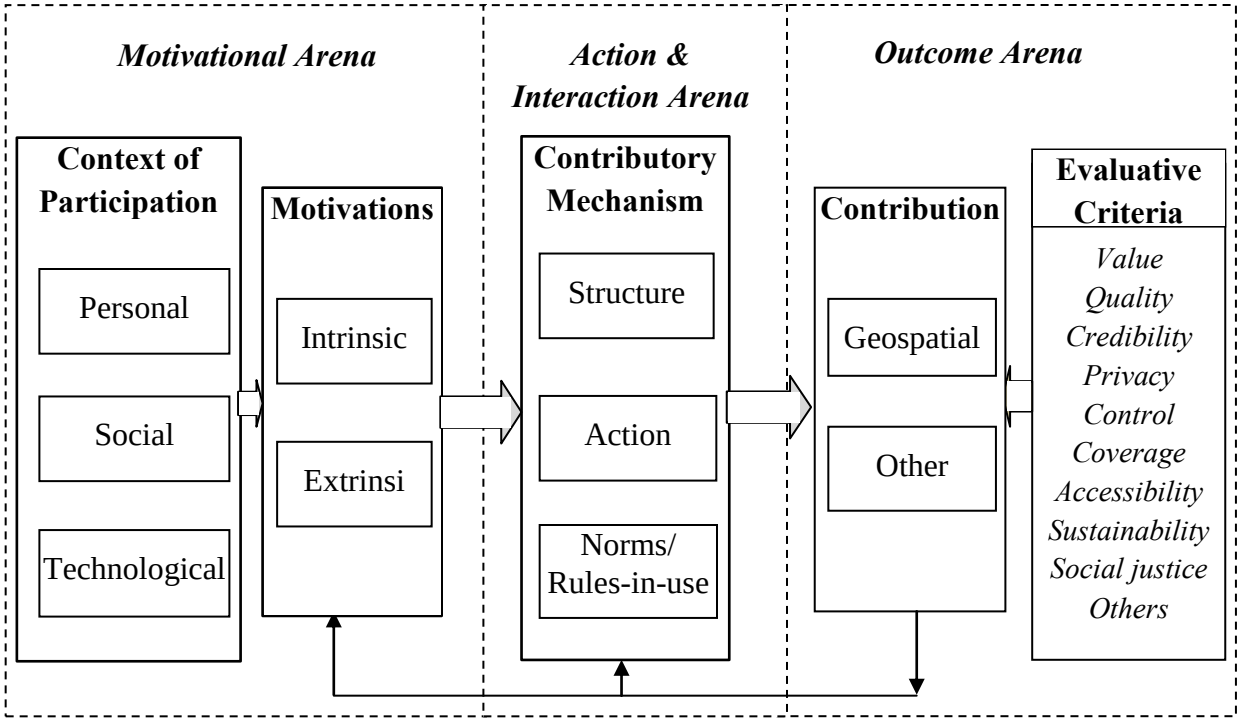
attitudes about multi-party database and GIS development. Motivations such as authority, common interest or various inducements (e.g., cost savings, returns on investment, power relationships, professional prestige, and organizational needs) are the factors that stimulate organizations to coordinate and undertake joint GIS development. Coordination mechanism comprises structures, processes, and policies that are set up by the involved entities and are crucial for effective management and success of geographic information relationships. Finally, outcomes refer to the organizational and broader impact of shared geographic information and systems. In addition to organizational efficiency, effectiveness, and public service, one could consider data quality, availability and accessibility, satisfaction with organizational returns, expanded or improved relationships and compatibilities, broadening of organizational mission and overall satisfaction. Although these constructs are developed to understand the development and reuse of geographic information in the settings of formal organizations, the elements of context, motivations, coordination, and outcomes are present in VGI—although their presence might be in different form and they might play differently—and hence these are useful in the construction of the VGI framework.

Ostrom and Hess's framework provides a tool for analyzing knowledge commons, where knowledge common is defined as a shared resource for addressing different problems (Ostrom and Hess 2007). Some of the elements of the framework in the context of online knowledge environment are: material conditions underlying the common (e.g. computer hardware and other accessories necessary to produce, store and use knowledge), online community and patterns of interactions among the members of the community who take part in the production and use knowledge, and rules that govern the community. Because GI in most VGIs is a kind of knowledge common, Ostrom and Hess's work informs for the construction of the VGI framework.

However, while both these frameworks offer valuable insights to build on, VGI has certain distinctive characteristics that require a new framework (Figure 3.1). For example, the absence of formal mandates and the self-organizing nature of the community distinguish it from inter-organizational GI sharing. Because monetary incentive and mandates are largely absent in non-formal and voluntary settings, participants' self motivations become crucial. Further, while distribution of contributors in terms of their physical locations is irrelevant in many online knowledge communities, it becomes crucially important in VGI. This is because only those who

have knowledge about the local spatial situation can contribute accurate information to VGI. Further, unlike many other knowledge commons, the geometric aspect of knowledge makes VGI a different kind of knowledge common.

Figure 3.1: A conceptual framework for VGI



3.2.1 Motivational Area

The motivational arena refers to people and the sources of their motivations to contribute to and manage a volunteered GI database and underlying technical infrastructure (e.g., hardware and software). It also includes people who provide input into the development of community norms and policies, or merely use information contributed by others. However, this paper is focused on peoples' motivations to contribute GI. Such motivations arise from one's personal, social, and technological context, which can be classified into intrinsic and extrinsic factors. There is a direct connection between motivation and personality traits (Deci & Ryan, 1985; Wagner, 1999). Motivations tend to be aimed at regulating the self—such as self-perception, self-esteem, self-actualization, and achievement (Wagner, 1999)—as well as maintaining consistency among beliefs, attitudes, feelings, and knowledge (Festinger, 1957). When

individuals experience a mismatch among these modes of cognition, the resulting state of cognitive dissonance motivates them to project a certain behavior to reduce the mismatch. Additionally, one's motivation to do certain things is likely to be associated with where one is situated in the hierarchy of human needs (Maslow, 1954).

Social framework, both structures and interactions, influences human behavior directly or indirectly. Behaviors such as status gain, self-presentation, reciprocity, cooperation, even altruism are deeply rooted in the social fabrics. If someone is motivated by status gain, that person might opt to accumulate wealth, education, or a position of authority, depending on what is recognized as status in a particular society (Walsh, 1992).

Scholars find that social factors are significant motivators behind contributions to online knowledge communities (Hertel, Niedner, & Herrmann, 2003; Kuznetsov, 2006; Nov, 2007; Raymond, 1999). However, engagement in online knowledge activities differs across societies. For example, Subramanyam and Xia (2008) report that North Americans have higher intrinsic motivation (motivation that comes from within the person) than Chinese and Indian contributors in open source software development. In universal, more modular, and large-scale projects, Chinese contributors are motivated by intrinsic motivation whereas Indians are motivated more by extrinsic motivation (motivation induced from external sources such as money or direction). Others have distinguished between gift and commodity economies, and have employed the perspective of a gift economy to explain motivation in online knowledge production. Because the contributor does not receive a direct monetary reward, commodity economy alone cannot explain the contribution. People contribute knowledge as a gift to the whole community that comes with a diffuse and usually unstated obligation to repay it at some future time (Kollock, 1999; Zeitlyn, 2003).

Emphasizing the role of technology, Benkler (2006) argues that new technical affordances enable people to freely create and share knowledge. The technological context in which one is situated (technical infrastructure, skill level, learning support system, etc.), may shape his/her motivation to contribute knowledge online. Scholars attribute the rise of VGI to several concomitant technological developments: computer storage and processing capacity; graphics hardware; geo-referencing; geo-tagging; the Global Positioning System (GPS); broadband communication (Craglia, et al., 2008; Goodchild, 2007b); web development techniques such as AJAX (asynchronous JavaScript and XML); removal of selective availability

of GPS signals (Haklay & Weber, 2008); web 2.0; and subsequent releases of application programming interfaces (APIs) from Microsoft, Google, and Yahoo! (Haklay & Weber, 2008; Miller, 2006). An individual's motivation and ability to contribute to VGI are influenced by the level of access to the technological tools and the capacity to utilize them.

3.2.2 Action and Interaction Arena

Motivation is a necessary, but not sufficient, condition for the production of knowledge commons in cyberspace. A group of motivated people still needs mechanisms to address common problems faced in the collective realm—for example, free riding, congestion, conflict, overuse, and pollution. The way people interact and coordinate plays an important role in collective action (Oslon, 1965), as evidenced in the areas of urban planning (Hopkins, 2001) and online knowledge production (Kollock, 1999).

The action and interaction arena of the framework addresses the process of decision-making and actually contributing GI. It focuses on how people interact and cooperate; what factors they consider in their decisions; and how different norms, processes, and structures affect such decisions. Careful analysis of this arena is needed to understand strategies for garnering contributions and successfully implementing VGI efforts.

Rules-in-use or norms are generally shared normative understandings that serve to make participants aware of what they must, must not, or may do in certain action situations (Ostrom & Hess, 2007). For example, contributors are not supposed to upload copyrighted GI materials to OSM (www.openstreetmap.org). Rules-in-use may also involve some sort of sanction for noncompliance. A thriving online knowledge community usually defines these norms itself, giving a sense of freedom and ownership to its members that is often missing in formal organizations.

When the members of a community begin to follow the norms, those norms gradually take the form of structures. Structures evolve as a result of the interactions between the people and the technology. They eventually constrain the members (and non-members) as they determine what a member can or cannot do (DeSanctis & Poole, 1994). Even seemingly loosely organized projects such as OSM have certain structures (e.g., its API). Application programming interfaces in OSM have been developed to let users import, export, edit, and tag data (Haklay & Weber, 2008). Once in place, these same APIs crucially determine what information one is able

to contribute, access, or use. However, one of the important features of many self-organizing knowledge communities is that structures are flexible and hence can be changed when members feel necessary.

Action refers to a user's actual decision to contribute within the constraints of structures. Examples of the relevant actions in VGI could be uploading the geometry of geospatial objects, editing someone's contribution, or initiating a new discussion thread to affect the existing community norms. Actions can be taken by an individual or a group or even an organization. The decision by Yahoo! to contribute its satellite imagery to OSM is an interesting example of an action at the organizational level. Analysis of actions and the resulting patterns of interaction might provide rich insights for understanding different aspects of VGI.

3.2.3 Outcome Arena

The outcome arena of the framework consists of contribution and evaluative criteria. *Contribution* can be divided into two categories: geospatial and other. Contributions under GI are the aggregate repository of user-contributed geo-referenced information. Such a repository may contain different types of information (e.g., points, lines, polygons, images, pictures, or text) depending on the goals of a specific VGI project. An individual can also make other contributions in VGI. For example, in OSM talk-pages, registered users can contribute by raising issues, commenting on issues raised by others, and engaging in conversations with other members of the community.

Many researchers have, indeed, shown interest in the outcome arena of the framework, examining, for example, trust and credibility of the volunteered source (Bishr & Mantelas, 2008; Flanagin & Metzger, 2008); quality, coverage, and social justice (Haklay, under review); privacy and control (Harvey, 2007); access, and empowerment (Tulloch, 2007, 2008); and overall value and impact on the social and political process (Elwood, 2008). These provide a variety of perspectives for evaluating data in VGI.

3.2.4 Extending the Definition of VGI

Goodchild (2007b) defines VGI as a new phenomenon, which consists of GI contributed largely by untrained citizens on a voluntary basis. However, our framework (Figure 3.1) suggests that those who participate in VGI may be situated in different personal, social, and technological

contexts, with different levels of intrinsic and extrinsic motivations and GIS expertise. While the major portion of data in VGI may continue to come from citizen volunteers, the reality is that other sources play an important role as well. For example, OSM uses satellite imagery from Yahoo! and CloudMade mobilizes its staff for organizing mapping parties in order to collect data for OSM. Google is putting a special effort into collecting GI from citizens through the system called Google Map Maker. Similarly, there are indications that local governments, non-profit and other organizations are interested in contributing their data to OSM. Thus, the VGI definition proposed by Michael Goodchild is somewhat limited, excluding participants whose contributions are not purely voluntary or who are professionals.

Further, the three arenas of the framework—motivation, action and interaction, and outcome—and its constituent elements interact and influence each other. For example, satisfaction gained by seeing one's contribution on a map might motivate an individual to contribute more GI; change in structure or community rules might motivate or demotivate a contributor; action of a motivated contributor might influence and eventually change the structure. Thus, the framework suggests that a variety of actors may take different actions to serve their motives in VGI. Further, interactions among different elements—which evolve over time—can be complex. Hence, we extend the original definition to conceive VGI as a complex GI ecology resulting from different actions and interactions that actors engage in order to serve their underlying motives.

In the remainder of the paper, we focus on VGI motivation and depict its manifestation in various other activities—volunteerism, leisure, and social production of online knowledge—and illustrating them in the context of OSM.

3.3 POTENTIAL MOTIVATIONS FOR GI VOLUNTEERING – LITERATURE REVIEW

Literature from the sociology of volunteering, leisure studies, and social production of knowledge are considered relevant for VGI. Volunteerism is the foundational concept in VGI (Goodchild 2007b; Elwood 2008). This strand of literature is reviewed to identify relevant frameworks and models of volunteers' psychological and social psychological constructs that drive them to volunteerism. The literature from leisure studies are used because contributions to VGI are likely a form of leisure activity, i.e., it does not constitute the main work role, at least for majority of contributors. Finally, we consider literature from social production of knowledge,

which refers to various kinds of media content users create on the web. These include news, videos, reviews, blogs, podcasts, pictures, software and wikis. We specifically consider open source software, Wikipedia and knowledge sharing in virtual community in our review as researchers have suggested that knowledge production in VGI is similar to the collaborative construction of knowledge in Wikipedia and open source software (Budhathoki et al. 2008).

3.3.1 Volunteerism

While people's voluntary participation in GI activities online is a relatively new trend, volunteerism in itself is not new. For example, there is an estimate that about 84 million American adults volunteered in 2001, representing the equivalent of over 9 million full-time employees at a value of $239 billion (Independent Sector, 2001). Because volunteerism involves a significant level of personal sacrifice, what motivates individuals to initiate volunteer actions, what directs them in these actions, and what helps their sustained engagement have been extensively studied (Clary, et al., 1998; Clary & Synder, 1999; Finkelstein, Penner, & Brannick, 2005; Houle, Sagarin, & Kaplan, 2005). For the purpose of this paper, we primarily draw on the motivational factors identified in Clary et al. (1998) and Clary and Synder (1999), as their findings have been widely used to examine different volunteering activities and hence have been tested and subsequently improved. Further, Clary et al.'s (1998) volunteer functions inventory (VFI) have already been applied to study motivations in online knowledge production systems such as Wikipedia (Nov, 2007).

Clary et al. (1998) define volunteerism as a planned contribution in which individuals: (1) often actively seek out opportunities to help others; (2) may deliberate for a considerable amount of time about whether or not to volunteer, the extent of their involvement, and the degree to which a particular activity fits their own personal needs; (3) may make a commitment to an ongoing helping relationship that may extend over a considerable period of time and that may entail a considerable personal cost in time, energy, and opportunity. Although people who engage in volunteerism might appear to be similar on the surface, they might have different underlying motivational processes and take the same actions for different psychological functions (Clary, et al., 1998).

The functional approach concerns the reasons, purposes, plans and goals that serve the volunteer’s personal and social functions. Clary et al. (1998) and Clary and Synder (1999) find

that individuals engage in volunteerism to serve the following six functions, collectively called the volunteer functions inventory (VFI):

Value: the individual volunteers in order to express or act on important values like humanitarianism.

Understanding: the volunteer is seeking to learn more about the world or exercise skills that are often unused.

Enhancement: one can grow and develop psychologically through volunteer activities.

Career: the volunteer has the goal of gaining career-related experience through volunteering.

Social: volunteering allows an individual to strengthen his social relationships.

Protective: the individual uses volunteering to reduce negative feelings, such as guilt, or to address personal problems.

Houle et al. (2005) have used Clary et al.'s (1998) VFI to examine whether potential volunteers have a task preference. They find that if there are different choices of tasks within a project, potential volunteers choose the tasks that best match their motives. Finkelstein et al. (2005) blended Clary et al.'s (1998) functional motives and role identity models to understand an individual's persistence in volunteerism. They identified two additional factors that drive continuation in volunteering: *role identity* and *perceived expectation*. With continued participation, the volunteers internalize their roles in volunteering work in order to develop an 'identity' or 'role identity'. Volunteers' persistence also depends on their perception of how valuable others think their voluntary contributions are and the extent to which their significant others expect them to continue the work.

Several studies have explored people's voluntary actions from the perspective of social movements such as movements for civil rights, peace, labor rights, community identity, and ethnic identity (Klandermans, 1997; Simon, et al., 1998). A social movement is defined as an effort by a large number of people to solve collectively a problem that they all share (Simon, et al., 1998; Toch, 1965). Klandermans (1997) distinguishes three major classes of motives behind people's participation in social movements. The first class is the collective motives, which comprise the *goals of the movement* and the volunteer's perception of the likelihood of achieving these goals. Thus, the higher the person's valuation of the goals and the prospect of attaining

these goals, the stronger the participation and the greater the contribution to the social movement. The second class is the social motives, which represent the *reaction of significant others* to an individual's participation in social movement. The third class is the reward motives, which include the analysis of the *cost* and *benefit*—such as time and money—resulting from an individual's involvement in voluntary works. Later, Simon et al. (1998) extended Klandermans's three classes of motives for social movement with an additional class called collective *identification* motives. In addition to weighing the costs and benefits, individuals define themselves as members of specific groups in a social movement and behave according to the norms and standards of those groups (Simon, et al., 1998).

3.3.2 Leisure

Stebinns (2006) defines leisure as: "uncoerced activity engaged in during free time, which people want to do and, in either a satisfying or a fulfilling way (or both), use their abilities and resources to succeed at this. 'Free time' is time away from unpleasant obligation, with pleasant obligation being treated here as essentially leisure,..." (p. 7). The leisure perspective has been used to study a variety of activities including learning beyond formal settings (Jones & Symon, 2001) and hacker culture in the Web (Brown, 2008).

