Public participation in the Geoweb era: Geosocial media use in local government

by

Shanqi Zhang

A thesis
presented to the University of Waterloo
in fulfilment of
the thesis requirement for the degree of
Doctor of Philosophy
In
Geography

Waterloo, Ontario, Canada, 2018

Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

External Examiner	Dr. Claus Rinner Professor and Chair, Department of Geography and Environmental Studies Ryerson University
Supervisor	Dr. Rob Feick Associate Professor, School of Planning University of Waterloo
Internal Member	Dr. Peter Johnson Associate Professor, Department of Geography and Environmental Management University of Waterloo
Internal Member	Dr. Colin Robertson Associate Professor, Department of Geography and Environmental Studies Wilfrid Laurier University
Internal-external Member	Dr. Stéphane Roche Professor, Département des sciences géomatiques Université Laval

Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contribution

I choose the manuscript option under the guidelines of the joint Waterloo-Laurier Graduate Program in Geography for this dissertation. Three manuscripts presented in Chapter 2, 3 and 4 are my own work. During the process of proposing and designing research, analyzing data and writing manuscripts, my supervisor and committee members have provided guidance and valuable advice under a supervision capacity. I hereby clarify authors' roles and contributions to the three manuscripts that comprise this dissertation.

The first manuscript is entitled "Evolving practices of citizen participation via geospatial technology: Defining a typology for geo-participation". I designed the research, collected and analyzed data, and prepared the manuscript. Dr. Peter Johnson and Dr. Rob Feick provided valuable feedback to the manuscript under a supervision capacity.

The second manuscript is published as Zhang, S., & Feick, R. (2016). Understanding Public Opinions from Geosocial Media. *International Journal of Geo-Information*, 5(6), 74. I designed the research, implemented coding, collected and analyzed data, and prepared the manuscript. Dr. Rob Feick aided with the preparation of the manuscript with valuable comments, edits, and advice under a supervision capacity.

The third manuscript is submitted as Zhang, S., & Feick, R. A geospatial data perspective to evaluating opportunities and challenges of using geosocial media for non-emergency reporting. *Applied Geography*. I designed the research, conducted citizen survey and local government interviews, analyzed data and prepared the manuscript. Dr. Rob Feick provided valuable advice and comments for the design of the research and preparation of the manuscript under a supervision capacity.

Abstract

Advances in spatially enabled information and communication technologies (ICTs) have provided governments with the potential to enhance public participation and to collaborate with citizens. This dissertation critically assesses this potential and identifies the opportunities and challenges for local governments to embark on emerging geo-enabled practices.

This dissertation first proposes a new typology for classifying geo-enabled practices related to public participation (termed here as geo-participation) and demonstrates the emerging opportunities presented by geo-participation to improve government-citizen collaboration and government operations. This dissertation then provides in-depth examinations of geosocial media as an exemplar geo-participation practice. The first empirical study assesses the potential of repurposing geosocial media data to gauge public opinions. The study suggests that geosocial media can help identify geographies of public perceptions concerning public facilities and services and have the potential to complement other methods of gauging public sentiment. The second empirical study assesses the usefulness of geosocial media for sharing non-emergency issues and identifies an important opportunity of enabling citizen collaboration for reporting and sharing non-emergency issues.

Altogether, this dissertation makes several conceptual, empirical, and practical contributions to local government adoption of geo-participation. Conceptually, the proposed typology lays the foundation for researching and implementing geo-participation practices. Empirically, this dissertation tells a story of opportunities and challenges that sheds light on how local governments may adopt geosocial media to solicit citizen input and enable new forms of government-citizen interaction. Practically, this dissertation develops a tool for processing text-based citizen input and models of implementing geosocial media reporting that can help local government develop proper strategies of adopting geosocial media.

Acknowledgements

When I first applied my U.S. visa, I was asked by the custom officer: “what is the biggest island in the world?”, as he saw I was going to pursue my masters in geography.

I am asked similar questions quite often. People often ask “PhD in Geography?”, seemingly confused, when they first know I am majored in geography. “What would you do after you finish?” they ask, “become a geography teacher?”

Once they know I have traveled from China to the U.S. and Canada for graduate studies, they often start laughing, “Ah, geographers!”

Before I started my undergraduate as a GIS student, I, too, considered geographers as those who travel around and know places that are rarely known; those who can read the sun and moon; those who survey the landscape and make maps.

I still remember my first GIS class, the professor told us everything is about geography. I did not fully understand at the time. Over the years, especially after I started my PhD research related to Volunteered Geographic Information (VGI), I started to understand more.

It is an era when every one of us is or can be a geographer. We use smartphones, make transactions, and talk about places in our daily conversations. Consciously or unconsciously, we are generators of spatial information, or we are parts of the spatial information ourselves.

Working on a topic that is so relevant to our everyday life is bestowed. Yet pursuing a PhD is not without challenges. Many times during my PhD, I felt that I was on a roller coaster, an extremely long one with so many ups and downs.

I love roller coasters. I feel relaxing and satisfying every time I finish a ride, after all the screams and laughter on the ride. Now I am close to the end of this possibly most challenging roller coaster I will ever have; and I know I cannot finish this long ride without helps from so many people.

A debt of gratitude goes to my supervisor Dr. Rob Feick for his guidance of developing and implementing this dissertation research; for his encouragement that helped me go through the highs and lows of PhD studies; and for him challenging me to grow in my early academic career. I would also like to thank my examining committee members, Dr. Peter Johnson, Dr. Colin Robertson, Dr.

Stéphane Roche and Dr. Claus Rinner, whose expertise, insights and advice have greatly encouraged my research and improved this dissertation.

I thank KWAccessAbility, City of Kitchener and Kitchener's farmers' market for their assistance with recruiting citizen participants for my study. I thank all of citizen participants and local government interviewees for their kindness to take their time to participate, and for sharing their insights without which this research cannot be completed. I thank MAD lab of environment faculty that offer technical assistance to the development of the study website.

I acknowledge GeoThink research project, which supports my PhD research and provides me with the opportunity to connect with scholars, students, and research opportunities that have greatly helped my professional development.

I am very fortunate to have many friends who have offered help during my PhD studies. I would like to thank the cohort of spatial decision support lab for their companionship, empathy and encouragement. I would like to thank my roommates over the years, Yue Dou, Hui Luan, Chen Chen, Qing Lu, Johnny Chen and Chengpei Shi, for being my family along the journey. I would like to thank my Yoga tribe for their inspirations of Yoga practice on and off the mat and for leading me to start a journey of self-discovery that I know will last for a lifelong time. I would also like to thank Pearl Chang, Carrie Zhou, Yunwei Dong, Chen Shang, Minghui Liu, Ibrahim Bendaya, Heidi Karst, Sara Harrison, Shawn Wang, and the Lyon couple. I am so thankful that I met them, learned from them, and shared parts of the journey with them. I know the love and memories will not fade wherever we are.

I would like to thank my parents, my grandparents and my extended family for loving me, raising me, and supporting me. I want to send a special thank-you to my grandmother Duojun Wang. She was not able to continue her education during the World War II, but never stopped learning all her life. She gave me the inspiration of becoming an educated and independent woman since I was a kid, and she is the best role model as a person with grit.

Lastly, I would like to thank Yu Yang, for being the best friend and partner in the past ten years, for being always supportive and considerate, for making me being me, and mostly importantly, for sharing the life.

Dedication

To grandma, Duojun Wang.

献给亲爱的外婆

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Context and motivation

With over 50% of the world's population now living in the cities and the number continuing to grow (United Nations, 2016), cities are increasingly responsible for delivering services to people and businesses as well as for meeting difficult social, economic, and environmental challenges associated with sustainable forms of development (Roche, 2014). Local governments have increasingly capitalized on technologies, Internet and Communication Technologies (ICTs) and web 2.0 technology in particular, to enhance connections with the public, promote participatory decision-making to better address public needs, and improve the efficiency of service delivery by collaborating with the public (McKinsey Center for Government, 2017; Sivarajah et al., 2015). Despite these efforts, governments are still struggling with the increasing expectations and demands of citizens (McKinsey Center for Government, 2017). Although the importance of improving citizen participation and engagement for policy and decision making has been recognized for some time now (Layne & Lee, 2001; United Nations, 2008), a recent report from The United Nations (2016) suggests that the progress in practice has been modest. Citizen participation initiatives still struggle with low participation rates and the difficulty of integrating participation outcomes with government procedures (Anthopoulos, Reddick, Giannakidou, & Mavridis, 2014).

Geospatial technologies have been used in public participation processes to encourage public engagement, identify community needs and enhance participatory decision-making (Sawicki & Peterman, 1996; Tang & Liu, 2015). Public agencies (e.g., local governments) use spatial information and methods (e.g., mapping) to provide the public with access to spatial information (e.g., spatial background of projects, spatial data about local environments) and to collect local spatial knowledge from the public (Brown & Kyttä, 2014; Rinner, 2006). More recent developments in geospatial technologies, such as the Geoweb and location-aware devices and services, have provided people with easier access to geospatial information and tools and enabled wider scale spatial data generation and collaboration (Sieber, Robinson, Johnson, & Corbett, 2016). Local governments now have the opportunity to obtain local spatial knowledge about more diverse topics from the broader public and to use this knowledge to improve their data, services and decision-making. However, local governments still face significant challenges in adopting the practices of citizen generating geospatial information because of perceived risks associated with the uncertain quality of citizen-generated data, needs of technical, financial and human resources, increased citizen requests and demands, and lack of regulation and legislation (Brandeis & Nyerges, 2016; Johnson & Sieber, 2012, 2013). It is necessary to examine the participation potential of citizens generating geospatial information in local government settings and to assess the benefits and challenges associated with these practices.

It is against this backdrop that this dissertation is carried out to investigate opportunities and challenges for local governments to take advantage of advances in geospatial technologies to enhance public participation. The rest of this chapter details the concept of public participation and reviews progress in public participation practices, particularly those that adopt geospatial information and technologies, in local government settings.

1.2 Public participation in government decision-making

1.2.1 Defining public participation

Public participation by itself is a nebulous concept that is variously defined by its purposes, methods and processes. In social science studies, for example, citizen participation is considered to be a collection of methods for involving the citizenry in the process of making decisions that affect them (Abelson et al., 2003). Xie & Jaeger (2008 p.3) considered the aim of citizen participation is to shape governmental policy, "either by influencing the selection of government personnel or by affecting their choices." The OECD (2001) emphasized the active partnership of citizens and government in public participation processes for "defining the process and content of policy-making." The International Association of Public Participation (IAP2) considers the form of public participation and suggests five types of participation activities that indicate different levels of citizen involvement. The five types include informing, consulting, involving, collaborating, and empowering (IAP2, n.d.). Specifically, informing refers to government informing the citizenry about public policies, issues and decisions; consulting refers to government collect public feedback on decisions or plans; involving suggests that local governments carefully consider public interests and concerns in the decision-making processes; collaborating suggests that citizens may participate in developing criteria for decision-making; and empowering implies that the public have the right of making the final decisions.

Public participation is also often used in relation to other terms and concepts such as citizen or public engagement. Rowe & Frewer (2005), for instance, used public participation and public engagement interchangeably to refer to "the practice of involving members of the public in the agenda-setting, decision-making, and policy-forming activities of organizations/ institutions responsible for policy development" (Rowe & Frewer, 2005 p.253). Other conceptualizations consider public participation and engagement to be relevant but different practices. For example, Ross, Baldwin, & Carter (2016) consider public engagement to be the broad terms that include public participation and other efforts of establishing public relations and media relations. Yet their definition conflicts with the definition of IAP2 in that they consider public consultation to be different from public participation, whereas IAP2 defines public consultation as one form of public participation.

This dissertation adopts the working definition of UNPAN (n.d.), which considers public participation to be the involvement of members of the public in a wide range of agenda-setting, decision and policy making activities of local governments. The goal of participation is "to orient government programs toward community needs, build public support, and encourage a sense of cohesiveness within neighborhoods"(UNPAN, n.d.). Participation is not limited to particular forms but may encompass a spectrum of activities such as government informing citizenry of public policies and decisions, public consultation, and citizen collaboration on service provision and data collection.

According to the definition of UNPAN (n.d.), public participation may happen both within institutional arrangements or as grassroots initiatives. That is, participatory projects may be developed, guided and facilitated by local government officials as part of the pre-established decision-making processes (Seeger 2008). Citizen may also initiate their own projects to discuss issues of their communal concerns and to give their voices to public affairs (Lin, 2013a; Panagiotopoulos, Bigdeli, & Sams, 2014). In contrast, public or citizen engagement refers only to collective and active citizen involvement through top-down participation initiatives led by government officials.

1.2.2 Rationale for public participation

Despite the challenges of defining public participation, few would argue with the fundamental belief in the democratic value of public participation. The International Association of Public Participation suggests that "those who are affected by a decision (should) have a right to be involved in the decision-making process" (IAP2, n.d.). The belief is that, at least in theory, decisions that are collectively made by citizens would reflect aggregated preferences of members of the public and will lead to public decisions that are democratic and legitimate (Innes & Booher, 2004). Others suggest that public participation is a means for eliminating unequal power relationships and advancing fairness and justice, as people who hold little power can have a voice (Fagence, 1977; Fischer, 1993). Participation is associated with empowerment as observed by Gaye & Diallo (1997 p.12): "the newly empowered local community, through democratic decision-making and problem solving, matures into a body capable of interacting collectively with the local authority and even with agencies from higher government."

In addition to the democratic ideal, a more practical rationale for public participation is that it contributes positively to governmental decision-making by facilitating "responsive administrative apparatus as well as policy that is more representative of citizens' desires and needs" (Day, 1997 p.425). It was reported that successful deliberative democracy projects can "vastly improve social outcomes, as balanced input from citizen participants allows factions to compromise and find solutions to previously intractable problems" (Irvin & Stansbury, 2004 p.57). For government administrators, public participation may yield better public acceptance of decisions, as the public is better informed of the problems and the rationale behind the decision-making (Irvin & Stansbury, 2004). This improved public acceptance will also increase the possibility of successful implementation of decisions (Thomas, 1995). More recently, it has been suggested that involving citizens in government solutions can help improve the efficiency of government operations and also enhance government transparency (Linders, 2012).

1.2.3 Conceptualizing public participation

Public participation may happen at different stages of decision-making, be motivated by different purposes, adopt different participation mechanisms, induce different relationships among participants and decision-makers, and involve members of the public that reflect different compositions (Schlossberg & Shuford, 2005). Conceptualizations of public participation vary accordingly. Table 1-1 lists a number of widely adopted conceptualizations of public participation that focus on public participation as a means to enhance citizen power and control over decision-making, as an administrative process, and in terms of information flow. For each conceptualization, a spectrum of public participation activities ranging from low-level engagement (bottom) to high-level engagement (top) is classified according to the orientation of the conceptualization.

Table 1-1 Different conceptualizations of public participation

Orientation	**Spectrum of public participation**
Citizen power (Arnstein, 1969)	• Citizen power • Tokenism • Nonparticipation
Administrative (Wiedemann & Femers, 1993)	• Public partnership in the final decision • Public participation in assessing the risks and recommending solutions • Public participation in defining the interest and determining agenda • Public right to object • Inform the public • Public right to know
Information flow (Rowe & Frewer, 2005)	• Public participation • Public consultation • Public communication
E-participation (United Nations, 2008)	• E-participation • E-consultation • E-information

Perhaps the most prominent model of citizen participation is the ladder model suggested by Arnstein (1969). This model frames participation based on citizen power and classifies participation activities into eight rungs. These rungs correspond to three broad categories, namely non-participatory, tokenism, and citizen power. Along the spectrum, citizen powers range from no power to full control of decision-making. At the bottom level of the ladder, citizens do not have the power in decision-making; rather, those who have powers make the decision and elicit public support by educating the public. At the other end of the ladder, citizens have the power to influence the entire processes of decision-making and may even possess the ability to directly impact and control public decisions.

Wiedemann & Femers (1993) suggest an alternative ladder model that focuses on how public participation is programmed within government agencies. Their model accounts for how government agencies differently consider public participation in risk-related decision-making. For example, one may consider "distributing information to concerned citizens" as being public participation (Wiedemann & Femers, 1993 p.356). In another case, public participation was considered to be the involvement of citizenry in assessing the risks of making a decision by public agencies. Accordingly, citizens are differently involved with government decision-making, ranging from "general education with little direct influence on decision-making to public participation in the final decision-making processes" (Schlossberg & Shuford, 2005 p.17).

Rowe & Frewer (2005) frame public participation based on "the flow of information between participants and sponsors" (p.254) and differentiate between three forms — public communication, public consultation and public participation — that all are used for public participation. For public communication, information is conveyed from conveners to the public. For public consultation, information is conveyed from the public to conveners and conveners should elicit and include public opinions in decision-making. Public participation suggests interactive information exchange between the public and the conveners. The dialogues between citizen representatives and conveners are believed to, to some degree, affect opinions of both parties and decision outcomes. Along the same line, The United Nations (2008) classifies e-participation activities into three types: *e-informing* (i.e., the one-way information provision from governments to citizens), *e-consultation* (i.e., the two-way communication through which governments solicit citizen opinions, input and feedback) and *e-decision-making* (i.e., and interactive government-citizen relationship through which citizen participation may impact the decision-making process).

The public participation frameworks outlined here are just a few of the many conceptualizations of public participation. For example, others suggest participation models in the context of conflict resolution, preventing public controversy, and open government (Connor, 1988; Dorcey, 1994; Lee & Kwak, 2012). This list of public participation frameworks demonstrates the vast differences in orientations of participation and accordingly the acts of participation. As suggested by Schlossberg & Shuford (2005), the orientation or objectives of participation will determine how public participation is conceived, implemented, and evaluated.

1.2.4 Public participation in practice

In practice, the acts of participation vary according to the purpose of and the rationale for participation and have evolved with technological developments. Initial citizen participation projects in contemporary society were limited to small groups of citizen leaders (Day, 1997). The 1954 Urban Renewal Act in the United States, for example, established an advisory board that was comprised of seven to fifteen citizen leaders who had connections with people involved with urban renewal projects (e.g. contractors and bankers) as representatives of the public

(Day, 1997). Starting in the 1960s, there was a transition from engaging a small elite group to engaging as many local communities and individuals that may be affected by a decision as possible (Callies, 1981). It was believed that ordinary citizens should have the right to give their voices in decisions that might impact them (Burke, 1979). The rise of ICTs has provided further opportunities to broaden public participation processes. Particularly, it was suggested that ICTs could help improve public access to government information and services and enable interactive dialogues among governments and citizens (Ho, 2002; Remmen, 2004). Accordingly, a wide range of digitally enabled participation activities including e-voting, online political discourse, online decision making, e-activism, e-consultation, e-campaigning, and e-petitioning have emerged (Medaglia, 2012).

In more recent years, developments in Web 2.0 technologies provide increasing networking opportunities for governments to enhance public participation and enable wider scale and new forms of government-citizen collaboration (Brabham, 2009). Web 2.0 technologies suggest a new paradigm of developing web technologies that highlight user-generated content, multidirectional information flows, and lightweight web application development cycles (O'Reilly, 2005). The roles of web users have shifted as they become both consumers and publishers of web content. According to Kaplan & Haenlein (2010), this paradigm shift has opened up the potential to achieve mass collaboration in that large numbers of web users can now collectively create content. In the government context, governments are taking advantage of the opportunity to enhance their participatory culture and embark on government-citizen collaboration initiatives to improve and augment public data and services (Brabham, 2009; Collins, Swart, & Zhang, 2013). The City of Chicago, for example, initiated a project called Snowportal for citizens to track snow-related information as well as to collectively update road and snow-removal conditions (Linders, 2012).

The collective capabilities of the public to address the challenge of real-time data collection offers the potential for governments to reduce the financial, time, and human costs of providing public services and to improve the efficiency of service provisions.

1.2.5 Challenges of implementing public participation

Despite the continuing efforts to enhance public participation, implementing public participation still faces challenges. The concern that the outcomes of a participation process will reflect the preferences or interests of only certain population groups has been longstanding (Day, 1997). For citizens, participation requires resources such as time, money, and energy; people who possess more resources are more likely to participate than those who possess fewer (McCarthy & Zald, 2001, 1977). Concerns of excluding socially disadvantaged people have been widely discussed as these people may not have the resource necessary to participate (Cinderby, 2010; Sieber, 2006). Some of the barriers to participation such as the confines of space and time are mitigated by Internet technologies, as people can participate remotely at times of their choices (Vicente & Novo, 2014). However, new technical and social barriers have emerged, as people need access to digital devices (e.g. computers) and must possess a certain level of digital and technical skills to participate (Crutcher & Zook, 2009; Lin, 2013a). Others have observed generational gaps in that younger generations are found to be more likely to accept digital participation methods (Corbett, 2013; Tulloch, 2008). The concern of excluding socially disadvantaged groups remains as these people may still lack necessary resources to digitally participate (Vicente & Novo, 2014).

In addition to the concern of a biased representation of the public, Etzioni-Halevy (2013) warns that a decentralized public participation process does not always equally empower citizens to share their concerns and aspirations. Smith & McDonough (2001) provided evidence that citizens are often not satisfied with participation processes, as citizens noticed that participation was unfair and participation outcomes were directed to particular results favored by elite groups or governments. In online environments, studies have similarly suggested that the free and self-expression channel does not eliminate inequality but is biased in favor of opinion leaders who have significant influences on online communications (Hong, 2013). Consequently, citizens may obtain a sense of social exclusion or have negative views of local authorities and would be less likely to participate (Lowndes, Pratchett, & Stoker, 2001b; Roeder, Poppenborg, Michaelis, Märker, & Salz, 2005).