Depending on the positive psychological state generated in an individual, leisure activities can be classified into one of three classes: serious, casual, and project-based (Stebbins, 2006). Individuals seek a pleasurable activity that provides immediate, intrinsic, and relatively short-lived rewards that requires little or no special training to enjoy it in casual leisure (Stebbins, 1997). Taking a short nap and passively watching television are some of the examples of casual leisure. Project-based leisure involves creative undertakings that are short-term, moderately complicated, either one-time or only occasional, and carried out in free time (Stebbins, 2005). Although this type of leisure requires considerable planning, effort, and sometimes skill, the occasional nature of project-based leisure distinguishes it from other types of leisure. Taking part in religious festivals or birthdays are examples of project-based leisure. Serious leisure is "....the systematic pursuit of an amateur, hobbyist, or volunteer core activity that is highly substantial, interesting, and fulfilling and where, in the typical case, participants find a career in acquiring and expressing a combination of its special skills, knowledge, and experience" (Stebbins, 1992, p.3). It requires the most intense effort and persistence among the

three types of leisure (Gould, Moore, McGuire, & Stebbins, 2008; Stebbins, 1982). In return, serious leisure participants receive a sense of self-fulfillment that is often missing in the other two types of leisure. The adjective 'serious' denotes earnestness, sincerity, importance, and carefulness, rather than gravity, solemnity, joylessness, distress, and anxiety (Stebbins, 2006). Serious leisure participants are driven to leisure activities by their unique ethos, are inclined to identify themselves with their chosen pursuit and seek both personal as well as social rewards out of the leisure engagements (Gould, et al., 2008; Stebbins, 1982). A *unique ethos* implies the existence of distinguishing ideals, values, sentiments, or guiding beliefs that are shared by the members of a serious leisure social world. Participants in serious leisure are inclined to strongly *identify* themselves with their chosen pursuit. For example, persons who have climbed the Himalayas several times are likely to introduce themselves as climbers. In addition, serious leisure participants seek a number of durable outcomes, both personal and social, in return for their time and effort.

Among the personal rewards are enrichment, self-actualization, self-expression, self-image, self-gratification, re-creation, and financial return (Gould, et al., 2008; Stebbins, 1982). *Personal enrichment* is a process of increasing one's intellectual or spiritual resources, by accumulating cherished and valued experiences. *Self-actualization* comprises the development and application of one's talents, capacities, and potential. *Self-expression* consists of the expression of one's abilities and individuality. *Self-image* is enhanced through the expression of unique skills, abilities, and knowledge. *Self-gratification* refers to the satisfaction of one's own desires in activities that may be at once fun, but also profound and fulfilling. *Re-creation* is the process of forming a new self; the serious leisure participant experiences a sense of renewal, regeneration or reinvigoration. *Financial return* is simply remuneration for products or expertise gained during the activity.

In addition to the individual outcomes, serious leisure participants also seek social outcomes: group attraction, group accomplishment, and group maintenance (Gould, et al., 2008; Stebbins, 1982). *Group attraction* outcomes are derived from associating with other serious leisure participants. *Group accomplishment* outcomes are derived from group collaboration, which gives the participants a sense of helping out, being needed and being altruistic. *Group maintenance* pertains to efforts on behalf of the serious leisure participant to ensure that the serious leisure group is maintained, continues to develop, and remains a cohesive unit.

3.3.3 Social Production of Knowledge Online

VGI research can benefit from the study of motivational dynamics that drive volunteers to contribute to other online communities. Production of knowledge in virtual communities such as open source software, Wikipedia, and blogging sites—collectively called social production of knowledge (Benkler, 2006)—can provide insights useful for investigating motivations in VGI. As the cost of computer and data communication technology continues to decrease, these technologies are becoming accessible to more people. Consequently, the online volunteer community is rapidly growing every year (Sproull & Kiesler, 2005).

Wasko and Faraj (2005) used the notion of collective action and social capital to study the individual's motivations in online knowledge sharing. They investigated an online community of professional lawyers where members of the community post questions and answers without remaining anonymous. They found that people participate in online communities to contribute knowledge if they perceive that it helps their professional *reputation* (individual motivation); if they are structurally *embedded in the network* (structural capital); and if they have *knowledge and skills* to contribute (cognitive capital or self efficacy); some people also contribute because they *enjoy helping* others.

Hertel et al. (2003) and Hertel, Konradt, & Orlikowski (2004) have proposed a model called VIST—valence, instrumentality, self-efficacy, and trust—to explain people's motivations to work in small virtual teams. Valence represents the potential participant's subjective evaluation of the *team goals*; the level of an individual's motivation to participate is directly proportional to the outcome of this subjective evaluation. *Instrumentality* is the perceived indispensability of an individual's contribution for the group outcome; the higher the perceived instrumentality of an individual's contribution, the greater is the motivation to contribute. *Self-efficacy* is an individual's perception about his own capability to meet the expectation of other members of the team; if an individual believes that he is unable to accomplish the task in the team, it lowers his motivations to contribute. Finally, trust has two components: interpersonal trust and system trust. *Interpersonal trust* is the expectation that other members of the team will not exploit an individual's contribution; instead it will be reciprocated. Since the existence of the community and the continuation of the contribution rely on the underlying electronic system, one's *trust in the system* itself is also important for sustained motivations to contribute.

Lee, Im, and Taylor (2008), who used a mixed method of survey and in-depth interview to examine individuals' motivations in voluntary self-disclosure of information through blogging, find seven primary motivational factors. Bloggers use Web space to present themselves in the desired light *(self presentation)* and believe that blog helps them to better manage their relationships *(relation management)*. Blogging helps people to keep up with the latest trends *(keeping up with trend)* and also allows sharing knowledge and expertise *(altruistic motive of information sharing)*. Some use blogs as spaces for storing information *(information storage)*. Finally motive of entertainment *(entertainment)* and showing off *(showing off)* also drive individuals in the voluntary sharing of their information and knowledge on the Web.

Lerner and Tirole (2002) used literature in labor economics to analyze people's contribution to open source software. They suggest that there are incentives related to *career* and *ego gratification*, which can collectively be called signaling incentives. Contributors who are more concerned about their careers signal their skills and talents to potential employers for future jobs and share in commercial companies or future access to the venture capital market. Ego gratification largely comes from peer recognition. Lakhani & Hippel (2003) analyzed the slightly mundane and peripheral field support system of the Apache Web server. In the field support system, individuals contribute their knowledge to others for overcoming software problems. It takes only a short time for contributors to respond to their peers' questions because they already know the answer; they actually spend more time reading the postings and *learning* from others (Lakhani & Hippel, 2003). Thus, volunteers visit the public posting of questions and answers to receive valuable information for themselves.

Hertel et al. (2003) uses theories of voluntary participation in social movements (Klandermans, 1997; Simon, et al., 1998)—the collective motive, social motive, reward motive and identity motive—to investigate the motivational process in Linux, a widely used open source operating system. They report the following as key motivational factors: *general identification* as a Linux user; *specific identification* as a Linux developer; the desire to *improve one's own software* and obtain *career related benefits*; reaction from *significant others* (family, friends etc.); *social* and *political* motives related to the development of non-proprietary software and *networking* with the Linux community; and *hedonic* motives related to programming. They find that the motivational forces in open source software are consistent with motivations behind voluntary actions in social movement and virtual networks. Shah (2006) compares participants'

motivations in two software communities with different governance structures: one is open source software and the other is a gated—the one where the benefits of collective development are selectively combined with the corporate benefits—software community. She suggests that there are two types of participants: need-driven and hobby-driven. Need-driven participants are motivated by *reciprocity*, future *software improvement*, the *desire to integrate one's own code* into the software, and *career* concerns. Hobby-driven participants are largely motivated by the *fun* and *enjoyment of creating* the software code. The freedom and creativity that participants experience in defining and developing software in open source environments, which contrast sharply with their structured and hierarchical workplace environments, is what motivates hobbyists (Shah, 2006). Thus, freedom of expression and use, which is the fundamental human desire, seems to play a role in participants' motivations in open source software.

Hippel and Krogh (2003) propose a "private-collective" model to explain open source software development. They argue that there are sufficient incentives for participants to contribute to public goods, as the contribution will enhance their benefits from the resulting wider diffusion of innovation. Contributors obtain private benefits such as *learning*, *enjoyment*, and *a sense of ownership* by making the software code public. Interestingly, some of these private benefits are obtainable only through the critiques and suggestions from other participants, which require the contributor to share. The common problem of "free riding" is also minimized in open source development because contributors gain more private rewards than free riders (Hippel & Krogh, 2003). For example, free riders cannot learn to the same extent as contributors. Thus, users have sufficient incentive to create a network that Hippel (2007) calls the 'users innovation network', and to participate in the collaborative knowledge production process. Raymond (1999) reveals that all open source development begins with the developers' own itch to contribute. In the same line, others have reported that when existing software functionalities *do not meet the user's requirement*, the user begins developing his own or customizing the ones created by others (Hippel, 2007).

Bryant, Forte, & Bruckman (2005) use the activity theory to study why participants contribute to Wikipedia and how their goals evolve as they change from newcomers to old-timers. They report that the overarching *goal of the project*, *community appeal*, and *perceived contribution* to the society motivate participants' contribution. Kuznetsov (2006) finds that participants contribute to Wikipedia for *altruistic reasons* (they believe that their contribution is

serving a purpose for humanity); for *reciprocity* (Wikipedians expect mutual cooperation to grow, maintain and develop Wikipedia); a *sense of community* (as they interact with each other, a community of shared needs, values and beliefs gets created); for *reputation* (those who make many edits receive respect from their peers); for *autonomy* (life is often dictated by regulations, hierarchy, authority; in Wikipedia, participants can choose their own topics and activities). Similarly, Nov (2007) applied the idea of a volunteer functional inventory (VFI) from social psychology, as proposed by Clary et al. (1998), to investigate the motivational process in the Wikipedia. In addition to Clary et al.'s (1998) six elements in the VFI (value, understanding, social, career, protective, and enhancement), she found two additional motivations—fun and ideology—in Wikipedia.

3.4 SUMMARIZING AND CLASSIFYING THE MOTIVATIONAL FACTORS

The factors identified in the previous section are drawn from three key areas: volunteering, leisure studies (serious leisure in particular), and social production of knowledge. The underlying meanings of many factors identified in these sources are the same, although some of them use different labels. For instance, leisure studies use the phrase 'unique ethos' (Gould, et al., 2008; Stebbins, 1982); volunteering uses 'value' (Clary, et al., 1998; Clary & Synder, 1999) whereas social production of knowledge uses 'sense of community' (Hertel, et al., 2003; Kuznetsov, 2006) to mean the same underlying motivational construct that drives people to the three respective activities. When there is more than one label for the same underlying motivational construct, we choose the one that makes the most sense in relation to the nature of VGI. In the cases of some other factors, both the labels and concepts employed in all three areas are the same. For example, the factor ‘career’ is found in volunteering in general (Clary, et al., 1998; Yeung, 2004), serious leisure (Stebbins, 1982), open source software development (Hertel, et al., 2003; Shah, 2006), and Wikipedia (Nov, 2007). Thus, volunteering, leisure activities and participation in social production of knowledge are not disjoint undertakings. Stebbins (1996), for example, argues that serious leisure has a volunteering component. It is thus valid to consider these phenomena when studying motivational processes in VGI.

However, some factors do not overlap. These factors provide a complementary basis to derive a comprehensive list of motivational factors for VGI. We derive and summarize a list of unique set of motivational factors along with their conceptual definitions and literature sources in

Tables 3.1 and 3.2 below. In addition to summarizing these factors, we classify them as intrinsic and extrinsic motivation and apply them to VGI, although it is not always easy to assign all motivations to one of these groups (Frey 1997). Intrinsically motivated people seek for different reward than extrinsically motivated people. "One is said to be intrinsically motivated to perform an activity when one receives no apparent reward except the activity itself" (Deci, 1971, p. 105). Conversely, extrinsic motivations come from outside the person, often in the form of money or coercion. A careful analysis about whether the participants of a VGI project constitute more intrinsically or extrinsically motivated people is needed while designing the incentive system to garner more contribution.

While orthodox economics, almost exclusively, focuses on extrinsic motivations, empirical evidence shows that they alone are insufficient and in many cases even counter-productive in directing humans to certain actions (Deci, 1972; Frey, 1997, 2006). In the last few years, intrinsically motivated human behavior is being increasingly observed in online knowledge communities, including in numerous instances of VGI. In these communities, knowledge is being produced and provided even in the absence of direct monetary reward or coercion (Benkler, 2005, 2006). However, the interactions between the intrinsic and extrinsic motivations are often complex. In many situations, drawing on the extrinsic motivations reduces the intrinsic motivations (Frey & Jegen, 2001). When a person perceives that the external intervention is impairing self determination, self esteem, or possibility of self expression, extrinsic motivations are counterproductive (Frey, 1997; Frey & Jegen, 2001). This applies to those people who are intrinsically motivated; on the other hand, people acting with less intrinsic motivation may respond better to external intervention.

Table 3.1: Summarizing and applying intrinsic motivations to VGI

Intrinsic motivations	Underlying concept	Literature Source	Relevance to VGI
Unique ethos	Distinguishing ideals, values, sentiments, or guiding beliefs that are shared by the members of a volunteering community.	Clary et al. (1998), Clary and Synder (1999), Stebbins (1982), Gould et al. (2008), Kuznetsov (2006), Nov (2007) Hertel et al. (2003),	Contributors believe that maps should be available freely, and resist the growing corporatization by contributing GI to VGI.

Table 3.1 (cont.)

Learning	A volunteer gets an opportunity to learn from his own as well as the experiences of other members of the community.	Clary et al. (1998), Clary and Synder (1999), Lekhani and Hippel (2003), Hippel and Krogh (2003), Nov (2007)	Contributors seek to learn geospatial technologies, and to develop new perspectives on the local area as well the world.
Personal enrichment	A volunteer seeks to increase his intellectual or spiritual resources, which is found in the accumulation of cherished and valued experiences resulting from the chosen pursuit.	Stebbins (1982), Gould et al (2008), Clary et al. (1998), Clary and Synder (1999), Nov (2007)	Contributors find that participation enriches their lives.
Self actualization	It comprises the development and application of one's talents, capacities, and potential.	Stebbins (1982), Gould et al. (2008)	Contributors realize their full potential and talent related to mapping and geospatial information.
Self expression	A volunteer seeks opportunity to express one's skills, abilities and individuality.	Stebbins (1982), Gould et al. (2008)	Contributors can display knowledge and expertise on mapping and geospatial technologies.
Self image	It is enhanced through the expression of unique skills, abilities and knowledge.	Stebbins (1982), Gould et al. (2008)	Contributors can improve their image as intelligent, generous, or competent persons.
Fun	An individual volunteers for hedonic gains that he derives from the pleasure of creation. Self-gratification or the satisfaction of one's own desires, pertains to depths of satisfaction that may be at once fun, but can also be profound and fulfilling.	Wasko and Faraj (2005), Lee et al. (2008), Hertel et al. (2003), Shah (2006), Hippel and Krogh (2003), Nov (2007), Stebbins (1982), Gould et al. (2008)	Seeing a contribution appear visually in the form of the map provides deep sense of satisfaction.
Recreation	It is the process of forming anew or creating one's self again; that is, volunteers retain a sense of renewal, regeneration or reinvigoration through the participation in volunteerism.	Stebbins (1982), Gould et al. (2008), Clary et al. (1998), Clary and Synder (1999)	Contributors often need to go outdoors to identify, measure, and/or describe geospatial features they want to map. This liberates them from indoor activities and provides outdoor recreation.
Instrumentality	An individual volunteers if he believes that his contribution is crucial to accomplish the goal of the project.	Houle et al. (2005), Hertel (2002), Hertel et al. (2004)	Contributors see discrepancies between their personal knowledge and the map, and seek to rectify it.

Table 3.1 (cont.)

Self-efficacy	A volunteer contributes if he perceives himself as having the knowledge and skills to meet the expectation of others in the team.	Wasko and Faraj (2005), Hertel (2002), Hertel et al. (2004), Bryant et al. (2005)	Contributors feel effective in the world.
Meeting own need	When existing product/service does not meet his own needs, an individual joins voluntary community to collectively develop the product/service.	Hertel et al. (2003), Shah (2006), Raymond (1999), Hippel (2007)	Contributors find that the GI of their need does not exist currently, is inadequate for their needs, or too expensive.
Freedom to express	An individual participates in voluntary activities as he has freedom to choose tasks and exercise his creativity.	Shah (2006), Kuznetsov (2006)	Contributors can self select a task and are free to complete it on their own schedule.
Altruism	Volunteered action is directed by altruistic reasons.	Lee et al. (2008), Kuznetsov (2006)	Contributors seek to benefit others.

Table 3.2: Summarizing and applying extrinsic motivations to VGI

Extrinsic Motivations	Underlying concept	Literature Source	Relevance to VGI
Career	An individual uses the voluntary work as a platform to signal his skills for career opportunity such as future jobs, share in commercial companies or future access to the venture capital market.	Clary et al. (1998), Clary and Synder (1999), Hertel et al. (2003), Shah (2006), Nov (2007), Lerner and Tirole (2002)	Although many participants use pseudonyms, many VGI projects still provide contributors ways to signal their knowledge to potential employers.
Strengthen social relation	An individual volunteers to strengthen his social relation; participation in volunteerism depends on the reaction of his significant others.	Clary et al. (1998), Clary and Synder (1999), Hertel et al. (2003), Nov (2007), Klandermans (1997), Lee et al. (2008)	Some VGI projects allow contributors to meet in mapping parties and conferences, a positive. However, if significant others consider mapping as irrelevant, this will be a negative.
Project goal	A volunteer carefully analyzes the goal of the project and its likelihood of attainment before participating in the activity.	Klandermans (1997), Hertel (2002), Hertel et al. (2004), Bryant et al. (2005), Stebbins (1982), Gould et al. (2008)	People contribute more if the overall goals of the VGI project match their own.

Table 3.2 (cont.)

Community	This pertains to efforts on behalf of the participants of a volunteering community to ensure that the community is maintained, continues to develop, and remains a cohesive unit.	Stebbins (1982), Gould et al. (2008), (Kuznetsov, 2006)	A sense of common purpose and belonging can motivate greater GI contributions.
Identity	By joining a group, an individual develops his identity with the chosen pursuit and is inclined to use this to identify himself. Further, he behaves according to the norms of the group.	Houle et al. (2005), Simon et al. (1998), Hertel et al. (2003), Stebbins (1982), Gould et al. (2008),	Sustained engagement in a VGI community, leads one to develop an identity, which will influence further contributions.
Reputation	A volunteer contributes to enhance his reputation and continuously seeks recognition from his peers.	Wasko and Faraj (2005), Kuznetsov (2006), Lee et al. (2008), Lerner and Tirole (2002)	The desire to be recognized and valued motivates people to contribute.
Monetary return	An individual participates in volunteering activities seeking a direct monetary benefit.	Stebbins (1982); Gould et al. (2008), Lerner and Tirole (2002)	Contributors make money, say by selling value-added GI products and services.
Reciprocity	An individual volunteers if he believes that others will reciprocate and will not exploit his contribution.	Hertel (2002), Hertel et al. (2004), Shah (2006), Kuznetsov (2006)	Individuals contribute GI with an anticipation that others will contribute to expand the coverage of the mapped area and increase the quality and granularity of data.
System trust	The volunteer's contribution depends on his belief about the reliability of the underlying technical infrastructure.	Hertel (2002), Hertel et al. (2004)	The contributor's perception of the reliability of the technical infrastructure affects the extent to which he will invest his time and effort.
Networking	An individual participates in voluntary activities to network with other members of the community. Denser the network one has, more is the contributions he makes.	Stebbins (1982), Gould et al. (2008), Wasko and Faraj (2005)	VGI allows people to form and grow networks at both local and global levels.
Socio-political	An individual participates in volunteerism to meet his socio-political motives.	Hertel et al. (2003)	By contributing the GI of their interest, contributors in VGI may advance a socio-political agenda.

3.5 HOW MOTIVATION OPERATES IN VGI

In this section, we discuss three motivational factors in depth and illustrate what those factors mean in the context of VGI using the case of OSM. The data used in this section come from two sources: (1) analysis of the conversational texts among OSM users (talk-pages) (2) responses to open-ended questions in recently conducted OSM user survey.

A talk-page provides space for communication among the members of OSM. As the members of OSM are geographically distributed, they rely on the Internet-based communications to identify, develop, and address issues pertinent to the growth of the project. Registered users raise issues, comment to the issues raised by others, and engage in conversations with other members of the virtual community using the talk-pages. First, we went through the entire talk-pages to identify pages that have relevant discussion on motivations. We then considered user conversations in seven months and analyzed them to understand their motivations to contribute to OSM using grounded theory (Graser and Strauss, 1967). We identified fulfillment of self need, anti corporate sentiment, reciprocity, visual power of map, outdoor entertainment, pride of local knowledge (or instrumentality), freedom of GI, concerns to larger issues, fun, and learning as most salient motivational factors. These findings were corroborated with data collected from open ended questions in a recent OSM survey. Description of the methodology in detail is beyond the scope of this paper.

Fun: Fun is a motivational factor found across the literature. In particular, it exists as a strong motivational factor in online knowledge sharing (Wasko and Faraj 2005), open source software development (Shah 2006, Hippel and Krogh 2003), and Wikipedia (Nov 2007). Most contributors to OSM report fun as one the motivational factors in VGI as well. However, the way fun plays out in VGI is different than in other online knowledge activities.

> *I find it fun mapping things and satisfying seeing my contributions appear on the various output maps. I have always found maps inexplicably fascinating. (**Mapper A)***
>
> *It's a lot of fun, and it's nice to see your work appear 1-2 hours after it's done available to the whole world :) (**Mapper B)***

In both these excerpts, the inherent source of fun is the visibility of their contributions. Maps, by their nature, are effective visual tools. When contributors see their data appear visually on maps, they receive deep satisfaction.

Learning: The literature on sociology of volunteering (Clary and Synder 1999), open source software development (Lekhani and Hippel 2003), Wikipedia (Nov 2007) all suggest that people's participation to these activities is driven by their desire to learn. Contributors in open source software learn programming skills by looking at the software codes written by other contributors. In Wikipedia, contributors might learn about a particular topic as they write an article on the topic.

We also find learning as one of the motivational factors in VGI. However, a careful analysis reveals that a more specific kind of learning occurs in VGI. Contributors often need to go out in the field to record the locations of geographic features or tag their attribute properties in VGI. This process offers them an opportunity for deep learning about the features on the Earth's surface and their interrelationships. Thus, VGI leads to the rediscovery of a local place and community as it becomes evident in the followings excerpts.

> *... I am also enjoying exploring on my bike new areas that I'm mapping - I've discovered some cool suburban places that I never knew existed - often within meters of roads that I drive down regularly. (**Mapper C)***
>
> *Also, mapping is relaxing - like doing a crossword puzzle. And it will greatly improve your knowledge of the place where you live. (**Mapper D)***

Instrumentality: In the knowledge contribution, instrumentality is defined as perceived indispensability of an individual's contribution for the group outcome; the higher the perceived instrumentality of an individual's contribution, the greater is the motivation to contribute (Hertel et al. 2003). Our study suggests that it is one of the strongest motivational factors in VGI as well. The instrumentality in VGI stems from one's local knowledge. When people see their areas blank on the map or notice errors of their area, they realize that their local knowledge can play an instrumental role to fill the area or correct those errors.

> *I contribute to the mapping, because existing commercial mapping data is often incomplete or erroneous where I live. Before I joined OSM, there was no mapping data available for Taiwan, where I live, on OSM. I contributed a big chunk (if not the biggest) of it and helped to initiate a mapping party, which was well received. Also, I promote OSM on local conferences by giving introduction speeches.**(Mapper E)***
>
> *... I love making maps and OSM allows me to make maps that I can use however I choose. I love to see the area around where I live accurately mapped (and updated in a timely manner). I get*

enormous satisfaction out of this entire process as well as know that I'm contributing towards a valuable resource that others can use. ***(Mapper F)***

Thus, unlike in open source software or in Wikipedia, instrumentality in VGI requires that in order to make a meaningful contribution the individual knows the local place either by travelling or living there.

3.6 CONCLUSIONS

In this paper, we propose a conceptual framework to facilitate the systematic investigation of different elements in VGI and motivational factors in particular. The framework depicts various VGI elements and their relationships providing a good starting point for their deeper investigation. We then illustrate the use of one aspect of the framework, namely how it addresses motivation. We review the literature in three relevant areas—volunteering, leisure studies, and social production of knowledge—that share some characteristics with VGI. The review suggests a set of motivational factors that influence participants' contributions to VGI. The factors are then classified into intrinsic and extrinsic motivations. Depending on the nature of the project or the social, political, cultural, and technological realities of a society where the contributor is situated, the intensity of these motivational factors might vary across VGI projects leading to different contributory behaviors (Haythornthwaite, 2009).

The motivational factors that emerged from the analysis of participants' conversations in OSM are consistent to the ones identified in the literature. It shows that the motivational factors derived from the literature are relevant for VGI. However, a detailed examination of some of these factors reveals that the exact way that motivational factors operate within VGI may be different. It suggests that—while VGI is a special case of social production of knowledge—it needs to be considered on its own terms as well, as a distinctive type of knowledge.

The three arenas of the framework—motivation, action and interaction, and outcome—provide apparatuses to ask different research questions. For example, how do motivations change with social context—that is, which motivational factors are strong in which societies? How does a self-organizing VGI community emerge and evolve (Budhathoki et al. 2008)? What drives people to cooperate? How are conflicts resolved? Is there some sort of organization within VGI or is it as chaotic as is seen from outside? If organization does indeed exist, what organizing principles govern a VGI community? Who defines the rules-in-use? The outcome arena helps to

understand the actual nature, quality, or potential use of volunteered information and similarly be used to generate important research questions. For example, why is the content of volunteered information in one project reliable whereas it is inferior in another project? Given that anyone can contribute GI in VGI, how should we define quality? Should we continue to use the same measures of quality as are used in authoritative source or should we redefine them?

Investigation into above and other questions might help to validate and refine the framework. However, a framework of the kind proposed here is not intended to define the territory fully, but rather to suggest productive lines of inquiry into different elements and the relationships. In the same way that a VGI invites participants to add to, modify, qualify, or otherwise reshape the GI, we invite researchers to examine, use, critique, and help develop the framework.

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CHAPTER 4
PARTICIPANTS' CHARACTERISTICS AND MOTIVATIONS IN AN ONLINE GEOGRAPHIC INFORMATION COMMUNITY

4.1 INTRODUCTION

In recent years, information and communication technology is increasingly being used for collaboration among geographically distributed individuals and groups. This has led to the emergence of a new model of information production and problem solving. This new model has attracted various sectors of society. For example, t-shirt design company Threadless.com, corporate research and development clearinghouse InnoCentive.com, and microstock photography agency iStockphoto.com incorporate it in their business models (Brabham, 2008).There is also a potential for nonproprietary and non-profit production of information. Open source software development and Wikipedia provide compelling examples (Benkler, 2006). This model of production is also being used in government. For example, NASA uses citizen input for marking and classifying craters on maps (http://clickworkers.arc.nasa.gov/). These examples indicate a new possibility of tapping citizens' knowledge and experiences.

One of the pressing questions in this emerging model of online production and problem solving is how to motivate citizens to contribute. Several researchers have studied this question over the last few years (Hippel & Krogh, 2003; Hertel et al., 2003). However, most of these studies have explored people's motivations to contribute to text-based systems. This study instead focuses on people's motivations to contribute to place-based systems and hence explores the phenomenon called volunteered geographic information (VGI). There are indications that motivations to contribute to place-based systems differ from text-based systems (Budhathoki et al., 2010).

VGI is an online, distributed information production model in which citizens are considered to be a legitimate source of geographic information. Citizen-contributed geographic information is promising, especially in situations in which other sources are costly or unavailable (Goodchild, 2007). The creation of online maps required in the rescue operation in the aftermath of the recent earthquake in Haiti can be taken as an example.

However, because VGI is a new phenomenon, we do not understand it well (Elwood, 2008). An important starting point in understanding this phenomenon is to gain insights about

who the contributors are and what drives them to invest their time and effort to contribute to geographic information. This leads to the following questions:

- Who are the contributors of volunteered geographic information?
- What motivates them to contribute geographic information?

Since all participants in VGI do not make the same level of contribution (Haklay, under review; Budhathoki et al., 2010), there is a related question: How do motivations differ between contributors? The goal of this study is to answer the above questions by identifying contributors' characteristics and underlying motivational constructs.

4.2 THEORETICAL FOUNDATIONS

It is posited that literature on sociology of volunteering, leisure studies, and social production of knowledge provide theoretical foundations for VGI. Volunteerism is the foundational concept in VGI (Goodchild, 2007; Elwood, 2008). This strand of literature provides frameworks and models of volunteers' psychological and social psychological constructs that drive them to volunteerism. The literature from leisure studies is useful as people's participation in VGI is likely to be their leisure activity—i.e. it is unlikely to be their main work—at least for a majority of participants. Finally, the literature on the social production of knowledge—open source software and Wikipedia in particular—provide important insights, as geographic knowledge production in VGI is similar to them in many respects (Budhathoki et al., 2008).

Budhathoki et al. (2010) have reviewed these strands of literature and provided a comprehensive list of potential motivational factors for VGI (See Tables 4.1 and 4.2). This paper uses these factors as a theoretical guide to find users' underlying motives for contributing geographic information to the online community.

Table 4.1: Potential intrinsic motivations for VGI (Budhathoki et al., 2010)

Intrinsic motivations	Underlying concept
Unique ethos	Distinguishing ideals, values, sentiments, or guiding beliefs that are shared by the members of a volunteering community.

Table 4.1 (cont.)

Learning	A volunteer gets an opportunity to learn from his own experiences as well as the experiences of other members of the community.
Personal enrichment	A volunteer seeks to increase his intellectual or spiritual resources, which is found in the accumulation of cherished and valued experiences resulting from the chosen pursuit.
Self actualization	It comprises the development and application of one's talents, capacities, and potential.
Self expression	A volunteer seeks opportunity to express one's skills, abilities and individuality.
Self image	It is enhanced through the expression of unique skills, abilities and knowledge.
Fun	An individual volunteers for hedonic gains that he derives from the pleasure of creation. Self-gratification or the satisfaction of one's own desires pertains to depths of satisfaction that may be at once fun, but can also be profound and fulfilling.
Recreation	It is the process of forming anew or creating one's self again; that is, volunteers retain a sense of renewal, regeneration, or reinvigoration through their participation in volunteerism.
Instrumentality	An individual volunteers if he believes that his contribution is crucial to accomplish the goal of the project.
Self-efficacy	A volunteer contributes if he perceives himself as having the knowledge and skills to meet the expectation of others in the team.
Meeting own need	When an existing product/service does not meet his own needs, an individual joins a voluntary community to collectively develop the product/service.
Freedom to express	An individual participates in voluntary activities as he has freedom to choose tasks and exercise his creativity.
Altruism	Volunteered action is directed by altruistic reasons.

Table 4.2: Potential extrinsic motivations for VGI (Budhathoki et al., 2010)

Extrinsic motivations	Underlying concept
Career	An individual uses the voluntary work as a platform to signal his skills for career opportunities such as future jobs, a share in commercial companies or future access to the venture capital market.
Strengthen social relations	An individual volunteers to strengthen his social relations; participation in volunteerism depends on the reaction of his significant others.

Table 4.2 (cont.)

Project goal	A volunteer carefully analyzes the goal of the project and its likelihood of attainment before participating in the activity.
Community	This pertains to efforts on behalf of the participants of a volunteering community to ensure that the community is maintained, continues to develop, and remains a cohesive unit.
Identity	By joining a group, an individual develops his identity with the chosen pursuit and is inclined to use this to identify himself. He also behaves according to the norms of the group.
Reputation	A volunteer contributes to enhance his reputation and continuously seeks recognition from his peers.
Monetary return	An individual participates in volunteering activities seeking a direct monetary benefit.
Reciprocity	An individual volunteers if he believes that others will reciprocate and will not exploit his contribution.
System trust	The volunteer's contribution depends on his belief about the reliability of the underlying technical infrastructure.
Networking	An individual participates in voluntary activities to network with other members of the community. The denser the network one has, the greater the contributions he makes.
Socio-political	An individual participates in volunteerism to meet her socio-political motives.

4.3 RESEARCH METHOD

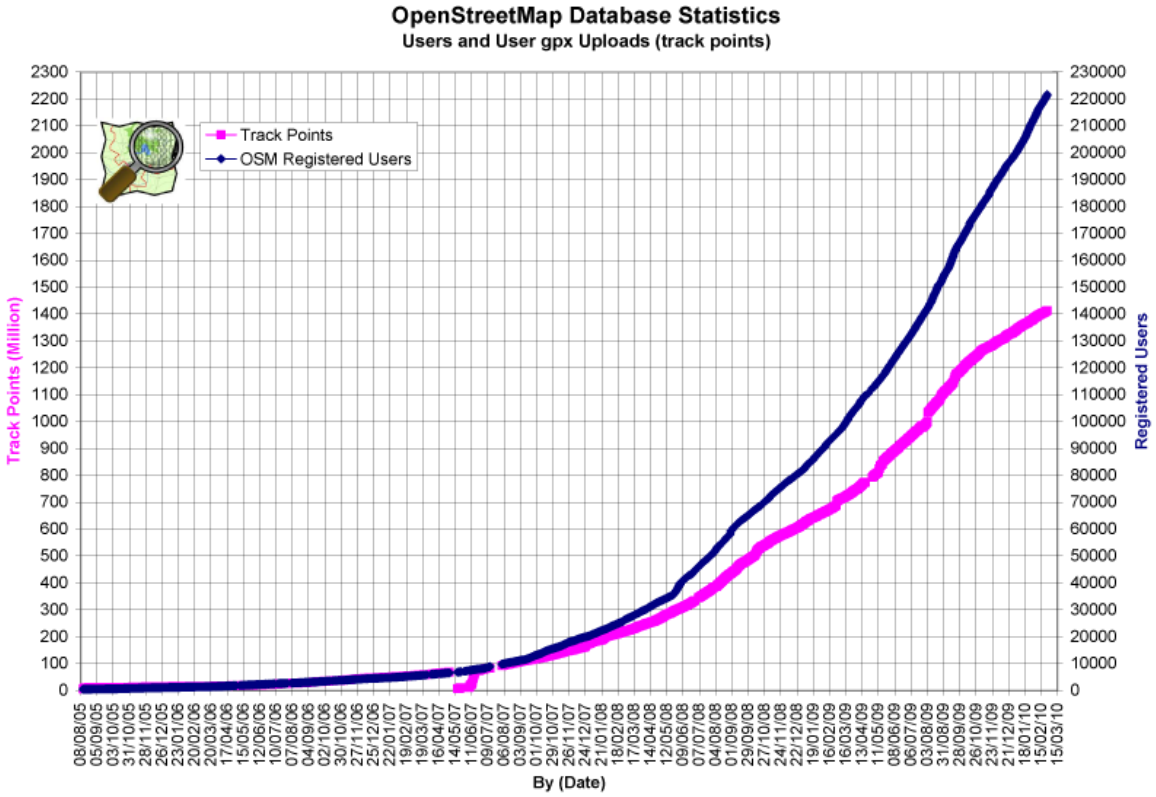
A case study approach is employed to empirically investigate VGI using the case of OpenStreetMap. Case studies are suitable to capture rich and in-depth information about a phenomenon (Hamel et al., 1993; Cresswell, 1994; Yin, 1994; Berg, 2004). Although the overall unit of analysis is the case as a whole, analysis is conducted at different levels for a deeper understanding. A well-designed case study takes into account information gained from many levels to build up a picture of the case (Vaus, 2001). For example, contributors are classified into different categories based on their level of contribution, and their motivational differences are compared. A mix of quantitative, qualitative, and computational methods is also employed in the study. As any single method of inquiry is inevitably partial, investigation of complex phenomena benefit from mixing multiple methods of knowing (Green, 2007).