Moreover, public participation outcomes do not always impact decision-making processes. According to an e-government survey conducted by the United Nations, "only 38 countries out of 193 member states (20%) indicate that e-consultation outcomes have resulted in new policy decisions, regulations, or service" (United Nations, 2016 p.65). The institutional settings of local government including its political structures, routines, and cultures are found to be counterproductive to public participation (Colombo, 2010; Grönlund, 2009). Operations in a bureaucratic organization such as government need to follow "a set of formal, explicit, comprehensive and stable rules that are impersonally enforced in decision making and lead to predictable and determinate results" (Cordella & Tempini, 2015 p.280). With inadequate representation of citizen interest, governments face risks of producing decisions that are unduly influenced by citizenry representatives (Irvin & Stansbury, 2004). As a result, public agencies are found to be more likely to trust their own capabilities of influencing decision-making from internal processes (Brown, 2012).

As such, the implementation of public participation remains challenging. It is suggested that further research and practices should pay attention to improving public engagement processes (Brown & Kyttä, 2014; Haworth, Whittaker, & Bruce,

2016) and seek technological solutions to broaden the participation process and encourage public collaboration for tackling urban problems (Brabham, 2009; Bright & Margetts, 2016).

1.3 Geo-participation

The incorporation of geospatial information and methods in public participation was motivated by the goals of: 1) educating the public on the spatial context of decisions, 2) bringing in local, experiential knowledge that often has a spatial component such as important locations for a planning or development proposal to decision-making processes and, 3) understanding geographies of public perceptions toward decisions made by public agencies and authorities (Brown & Kyttä, 2014; Kingston, 2007; Sieber, 2006).

1.3.1 PPGIS

In the 1990s, the term public participation GIS (PPGIS) was proposed to describe uses of GIS systems as tools for government agencies to enhance public involvement (Brown & Kyttä, 2014; Kar, Sieber, Haklay, & Ghose, 2016). Numerous studies have reported applications of PPGIS in a wide range of participatory planning projects for land-uses, forest, marine and community development (Atzmanstorfer, Resl, Eitzinger, & Izurieta, 2014; Brown, 2009; Brown & Brabyn, 2012; St. Martin & Hall-Arber, 2008). PPGIS was articulated as a well-established technical method for citizens to use to "map alternate views of the same problem and analyze the same data differently from those with political power" (Kar et al., 2016 p.296) and for the public, stakeholders and decision-makers to use to communicate and even collaborate through creating and disseminating map-based information (Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010).

PPGIS is not merely tool development. An important thread throughout PPGIS studies is whether or not the technology would empower local communities and individuals, include marginalized groups in decision-making processes, and increase public acceptability of authoritative decisions (Brown, 2017; Corbett, Cochrane, & Gill, 2016). Studies have suggested steady progress in improving public access to map-based information (Sawicki & Peterman, 1996), engaging with "hard-to-reach" groups (Cinderby, 2010) and senior population (Gottwald, Laatikainen, & Kyttä, 2016), and increasing social acceptability of land-use decisions (Brown, 2017). Yet concerns remain that the representation of the public in PPGIS approaches is biased toward those comfortable using map-based interfaces and also that the technologically driven approaches benefit some communities and individuals more than others (Brown, Kelly, & Whitall, 2014; Elwood & Ghose, 2011).

1.3.2 The Geoweb and public participation

Influenced by web 2.0 technologies, Geoweb, a collection of online geospatial technologies that support online generation, dissemination and management of geospatial data, information and maps, emerged (Elwood, 2010). The Geoweb brought a significant paradigmatic shift of spatial data production (Elwood & Leszczynski, 2013). With increasing use of location-aware devices (e.g. smartphones, wearable devices, and GPS-enabled sensors), ubiquitous access to the Internet, and growing popularity of web mapping applications (e.g. OpenStreetMap) and location-based services, generating spatial data is no longer exclusive to trained experts but has become accessible to average citizens (Goodchild, 2007). On the one hand, the paradigm shift has greatly expanded capabilities of PPGIS systems, as people now have fewer physical (e.g., space and time) and technical barriers to using online mapping applications (Tang & Liu, 2015). On the other hand, the paradigm shift has given rise to new forms of participation that differ significantly from PPGIS in terms of their purpose, processes, and methods, and provides local governments with the potential to enhance public participation and spur citizen collaboration and innovation (Sieber et al., 2016; Unsworth, Forte, & Dilworth, 2014).

The Geoweb technologies have reduced technical barriers for lay people to create maps and have encouraged participation with little or no formal coordination (Sieber et al., 2016). Lin (2013), for example, suggests that practices such as neogeographic mapping enable local communities or individuals to initiate participatory activities and express their opinions through collective mapping outside the traditional arena of participation. Crowdsourcing mapping applications, such as OpenStreetMap, are successful examples of community-initiated collective efforts of generating and validating geospatial information that can be used by individuals, communities, private and public sectors (Neis & Zielstra, 2014).

The Geoweb has spurred new forms of government-citizen collaboration. Mirroring the vision of Goodchild (2007), that citizens could act as sensors to revitalize costly expert-driven data systems and to collectively observe a phenomenon and possibly respond faster to the phenomenon, a full spectrum of knowledge producers (e.g. from expert cartographers to lay public) may collectively contribute to government data, services and infrastructure. For example, citizens may provide up-to-date information (e.g. snow, flooding, traffic) and collaborate with governments on providing customized geolocation services (Linders, 2012). Inspired by successful crowdsourcing mapping applications, there is potential for governments to embark on collective mapping practices and involve citizens in updating, correcting and vetting government geospatial datasets (Johnson, 2016). According to Sieber & Johnson (2015), this collaboration can be considered a participatory model where data becomes a conduit for integrating citizen contribution into government operations and decision-making. Citizens could also collaborate with governments to produce public services and applications for solving urban problems. According to Desouza & Bhagwatwar (2012), citizen collaborate with governments for problem identification and resolution through citizen apps on a variety of topics including transportation, public utilities, health and recreations, and information awareness and access.

A new form of passive citizen sensing has also emerged because of abundant geospatial data generated through the Geoweb. That is, citizens generate geospatial information when using GPS-enabled devices and online location-based services without a participatory intention. Yet the information can be used to obtain aggregated local spatial knowledge related to lived experiences, public perceptions, and local environments (Crooks, Croitoru, Stefanidis, & Radzikowski, 2013). Volunteered geographic information (VGI), geospatial content contributed to the Geoweb by web users, for example, is increasingly adopted to obtain information about time-critical situations and help enhance situation awareness (Hughes & Palen, 2009; Yin, Lampert, Cameron, Robinson, & Power, 2012). In the local government context, passive citizen sensing has the potential to supplement or augment existing public participation approaches. Gao et al., (2017), for instance, found that public perceptions extracted from social media are comparable to those collected using in-person techniques.

Local governments may adopt these emerging practices and opportunities for different purposes and uses. For example, governments may feed citizen-generated data to "higher-level decision-makers in a one-way process" or interactively engage with citizens in a two-way dialogue to improve their efficiency, transparency and accountability (Johnson & Sieber, 2013 p.77). Applications of some practices are still in their early stages. Citizen collaboration on vetting government open data (considered as participatory open data by Sieber

& Johnson, (2015)), for example, is an initiative that governments are only beginning to embark on. Therefore, further studies are necessary to assess the participation potential of these practices, investigate how these practices may fit into government procedures, and determine the best practices for government decision-making.

1.3.3 Defining geo-participation

Various terms are used for the emerging practices spurred by the Geoweb, including VGI (Goodchild, 2007), citizen-generated spatial data (Mooney, Sun, Corcoran, & Yan, 2011), neogeographic mapping (Turner, 2006), crowdsourced mapping (Miller & Goodchild, 2015), civic issue trackers (Sieber & Johnson, 2015), citizen sensing (Schade et al., 2013), and social sensing (Liu et al., 2015), to name a few. In the context of participation, this multiplicity of terms raises confusion as the terms are often used interchangeably, the lines between concepts and practices are often blurred, and the participatory contexts and objectives they involve are often not clearly defined. Geo-participation is used in this dissertation to refer to a collection of practices that are "infused with geospatial and participatory potential" (Kar et al., 2016 p.296).

Some may argue that these practices are not wholly developed based on the intention of participation nor compatible with traditional conceptualizations of public participation. For example, VGI primarily focuses on generating and disseminating geographic information, which may or may not have a participation goal (Verplanke, McCall, Uberhuaga, Rambaldi, & Haklay, 2016). Some types of citizen sensing (e.g., passive citizen sensing, ambient VGI) may not involve active public engagement that is usually key to public participation processes but relates to mining aggregated public perceptions using data-driven approaches (Gao et al., 2017). However, these practices can be used for participatory purposes, as governments may benefit from these practices in terms of broadened public engagement, better understanding of public needs and improvements of public services and decision-making (Bright & Margetts 2016).

1.3.4 Geo-participation: Challenges and research issues

Geo-participation encompasses a range of practices that adopt different tools, involve different participation processes, and may produce different participation outcomes. For example, some VGI practices facilitate direct map-based discussions between citizens and decision-makers and should be considered along the lines of traditional PPGIS research (Tang & Liu, 2015). Other practices deviate from traditional conceptualizations of public participation, as they may have an orientation (e.g., enriching government data) that is not emphasized in traditional conceptualizations of public participation based on citizen powers, conflict resolutions and administrative mandates. As a result, new forms of government-citizen interaction may emerge that cannot be conceptualized by the traditional ladder metaphor (Sieber et al., 2016). To assess the participation potential of geo-participation, it is necessary to classify the emerging geo-participation practices and identify the participation purposes, processes, and outcomes associated with each type of geo-participation.

Based on the classification, we should then identify and assess if and how geo-participation can enhance citizen participation and improve decision-making. First, while studies suggest that the Geoweb may increase the number of participants and bring in a more diverse composition of participants (Brown, Kelly, et al., 2014; Lin, 2013a), Elwood & Leszczynski (2013) warn us that digital divides are likely to persist with technological developments, as people may use technology differently due to non-uniform motivation, access, and skills. Alternatives such as mining public opinions using online sources may help us to solicit citizen input from some underrepresented groups (e.g. youth) and obtain unfiltered public views (Dunkel, 2015; Schweitzer, 2014). However, this potential needs to be further assessed in terms of its usefulness (e.g. what information can be elicited) and in terms of government acceptance of such an approach (Bright & Margetts 2016).

Section 1.2.5 suggests that one challenge of public participation is that participation outcomes may not be incorporated into decision-making. According to Brown & Kyttä (2014), uncertain data quality of contributed data is one factor that may impede the integration of citizen contribution into official decision-making. With wider scale citizen contribution through the Geoweb, varying geographic knowledge, diverging perceptions of on-the-ground situations, diverse technical skills, and less agreement on terminologies by contributors further exacerbate the consistency of heterogeneous datasets (Bakillah, Liang, Zipf, & Arsanjani, 2013; Senaratne, Mobasheri, Ali, Capineri, & Haklay, 2017). This presents significant technical challenges for governments to integrate contributed data to their operations and decision-making, as governments need to develop mechanisms of validating data quality, managing heterogeneous data sets and supporting interoperability among data sets (Bakillah et al., 2013; Garnett & Kanaroglou, 2016). Moreover, the anonymity of online participation raises an issue of trustworthiness for governments to adopt contributed data (Johnson, 2016). PPGIS approaches emphasize the localness of participants, as they would bring in local knowledge to decision-making. With online participation, the extent to which anonymous participants are familiar with local issues is unknown to local governments. Further studies are necessary to identify proper mechanisms that can assure quality of citizen input yet not deteriorate the intention of broadening participation (Brabham, 2009).