4.3.1 Overview of OpenStreetMap as the Case

OpenStreetMap.org (OSM) is an online mapping community. It was founded in 2004 by Steve Coast, a student at University College London. The goal of the project is to create geographic data that is free to edit and use. The project aims to meet the geographic information needs of small businesses, non-profits, and individual users, who cannot access traditional sources because of the cost or other restrictions (Haklay & Weber, 2008). OSM is chosen as the case for this study, as it is frequently cited as one of the most successful VGI projects within the GIScience community (Goodchild, 2007; Haklay, under review; Budhathoki et al., 2010). OSM is driven by a community of volunteers who contribute to different aspects of the project. While the contributions of many volunteers build a geographic database and online maps, contributions of others help develop and maintain the underlying technical infrastructure, such as software codes for tools necessary for uploading data, editing and rendering maps, maintaining the transaction history, and implementing tagging schemas. An interesting part of the project is that the participants themselves choose the task to volunteer for, i.e. there is no central authority to design and delegate tasks. Even complex tasks such as the development of a taxonomy of real world objects and feature classes are driven by the community (Haklay & Weber, 2008). Anyone is free to propose a new tag to describe a real world feature or update the existing tag. Unlike professional GIS development, there are no priori defined standards; a community member makes a proposal when need arises, and the community discusses and decides on it.

Although the project was started in London, people from all seven continents are taking part in the mapping activities. The registered users are growing exponentially over the last few years, as shown in Figure 4.1. The users may contribute geographic data in different ways in OSM. They may use GPS-enabled handheld devices to measure the locations of the earth's features and upload the information; digitize on-screen features using satellite imagery; upload freely available information such as street networks in the United States; and label names and other properties of the features created by other users.

Figure 4.1: Registered users and user-contributed latitude/longitude points



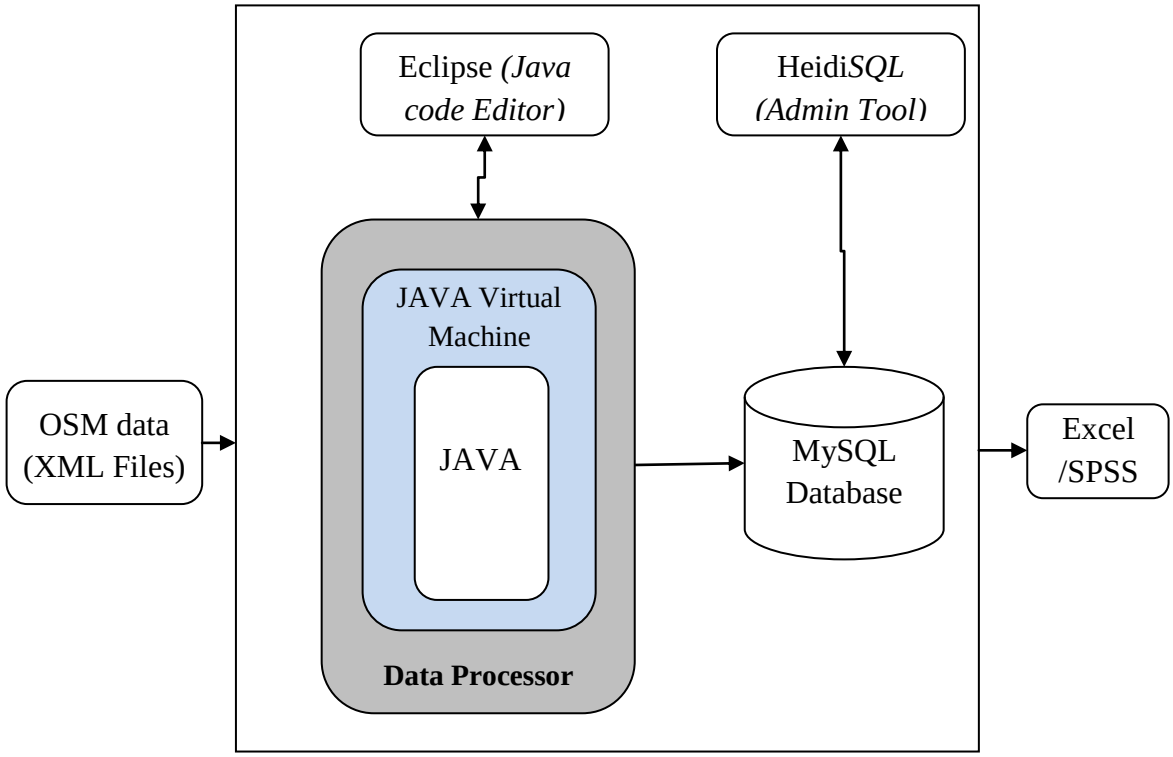
One of the distinguishing aspects that is not typical in other crowdsourced projects—which make an open call for accomplishing a task by a large group of people instead of employees or contractors (Howe, 2008)—is that many users meet face-to-face in what is known as a "mapping party" in OSM. They announce and coordinate mapping parties using the wiki, which is provided as a part of the OSM interface. Users meet at certain location in the community, get to know each other, share experiences, and spend some time exploring and mapping the community. Mapping parties help meet the social and technical needs of many users.

4.3.2 Identification of the Contributors and Recruitment for Survey

When this research began in April 2009, there were about 120,000 registered users in OSM. For the purpose of identifying the contributors from the pool of the registered users, OSM data was downloaded from http://downloads.cloudmade.com/. This data consisted of user-contributed geographic data (latitude/longitude values) worldwide, who contributed that information (user name), and when it was contributed (time stamp). The information was

extracted using the data table definition (DTD) given in Appendix A and transferred to a MySQL database server. This resulted in about 800 million database records in the MySQL server. Figure 4.2 depicts different tools and processes used to process the data. The snippet of the Java source code written to process the data is presented in Appendix B.

Figure 4.2: Processing and extraction of OpenStreetMap data in MySQL database



The analysis led to a list of 33,440 contributors along with the total number of nodes each contributor has contributed, the contributor's first date and the last date of contributions, and the number of distinct days the contributor has contributed between these dates.

OSM has a messaging system, which allows for the exchange of messages between users. It has been implemented using users' email addresses provided at the time of the registration. However, it was identified that, for different reasons, all the contributors may not be reached using the messaging system. Hence, a Perl Script (Appendix C) was written, which generated a list of 31,015 contributors who could be reached using the messaging system.

4.3.3 Survey Questionnaire Development and Data Collection

The potential motivational factors identified by Budhathoki et al. (2010) (Tables 4.1 and 4.2) were used as a theoretical guide in the survey questionnaire development. Prior to the development of the survey instrument, about 3,000 text messages (users' conversations archived in OSM talk-pages) were qualitatively analyzed. The goal of the qualitative analysis was to make sense of the case in general and gain insight into users' motivations in particular in order to contextualize the literature-suggested motivational factors in VGI. Table 4.3 provides the salient motivational factors that emerged from the qualitative analysis. Further details of the qualitative analysis are given in Appendix D.

Table 4.3: Motivational factors as emerged from the qualitative analysis

Motivational Factor	***Conceptual Definition***
Self need	An individual may contribute to online geospatial information community in order to fulfill self need. Such a situation may generally arise when the information the individual is looking for does not exist in the first place, does not meet his requirements even if it exists, or cannot be found or is unaffordable.
Anti-corporate sentiment	Many contributors are concerned about the growing corporatization of geospatial data and the potential consequences to the access and use of these data. This sentiment drives them to contribute to projects that have characteristics of public good.
Expectancy of reciprocity	Contributors are aware that one's self-effort alone is not sufficient to create the kind of geospatial data necessary for fulfilling their own needs as well as the needs of other users. Hence, while making their own contributions, they anticipate contributions from other members of the community.
Visual power of maps	Data suggests that the visibility of one's contributions is an important motivational factor. Maps, by their very nature, are effective visual tools, and hence appeal to members of the community to contribute. Many contributors have been addicted to maps since their childhood, and mapping is fun for them. When they see their contributions appear visually in maps, it provides them deep satisfaction. Also, the visual power of maps motivates contributors in other ways. For example, when someone sees blank area in the map, it inducts the potential contributor to map that area.
Outdoor entertainment	In many cases, members of an online mapping community need to go outdoors to identify, measure, and/or describe geospatial features they are interested in mapping. Hence, mapping provides a good opportunity for people to get rid of their mundane indoor work and get out to the physical space.
Pride of local knowledge	When one sees a map with some discrepancy between the content and the person's current state of knowledge, it motivates the person to use their knowledge and rectify errors on the map. Since most mapping systems do not allow for rectification of such discrepancies, an individual may begin to contribute to open mapping project for utilizing local geospatial knowledge.

Table 4.3 (cont.)

Concerns of larger issues	Many contributions are driven by individuals' interests/concerns in larger issues. For example, some contributors are interested in bird hides, while others are interested in bingo halls. Yet others are concerned to show the declining green space in certain areas to draw public attention. For them, mapping is a means to address certain larger concerns.
Learning	Many OSM contributors are driven by their desire to learn. Some are interested in enhancing their mapping skills, while others are interested in expanding their knowledge about world geography. Yet others are interested in exploring different aspects of their local community.
Monetary	Although concrete evidence of monetary motivations were not found, there are some indications of monetary motivation as seen in the following excerpt: *"Fascinating idea, being paid to war drive the neighborhood. It could make it a lot easier to collect GPS points. Are you interested in the rest of Europe as well. I'm trying to map Oslo, Norway. :) What kind of payment rates are we talking about here? Enough to buy the equipment needed to lend out collection stations?"*

The insights gained from the qualitative analysis were used to determine the relative importance of the factors in Table 4.1 and 4.2. Accordingly, four items were used to measure four factors (instrumentality of knowledge, learning, fun, and outdoor recreation), three items were used to measure two factors (unique ethos and monetary), two items were used to measure six factors (altruism, reciprocity, community, project goal, career, and self need), and one item was used to measure the remaining ten factors (socio-political, reputation, social relation, self actualization, self image, personal enrichment, identity, self efficacy, system trust, and freedom to express). Thus, a total of 44 items were used to measure 22 out of 24 motivational factors identified by Budhathoki et al. (2010). All the motivational items were measured using a seven point Likert scale with '1' being 'strongly disagree' and '7' being 'strongly agree'.

Among the remaining two factors, 'recognition' was discarded with the assumption that it may already have been measured in 'reputation' and 'identity'. 'Networking' is measured in terms of the respondent's number of contacts instead of the Likert scale and therefore was not included in the factor analysis. Most measurement items were used from Clary et al. (1998) and Gould et al. (2008), either as is or with minor adaptations. New items were developed where existing items were not available. Selections, adaptations, or the development of new items were informed by the qualitative analysis. Measurement items and their sources for each motivational factor are given in Appendix E.

The survey questionnaires were reviewed by four faculty members at a Midwest university in the US, a faculty member in the UK, and a survey research expert. The questionnaires were then pretested with four PhD students in a Midwest university in the US who are conversant with survey research and have GIS experience either as an instructor or as a teaching assistant. Finally, the questionnaires were pilot tested with five OSM users who have firsthand experience contributing to OSM.

A message was sent to all 31,015 contributors of the OSM with a URL to the online survey embedded in it on the third week of December 2009 using Perl Script. A reminder notice was sent two weeks later. The survey, which was implemented in Survey Monkey, was open for about a month. The responses were received and automatically stored in its server. A total of 459 responses were received, among which 444 were valid after removing 15 duplicate responses. Web surveys are usually posted on the website or list-server, and it is often difficult to know if the same person responded to the survey multiple times. In order to overcome this problem, a personal identification number (PIN) was given for each respondent and multiple responses were identified using this PIN. Thus, the online survey made it possible to capture information from an internationally distributed OSM population; there was no other method to collect information from such a population within the limitations of this project. However, like most surveys, this study encounters issues related to sampling, coverage, measurement, and nonresponse errors at varying degrees (Dillman, 2007).

Attempts have been made to address each of these issues. The sample size of 444 is sufficient to conduct the analysis; hence the sampling error is not a huge issue. The study attempted to address the coverage error by sending the survey to all of the contributors. However, it is possible that people did not receive the message, or they did not open it for various reasons. The survey instrument was designed after studying the case qualitatively. It was also reviewed by four experienced faculty, a survey research expert, four graduate students, and five OSM contributors. Moreover, where possible, the study used already tested instruments in order to minimize measurement errors.

To get some idea of nonresponse bias, the respondents were compared with the population at the continent level (i.e., all the contributors). The analysis revealed that the respondents represent all the continents except South America. Among 665 total contributors who have contributed to South America, none of them participated in the study. However, in the

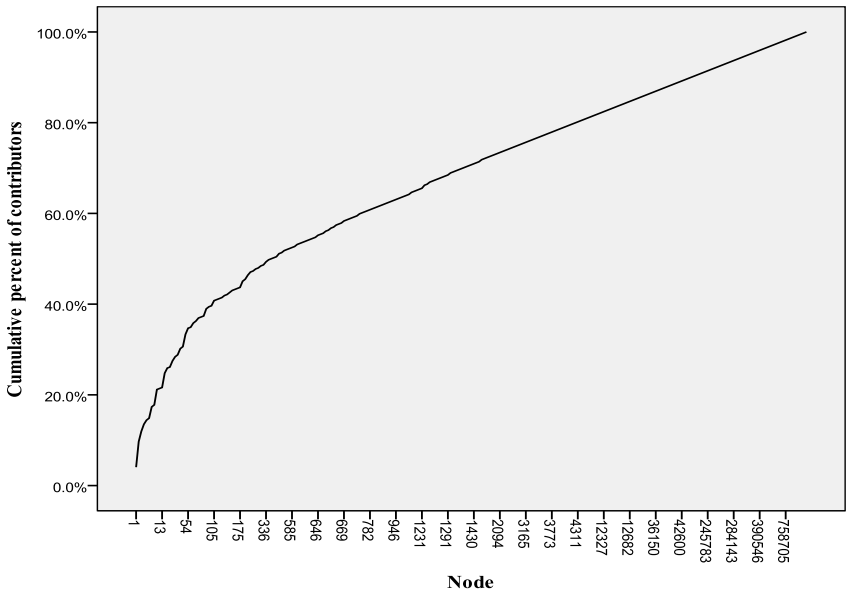
case of other continents, there was a good representation, as the proportion of respondents closely resembled the contributors who have contributed to different continents (Table 4.4).

Table 4.4: Distribution of the subjects and respondents among continents

Contributed to	***Total contributors(i.e. population)***	***Survey respondents***
Africa	442 (1.4%)	29 (6.5%)
Asia	1798 (5.8%)	16 (3.6%)
North America	3284 (10.6%)	41(9.2%)
South America	665 (2.1%)	0 (%)
Europe	23111 (74.5%)	316 (71.2%)
More than one continent	1715 (5.5%)	42 (9.4)%
Total	**31,015**	**444**

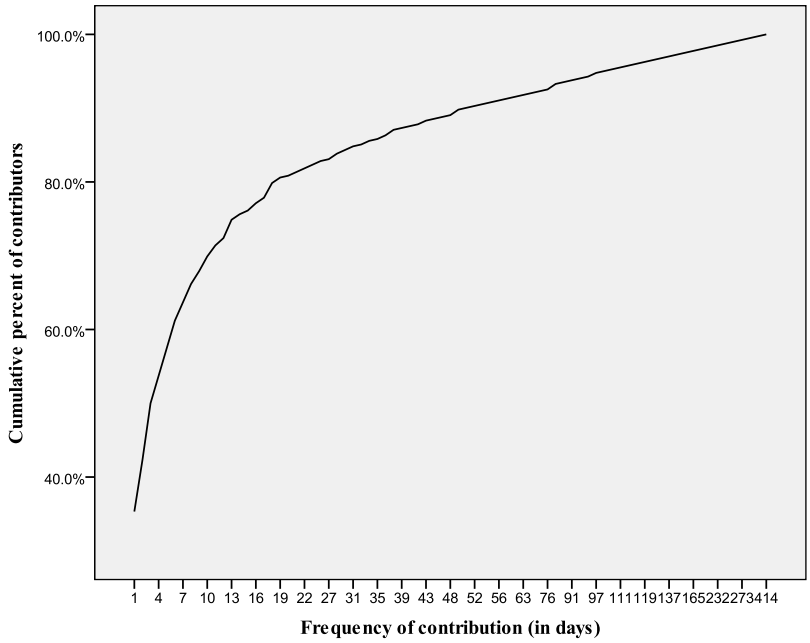
The nodes contributed by the respondents were also analyzed to get a better idea of bias. For example, a strong bias would be present if only those who have contributed a large number of nodes responded to the survey. Fortunately, the respondents were contributors of a wide range of nodes (1 node to about million nodes). As shown in Figure 4.3, about 20% of the respondents had contributed less than 10 nodes, 60% had contributed between 10 and 4000 nodes, whereas the remaining 20% have contributed more than 4000 nodes. Thus, respondents represented contributors of a few nodes to a large number of nodes.

Figure 4.3: Contribution of nodes by the survey respondents



Additionally, respondents' frequency of contributions were analyzed to see if only the frequent contributors responded the survey. As shown in Figure 4.4, 35% respondents had contributed only once during the entire project period, 70% respondents contributed less than 10 days, whereas several respondents contributed more than 100 days. This shows that the respondents represent both frequent contributors and occasional contributors. Thus, there does not seem to be systematic biases in terms of the contributors' number of nodes or frequency of contributions.

Figure 4.4: Frequency of contribution by the survey respondents



4.3.4 Contributors' Characteristics

Most of the respondents are young adult males living in Europe. Among 444 contributors who took part in the study, 80.2% live in Europe, 10.9% in North America, 5.2% in Africa, 2.4% in Asia, 0.5% in Australia, and 0.3% in South America. They are predominantly male (96.2%), 2.7% female, and 1.1% did not prefer to mention their sex. About two thirds of the contributors are between 20 and 40 years old, 32.2% are in the range of 20-30, another 32.4% are between 31-40, with 3.8% below 20 years, 21.3% in the range of 41-50 years, and 10.4% above 50 years.

Most of the participants are employees (61.2%), followed by students (12.4%), and then freelancers, i.e., self-employed (11.8%). There are also part-time employees (9.1%) with other part spending either in freelancing or in studying. There are 2.2% of retired employees, and the remaining 3.3% respondents chose the 'other' category. Most of those who are employed work in the commercial sector (71.6%), with 12.2% in government, 10.8% in academia, and 2.3% in nonprofits. The remaining 3.2% responded that they work in areas other than the above.

Supporting the hypothesis posited by Budhathoki et al. (2008), there is a strong influence of open source development and Wikipedia in the OSM community. The majority of the contributors have contributed to open source software projects (60.3%) and Wikipedia (71.5%). Most contributors contribute only from home (72%), whereas only a few contributors (2.7%) use their office as the only place to contribute. Interestingly, the number of respondents who contribute only from the office is close to the number of contributors who contribute to OSM as a part of their jobs (2.9%). Few (1.1%) contribute only while they are traveling, whereas none contribute from cybercafes. Others use a combination of places for their contribution—home, office, and travel.

About half of the contributors have college/university degrees (49.7%), 20.4% have postgraduate degrees, and 7.9% have PhDs. Contributors with some college education make up 17.4% and there are only 4.6% contributors with high school or lower education. Half of the contributors (50.5%) do not have professional GIS experience. However, other half has some GIS experience: 25.1% contributors have some GIS experience, 14.8% contributors have 1-5 years of experience, 6.6% have 6-10 years of experience, and 3% have more than 10 years of experience. This shows the OSM community does not constitute with GIS amateurs as is speculated in VGI.

4.4 MEASURES, DATA ANALYSIS, AND RESULTS

4.4.1 Motivations to Contribute Geographic Information

Based on the motivational theories on volunteerism, leisure studies, and social production of knowledge, 44 items were used to measure motivation. Only 39 items were subsequently used in the factor analysis. Four items measuring the *'outdoor recreation'* were not included because those items were answered only by a subset of the respondents who had been to a mapping party

(the skip pattern was enforced in the questionnaire for those items). Further, the item *"I map only those places I have visited,"* was not used as it did not seem to measure any motivation. The perceived importance of each of the 39 motivational elements is given in Table 4.5.

Table 4.5: Perceived importance of motivation to contribute

Motivation to contribute (Items that loaded in factors)	*Mean*	*SD*
Value of the free availability of digital geographic information	6.45	0.897
Desire to help others with free geographic information	6.13	0.864
Fascination to map	6.05	1.042
Enjoyment	6.00	0.938
Perceived achievability of the project goal	5.97	0.93
Belief of the goal of the project	5.95	1.053
Creation of an accurate map	5.94	0.919
Meeting the geographic information needs of others	5.87	1.039
Creation of the map data to satisfy one's own requirement	5.57	1.143
Representation of place	5.41	1.088
Development of a new perspective about the local area	5.28	1.348
Expectancy that other members of the community will contribute	5.24	1.324
Self efficacy	5.09	1.305
Develop mapping skills	4.97	1.218
Unavailability of the map data one is seeking	4.88	1.695
Explore world geography	4.80	1.272
Develop technical skills	4.58	1.304
Enhance resume	3.86	1.327
Show to friends and family	3.71	1.263
Display skills to potential employers	2.48	1.362
Future business plan	2.28	1.442
Business profit	1.93	1.216
Financial benefit	1.78	1.205
Items that did not load in factors		
Perceived importance of the community for project success	6.16	1.108
Self confidence in one's local knowledge	6.01	0.964
Freedom to self select areas to contribute	5.5	1.121
Perceived reliability of the underlying technical infrastructure	5.47	1.022
Visibility of one's contribution	5.38	1.243
Anti-corporate sentiment	5.06	1.664

Table 4.5 (cont.)

Map data entry	4.98	1.301
Use of one's mapping skills	4.43	1.539
Importance of the community for the self	4.25	1.420
Highlight socio-political issues	4.18	1.497
Enrich one's life	3.84	1.512
Recognition	3.77	1.370
Non-commercial use of maps	3.55	1.942
Enhancement of self view	3.19	1.496
Identity	2.96	1.5
Discourage free riding	1.93	1.264

The factor analysis indicated eight motivational constructs, with each construct containing multiple items. Only 23 out of the 39 items shown in Table 4.5 were retained through the factor loading and reliability checking; the remaining 16 items did not load in any factors. The reliability test was carried for each of the eight constructs, and the eighth construct was removed as the Cronbach's Alpha showed no internal reliability. The remaining seven constructs, as shown in Table 4.6, are: (1) learning (2) instrumentality of local knowledge (3) monetary (4) social/show off (5) altruism (6) project goal and (7) self need.

Four items loaded for learning (explore world geography, develop mapping skill, develop a new perspective about the local area, and fascination to map); four items for instrumentality of local knowledge (representation of place, creation of accurate map, self efficacy, and enjoyment); four items for monetary goals (business profit, financial benefit, future business plan, and display skills to potential employers); three items for social/show off (develop technical skills, enhance resume, and show to friends and family); three items for altruism (desire to help others with free geographic information, meeting the geographic information needs of others, and expectancy that other members of the community will contribute); three items for project goals (value on the free availability of digital geographic information, belief in the goal of the project, and perceived achievability of the project goal); and two items for self need (unavailability of map data one is seeking and creation of map data to satisfy one's own requirement).

The measurement model was evaluated using criteria of overall fit with the data, convergent validity, and reliability. The factor structure appears to be valid as acceptable

coefficient alpha values were obtained and thus provide support for internal consistency. All measures loaded significantly on their intended latent construct, except the seventh one, establishing convergent validity. Additionally, the percentage of variance support convergent validity as a substantial amount of the variance in the measures is captured by the latent constructs.

As shown in Table 4.6, the Cronbach's alpha for the first three constructs—monetary, learning, and instrumentality of local knowledge—show very good reliability as their alpha values are above 0.7. The reliability of other three constructs—project goal, altruism, and social/show off—is good enough to include in the motivational analysis. Typically, for an exploratory study in which the scales used have not been fully established through prior investigation, an alpha value of 0.6 is recommended (Nunnally, 1967). Despite its alpha being slightly less than the recommended threshold, the motivational construct *self need* is still considered, as literature suggests that self need is one of the motivators for knowledge contribution in an online community. Thus, it can be said that the first six factors emerged from factor analysis, whereas the seventh factor was suggested.

Table 4.6: Factor loadings and reliability test for the motivation measurement model

Motivation construct	*Factor loading*	*Eigen value*	*% of Variance*	*Cumulative % of Variance*	*Cronbach Alpha*
Monetary		4.76	20.68	20.68	.79
Business profit	.87				
Financial benefit	.78				
Future business plan	.77				
Display skills to potential employers	.60				
Learning		2.70	11.77	32.45	.75
Explore world geography	.80				
Develop mapping skills	.79				
Develop new perspectives about the local area	.67				
Fascination to map	.59				
Instrumentality of local knowledge		1.94	8.43	40.88	.71
Representation of place	.79				
Creation of accurate maps	.78				
Enjoyment	.63				
Self efficacy	.59				
Project goal		1.54	6.68	47.57	.64
Perceived achievability of the project goal	.84				

Table 4.6 (cont.)

Belief in the goal of the project	.76				
Value of the free availability of digital geographic information	.49				
Altruism		1.27	5.54	53.10	.59
Meeting geographic information needs of others	.74				
Desire to help others with free geographic information	.72				
Expectancy that other members of the community will contribute	.64				
Social/show off		1.14	4.95	58.05	.59
Enhance resume	.72				
Show to friends and family	.71				
Develop technical skills	.53				
Self need		.97	4.26	62.28	.50
Unavailability of the map data one is seeking	.82				
Creation of the map data to satisfy one's own requirement	.73				

Extraction method: Principle Component Analysis
Rotation Method: Varimax with Kaiser Normalization

The correlation matrix of the 23 motivational items that loaded in seven factors is reported in Table 4.7. The matrix provides a quick reference of correlations among items that loaded in the same motivational construct as well as with items in other motivational constructs. For example, if we look at the cell at the intersection of row 16 (desire to help others with free geographic information) and column 9 (future business plan), there is a negative correlation. This makes perfect sense as the concepts being measured by these two items are unrelated or even negatively related. On the other hand, if we look at the intersection of row 10 (business profit) and column 9 (future business), the high positive cell values tell that these items are measuring same, or different but related, concept.

Table 4.7: Correlation of motivational elements

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	Explore world geography	1.00																						
2	Develop mapping skill	0.61	1.00																					
3	Fascination to map	0.36	0.32	1.00																				
4	Develop new perspectives about the local area	0.54	0.51	0.18	1.00																			
5	Creation of accurate maps	0.16	0.19	0.09	0.26	1.00																		
6	Representation of place	0.28	0.22	0.12	0.27	0.55	1.00																	
7	Enjoyment	0.34	0.33	0.26	0.34	0.41	0.48	1.00																
8	Self efficacy	0.17	0.20	0.12	0.26	0.28	0.32	0.38	1.00															
9	Future business plan	0.11	0.15	0.02	0.12	-0.03	0.09	0.06	0.13	1.00														
10	Business profit	0.15	0.15	0.02	0.11	0.01	0.10	0.02	0.10	0.61	1.00													
11	Financial benefit	0.12	0.11	0.06	0.09	-0.02	0.09	0.08	0.12	0.43	0.60	1.00												
12	Show to friends and family	0.25	0.24	0.11	0.24	0.15	0.20	0.26	0.16	0.17	0.17	0.16	1.00											
13	Display skills to potential employers	0.30	0.30	0.12	0.25	0.02	0.17	0.12	0.20	0.40	0.49	0.45	0.31	1.00										
14	Enhance resume	0.26	0.27	0.14	0.16	0.05	0.13	0.18	0.09	0.16	0.19	0.17	0.33	0.40	1.00									
15	Develop technical skills	0.32	0.45	0.17	0.33	0.14	0.15	0.22	0.18	0.20	0.21	0.12	0.31	0.33	0.33	1.00								
16	Desire to help others with free geographic information	0.10	0.05	0.05	0.06	0.16	0.12	0.18	0.04	-0.02	-0.11	0.00	0.20	0.05	0.10	0.07	1.00							
17	Meeting the geographic information needs of others	0.16	0.15	-0.02	0.20	0.22	0.22	0.31	0.18	0.06	-0.01	0.01	0.13	0.08	0.07	0.13	0.45	1.00						
18	Expectancy that other members of the community will contribute	0.12	0.08	-0.01	0.06	0.18	0.22	0.20	0.12	0.08	0.07	0.11	0.19	0.12	0.16	0.16	0.30	0.30	1.00					
19	Value on the free availability of digital geographic information	0.01	0.04	0.03	0.01	0.18	0.13	0.21	0.10	-0.10	-0.14	-0.08	0.17	-0.04	0.09	0.05	0.48	0.28	0.14	1.00				
20	Belief on the goal of the project	0.08	0.07	0.07	0.05	0.18	0.19	0.26	0.14	0.07	0.10	0.11	0.10	0.07	0.07	0.02	0.34	0.23	0.27	0.24	1.00			
21	Perceived achievability of the project goal	0.07	0.05	0.07	0.04	0.17	0.19	0.26	0.16	0.03	0.03	0.03	0.09	0.03	0.08	0.02	0.27	0.22	0.07	0.34	0.57	1.00		
22	Unavailability of the map data one is seeking	0.10	0.05	0.02	0.23	0.07	0.13	0.08	0.09	0.07	0.07	0.08	0.16	0.12	0.02	0.13	-0.01	0.12	0.08	0.07	0.17	0.08	1.00	
23	Creation of the map data to satisfy one's own requirement	0.08	0.11	-0.11	0.23	0.26	0.19	0.21	0.16	0.06	0.07	0.08	0.06	0.04	0.02	0.09	0.05	0.23	0.18	0.05	0.17	0.06	0.36	1.00

The means and standard deviations of all seven motivational factors are given in Table 4.8. The table shows that contributors identify themselves as motivated highly by the goal of the OSM project, geographic information altruism, instrumentality of their local knowledge, desire for learning geospatial situations, their own geographic information need, and desire to show off to others.

Table 4.8: Perceived importance of motivational constructs

Motivational construct	*Mean*	*SD*
Project goal	6.14	.77
Altruism	5.73	.83
Instrumentality of local knowledge	5.58	.81
Learning	5.29	.95
Self need	5.2	1.19
Social/Show off	4.04	1.00
Monetary	2.14	1.06

4.4.2 Motivational Difference between Serious and Casual Mappers

A contributor can be classified as either a serious or a casual mapper based on the level of one's engagement in the mapping activity. At first, it was attempted to classify contributors into serious and casual mappers based on the number of nodes of their contribution. However, when the contributions of all 31,015 subjects were computed and analyzed, the data revealed that the number of nodes alone cannot be taken as a measure of one's engagement, as some contributors were found to have contributed a huge number of nodes for few times and then stopped contributing; they may have uploaded the freely available existing data as in the case of Tiger files in the US.

It was then decided to measure one's engagement in the project along three dimensions—number of nodes, longevity of engagement, and frequency of contribution—as their combination provides a better measure of user's contribution than any one of them alone. Thus, for the purpose of comparing the motivations, a contributor is defined as a serious mapper if s/he is above two standard deviations from the mean in one or more of the three measures: number of nodes one has contributed, longevity of contribution (i.e. the difference in date between the last and first contribution), and number of days of contribution during the period of longevity (i.e. frequency of contribution). When these criteria were applied to all 31,015 contributors (i.e. population), it resulted in 3,519 serious mappers (11.3%) and 27,496 casual mappers (88.7%).

The same criteria categorized the survey respondents into 66 serious mappers (14.9%) and 378 casual mappers (85.1%). Thus, the application of the above criteria was found to be satisfactory, as the proportion of the serious and casual mappers who responded to the survey closely corresponded to the actual population.

Comparing the means of contributors in the serious and casual mapper groups showed some interesting differences, as shown in Table 4.9. Serious mappers showed a significantly higher perception of the instrumentality of their local knowledge (M=6.0 versus 5.5; $t(387)=4.53$; $p<0.001$) and a higher desire to learn geospatial situations (M=5.5 verses 5.2; $t(388)=2.44$; $p=0.015$). Similarly, serious mappers are motivated significantly more by monetary motivations than casual mappers (M=2.7 versus 2.0; $t(375)=4.99$; $p<0.001$), although the low mean values in both groups showed that monetary motivations are not as strong as other motivations. The motivation to show the contributions to family and other members of the social network is significantly higher in serious mappers than casual mappers. As shown in the table, both serious and casual mappers are highly and equally motivated by geographic information altruism as well as the goal of the OSM project. Interestingly, both serious and casual mappers are equally driven by their own geographic information need.

Table 4.9: Motivational difference between serious and casual mappers

Motivational construct	*Serious mapper (n=63)*		*Casual mapper (n=343)*		*Significance of Difference*
	Mean	*SD*	*Mean*	*SD*	
Project goal	6.1	0.7	6.2	0.8	P=0.442
Altruism	5.6	0.8	5.8	0.8	P=0.258
Instrumentality of local knowledge	6.0	0.7	5.5	0.8	p<0.001*
Learning	5.5	0.9	5.2	1.0	P=0.015*
Self need	5.2	1.3	5.2	1.2	P=0.996
Social/Show off	4.2	0.8	4.0	1.0	P=0.099
Monetary	2.7	1.1	2.0	1.0	p<0.001*

**p<0.01*

Scale range of all scales varied between 1 and 7. Higher means indicate contributors' higher perceived motivation to contribute geographic information. The significance of difference column indicates the results of t-tests (two-tailed) between the means of the two groups for each motivational construct.

4.5 DEVELOPMENT OF HYPOTHESES

All seven motivational constructs identified earlier are suggested by the theories of motivations in volunteerism, leisure studies, and social production of knowledge (Budhathoki et al., 2010). Hence, it is posited that these motivational constructs drive a member's contribution in an online geographic information community. These motivational constructs are also consistent with the motivations that emerged from the qualitative analysis of OpenStreetMap as shown in Table 4.3.

A member's contribution in an online geographic information community such as OpenStreetMap can be measured along three dimensions: number of nodes, longevity of engagement in the community, and frequency of contribution. Thus, the following hypotheses are proposed:

H1: The level of contribution increases as project goal oriented motivation increases.

$H1_a$: The number of nodes increases as project goal oriented motivation increases.

$H1_b$: The longevity of contribution increases as project goal oriented motivation increases.

$H1_c$: The frequency of contribution increases as project goal oriented motivation increases.

H2: The level of contribution increases as altruistic motivation increases.

$H2_a$: The number of nodes increases as altruistic motivation increases.

$H2_b$: The longevity of contribution increases as altruistic motivation increases.

$H2_c$: The frequency of contribution increases as altruistic motivation increases.

H3: The level of contribution increases as instrumentality of local knowledge increases.

$H3_a$: The number of nodes increases as instrumentality of local knowledge increases.

$H3_b$: The longevity of contribution increases as instrumentality of local knowledge increases.

$H3_c$: The frequency of contribution increases as instrumentality of local knowledge increases.

H4: The level of contribution increases as learning motivation increases.

$H4_a$: The number of nodes increases as learning motivation increases.

$H4_b$: The longevity of contribution increases as learning motivation increases.

$H4_c$: The frequency of contribution increases as learning motivation increases.

H5: The level of contribution increases as motivation arising from self need increases.

$H5_a$: The number of nodes increases as motivation arising from self need increases.

$H5_b$: The longevity of contribution increases as motivation arising from self need increases.

$H5_c$: The frequency of contribution increases as motivation arising from self need increases.

H6: The level of contribution increases as social/show-off motivation increases.

$H6_a$: The number of nodes increases as social/show-off motivation increases.

$H6_b$: The longevity of contribution increases as social/show-off motivation increases.

$H6_c$: The frequency of contribution increases as social/show-off motivation increases.

H7: The level of contribution increases as monetary motivation increases.

$H7_a$: The number of nodes increases as monetary motivation increases.

$H7_b$: The longevity of contribution increases as monetary motivation increases.

$H7_c$: The frequency of contribution increases as monetary motivation increases.

A mapping party, which is one of the interesting aspects of OpenStreetMap, provides a mapper with an opportunity to meet other mappers face-to-face, socialize, and learn from their experience (Haklay M. & Weber, P., 2008). Thus, a mapping party is expected to engage a mapper in the community and increase contribution. This leads to the following hypothesis:

$H8_a$: One who participates in mapping parties is likely to contribute more than those who do not participate.