It is also necessary to examine how geo-participation practices may fit into local government procedures by addressing various organizational, institutional, technical and legislative factors. In practice, local governments need to consider how many human and financial resources need to be allocated for the new practice; whether the new practice conflicts with existing frameworks and procedures; if new strategies, procedures, policies and legislation need to be established; and whether new tools and systems need to be developed and how they are compatible with the legacy IT systems of local governments (Bertot, Estevez, & Janowski, 2016; Janowski, 2015; Johnson & Sieber, 2013; Nam & Pardo, 2014a). As such, authorities' perspectives are critical to the examination and assessment of geo-participation practices.

1.4 Research objectives, scope and questions

As stated in previous sections, there is a global need for governments to enhance public participation and enable government-citizen collaboration. The Geoweb related technologies present significant potential for local governments to improve public participation and embark on new participatory initiatives. Yet this potential need to be further examined and assessed as stated in section 1.3.4. As such, this dissertation aims to provide a conceptual and empirical investigation of emerging geo-participation practices by addressing the following research objectives: 1) situating geo-participation in local government context; 2) empirically examining the use of geosocial media as an example of geo-participation for local governments to understand public opinions and to communicate non-emergency issues with citizens.

1.4.1 Geosocial media

In this dissertation, I chose geosocial media for empirical investigations of geo-participation considering its participatory potential. Social media is defined as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content" (Kaplan & Haenlein, 2010 p.61). In addition to this definition, social media is characterized by providing a platform for Internet users to socialize and connect with each other and to achieve certain goals with others who share common goals or interests (Magro, 2012). Exemplar applications include social networking applications such as Facebook, microblogging services such as Twitter, content sharing services such as blogs and wikis, and media sharing sites such as YouTube and Instagram (Magro, 2012). Geosocial media refers to social media that is associated with implicit or explicit geographic information (e.g. geotags, coordinates, and place names).

The participatory potential of geosocial media is twofold. First, social media is a widely used communication and citizen engagement tool by municipal governments (Reddick & Norris, 2013). Social media is commonly used by local governments to inform citizens of local issues and new policies or redirect social media users to other government websites, articles and news (Khan, Yoon, & Park, 2014). It is also considered to be an important engagement tool for governments to enhance their connection and interaction with citizens as well as to increase participation rates (Lev-On & Steinfeld, 2015; López-Ornelas & Zaragoza, 2014). Recent studies also suggest the appealing potential of social media as a platform to facilitate government-citizen collaboration. For example, Linders (2012) suggests that social media provides an environment for governments and citizens to communicate real-time information and foster collaboration and innovation.

Second, geosocial media has potential as a data source of monitoring urban environments and understanding public needs (Poorthuis & Zook, 2017). A range of studies examined the usefulness of geosocial media in understanding dynamic environments and enhancing situation awareness (De Longueville, Annoni, Schade, Ostlaender, & Whitmore, 2010; Spinsanti & Ostermann, 2013). Other studies have suggested the potential of geosocial media for understanding public perceptions in terms of collective sentiments of local environments and infrastructure (Cao, Zeng, Wang, & Cheng, 2014; Mitchell, Frank, Harris, Dodds, & Danforth, 2013).

Despite the potential, using geosocial media for participatory purposes reveals several issues that are common to geo-participation practices. First, while geosocial media is a potential data sources for understanding public opinions, it is unknown how much information related to public opinions or perceptions regarding general or specific policy and decision-making can be harvested and how this information might differ from public input collected from other participation approaches. In other words, if and how can it improve public participation or improve decision-making remains unclear. Second, there is a lack of empirical evidence on payoffs and uncertainties of using social media to enhance citizen participation and collaboration (Criado, Sandoval-Almazan, & Gil-Garcia, 2013). Further studies are necessary to understand the practical challenges of government adopting geosocial media for participatory purposes.

1.4.2 Research questions

This dissertation adopts a manuscript format to address the three aforementioned research objectives through three independent yet related works. The first manuscript addresses the first objective by answering the following research question.

- RQ1: In general, how can geo-participation practices be classified? What implications does this classification have for researching and implementing geo-participation?

The second manuscript addresses the second objective by answering the following research question.

- RQ2: As an example of geo-participation, how useful is geosocial media as a data source for understanding public opinions?

The third manuscript addresses the third objective by answering the following research question.

- RQ3: From the perspective of both local governments and citizens, how useful is geosocial media for citizen reporting non-emergency issues such as deficiencies in public infrastructure and routine government services? What are the opportunities and challenges of adopting geosocial media for municipal reporting?

1.5 Overview of the dissertation

Chapter 2 of this dissertation synthesizes recent advancements in spatially enabled ICT-driven citizen participation and proposes a new typology for classifying and characterizing concepts and practices related to geospatial technology-mediated public participation. Each type of geo-participation practice is examined with practical examples to illustrate how new dynamics between governments and citizens are formed and new methods of collecting local spatial knowledge are enabled. The proposed typology is then applied to academic literature and government programs to demonstrate its use. The chapter concludes with emerging research and implementation needs.

Chapter 3 focuses on the potential for local governments or researchers to repurpose geosocial media data to gauge spatial and temporal dynamics of public opinions in ways that complement information collected through traditional public engagement methods. Text-processing methods are used to analyze Twitter data collected for the Region of Waterloo (Ontario, Canada) between March 2014 and July 2015 to assess citizens' concerns related to the planning and construction of a new Light Rail Transit (LRT) line. The case study illustrates how geosocial media can help identify geographies of expressed public concerns. The toolkit that is developed also addresses technical challenges of using the geosocial data that are usually unstructured, vary in quality, and require considerable effort to extract information that is relevant to local governments' needs.

Chapter 4 examines new opportunities for citizens to communicate transitory issues regarding dynamic urban environment and to report non-emergency issues to local governments. A case study centered on sidewalk issues in the City of Kitchener, (Ontario, Canada) compared citizen evaluations of the usefulness of geosocial media reporting with interview findings from staff of twelve Canadian municipalities. Bringing together government staff and citizen perspectives, chapter 4 presents key opportunities and challenges of using geosocial media reporting and suggests new forms of citizen collaboration to address data quality challenges and augment public service delivery.

Chapter 5 revisits recurring outcomes identified in chapters 2, 3, and 4, identifies the key contributions of the dissertation and discusses directions for future academic research.

Chapter 2: Evolving Practices of Citizen Participation via Geospatial Technology: Defining a Typology for Geo-Participation

2.1 Introduction

With the growing digital culture in our society, content generation no longer takes place only within the wall of mainstream organizations (Deuze, 2006; O'Reilly, 2005). The more networked digital media enables new forms of mass collaboration among individuals and private and public sectors (Brabham, 2009). Against this backdrop, governments are changing how they operate. According to The United Nations, there is a global trend of governments seeking for Internet-based participatory solutions to improve their service delivery, enhance citizen participation, and increase their transparency, openness and accountability (United Nations, 2016).

Developments in geospatial technologies have contributed to these government efforts. Using map-based approaches to engage with the public and to seek participatory solutions for spatial planning decisions by incorporating local spatial knowledge is not new. In the 1990s, the term public participation GIS (PPGIS) was proposed to describe uses of GIS systems as tools for government agencies to enhance public involvement (Carver, Evans, Kingston, & Turton, 2001; Sieber, 2006). With increased access to Internet and location-aware technologies, technical barriers of participation have been reduced and a wider scale spatial data generation by ordinary citizens has been enabled. Goodchild (2007) proposes the term volunteered geographic information (VGI) to describe transforming roles of lay people to become spatial data creators. The term has since been used vigorously and often interchangeably with other terms such as citizen-generated spatial data (Mooney, Sun, Corcoran, et al., 2011), neogeographic mapping (Turner, 2006), crowdsourced mapping (Miller & Goodchild, 2015), citizen sensing (Schade et al., 2013), and social sensing (Liu et al., 2015) to describe a collection of practices that involve collective mapping and spatial data generation by citizens.

Geo-participation is used in this paper to refer to a collection of practices that uses geospatial information and technologies (e.g., maps and location-aware devices and services) and have participatory potential (Kar et al., 2016). The geo-participation practices and citizen-generated spatial data present opportunities for governments to embark on new methods of delivering public services, collecting citizen feedback broadening public participation and spur citizen collaboration and innovation (Degbelo et al., 2016; Sieber & Johnson, 2015). However, there have not been clear roadmaps for local governments to implement some of the new methods. Some of the geo-participation practices differ from PPGIS practices in terms of "geographic scale, data volume, and reach, as well the need for technological and cartographic expertise" (Sieber et al., 2016 p.1033) and therefore require local governments to adopt different geospatial tools of collecting and managing data and to develop different participatory processes of spatial data generation.

Moreover, the multiplicity of terms generates confusion, as the lines between concepts and their associated practices are often blurred (See et al., 2016). For example, researchers have suggested that while PPGIS and VGI may involve similar spatial data collection processes, they often are used for distinct goals (i.e., PPGIS focuses on broadening participation, whereas VGI is primarily for spatial data generation)(Brown & Kyttä, 2014). It may not be clear to practitioners that how they may implement a geo-participation practice and how they may capitalize on a geo-participation practice to improve public participation. For researchers, the lack of a clear understanding of the association between geo-participation practices and their participation context may prevent researchers from examining relevant practices, assessing the usefulness of geo-participation for public participation in local government settings, and determining the research focus of one or a group of relevant geo-participation practices.

To this end, the first objective of this paper is to propose a common typology that classifies geo-participation practices in the local government context. Geo-participation practices are classified based on their mechanisms of spatial data production and their potential uses for public participation in local government context. Based on the proposed typology, the second objective of this paper is to identify the potential of emerging geo-participation practices for local governments to enhance public participation and to improve government operations. The identified opportunities have implications on the emerging needs of researching geo-participation.

2.2 Context: Geoweb and geo-participation

The initial efforts of incorporating GIS technologies into participatory public policy and planning process were motivated by the goals of bringing in local, experiential knowledge that often has a spatial component (e.g., important locations for a planning or development proposal) to decision-making processes and facilitating a wider scale participation (Brown & Kyttä, 2014; Kingston, 2007; Sieber, 2006). Digital mapping methods are primarily used in PPGIS projects for citizens to "map alternate views of the same problem and analyze the same data differently from those with political power" (Kar et al., 2016 p.296). Government agencies primarily implement PPGIS projects to enhance public involvement and fulfill specific participation goals, such as engaging with marginalized groups, improving social inclusion, and building social capital (Brown & Kyttä, 2014). Participation, accordingly, is purposive, agency-driven, mostly small-scaled, and often involves deliberative activities (Brown, 2012; Sieber et al., 2016).