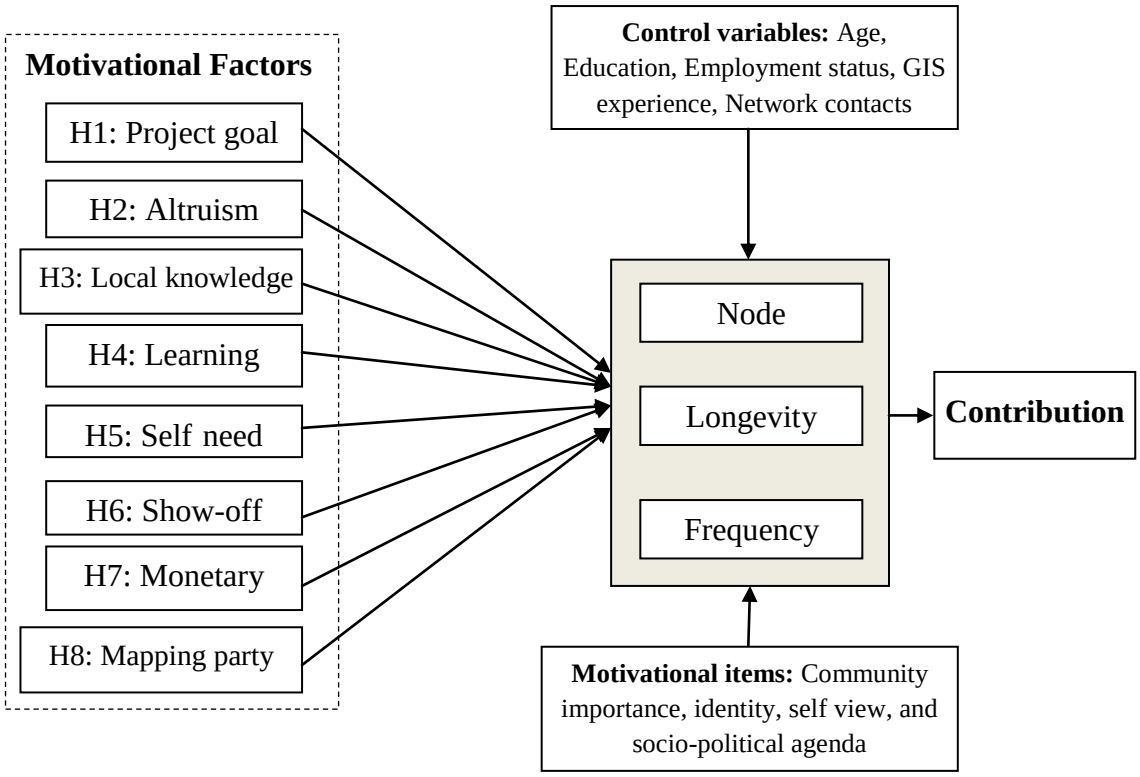
$H8_a$: One who participates in mapping parties contributes more nodes than those who do not participate.

$H8_b$: One who participates in mapping parties contributes for a longer period of time than those who do not participate.

$H8_c$: One who participates in mapping parties contributes more frequently than those who do not participate.

The specification of the hypotheses is summarized in Figure 4.5.

Figure 4.5: Hypothesized model of member contribution in an online geographic information community



4.6 MODEL SPECIFICATION AND HYPOTHESES TESTING

A member's contribution to an online community is determined by motivations to contribute, member characteristics, and contribution facilitators (Wang & Fesenmaier, 2003). Along the same line, in the context of geographic information, Budhathoki et al. (2010) have proposed a framework depicting that the level of contribution is determined by motivations, contributory mechanisms in place (structure, process, and norms of an online community), and characteristics of the contributor. Because the contributors use the same system in the OSM, the contributory mechanism is the same for all of them, and hence no variables were used to measure it. Regarding the member characteristics, the five most relevant variables—age, education, employment status, GIS experience, and number of network contacts in the community—are used in the model as control variables. For the motivations, all seven motivational constructs defined through factor analysis are used. For the 16 motivational items that did not load in any factors, four items—self view, identity, importance of the community for the self, and highlighting a socio-political agenda—are used in the model; the remaining 12 items are not

used. This decision was taken after carefully revisiting the motivational theories and original survey questions. Additionally, a variable measuring whether or not a member has ever participated in a mapping party is also used. Thus, a total of 17 variables are used in the model. The three dependent variables measuring the number of nodes, longevity of engagement in the community, and the frequency of contribution were derived from the data downloaded in April 2009. All independent variables were measured from the survey. The dependent variables were found to be significantly correlated to each other, as shown in Table 4.10. The correlations suggest that frequent contributors are likely to contribute more nodes and get involved in the project for a longer period of time. Similarly, those who are engaged in the project for a longer period of time are likely to contribute more nodes.

Table 4.10: Pearson correlation coefficients among the three dimensions of contribution (two-tail)

	Nodes	Longevity	Frequency
Nodes	1	0.797*	0.913*
Longevity	0.797*	1	0.866*
Frequency	0.913*	0.866*	1

In order to explore the research hypotheses regarding the relationship between the level of contribution and various motivational factors, multivariate analysis of variance (MANOVA) was conducted. Multivariate analysis of variance is a statistical procedure that determines if a set of independent variables can explain the variability in a set of continuous dependent variables (Agresti & Finlay, 1997; Huberty & Olejnik, 2006). Since the dependent variables (number of nodes, longevity, and frequency of contribution) did not follow a normal distribution curve, they were transformed using the logarithmic function before the analysis. Further, Pillai's trace is used among the four tests of significance displayed in the multivariate tests table, as it is more robust than other statistics in handling violations of model assumptions (Olson, 1974). The results of the analysis are given in Table 4.11.

Table 4.11: Evaluation of the hypothesized model

Main hypotheses *(in terms of the level of overall contribution)*	**Sig value (Pillai's trace)**	**Sub-hypotheses** *(in terms of natural log of the three dimensions of contribution)*	**Unstandardized parameter estimates**	**Sig-value**
H1: Project goal	0.030*	Node ($H1_a$)	-0.615	0.012*
		Longevity ($H1_b$)	-0.328	0.093
		Frequency($H1_c$)	-0.362	0.005*
H2: Altruism	0.080	Node ($H2_a$)	-0.440	0.049*
		Longevity($H2_b$)	-0.072	0.689
		Frequency($H2_c$)	-0.206	0.080
H3: Instrumentality of local knowledge	0.000*	Node($H3_a$)	2.011	0.000*
		Longevity($H3_b$)	1.275	0.000*
		Frequency($H3_c$)	1.038	0.000*
H4: Learning	0.877	Node($H4_a$)	0.054	0.794
		Longevity($H4_b$)	-0.064	0.697
		Frequency($H4_c$)	0.001	0.995
H5: Self need	0.977	Node($H5_a$)	0.022	0.868
		Longevity($H5_b$)	-0.009	0.936
		Frequency($H5_c$)	0.015	0.837
H6: Show off	0.454	Node($H6_a$)	-0.263	0.180
		Longevity($H6_b$)	-0.215	0.171
		Frequency($H6_c$)	-0.105	0.311
H7: Monetary	0.724	Node($H7_a$)	0.097	0.593
		Longevity($H7_b$)	-0.033	0.822
		Frequency($H7_c$)	0.046	0.633
H8: Mapping party	0.486	Node($H8_a$)	0.710	0.242
		Longevity($H8_b$)	0.029	0.953
		Frequency($H8_c$)	0.239	0.454

N=343; *p<0.05

Since the p-values (Pillai's trace) for project goal and local knowledge are less than 0.05, data suggests significant relationships between the level of contribution and the motivations related to the project goal and local knowledge. In addition, when relationships between these motivations and the three dimensions of contributions are looked at, it is suggested that the project goal has significant relationships only with the number of nodes and frequency of contribution, whereas local knowledge has significant relationships with all three dimensions of contribution. The parameter estimates show that the level of contribution is positively associated with instrumentality of local knowledge, whereas it is negatively associated with the project goal. Hence, only H3 (including all its sub-hypotheses $H3_a$, $H3_b$, and $H3_c$) is supported as hypothesized.

A binary logistic model was run with a dichotomous dependent variable (serious or causal mapper). The same set of independent variables used in the multivariate analysis—seven motivational constructs, four motivational items, and 6 demographic variables—were used in the model. As given in Table 4.12, the results show that instrumentality of local knowledge, self view, and monetary motivations are significant with positive effects. This suggests that those with high self view, monetary motivation, and local knowledge are likely to be serious mappers.

Table 4.12: Results of the binary logistic model

Motivations	**Unstandardized parameter estimates**	**Sig. Value**
Monetary	0.512	0.035*
Learning	-0.030	0.922
Instrumentality of local knowledge	1.037	0.008*
Project Goal	-0.193	0.574
Altruism	-0.385	0.200
Show-off	-0.450	0.110
Self need	-0.085	0.625
Community importance	-0.107	0.622
Identity	-0.108	0.595
Self view	0.472	0.012*
Socio-political agenda	0.040	0.794

N=338; *p<0.05

4.7 DISCUSSION

This empirical study has important implications for the development of online communities, as most communities have explicit or implicit spatial dimensions. It provides insight for designing mechanisms to stimulate citizen participation in the production of knowledge.

Returning to the original research questions, it is found that majority of the contributors are educated males living in Europe. Many contributors are employed in commercial sector and about two-thirds have contributed at least once to open source software and Wikipedia. Regarding the motivations, the goal of the OpenStreetMap project—which is a "free wiki world map" —is the most important motivator, as per contributors' self report depicted in Table 4.8. Contributors believe that this goal is achievable and expect the members of the community to reciprocate contribution, not get a free ride. Since they also report self need and altruism as motivational factors, their interest in creating a free wiki world map can be interpreted as an interest in freely available geographic information both for meeting their own needs as well as the need of others.

Additionally, learning and local knowledge are reported as other motivations. Members of the OSM community believe that contributing to the OSM allows them to widen their knowledge about world geography and deepen their understanding of local community. They see an instrumental role for local knowledge about places they know and a value in creating a free wiki world map. The motivational show off factor is borderline, whereas money is reported as not a motivator.

Members contribute at varying levels in an online community (Ortega et al., 2008), which suggests differences in their underlying motivations. In order to explore this, contributors were classified into two broad groups—serious and casual mappers—and their motivations were compared as depicted in Table 4.9. It is found that the differences are significant only in local knowledge, learning, and monetary motivations, serious mappers being motivated more in all of them.

The above-mentioned motivations were then tested against the actual contributions. Because it is difficult to measure the actual contributions in an online community, most research relies on the self reported measures such as number of hours one spends in a typical week. In this research, we were able to measure the actual contribution in terms of the number of nodes,

longevity of one's engagement in the project, and frequency of contribution. When we connected the reported motivations with their actual contribution and analyzed, only the motivation related to local knowledge was found to be positively related with the level of contribution. This means when people see the areas they care about missing or erroneously mapped in online maps, they contribute more, as it helps them realize the instrumental role their knowledge about those areas can play in mapping or correcting those maps. For them, mapping is a way to manifest their identity and a means of representation in cyberspace. Since geospatial situations keep on changing, local people are better positioned to update and correct maps than remote agencies. Those who are more concerned with the representation and maintenance of their place and identity contribute more in order to address their concerns.

The fact that local knowledge turns out to be the most important motivational factor suggests a unique nature of VGI, which is grounded in place. Although researchers have found the instrumentality of knowledge as an important motivation in online knowledge contribution (Houle et al., 2005; Hertel et al., 2004), the 'local' nature of knowledge distinguishes VGI from other online communities and uniquely positions it in the discourse of online knowledge production.

Further analysis of self-reported motivation and actual contribution shows that monetary and self view motivations have some effect in the likelihood that someone becomes a serious mapper. This implies that those who view themselves highly and have higher monetary motivation are likely to contribute more actively. Interestingly, the positive association of monetary motivation with serious mapping contradicts contributors' self reports in the survey. The indication of monetary motivation among serious mappers is consistent with our observations. For example, several active contributors have started doing business with OSM data. Along the same lines, there were presentations on 'Monetizing OSM Data' in the State of OpenStreetMap Conferences in both 2009 and 2010.

Although the study did not find evidence to support a positive association between the level of contribution and motivations such as project goal, altruism, and learning, we do not claim that these motivations do not exist. Contributors reported these as strong motivations. Motivation is necessary, but is not a sufficient condition for contribution in an online community (Kollock, 1999), implying that a variety of factors might affect the translation of motivation into contribution. In the context of geographic information, Budhathoki et al. (2010) argue that

contributory mechanisms (i.e. structure, process, and norms/rules-in-use of the online community) mediate motivation and contribution. It could be possible, for instance, that the OSM interface and inner dynamics of the community are not conducive for those motivated by the goal of the project, altruism, or a desire to learn. More research, particularly qualitative, is needed to understand these in depth.

The results of this research offer important implications for garnering an enhanced contribution to an online knowledge community in general and VGI in particular. It suggests that a visualization of underrepresentation or inaccuracies of issues, if contextualized in a geographic place, might entice more contribution. This is in line with a recent initiative by the US Census 2010 (US Census, 2010). Place-based visualization helps realization that each individual possesses knowledge about certain aspects of geography. At the same time, place-based local knowledge implies that one's potential to contribute to VGI is limited to places one has visited or lived. This means that the places with a higher number of "human sensors"—big cities, tourist sites etc.—are likely to be mapped in finer details whereas small towns and country sites might not be represented well in cyberspace. This challenges the assumption that VGI will serve as a universal source of geographic information (Goodchild, 2007).

Limitations to this study include the fact that the established principles of traditional surveys such as random sample and high response rate could not be met. These are the key methodological challenges for the online survey research (Dillman, 2007). It is also possible that the respondents did not understand the questions in the way they were intended. We also employed a case study approach and studied www.openstreetmap.org, which limits the generalization of the findings. It will be interesting to extend this study to other VGI cases such as Google Maps, Google Earth, Wikimapia, Open Planning Project, and even Flickr.

Additionally, there is a time lag between the measurement of dependent and independent variables used in the model. The three dependent variables—number of nodes, longevity of one's engagement in the project, and frequency of contribution—used in measuring the level of contribution were derived from the data downloaded in April 2009, whereas the independent variables were measured from the survey taken in December 2009. Although a drastic change is unlikely in this short period, certain changes in contributory behavior cannot be rejected. Although we find the positive association between the motivation related to local knowledge and contribution, we are unable to tell the causality. For example, does local knowledge increase

contribution or does seeing one's contribution visually on map trigger the local knowledge further? This study is about human information behavior, which is complex and contextual. It should be recognized that modeling human behavior and motivation is a difficult task, as people often take the same action to satisfy different motives (Clary et al., 1998). This complexity makes VGI motivational research difficult. It also makes the design of online geographic information community challenging, as it is difficult to identify and meet the needs of its members. It is hoped that this empirical study contributes to our better understanding of this rapidly growing phenomenon and that it stimulates further research.

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CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 MAIN CONCLUSIONS

The broad objective of this research is to understand a rapidly emerging phenomenon called volunteered geographic information (VGI) (Goodchild, 2007). VGI refers to an online geographic information community in which there is no central authority to define and delegate tasks to its members. In order to accomplish the broad objective, the following three sub-objectives are set for this study:

1. Analyze the role of the user as implicated by VGI
2. Define and develop an overall framework for VGI
3. Explore users' motivations to contribute geographic information in VGI

The research accomplished these goals, culminating in three international journal papers corresponding to each of them. The first two papers are already published (Chapters 2 and 3) and the third one will be developed from the empirical part of the dissertation (Chapter 4). The research employed a mix of different methods—literature review, qualitative analysis of text, and quantitative survey—to accomplish these goals. Additionally, contributions of all the contributors of openstreetmap.org were analyzed to identify the actual contribution of each contributor. This involved processing nearly 800 million records and generated a database of the contributory pattern in www.openstreetmap.org. The pattern of contribution helped to understand the case and also to connect survey responses to actual contributions. When the survey responses were connected to the actual contributions, it yielded interesting results.

The analysis of users' contributions were not envisaged in the original research design. As the focus of the research was to study contributors' motivations, it was later realized that the identification of contributors from the pool of registered users was necessary to send the survey to the contributors. Without this, the survey would have to be posted on the openstreetmap website, which would severely suffer from bias as anyone (both contributors and non-contributors, and even outsiders) could respond to the survey.

The major conclusions in relation to each sub-objective mentioned above are presented in the following sub-sections.

5.1.1 Analyze the Role of the User as Implicated by VGI

An argument for reconceptualizing the role of the user of geographic information is developed after reviewing literature and analyzing people's participation in Web 2.0 geospatial tools. The argument is elevated in the context of Spatial Data Infrastructure (SDI) and a term 'produser' is proposed. As soon as a user is viewed as a produser (i.e. both user and producer), it brings important implications for GIScience research and practice. For example, it allows for the treatment of SDI and VGI as supplementary phenomena, leading to a hybrid SDI model. The argument for a hybrid SDI model is articulated, and relevant research questions are framed.

SDI efforts that have been on-going since the middle of the 1990's are not gaining momentum. One of the major reasons is that SDIs have adopted a supply-driven approach, ignoring users' input in the design and implementation process (Masser, 2005; Budhathoki & Nedovic-Budic, 2007). It is hoped that the notion of the hybrid SDI model addresses this issue and opens up the possibility of capitalizing on users' potential in developing more useful SDIs.

5.1.2 Define and Develop an Overall Framework for VGI

Relevant literature on the sociology of volunteering, leisure studies, and the social production of knowledge in an online community are extensively reviewed. Following the review, an overall framework for VGI is developed. The framework helps to identify the limitations of VGI as a purely voluntary activity. The VGI definition proposed by Goodchild (2007) is then extended in a more encompassing way to understand diverse actors, their actions, and their underlying motives. The proposed framework is used to study contributors' motivations in VGI. OpenStreetMap users' conversation text messages are analyzed to contextualize literature-suggested motivational factors and explore how they operate in VGI. It is found that many motivational factors identified in literature play differently in VGI. This indicates that while VGI is a special case of the social production of knowledge, it needs to be considered on its own terms as well, as a distinct type of online knowledge community.

5.1.3 Study Users' Motivations to Contribute Geographic Information in VGI

This empirical part of the study builds on the outcomes of the research associated with the previous two sub-objectives. Key questions related to this sub-objective were: who are the mappers taking part in VGI? Why do they contribute geographic information? Is there any

difference in motivation between serious and casual mappers? These are interesting questions particularly because there is an assumption that contributors neither receive a direct monetary reward nor are directed to contribute.

A set of hypotheses were developed based on the insights gained while accomplishing the first two sub-objectives. The hypotheses were tested using the data collected from the survey and the analysis of users' actual contributions in openstreetmap.org. The results show that only those who are motivated by local knowledge—i.e. those who see their local knowledge as instrumental for mapping the areas they value and correcting errors on the map—make a good level of contributions. Positive associations were not supported between the level of contribution and other motivations. This implies that other motivations did not necessarily translate into contributions to openstreetmap. Thus, the place-based 'local' nature of knowledge distinguishes VGI from other online knowledge production communities.

When looking into the effects of different motivations on a contributor's likelihood to be a serious mapper, in addition to local knowledge, I find self view and monetary motivations as significant factors. This means that those who have high view of the self, monetary motivation, and realize the value of local knowledge are likely to contribute far more than casual mappers. The effect of monetary motivation in serious mapping is interesting because mappers rated monetary motivation low and motivations related to project goals and altruism high in their self report.

In line with other researchers such as Goodchild (2007), I had a view that VGI is driven by altruism when I started this research. The analysis of the users' contributions did not support it. Instead, the analysis indicates some positive association between the monetary motivation and serious mapper contributions, which directly challenges this speculative and anecdotal claim. This leads to a vexing question: To what extent, if any, is VGI a voluntary activity? Further research is required for this.

This research has important implications for different fields. Planning, for instance, is a field where current and detailed information plays a pivotal role (Nedovic-Budic, 2000). Since technologies are increasingly available, we now need to understand the ways to motivate citizens in order to capitalize their potential to supply information for urban planning, environmental planning, and emergency situations. In a Web 2.0 environment, citizens are uniquely positioned to provide a wide range of information to planners (Carrera & Ferreira, 2007; Bishr & Mantelas,

2008). If we can motivate citizens, it brings two-way benefits for planning: they become the source of information and also become engaged in the planning process, increasing the ownership of the planning outcomes.

Citizen participation is the heart of a democratic system. Understanding who participates and why in an online geographic community has some implications for government-citizen dialogue. People's desire to contribute local knowledge, as found in this research, should not be understood in limited terms of the geometric primitives of point, line, and polygon; rather, it should be interpreted as their expression of interest to participate in a broad process of governance. If their desire for participatory discourse with the government and fellow citizens can be correctly understood and shaped, the resulting collective intelligence might prove to be an asset in the 21st century knowledge society (Benkler, 2006).

Online maps and geographic information are becoming the 'next utility' (NRC, 2010). Most online communities have implicit geospatial dimensions. Even seemingly text-based systems such as Wikipedia maintains geospatial information with geo-tagging its articles. In addition to geo-tags, photo sharing communities such as Flickr and Picasa can be considered explicitly geographic information communities. Efforts are already in place to add geospatial dimension in social networking sites (for example, whereyougonnabe.com). Given the heightening interest in geographic information in most online communities, this research provides some insights to the designers and managers of such communities.

5.2 RECOMMENDATIONS FOR FUTURE RESEARCH

5.2.1 Study VGI Adoption and People's Motivations in More Specific Contexts

This dissertation studies contributors in VGI and their motivations worldwide. To the best of my knowledge, this is the first study on the topic. Studies at a country or cross-country level will provide a deeper understanding of people's motivations to contribute geographic information and adopt VGI. For example, how do cost, use restrictions, and availability of digital geographic data through spatial data infrastructure affect VGI adoption? Is there a relationship between the diffusion of VGI with the socio-economic status of a country such as the human development index, gross domestic product, literacy rate, Internet connectivity or even national security policy? Masser (2005) uses Roger's (1995) diffusion of innovation theory to study the

diffusion of SDIs around the world. It would be interesting to compare the diffusion of VGI with that of SDI to see if it follows the same path.

5.2.2 Study Use and Value of VGI Data

This research is focused on the creation and supply side of VGI. An equally pressing area of research is the use side. Who is using VGI data? How are they using it? Why are they using it? There is an inherent uncertainty about the quality of VGI data as anyone can edit it any time, so these questions would be interesting to explore. Their answers would shed light on the value of VGI and its potential use in different applications.

5.2.3 Investigate Organization and Governance Issues in VGI

How does a VGI community emerge and evolve? How are decisions made? How are conflicts resolved and cooperation promoted? These questions are crucial in designing and managing a thriving community. In addition, these questions might also provide interesting insights for organizing humans in general.

5.2.4 Examine Policy Implications

VGI brings important implications for traditional producers of geographic information. A crucial question is: How should traditional producers such as national mapping agencies (NMA) respond to VGI? Which of the framework data layers it has been producing should be crowd-sourced, if any? Which layers should it retain? NMAs are immensely interested in these questions as is evident from a recent VGI workshop USGS organized (http://cegis.usgs.gov/vgi/).

5.2.5 Study Organizational Motivation

This research explored motivations of individual contributors to openstreetmap. However, there are also organizational players influencing most VGIs. For example, in openstreetmap, Yahoo! donated high resolution imagery, the Netherlands-based company Automotive Navigation Data (AND) uploaded its data on the highways in China and India. Several other local government and community organizations have also uploaded their data to openstreetmap. In order to understand this complete picture, it is important to study the motivations of the organizations involved in VGI.

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APPENDIX A

DATA TABLE DEFINITION (DTD) FOR OSM DATA FILES

```
<!ELEMENT node (tag*)>
<!ATTLIST node id        CDATA #REQUIRED>
<!ATTLIST node lat       CDATA #REQUIRED>
<!ATTLIST node lon       CDATA #REQUIRED>
<!ATTLIST node visible   CDATA #IMPLIED>
<!ATTLIST node user      CDATA #IMPLIED>
<!ATTLIST node timestamp CDATA #IMPLIED>
-----------------------------------------------------------------------------------------------
<!ELEMENT tag EMPTY>
<!ATTLIST tag  k         CDATA #REQUIRED>
<!ATTLIST tag  v         CDATA #REQUIRED>
```

APPENDIX B

JAVA SCRIPT FOR PROCESSING OSM DATA

```
/* Database connection and update. */
package nama.com;

import java.sql.*;
import java.util.List;
import java.util.Iterator;
import java.util.HashMap;
import java.util.Set;

public class MySqlConnection {

private static final String DB_URL = "jdbc:mysql://localhost:3306/";
private static final String DB_NAME = "osm_contribution";
private static final String MYSQL_DRIVER = "com.mysql.jdbc.Driver";
private static final String USER_NAME = " ";
private static final String USER_PASS = " ";
private static String INSERT_OSM_NODES = "INSERT INTO
OSM_NODE(node_id,time_stamp,user,latitude,longitude,country_name) VALUES(?,?,?,?,?,?)";
        private static String INSERT_OSM_TAG = "INSERT INTO OSM_TAG(node_id,
tag_key,tag_value) VALUES(?,?,?)";
        private Connection conn = null;
        public Connection getConnection(){
                if(conn != null)
                        return conn;
                try{
                        Class.forName(MYSQL_DRIVER).newInstance();
                   conn =
DriverManager.getConnection(DB_URL+DB_NAME,USER_NAME,USER_PASS);
                }catch(Exception mysqle){
                        System.out.println("Cannot connect to Mysql db.");
                        mysqle.printStackTrace();
                }

                return conn;
        }

        public void saveOsmNodes(List <OsmNode>nodes){
                Connection myConn = getConnection();
                PreparedStatement stmt1 = null;
                PreparedStatement stmt2 = null;
                ResultSet rs = null;
                Iterator it = nodes.iterator();
                Iterator keyIterator;
```

```
HashMap tempTag;
Set keySet;
String tagKey;

try{
        //System.out.println("MySqlconnection-insert osm nodes starts.");
        stmt1 = myConn.prepareStatement(INSERT_OSM_NODES);
        //stmt2 = myConn.prepareStatement(INSERT_OSM_TAG);

        while(it.hasNext()) {

                OsmNode tempOsmNode = (OsmNode)it.next();
           stmt1.setInt(1, tempOsmNode.getNodeId());
           java.util.Date date = tempOsmNode.getTimeStamp();
           long t = date.getTime();
           java.sql.Date sqlDate = new java.sql.Date(t);
           stmt1.setDate(2,sqlDate);
           stmt1.setString(3, tempOsmNode.getOsmUser());
           stmt1.setDouble(4, tempOsmNode.getLatitude());
           stmt1.setDouble(5, tempOsmNode.getLongitude());
           stmt1.setString(6, tempOsmNode.getCountryName());
           stmt1.addBatch();
           /*
           tempTag = tempOsmNode.getOsmTag();
           keySet = tempTag.keySet();
                keyIterator = keySet.iterator();
                while(keyIterator.hasNext()){
                        tagKey = (String)keyIterator.next();
                        //System.out.println("Inserting tag.");
                        stmt2.setInt(1, tempOsmNode.getNodeId());
                        stmt2.setString(2, tagKey);
                        stmt2.setString(3, (String)tempTag.get(tagKey));
                        stmt2.addBatch();
                        //System.out.print(" "+tagKey+"="+tempTag.get(tagKey));
                }
           */
        }

 stmt1.executeBatch();
/*
 try{
          stmt2.executeBatch();
 }catch(Exception tagExp){
         System.out.println("Could not inset tag.");
         tagExp.printStackTrace();
```

```
            }
            */
            System.out.println("insert nodes completed.");
        }catch(Exception svNodeExp){
                System.out.println("Could not save osm nodes.");
                svNodeExp.printStackTrace();
        }finally{
                try{
                        stmt1.close();
                        //stmt2.close();
                        //myConn.close();
                }catch(SQLException sqlExp){
                        System.out.println("Could not close connection.");
                        sqlExp.printStackTrace();
                }
        }
}
public void closeConnection(){
        if(conn != null){
                try{
                        conn.close();
                }catch(Exception connExp){
                        System.out.println("Could not close connectioin.");
                        connExp.printStackTrace();
                }
        }

}
public static void main(String arg[]){
        /*
        System.out.println("MySQL Connect Example.");
    Connection conn = null;
    String url = "jdbc:mysql://localhost:3306/";
    String dbName = "osm_contribution";
    String driver = "com.mysql.jdbc.Driver";
    String userName = " ";
    String password = " ";
    try {
      Class.forName(driver).newInstance();
      conn = DriverManager.getConnection(url+dbName,userName,password);
      Statement stmt = conn.createStatement();
      ResultSet rs = stmt.executeQuery("SELECT *FROM USER_ACCOUNT");
      while(rs.next()){
            String name = rs.getString("USER_NAME");
            String pass= rs.getString("USER_PASS");
            System.out.println("User Name: "+name);
```

```
                System.out.println("User Password: "+pass);
            }
            System.out.println("Connected to the database");
            conn.close();
            System.out.println("Disconnected from database");
           } catch (Exception e) {
            e.printStackTrace();
           }
           */
        }


}

/* Parse XML */
package nama.com;

import java.io.IOException;
import java.util.*;
import java.text.*;
import javax.xml.parsers.*;
import org.xml.sax.Attributes;
import org.xml.sax.SAXException;
import org.xml.sax.helpers.DefaultHandler;
import com.sun.xml.internal.ws.api.pipe.Fiber;

public class LoadOsmNodes extends DefaultHandler{
        public static final int MAX_NODES_SIZE = 2000;
        public static String FILE_NAME = "central_african_republic.osm";
   private MySqlConnection mySqlConn = null;
        List <OsmNode>nodes;

        private OsmNode osmNode;

        //to maintain context
        private OsmNode tempNode;


        public LoadOsmNodes(){
                nodes = new ArrayList<OsmNode>();
        }

        public void runExample() {
                parseDocument();
                //printData();
        }
```

```
	private void parseDocument() {

		//get a factory
		SAXParserFactory spf = SAXParserFactory.newInstance();
		try {

			//get a new instance of parser
			SAXParser sp = spf.newSAXParser();

			//parse the file and also register this class for call backs
			sp.parse(FILE_NAME, this);

		}catch(SAXException se) {
			se.printStackTrace();
		}catch(ParserConfigurationException pce) {
			pce.printStackTrace();
		}catch (IOException ie) {
			ie.printStackTrace();
		}
	}

	/**
	 * Iterate through the list and print
	 * the contents
	 */
	private void printData(){

		System.out.println("No of osm Nodes '" + nodes.size() + "'.");

		mySqlConn.saveOsmNodes(nodes);
		nodes = new ArrayList<OsmNode>();

	}


	//Event Handlers
	public void startElement(String uri, String localName, String qName, Attributes
attributes) throws SAXException {
		//reset

		if(qName.equalsIgnoreCase("Node")) {
			//create a new instance of employee
			osmNode = new OsmNode();
			osmNode.setCountryName(FILE_NAME.substring(0,
FILE_NAME.indexOf('.')));
```

```
                        osmNode.setNodeId(new Integer(attributes.getValue("id")).intValue());
                        String timeStamp = attributes.getValue("timestamp");
                        osmNode.setTimeStamp(getDate(timeStamp));
                        osmNode.setOsmUser(attributes.getValue("user"));
                        osmNode.setLatitude(new
Double(attributes.getValue("lat")).doubleValue());
                        osmNode.setLongitude(new
Double(attributes.getValue("lon")).doubleValue());
                }else if(qName.equalsIgnoreCase("tag")){
                        osmNode.getOsmTag().put(attributes.getValue("k"),
attributes.getValue("v"));
                }

        }

private Date getDate(String timeStamp){
        Date osmDate = null;
        String tempDate = "";
        String tempTime = "";
        tempDate = timeStamp.substring(0,timeStamp.indexOf('T'));
        tempTime = timeStamp.substring(timeStamp.indexOf('T')+1, timeStamp.indexOf('Z'));
        //System.out.println("Date: "+tempDate+" "+tempTime);
        try{
                DateFormat df = new SimpleDateFormat("yyyy-MM-dd HH:mm:ss");
                osmDate = df.parse(tempDate+" "+tempTime);
        }catch(Exception e){
                e.printStackTrace();
        }
        return osmDate;
}
        public void characters(char[] ch, int start, int length) throws SAXException {
                String tempVal = new String(ch,start,length);
        }

        public void endElement(String uri, String localName, String qName) throws
SAXException {

                if(qName.equalsIgnoreCase("Node")) {
                        //add it to the list
                        nodes.add(osmNode);

                }
                if(nodes.size() == MAX_NODES_SIZE){
                        printData();

                }
```

```
	}

	public static void main(String[] args){

		LoadOsmNodes loadOsmNodes = new LoadOsmNodes();

		loadOsmNodes.mySqlConn = new MySqlConnection();
		loadOsmNodes.runExample();
		loadOsmNodes.printData();
		loadOsmNodes.mySqlConn.closeConnection();
	}

}


/* OSM Node Data Object */
package nama.com;

import java.util.*;
public class OsmNode {
	int nodeId;
	Date timeStamp;
	String osmUser;
	double latitude;
	double longitude;
	String countryName;
	public String getCountryName() {
		return countryName;
	}
	public void setCountryName(String countryName) {
		this.countryName = countryName;
	}
	HashMap osmTag = new HashMap();
	public int getNodeId() {
		return nodeId;
	}
	public void setNodeId(int nodeId) {
		this.nodeId = nodeId;
	}
	public Date getTimeStamp() {
		return timeStamp;
	}
	public void setTimeStamp(Date timeStamp) {
		this.timeStamp = timeStamp;
	}
	public String getOsmUser() {
```

```
		return osmUser;
	}
	public void setOsmUser(String osmUser) {
		this.osmUser = osmUser;
	}
	public double getLatitude() {
		return latitude;
	}
	public void setLatitude(double latitude) {
		this.latitude = latitude;
	}
	public double getLongitude() {
		return longitude;
	}
	public void setLongitude(double longitude) {
		this.longitude = longitude;
	}
	public HashMap getOsmTag() {
		return osmTag;
	}
	public void setOsmTag(HashMap osmTag) {
		this.osmTag = osmTag;
	}
}
```

APPENDIX C
PERL SCRIPT TO IDENTIFY OSM USERS

```
use strict;
use WWW::Mechanize;
use HTML::TokeParser;

my $line;
my $counter = 0;
my $url;
my $doc;

# Title and message

my $title = "Survey about OpenStreetMap - Research by University of Illinois";
my $content =
   "hello!\n" .
   "I would like to experiment with a block of text that I am writing \n" .
   "Another line of text\n" .
   "Yours\n" .
   "--";

#Open users file - users file is every user name in a new line.

open (INPUT_FILE, "emaillist.txt") || die "Can't open input file.\n";
open (OUTPUT_FILE, ">emailoutput.txt") || die "Can't open output file.\n";

#Login to OSM
my $user = " ";
my $password = " ";
my $browser = WWW::Mechanize->new(autocheck =>0);
$browser->agent_alias('Linux Mozilla');
$browser->get("http://www.openstreetmap.org/login");
$browser->submit_form(
      form_number => 1,
      fields => { 'user[email]' => $user, 'user[password]' => $password});

# Now go through every single user and check if we can email or not. Output to a CSV file.


while (<INPUT_FILE>)
{
  sleep 1;
  chop;
  $line = $_;
  $counter = $counter + 1;
```

```
  $url = "http://www.openstreetmap.org/message/new/" . $line;

  print "[",$counter,"]: ";
  print $line," \t";
  $browser->get($url);
  if ( ! $browser->success ) {
    print "No Email\n";
    print OUTPUT_FILE "No Email, ",$url,"\n";
    next;
  }

  $doc = $browser->content;
  if ( $doc =~ /Send a new message/ ) {
      print "Email\n";
      print OUTPUT_FILE "Email, ",$url,"\n";

      $browser->submit_form(
        form_number => 1,
        fields => { 'message[title]' => $title, 'message[body]' => $content});

    } else {
      print "No Email\n";
      print OUTPUT_FILE "No Email, ",$url,"\n";
    }
}

close INPUT_FILE;
close OUTPUT_FILE;
```

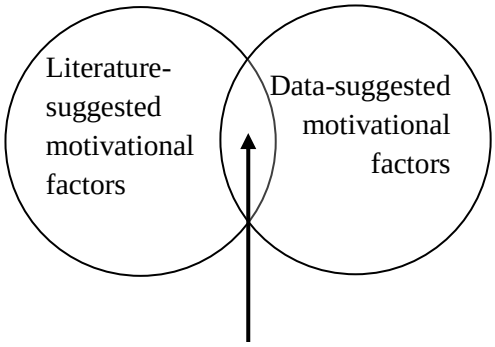
APPENDIX D
QUALITATIVE ANALYSIS OF OSM TALK-PAGES

PURPOSE OF THE ANALYSIS

Literature on volunteerism, leisure study, open source software, Wikipedia, and virtual communities suggest about two dozen factors for understanding contributors' motivational dynamics in VGI. After identifying these factors, in the next step, the research uses these literature-suggested factors to design a theoretically informed survey to determine the motivational factors in VGI. While many of these factors could be present, all of them might not be present in VGI, or those which are present may not have a significant presence. Hence, one of the challenges is to determine each factor's relative importance and contextualize them in the context of VGI. For this purpose, the OpenStreetMap (OSM) talk-pages were analyzed to trace the motivational factors at the preliminary level.