Developments in the Geoweb, a geographical version of Web 2.0, have expanded this view of participation. Web 2.0 is characterized by ubiquitous content generation by Internet users as a form of participation (O'Reilly, 2005). In the geographical context, the Geoweb technologies (i.e., a collection of online geospatial technologies that support online generation, dissemination and management of geospatial information) have reduced technical barriers for lay people to create maps and have spurred a variety of activities of generating geographic information that is intrinsically participatory (Sieber et al., 2016). The wider scale spatial data generation has greatly expanded the outreach of PPGIS systems, as people now have fewer physical (e.g., space and time) and technical barriers to using online mapping applications (Tang & Liu, 2015). Moreover, new forms of participation that are intrinsic to the Geoweb have emerged and have brought a paradigm shift of how citizens engage with civic issues and policymaking (Elwood & Leszczynski, 2013). According to Sieber et al., (2016), participation that is intrinsic to the Geoweb differs from traditional PPGIS practices as it is often low-cost, less time-consuming, larger-scaled and involves less formal coordination.

In the government context, new forms of government-citizen collaboration have emerged accordingly. Mirroring the vision of Goodchild (2007), that citizens could act as sensors to revitalize costly expert-driven data systems and to collectively observe and respond to a phenomenon, citizens may collaborate with government to improve and augment public data and services (Brabham, 2009; Collins et al., 2013). For example, citizens may provide up-to-date information (e.g., snow, flooding and traffic) to government services (Linders, 2012). There is also a potential for governments to involve citizens in updating, correcting and vetting government geospatial datasets (Johnson, 2016; Sieber & Johnson, 2015).

A new form of passive citizen sensing has also emerged because of abundant geospatial data generated by citizens when they use location aware devices and online location-based services. While the information is not generated with a participatory intention, it can be used to obtain aggregated local spatial knowledge related to time-critical situations (e.g., flood and earthquake), lived experiences (e.g., activity space and tourism experience) and public perceptions (e.g., public sentiment and perceived environment)(Cranshaw, Hong, & Sadeh, 2012; Crooks et al., 2013; de Albuquerque, Herfort, Brenning, & Zipf, 2015; Dunkel, 2016; Zhou, Xu, & Kimmons, 2015). In the local government context, passive citizen sensing has the potential to supplement or augment existing public participation approaches. Gao et al., (2017), for instance, suggest that public perceptions extracted from geotagged social media are comparable to those collected using in-person techniques.

The implementation of some of the new practices require local governments to adopt geospatial tools and design participation mechanisms that differ significantly from those of PPGIS. For example, passive citizen sensing may not involve the process of engaging with the public but requires local governments to deploy computational methods for extracting and analyzing user-generated data (Bright & Margetts, 2016). Some of the collaborative mapping practices may use digital mapping methods similar to those that are often used in PPGIS projects but aim to assembling data rather than to fulfill participation goals (e.g., widening participation and engaging with socially excluded groups) that are often addressed by PPGIS projects (Brown, 2017). Accordingly, the design and implementation of a collaborative mapping project may differently focus on spatial data collection rather than public engagement.

2.3 Developing a typology for geo-participation

The Geoweb has spurred new forms of participation that differ from PPGIS. Participation that is on or intrinsic to the Geoweb can further be classified based on how information is generated by Internet users. According to Craglia, Ostermann, & Spinsanti (2012), there are two ways of generating geographic information on the Geoweb (i.e., VGI). One is active sensing where users are explicitly volunteered to contribute specific information required by prior guidelines following pre-designed frameworks. The other is passive sensing where users are implicitly volunteered to contribute geospatial information usually with little prior guidance or as a by-product of other activities (e.g., using social media, making transactions and using navigation apps).

In the government context, the two ways of generating geographic information associate with different uses of the information. Active sensing often relates to large-scaled practices of citizens actively contributing information for short-term goals, such as communicating service and infrastructure deficiency and reporting issues within spatial datasets. For example, citizens may directly report issues about public infrastructure and services and their locations to the government using location-enabled applications. Passive sensing may be used by local governments to obtain insights on public needs, lived experience and human-environment interactions from user-generated spatial data (Liu et al., 2015).

Combining the differentiation of PPGIS and new forms of participation spurred by the Geoweb as well as the differentiation of active and passive sensing on the Geoweb, Table 2-1 describes a new typology for geo-participation. Consultative geo-participation refers to participatory practices that are aligned with traditional practices of PPGIS. While PPGIS is perhaps the most used term for participatory approaches with GIS components, there are other terms such as participatory GIS (PGIS), facilitated VGI (f-VGI), geo-questionnaire and neogeogaphic mapping that brought by practitioners from various background to the field of PPGIS (Brown, 2017). Transactional geo-participation refers to active sensing on the Geoweb and often relates to government data and service delivery. Examples of transactional geo-participation include citizen reporting location-based civic issues to governments and citizen collaboration on collecting spatial data that can be used for government data and services. Passive geo-participation refers to passive sensing on the Geoweb and relates to a variety of terms (e.g., social sensing, ambient VGI, passive VGI) that describes the use of data-driven approaches to obtain collective perceptions and observations of real-world situations.

Table 2-1 A classification of geo-participation methods

Classification criteria		**Geo-participation methods**	**Related terms and practices**
Participation that utilizes GIS/the Geoweb	**Active**	**Consultative Geo-Participation**	PPGIS (Sieber, 2006); PGIS (Harris & Weiner, 1998); Facilitated VGI (f-VGI) (Tulloch, 2008); Geo-questionnaire (Jankowski, Czepkiewicz, Młodkowski, & Zwoliński, 2016); Neogeographic mapping (Lin, 2013a)
Participation that is intrinsic to the Geoweb	**Active**	**Transactional Geo-Participation**	Civic issue tracker (Sieber & Johnson, 2015); Participatory open data (Sieber & Johnson, 2015); OpenStreetMap
	Passive	**Passive Geo-Participation**	Social sensing (Liu et al., 2015); Ambient VGI (Stefanidis, Crooks, & Radzikowski, 2013); Passive VGI (Craglia et al., 2012)

2.3.1 Consultative geo-participation

The aim of consultative geo-participation is to bring together multiple viewpoints and assist decision-making through "careful and serious weighing of reasons for and against some proposition" (Fearon, 1998 p.63). The projects are usually initiated, guided and facilitated by the officials and are developed "as part of a pre-established planning or design process" (Seeger 2008 p.200). Citizen participants are primarily motivated by a "tendency to take part in activities that contribute to society" to participate (O'Brien et al., 2016 p.321). Ideally, a participation project seeks to achieve a high level of citizen engagement where citizens may have the power to influence the processes and outcomes of decision-making (Aladalah, Cheung, & Lee, 2015). Outside the traditional arena of public participation, the Geoweb has spurred grassroots projects of citizen initiating their own mapping applications (i.e., neogeographic mapping) to discuss place-based issues. Although the grassroots projects may not directly impact decision-making, they create a virtual participatory space for citizens to give their voices and make the voices from below to become more visible (Lin, 2013a; Sieber et al., 2016).

Digital mapping applications are often used in consultative geo-participation projects to collect local spatial knowledge regarding public perceptions of local environments; and participants are actively involved with commenting and discussing place-based issues regarding specific planning and development projects (Brown, 2012; Sieber, 2006). Particularly, visualization, sketching, communication and evaluation functions are often included in digital mapping applications for participants to view spatial information, sketch and comment on important locations and places, and reflect on each other's viewpoints and have in-depth discussions about place-based issues (Bugs, Granell, Fonts, Huerta, & Painho, 2010; Carver et al., 2001; Kingston, Carver, Evans, & Turton, 2000). With developments in the Geoweb, web-based digital mapping projects are increasingly used in consultative geo-participation projects to reduce the time and geographical constraints for citizens to participate.

Geospatial data collected from consultative participatory projects are mostly important locations and public perceptions related to specific planning and development projects (Brown, 2012). To what extent can these data affect decision-making outcomes, however, largely depends on whether and how governments accept processes and results of public participation (Brown, 2012b). Less-controlled participation procedure and subsequently unassured quality of user-generated spatial data are identified as major barriers to local government adoption of geo-participation (Sieber, 2006). Besides, organizational constraints of public agencies being more likely to trust their own capabilities of influencing the public "from the inside through pressure politics and their own technical expertise" may also obscure the incorporation of citizen contributed spatial data (Brown, 2012b p.15).

2.3.2 Transactional geo-participation

Transactional geo-participation intersects with consultative geo-participation in terms of active citizen contribution of spatial data and officially guided and facilitated data collection. Unlike consultative geo-participation projects that often involve deliberations on a particular planning or development project, transactional geo-participation is often used for improving government data and services. One example of transactional geo-participation is "Municipal 311", a program for issue reporting and service monitoring by municipal governments in North America (Nam & Pardo, 2014b). Mostly following specific reporting procedures and prescribed to particular categories of civic issues, collective citizen reporting generates large amounts of geographic data that are mostly structured, and geographically and topically bounded (Sieber & Johnson, 2015). Government officials can use these data to further understand the geography of common issues and optimize service maintenance planning (O'Brien et al., 2017; Wiseman, 2014). Another instance of transactional geo-participation is the emerging practice of spurring citizen collaboration for correcting, updating, and editing government open geospatial data (Johnson, 2016). According to Sieber & Johnson (2015), this collaboration can be considered as a participatory model where data becomes a conduit for integrating citizen contribution into government operations and decision-making.

Two types of geospatial methods and techniques are primarily used for transactional geo-participation. The first are location-based applications and services. Civic issue tracking, for example, has been expanded from telephone-based reporting to web and mobile based reporting applications (Sieber & Johnson, 2015). Geotagging or geocoding functions are usually embedded in these apps for users to add location information. In some municipalities, reports of civic issues are further displayed using web maps to allow citizens to query and track reports[1]. With emerging practices such as participatory open data (i.e., citizens collaboratively update and vet government open data), mapping and groupware tools are necessary for citizens to collaboratively contribute and edit data (e.g., tools of managing multiple contributions or versions for the same data). For local governments to enable such citizen collaboration, it is also necessary to develop proper mechanisms (e.g., establishing proper workflows of integrating citizen data and determining how much control the officials may possess for the data vetting process) to assure the fitness of citizen collaboration with government procedures (Johnson, 2016).

2.3.3 Passive geo-participation

Passive geo-participation deviates from traditional participation theories that consider public participation as a process that involves active participants (Rowe & Frewer, 2000). While some argue that citizens might be passive in public participation process, they refer to citizens being receiving information from governments rather than actively contributing opinions and knowledge. Passive geo-participation differently emphasizes the unconsciousness and indirect citizen involvement and adopts data-driven approaches to extract public needs and opinions from citizen-generated data (Bright & Margetts, 2016).

In the context of government, passive geo-participation is only an emerging practice that has not been widely adopted and assessed. Two types of user-generated spatial data can be of potential uses for local governments to understand public needs and perceptions. The first is digital footprints of human activities (e.g., social media check-in data, taxi trajectories, cell phone positioning data), which

[1] cf: https://data.edmonton.ca/apps/311explorer/

are used to understand human-demarcated social areas, functional zones, commuting patterns, and spatial interaction (Cranshaw et al., 2012; Crooks et al., 2015; Liu, Sui, Kang, & Gao, 2014). The second is geo-located qualitative data (e.g. geo-tagged short text and images, online articles and blogs that have implicit geographic information) that are mixture of spatial information and multimedia content including text, image, video and sound. These data are considered as, to some extent, reflections of lived experience and are used to explore collective perceptions of places, identify important locations of communal concern, and understand patterns of agreement and disagreement (Crooks et al., 2015; Dunkel, 2015).

To interpret big geospatial data and understand spatiotemporal patterns of human behaviors, developments of spatiotemporal analysis and visualization methods and geoprocessing frameworks that account for veracity, velocity, and volume of big data are needed (Zhou et al., 2015). The increasing amounts of qualitative data and network-based data (e.g., communication networks) also call for the needs of combining text, image, and social network analysis methods with GIS systems to shed light on spatial expressions of public perceptions and social-spatial processes underpinning digital communication and interaction (Andris, 2016). Accordingly, the focus of deploying geospatial technology for passive geo-participation should be placed on collecting, processing, analyzing and managing user-generated data.

2.4 Applying the typology to geo-participation literature

To demonstrate the relevance of the typology, this section applies the proposed typology to scholarly literature that present empirical works related to geo-participation from year 1995 to 2017. A comprehensive search was carried out on academic databases Web of Science and Scopus using searching terms PPGIS,

PGIS, participatory GIS, VGI, f-VGI, neogeographic mapping, neogeography, crowdsourced mapping, crowdsourcing and GIS, crowdsourcing and planning, participatory and open data, ambient and geospatial planning, ambient and geospatial and decision making. After removing duplicates in two databases, 2513 articles that contain at least one of aforementioned combination of keywords in their titles, abstracts, or keyword lists, were retrieved. A manual screening of titles and abstracts of these articles was then implemented to exclude irrelevant studies (e.g., studies that do not have a geospatial or participation component) and non-empirical studies (e.g., conceptual and theoretical studies, review papers, and tool developments). Note that some of the works included in the following analysis may indicate innovations in geospatial tools for public participation, yet they also present empirical case studies that provide evidence on public participation. Additionally, although this paper is set in the context of governments, the selected scholar literature are not government studies only given the consideration that public participation mechanisms used in governments and public agencies may overlap.

In the remaining 157 articles, 24 articles are selected for further examination and classification using proposed typology (Table 2-2). These articles are citied the most (citation number no less than 15)[2]. In addition, only the most cited article is included if multiple articles are presented in one subject of application (e.g., among five highly cited articles regarding consultative geo-participation for marine spatial planning, only the one with highest citation number is used). In the

[2] Note that different databases may differently count how many times an article is cited. For example, the article "The relationship between place attachment and landscape values: Toward mapping place attachment" (Brown & Raymond, 2007) was cited 225 times according to Scopus and 201 times according to Web of Science;. To keep the consistency, this study uses citation number based on statistics of Scopus if an article is included in both Scopus and Web of Science databases.

table, the enabling geospatial technologies and the research focus of each type of geo-participation are summarized based on identified articles.

Table 2-2 Geo-participation studies classified using the typology

Category	Examples	Summary	
		Geo	Participation
Consultative Geo-Participation	▪ Evaluating values of public lands using PPGIS (Brown & Raymond, 2007) ▪ Participatory mapping of cultural ecosystem services (Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013) ▪ Participatory GIS for neighborhood planning (Al-Kodmany, 1999); marine spatial planning (St. Martin & Hall-Arber, 2008); national park planning (Brown & Weber, 2011); forest planning (Brown, 2009); wind energy planning (Simão, Densham, & Haklay, 2009); land use suitablity (Higgs, 2006); land use needs (Sandström et al., 2003); air pollution (Yearley, Cinderby, Forrester, Bailey, & Rosen, 2003); urban densification (Kyttä, Broberg, Tzoulas, & Snabb, 2013) ▪ Map-based online forums for university master plan (Rinner, Keßler, & Andrulis, 2008) ▪ Reach the hard-to-reach (Cinderby, 2010) ▪ Neographic mapping of Donghu, China (Lin, 2013a)	▪ Digital mapping is primarily used in selected examples. In particular, map visualization and sketching functions are widely used	▪ The applications of consultative geo-participation encompass a wide range of fields ▪ The participation outcome is strongly emphasized in the scholarly literature. Issues including how technology uses may enhance citizen participation, empower (or disempower) marginal groups, inducing digital divides are widely discussed
Transactional Geo-Participation	▪ Crowdsourcing through mobile phone applications for noise mapping (Rana, Chou, Kanhere, Bulusu, & Hu, 2010); road safety (Aubry, Silverston, Lahmadi, & Festor, 2014) ▪ Social media reporting for soil and water conservation (Werts, Mikhailova, Post, & Sharp, 2012) ▪ VGI for cadastral mapping (Basiouka & Potsiou, 2012); transportation data collection (Misra, Gooze, Watkins, Asad, & Le Dantec, 2014)	▪ Geo-enabled instruments for transactional geo-participation include location-aware mobile devices and applications, social media, digital mapping ▪ Spatial data quality is a significant challenge facing public agencies to adopt contributed data	▪ Transactional geo-participation is often applied to situations that are time-critical or lack accurate/ up-to-date data ▪ The emphasis of scholar literature mostly centers upon the improvement of data/service

Category	Examples	Summary	
		Geo	Participation
Passive Geo-Participation	▪ Real-time crisis mapping using social media (Middleton, Middleton, & Modafferi, 2014) ▪ Mining location data to acquire spatiotemporal knowledge of forest fires (Longueville & Smith, 2009) ▪ Crowdsourcing air temperature for energy planning (Overeem et al., 2013) ▪ Understanding human-demarcated areas using social media data (Cranshaw et al., 2012) ▪ Understanding perceived environment using crowdsourced photos (Dunkel, 2015)	▪ Passive geo-participation applications heavily rely on geospatial analytics ▪ Commonly used geospatial methods in scholarly literature include: spatiotemporal analysis, geographic information retrieval (GIR), spatial data visualization, text analysis, topic modeling, spatial network analysis	▪ Selected examples are mostly experimental in that few have reported how these applications are used by practitioners ▪ Emphasis of scholarly literature focuses primarily development of geospatial methodology, quality and fitness-for-use of passively contributed data in specific application context

The results show the conformity of studies within each category of geo-participation in terms of their research focuses. The results also suggest significant differences in techniques and processes used for three geo-participation practices, which indicate the validity of the proposed typology (Rowe & Frewer, 2005). Consultative geo-participation is applied to a variety of disciplines and relies heavily on participatory mapping and commenting platforms. An important emphasis of consultative geo-participation studies is the implications of mapping technologies on citizen empowerment, digital divide, and social inclusion. In particular, mapping practices are considered as complex social practices embedded with powers that may affect how and what local spatial knowledge is produced (Parker, 2006; Pickles, 2004). Transactional geo-participation initiatives are highly reliant on mobile technologies, location-based services, and groupware tools for crowdsourcing and collaboration. Studies in this category are often intertwined with citizens co-producing public services with governments and are evaluated by how the initiatives may improve the efficiency of public data and service delivery. Passive geo-participation initiatives mostly focus on development of methods for analyzing and interpreting user-generated spatial data. Not surprisingly, little scholarly literature has reported empirical evidence regarding how passive geo-participation may fit into government procedures. Technological developments are still heavily emphasized given the challenges of processing, analyzing, and managing the so-called big data. Nevertheless, a growing body of studies critically examines practices of adopting big data (Housley et al., 2014; Zook, 2017). These studies may shed light on further understandings of passive geo-participation initiatives.

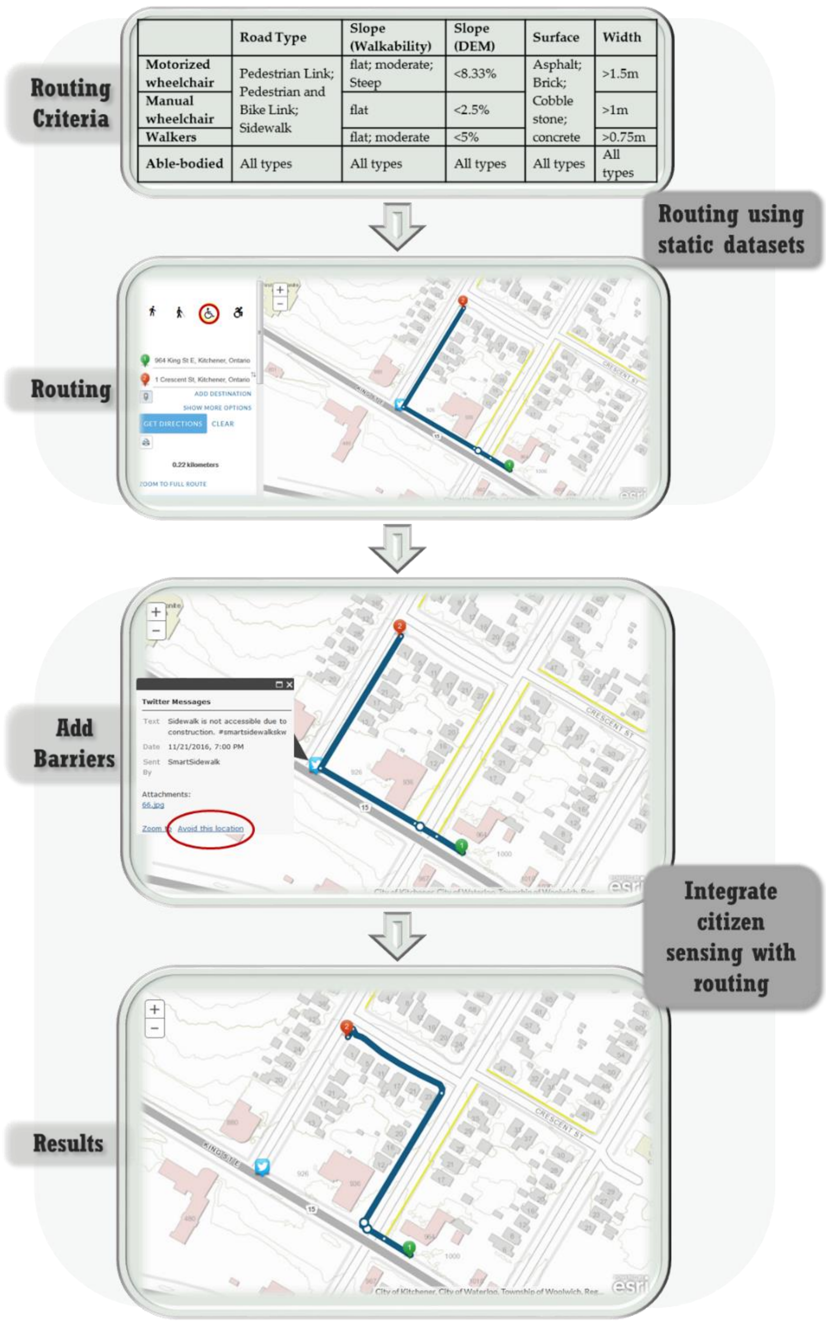
2.5 Emerging opportunities for local government operations

With developments in ICTs, promising new vehicles have emerged for local governments to better understand public needs, augment government services, improve government openness and accountability, and enhance citizen participation. In this section, we reflect on a collection of examples to shed light on the emerging opportunities presented by geo-participation for local government operations.