A talk-page—which is a discussion list—provides space for communication among the members of OSM. As the members of OSM are geographically distributed, they rely on Internet-based communications to identify, develop, and address issues pertinent to the growth of the project. Registered users raise issues, comment to the issues raised by others, and engage in conversations with other members of the community using the talk-pages. To stimulate more specialized conversations, OSM organizes conversations using different talk-pages: 'talk' for general conversations, 'dev' for issues related to the development of technical infrastructure and 'legal-talk' for legal issues. In addition, there are also country-specific talk-pages. The list of all talk-pages can be found at: http://lists.openstreetmap.org/listinfo/. In many cases, issues are raised in 'talk' and then forwarded to a more specialized talk-page depending on the nature of the issue. 'Talk' receives the highest traffic among all the pages.

Motivational factors traced in talk-pages (i.e. data-suggested factors) will be used to contextualize the literature-suggested factors. If a factor is suggested by both the data and the literature, then it is considered to be a strong candidate for the survey. The intersection of two circles in below diagram represents such factors.



Motivational factors to be considered in surveys

DOWNLOADING, SELECTING AND MAKING SENSE OF CONVERSATIONS

After scanning conversations in different talk-pages, I decided to study 'talk' for the following reasons:

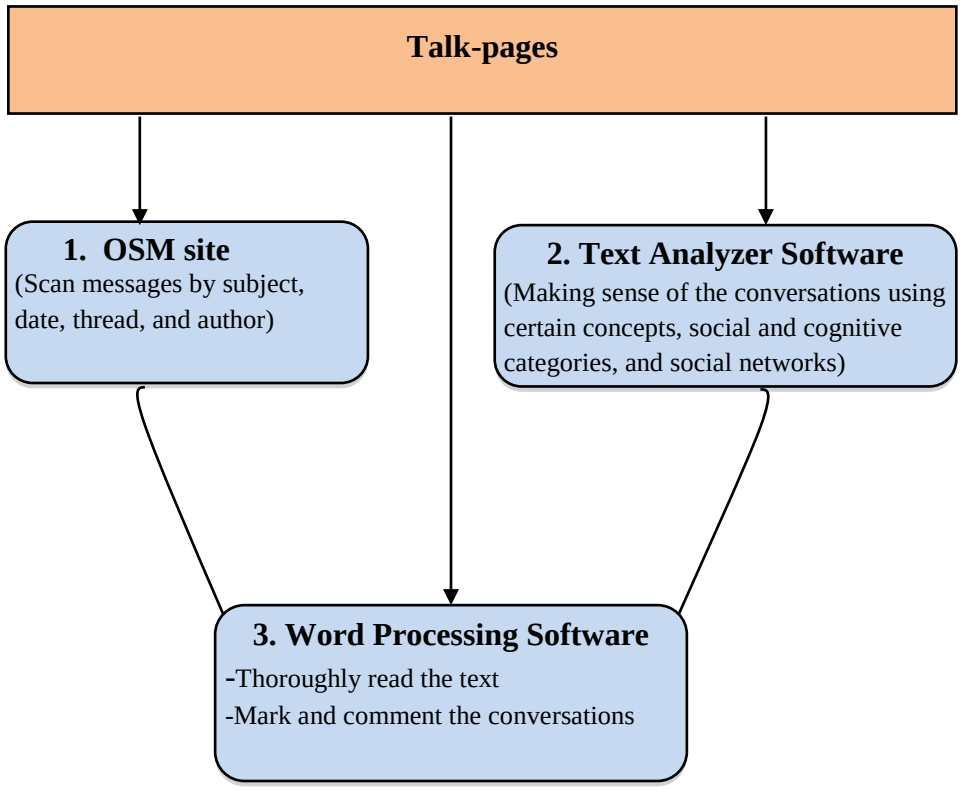
- 'Talk' is used to discuss general issues that include participation and contribution;
- Unlike a country-specific page, 'talk' is used by users from all over the world;
- Among all the pages, 'talk' is the only page which documents all conversations since the beginning of the project. In this sense, it provides the richest information about the evolution and history of the project. All talk-pages—consisting of conversations of 55 months when the analysis began in February 2009—are archived in monthly basis at: http://lists.openstreetmap.org/pipermail/talk/.

I then downloaded all the pages archived in 'talk'. Conversations in certain months are up to thousand pages long. Hence, it was not possible to thoroughly analyze all 55 months of conversations archived in 'talk'. As I began to scan different pages, I soon realized that all the conversations are not relevant for my purpose. I then decided to analyze the conversations of seven months—the months and the rationales behind their selection are given in below table.

Months	**Rationale behind the selection**
September, October, November, and December 2004	Steve Coast started the project in August 2004. Bringing other people in the project should have been an obvious challenge at the beginning. I expect that the first few months might consist of important conversations reflecting motivation.
January and	I chose these latest conversations to supplement

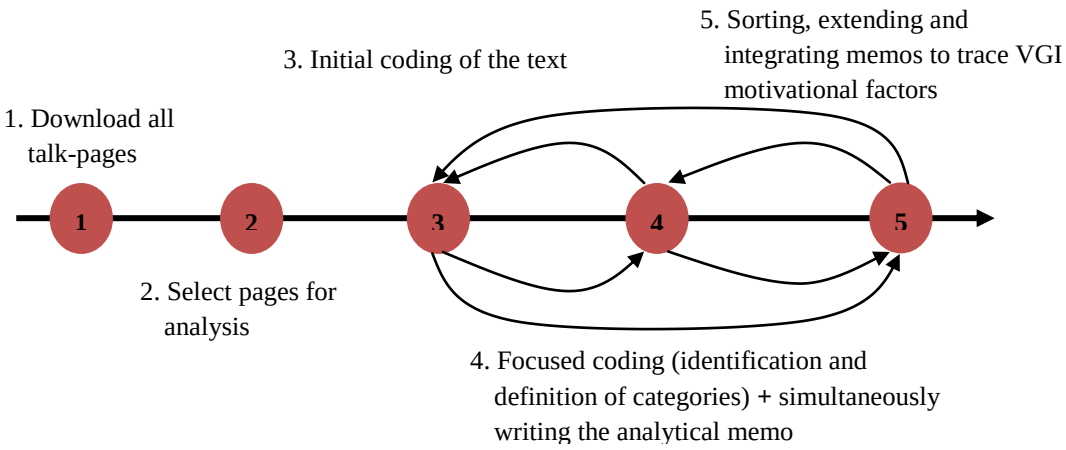
February 2009	initial conversations. Often, the analysis of the beginning and end helps to make sense of the whole.
September 2008	While scanning the entire 'talk' archive, I identified that this month consisted of important conversations regarding participants' motivations to contribute to the OSM. In response to a posting about motivations, several members of the OSM community expressed their underlying motives for contributing geospatial information in that month.

After the selection of the talk-pages, I scanned the entire messages directly from the OSM site using the date, discussion thread, subject, and author as shown in the below figure. An online text analyzer (http://textanalytics.net) was also used to supplement the scanning process. The scanning of the messages helped to make sense of the conversations. This was followed by the import of the messages into Microsoft Word and reading the text line by line. Different tools available in Microsoft Word, such as highlight and comment, were used to select, mark, and comment relevant text to make it easier for later processing: coding, and writing and integrating memos.



CODING THE TEXT: INITIAL AND FOCUSED CODING

Grounded theory originally proposed by Glaser and Strauss (1967)—and later explicated with highly useful illustrations of the analytical procedure by Charmaz (1983)—was used as a theoretical guide in analyzing the talk-pages. Following Charmaz (1983), the following figure depicts the process employed in my analysis of conversations.



IDENTIFICATION OF MOST IMPORTANT MOTIVATIONAL FACTORS

The following motivational factors (VGI-MF) are derived from the analysis of talk-pages:

- **Fulfillment of self-need:** An individual may contribute online to public geospatial information and knowledge good (i.e. geospatial information commons) in order to fulfill self need. Such a situation may generally arise when the good the individual is looking for does not exist in the first place, does not meet his requirements even if it exists, or he cannot find or afford it.

- **Anti-corporate sentiment:** Many contributors are concerned about the growing corporatization of geospatial data and its potential consequences to the access and use of these data. This anti-corporate sentiment drives them to contribute to projects that have characteristics of public good (i.e. commons).

- **Expectancy of reciprocity:** Contributors are aware that one's self effort alone is not sufficient to create the kind of geospatial data necessary for fulfilling their own need as well as the needs of other users. Hence, while making their own contributions, they anticipate contributions from other members of the community. Contributors view their contributions as encouraging and enticing for other members of the community to reciprocate.

  The expectation of reciprocity in the online mapping community is strikingly similar to 'hacker culture' observed in the open source software community. In hacker culture, members of the community freely share resources and work together towards achieving a common goal. One needs to understand this culture and behave accordingly to gain respect within the community.

- **Visual power of map:** Data suggest that the visibility of one's contributions is an important motivational factor. Maps, by their very nature, are effective visual tools, and hence appeal to members of the community to contribute. Many contributors have been addicted to maps since their childhood, and mapping is fun for them. When they see their contributions appear visually in maps, it provides them with deep satisfaction. The visual power of maps also motivates contributors in other ways. For example, when someone sees a blank area in the map, it induces the potential contributor to map that area.

- **Outdoor entertainment:** In many cases, members of an online mapping community need to go outdoors to identify, measure, and/or describe geospatial features they are interested in mapping. It provides them with an opportunity to visit and interact with physical space.

  As contemporary human life, particularly in cities, is getting busier and increasingly confined indoors, many people find these mundane jobs boring. Mapping provides a good opportunity for people, including outdoor enthusiasts, who are seeking an excuse to get out into the physical space.

  Individuals who engage in outdoor mapping activities may come from different life situations. Examples are: college graduates who are waiting to begin another degree and computer nerds who spend most of their time in front of the computers. Although they take

part in mapping activities, their underlying motive is to get outside to the physical space for entertainment.

- **Pride of local knowledge:** When one sees a map with some discrepancy between the content of the map and his current state of knowledge, it motivates him to use his knowledge and rectify it. Since most mapping systems do not allow rectification of such discrepancies, he may begin to contribute to the map in order to utilize his local geospatial knowledge and create superior maps (in his view).

  Because of cost, traditional mapping agencies map only periodically, often once every several years. Hence, these maps are not always up-to-date. Moreover, due to the lack of sufficient local knowledge, maps produced by central organizations are not as detailed as local people would like to see.

- **Movement for freedom of geospatial information:** After reading the selected conversations, it became clear to me that the members of OSM community have ideological reasons to contribute for creating geospatial information commons. Many of them hold quite a strong belief that maps should be free as in the copyleft movement.

  This ideological thrust seems to have several roots. Many contributors were—and still are—involved in open source software projects. They carry this ideological belief from there. Some contributors developed this position when they were asked to pay a price far beyond their imagination when they needed geospatial data for their class projects. Others were simply annoyed by the increasing commercial control of geospatial data. Members of the community frequently cite Google maps, NavTeq, and TeleAtlas and believe that their movement will one day replace these commercial giants' geospatial services.
  However, it is very interesting that OSM community accepts Google sponsorships for different events, have accepted multi-million dollar satellite imageries from Yahoo!, and a huge amount of geospatial data from a Netherlands based commercial company called AND.

- **Concerns about larger issues:** Although 'map' and 'mapping' are the key terms used in OSM community, many contributions are driven by their interests/concerns about some larger issues. For example, some contributors are interested in bird hides while others are

interested in bingo halls. Yet others are concerned with showing the declining green space in certain areas to draw public attention. For them, mapping is only a means to address their larger concerns.

This suggests different strategies to attract more contributions. Instead of saying "let's go mapping," we should perhaps say "every year, X number of people die due to the contaminated drinking water. Let's find the places with the highest number of deaths and call for action."

- **Learning:** Many OSM contributors are driven by their desire to learn. Some are interested in enhancing their mapping skills, while others are interested in expanding their knowledge about the world geography. Yet others are interested exploring different aspects of their local community.

- **Monetary:** Although concrete evidence of monetary motivation was not found, there are some indications of monetary motivation as seen in the following excerpt:

> *Fascinating idea, being paid to wardrive the neighborhood. It could make it a lot easier to collect GPS points. Are you interested in the rest of Europe as well. I'm trying to map Oslo, Norway. :) What kind of payment rates are we talking about here? Enough to buy the equipment needed to lend out collection stations?*

APPENDIX E

MOTIVATIONAL FACTORS, MEASUREMENT ITEMS, AND SOURCE OF MEASUREMENT

Motivational factor and the source	**Measurement instrument**	**Source of measurement**
Unique ethos	Digital maps should be available for free.	Self made
	Digital maps should be available for free only for non-commercial applications.	Self made
	Corporate control of digital maps is a concern to me.	Self made
Learning	Contributing to OSM lets me develop my mapping skills.	Clary et. al.(1998)
	Contributing to OSM lets me develop my technical skills through direct, hands on experience.	Clary et. al.(1998)
	OSM allows me to gain a new perspective about the area I live in.	Clary et. al.(1998)
	Contributing to OSM helps to develop a new perspective about the geography of the world.	Self made
Personal enrichment	OSM has added richness to my life.	Gould et al. (2008)
Self actualization	OSM has enabled me to use my mapping skills.	Gould et al. (2008)
Self image	OSM has improved how I think about myself since I joined it.	Gould et al. (2008)
Fun	I find maps fascinating.	Self made
	I enjoy contributing to OSM.	Self made
	Seeing my contribution appear visually on OSM map provides me with a profound sense of satisfaction.	Adapted from Gould et al. (2008)
	Entering map data on the computer is an enjoyable part of my OSM experience.	Adapted from Gould et al. (2008)
Outdoor recreation	Being part of a mapping party is an enjoyable part of my OSM experience.	Self made
	Going out to collect mapping data is an enjoyable part of my OSM experience.	Self made
	OSM allows me to spend some time outdoors.	Self made
	Meeting new people while participating in an OSM party is an enjoyable part of my OSM experience.	Self made
Instrumentality of local knowledge	When I see information about the places I know missing from OSM, I map them.	Self made
	When I see errors on the map for the area in which I live, I correct them.	Self made
	I map only those places I have visited.	Self made
	I contribute to OSM because I can provide accurate information from my local knowledge.	Self made

Self efficacy	I think that my contributions are as good as those of others.	Self made
Meeting self needs	I contribute to OSM because the map data I am looking for does not exist elsewhere.	Self made
	I contribute to OSM to create maps that can meet my needs.	Self made
Freedom to express	I contribute to OSM because I have the freedom to select the areas to map.	Self made
Altruism	I contribute to OSM because those who are in need of digital map data will use my contribution.	Adapted from Clary et. al.(1998)
	It is important to help others by providing digital maps that are available for free.	Adapted from Clary et. al.(1998)
Career	I use OSM to display my skills to potential employers.	Self made
	OSM experience will look good on my resume.	Clary et. al.(1998)
Social relation	My friends and family value my contribution to OSM.	Self made
Project goal	I believe in "Free Wiki World Map", which is the goal of the OSM project.	Adapted from Gould et al. (2008)
	I believe that 'Free Wiki World Map', which is the goal of OSM, is achievable.	Adapted from Gould et al. (2008)
Community	OSM will not succeed in developing a world map without the community.	Self made
	OSM community is important to me.	Self made
Identity	OSM has given me a sense of identity.	Gould et al. (2008)
Reputation	I want to be recognized as an active OSM contributor.	Self made
Monetary return	I have benefited financially from my involvement in OSM.	Gould et al. (2008)
	I use OSM data in making profit in my business.	Self made
	I am planning a commercial business in the future using OSM data.	Self made
Reciprocity	I expect OSM users to actively contribute geographic data to the project.	Self made
	The right to use OSM data should be based on how much one has contributed to OSM.	Self made
System trust	I trust that my contributions are safe with OSM, as its technical system is reliable.	Self made
Socio-political	Contributing to OSM allows me to highlight social issues (these can be environmental, political or other social issues) that are important to me.	Self made

Note: The choice, adaptation, or development of measurement items were informed by the qualitative analysis.

AUTHOR'S BIOGRAPHY

Nama Budhathoki has a Bachelors degree in Computer Science. He worked as an information and communication technology (ICT) specialist for two years for the government of Nepal before he went to the Netherlands to pursue graduate study. He completed a Master of Science degree in Geographic Information Science (GIS) from the International Institute of Geo-Information Science and Earth Observation (ITC) in 1999. Following the Master of Science degree, he continued working for the development of a national land information system in Nepal for five years. He began his PhD studies at the University of Illinois at Urbana-Champaign in 2005. Following the completion of his PhD, Nama will begin a postdoctoral research position with the "Participatory Governance with Web 2.0 project" at McGill University.