2.5.1 Going beyond transactional geo-participation

The increasing usage of smartphones and location-based services allow citizens to report emergencies and routine government services in a timely manner. According to Clark, Brudney, Jakobsen, & Andersen, (2013 p.697), the wide scale citizen reporting enabled by smartphone application have "transformed citizens into 'sensors', 'detectors', or 'reporters' to the problems facing the city". Ideally, citizens may collaborate via social networking functions and co-produce public services that are tailored to individual needs of citizens (Linders, 2012).

Figure 2-1 depicts a proof-of-concept of citizens collectively sharing information specific to pedestrian mobility. Citizen-generated information can be incorporated into the routing service that considers important factors (e.g., elevation, sidewalk width, surface materials) affecting pedestrians in order to help pedestrians find proper routes that suit their mobility. While road and sidewalk conditions are critical for people's daily commute, it is often challenging to rely solely on governments to update the dynamic situation in a timely manner (Rice, Aburizaiza, Rice, & Qin, 2016). When citizens report a potential trip hazard to governments, this information is not immediately accessible to other citizens who need the information. The collective efforts, in contrast, may alleviate the challenges of timely updating sidewalk conditions (Neis & Zielstra, 2014). Moreover, multiple observations from the broader public have the potential of offering personalized services to accommodate various public needs. Specialized datasets of accessible or inaccessible features for disabled people is often lacking, not to mention up-to-date routing information that is tailored to disabled people (Prandi, Soave, Devigili, & Amicis, 2014; Rice et al., 2016). Collectively sharing of information specific to pedestrian mobility (e.g. "intersection is not accessible for wheelchair users") can help citizens with varying needs to maneuver changing urban environment where transient barriers (e.g. crowds, temporary obstruction and surface issues) often occur (Neis & Zielstra, 2014).



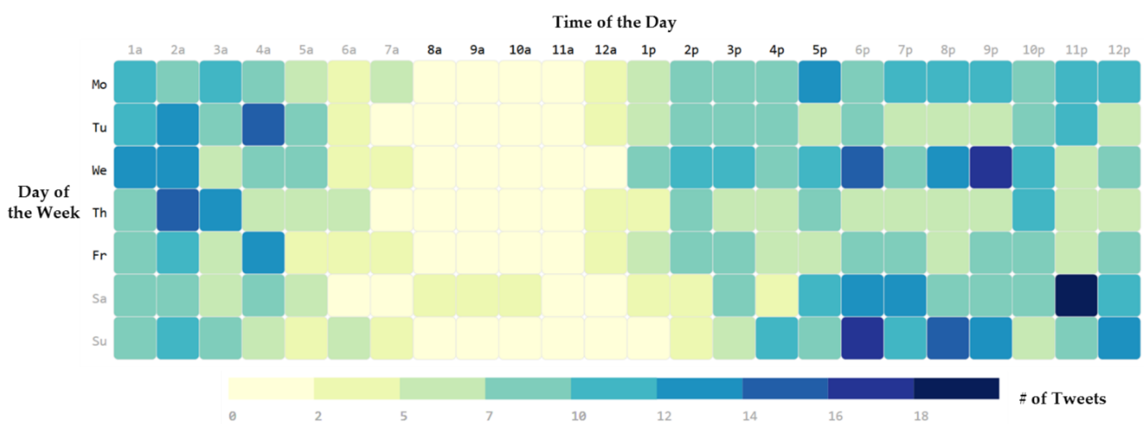
	Road Type	Slope (Walkability)	Slope (DEM)	Surface	Width
Motorized wheelchair	Pedestrian Link; Pedestrian and Bike Link; Sidewalk	flat; moderate; Steep	<8.33%	Asphalt; Brick; Cobble stone; concrete	>1.5m
Manual wheelchair		flat	<2.5%		>1m
Walkers		flat; moderate	<5%		>0.75m
Able-bodied	All types	All types	All types	All types	All types

Figure 2-1 A citizen sensing approach to pedestrian route planning

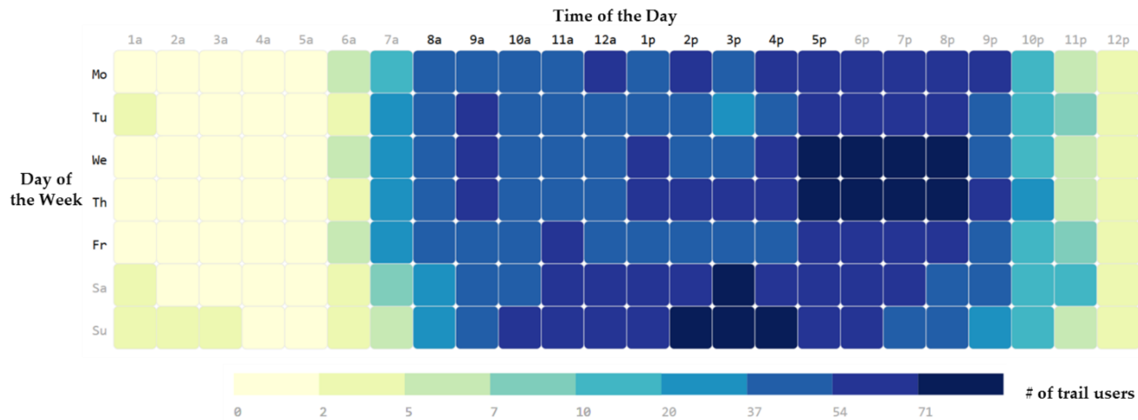
2.5.2 Passive geo-participation as an aid to understanding local spatial knowledge

An ideal goal of utilizing passive geo-participation is to collect unfiltered views from broader segments of the society (Dunkel, 2015; Zhang & Feick, 2016). Figure 2-2 presents an example of using geo-tagged Twitter messages to collect public perceptions and needs related to a trail that is planned for improvement by the city. Iron Horse Trail is a landmark in the City of Kitchener, Canada. The trail provides local residents with unique outdoor experience and walking and cycling routes for commuting and exercising. Understanding and addressing public needs are important for city to develop improvement plan of the trail. From May 2016 to August 2016, 7789 geo-tagged Twitter messages were collected along the trail in the City of Kitchener using Twitter Streaming API.

Figure 2-2a shows the average numbers of geo-tagged Twitter messages collected within every hour at each day of the week. Compared to the pedestrians and cyclists counts at Iron trail based on the city’s open data (Figure 2-2b), a larger portion of Twitter messages were collected during the non-working hours before 8am or after 6pm, possibly due to the reduced likelihoods of people using Twitter during commuting.



(a)

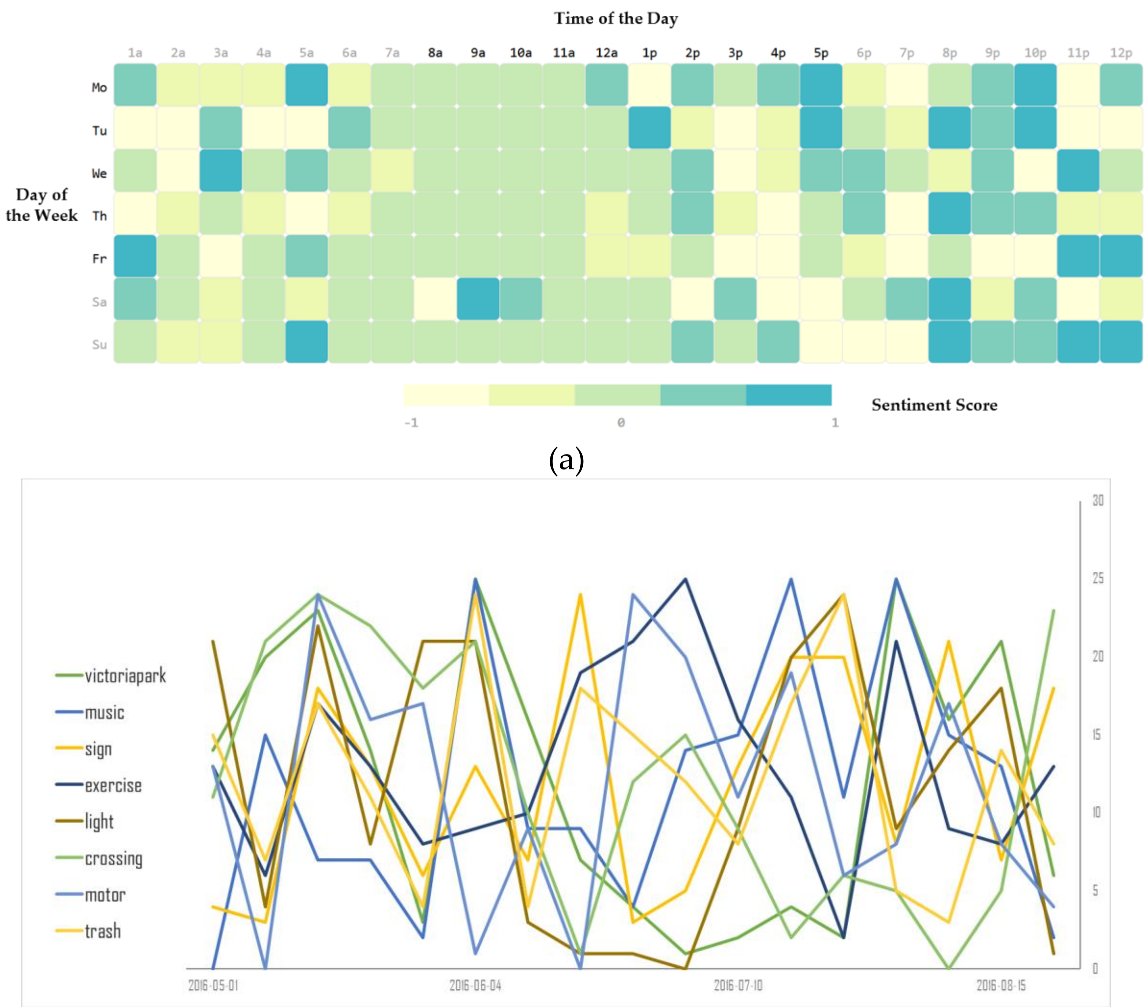


(b)

Figure 2-2 (a) Average numbers of Twitter messages for every hour at weekdays; (b) Average numbers of trails users (pedestrians and cyclist) for every hour at weekdays (data source: City of Kitchener open data catalogue)

To understand public's perceptions and preferences of urban space, sentiment analysis can be used to analyze tweets to obtain collective sentiments as indictors. Originated from computational linguistics and natural language analysis methods, sentiment analysis is widely used for quantifying affective states from texts (Zavattaro, French, & Mohanty, 2015). Analyzed texts will be given a score with positive numbers indicating positive sentiment, and a higher score representing more positive sentiment. If analyzed texts receive a negative score, it means the texts express a negative sentiment, with lower scores representing more negative sentiment.

Figure 2-3a reveals average sentiment scores of tweet messages in every hour of the day at different days of the week. Interestingly, Twitter messages tended to be more positive on weekdays than weekends. Further examination of the dataset suggested that Twitter messages on weekends had more polarized sentiment scores of very high positive scores or very low negative scores and resulted in an average score that is close to zero. In particular, sentiments expressed in the daytime were more positive as people enjoyed the environment, whereas mixed sentiments were expressed especially after midnight. Further text analysis suggested several keywords such as light, sign, and crossings that might relate to the design of the trail (Figure 2-3b). Not having streetlights and signage at some segments of the trail were mentioned in the tweets as people raised safety concerns. Positive words, comparatively, were more personalized and were not associated with particularly frequently used words.



(a)

(b)

Figure 2-3 (a) Average sentiment scores of Twitter messages for every hour at seven weekdays. (b) The frequency of the top words extracted from Twitter messages

Although not all of the Twitter messages were directly related to the surrounding environments, the sentiments expressed in the messages were mixed results of personal factors and people's emotional response to the places surrounding environment (Weinreb & Rofè, 2013). Using text analysis methods as presented in this example, decision makers may obtain insights on the trending expressions and shared feelings that present unfiltered views of landscapes and surrounding environments.

2.5.3 Integration of geo-participation with government open data programs

Recently, there is growing trend of fostering greater openness of governments at different levels. As an important component of this effort, government open data programs serve as the basis of information sharing, as it allows the public to use and share government data (Open Knowledge, n.d.; Veljković, Bogdanović-Dinić, & Stoimenov, 2014). Given the significant amounts of open geospatial data, spatial technology plays an increasingly critical role for data sharing, visualization, and interpretation (Johnson, Sieber, Scassa, Stephens, & Robinson, 2017). For instance, map interfaces are widely used by municipalities for visualizing and cataloguing open data. Citizen contributions are also becoming an important component of government open data processes. Sieber & Johnson (2015), for example, suggested that citizens can contribute data by reporting civic issues and collectively vetting government open data. Some citizen data coming from consultative and passive participation channels is also made public accessible.

Through a comprehensive review of City of Toronto's open data catalogue, we identified 14 datasets out of total 267 open datasets that are relevant to geo-participation (Table 2-3)[3]. The selection criteria include: 1) the dataset must have geospatial attributes and, 2) the dataset must involve with either active or passive public input. Among the 14 selected datasets, 8 datasets are related to consultative participation approaches, such as public survey, e-polling, and public consultation. Four are related to transactional geo-participation such as non-emergency (2

[3] The website was accessed on Oct.1st.2017

datasets) and emergency (1 dataset) reporting. The other three datasets are citizens' travel behaviors recorded by traffic cameras, Bluetooth and Wi-Fi sensors, which are related to passive geo-participation.

Table 2-3 A list of Toronto open data sets related to geo-participation

Datasets related to Consultative Geo-participation	**Datasets related to Transactional Geo-participation**	**Datasets related to Passive Geo-participation**
• Casino Survey Results • E-Bike Survey Response Results • Open Government Public Survey • TransformTO Community Feedback • Woodbine Racetrack Casino Consultation 2015 • Polls conducted by the City • Poverty Reduction Strategy Consultation - Qualitative Input • Street Needs Assessment Results	• 311 - Open311 API Calls for Service Requests • 311 Service Requests - Customer Initiated • Flood Reporting Noted by Toronto Water Districts	• Traffic Signal Vehicle and Pedestrian Volumes • Travel Times - Bluetooth • TTC - Average Weekday Ridership

Although there are more government programs related to geo-participation practices, datasets listed in Table 2-3 provide us with a glance of how geo-participation practices are closely related to government programs. Geospatial data resulted from participation practices can further support other forms of citizen participation such as app developments by independent developers or third-party companies and organizations (Kassen, 2013). For example, public survey results of developing a casino were visualized using map applications[4].

[4] (a) Source: http://justinpierre.ca/casino/
(b) Source: http://laurenarcher.github.io/CasinoSurveyVis/

Outside of the government mandate, these third-party applications help the public examine survey results and serve as intermediaries to provide the public with value-added information and assist with those who may not possess technical understandings of open data (Gagliardi et al., 2015). In this regard, while three geo-participation methods involve different techniques and processes, geospatial data generated from different geo-participation methods may be used across the three categories and facilitate governmental initiatives of collaborating with citizens.

2.6 Implications for implementing and researching geo-participation

To move forward with the emerging opportunities presented by geo-participation practices, further investigations are necessary to develop tools and techniques for implementing the emerging geo-participation practices and to understand the social implication of the practices.

2.6.1 Spatial data management

The practices of opening up citizen data and associated civic engagement activities as introduced in section 2.5.3 have indications on producing, disseminating, and managing geospatial data within local governments (Figure 2-4). Data collected from all geo-participation methods can be brought together to support decision-making, government operation, and service delivery. Some of these data may also be included in open data programs following open data standards. The release of these data can further facilitate citizen participation through app developments, which are conducive to enhancing citizen participation and augmenting government services. Similar to open data and innovation ecosystem suggested by Gagliardi et al., (2015), it is important to leverage data needs of both governments and citizens and generate mechanisms to provide feedback and initiate secondary use of geospatial data (i.e. use data for app development, produce public services, etc.).

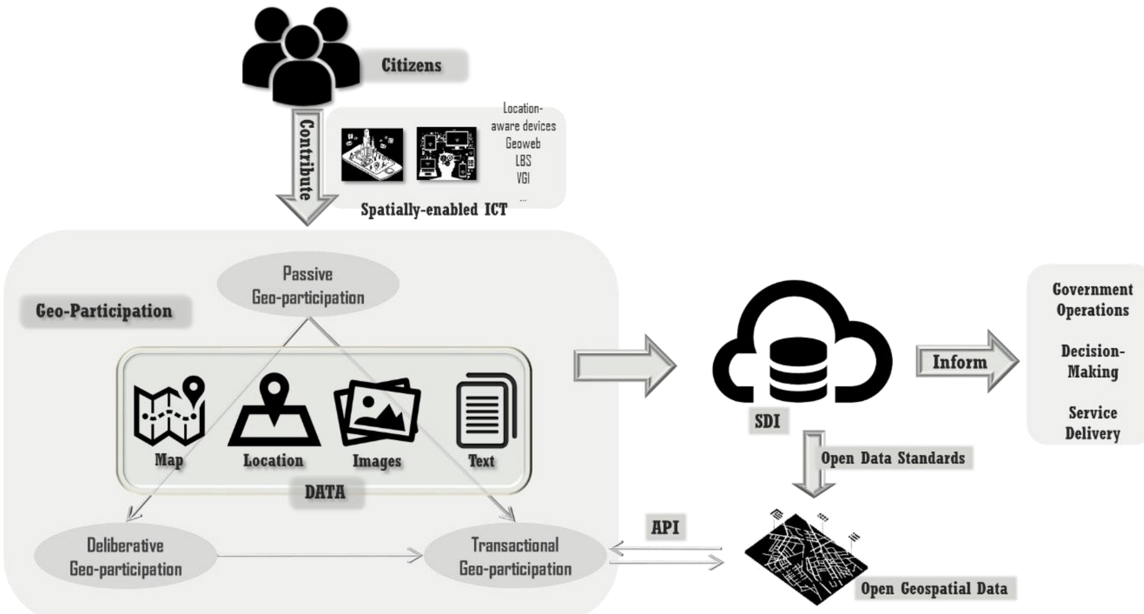


Figure 2-4 A synthesized view of spatial data flows among geo-participation and government operations

At the core of this data ecosystem, spatial data infrastructure (SDI) should provide an environment for managing and using heterogeneous geospatial data. SDI refers to "Internet-based mechanisms for the coordinated production, discovery, and use of geospatial information in the digital environment" (Budhathoki, Bruce, & Nedovic-Budic, 2008 p.49). Traditional SDIs are based on the model of governments being publishers and citizens being data users (Hu & Li, 2017). SDIs for the data ecosystem needs to further consider seamlessly integrating spatial data from different sources, particularly data vetted and published by non-experts (i.e., citizens). The efforts of integrating input from citizen input into government SDIs are still in the early stages given the challenge of reconciling relevant yet heterogeneous datasets (Coleman, Rajabifard, & Kolodziej, 2016). Geospatial data may be created with various formats (e.g., user-generated maps, text-based comments and tags, media content such as images and videos) and by authors with varying geographic knowledge and diverging perceptions of on-the-ground situations (Bakillah et al., 2013). It is required to develop relevant technologies, standards and polices to accommodate the influx of data with varying accuracy and currency (Hu & Li, 2017). To enable citizen collaboration as suggested in section 2.5.1, governments also need to develop mechanisms that support data and service interoperability and to tackle the issues of liability and privacy raised by making data and services publicly available (Bakillah et al., 2013; Scassa & Diebel, 2017).

2.6.2 Utilizing passive geo-participation

Passive geo-participation is an emerging practice that has the potential to help local governments harvest local spatial knowledge from citizen-generated data and enlarge public participation processes (Bright & Margetts, 2016). However, little evidence insofar has been provided in scholarly literature regarding applying findings from passive geo-participation to government decision-making. The potential of using passive geo-participation to solicit input from broader groups of citizens needs to be further assessed by addressing the following two questions (Bright & Margetts, 2016): first, what kinds of public opinions or perceptions regarding general or specific policy and decision making can be harvested? Second, whom do the data represent? In other words, who are the participants? Answers to these questions are essential for evaluating passive geo-participation practices and understanding their impacts on participation outcomes.

From a spatial data perspective, incorporating passive geo-participation into government operations may face a number of challenges. First, lacking the trustworthiness of user-generated data, particularly relating to multiple data resources and lacking provenance information, can be major barriers for local government to integrate research findings with decision-making (Johnson, 2016).

Second, exploitation of passive geo-participation is often associated with big spatial analytics for processing and analyzing unstructured data. In particular, increasing amounts of text, video stream, and image data are used by government as reported by Gagliardi et al., (2015). On the one hand, it is necessary to develop data-driven approaches such as geographic information retrieving (GIR) methods to extract geospatial information from non-spatial data (e.g., text descriptions, images, and videos) that include abundant local spatial knowledge (Vasardani, Winter, & Richter, 2013). On the other hand, the heavy reliance on the technical capability to processing big geospatial data can also prevent local governments from using passive geo-participation (Zhang & Feick, 2016). Empirical studies are necessary to further investigate the challenge and to identify proper mechanisms of utilizing geo-participation in local government context.

2.6.3 Understanding the social and spatial implications of geo-participation

One premise of utilizing the Geoweb for public participation is that the wider scale spatial data generation may broaden public participation and accordingly enable collective wisdom. However, there are continuing debates on whether the technological-driven methods may exacerbate existing social disparity or generate new digital divides (Sieber et al., 2016). For example, citizens will need access to Internet and digital devices (e.g., computers, mobile phones) to use the digital services. Empirical studies have suggested that factors including geography and sociodemographic characteristics differently affect how people participate via digital methods (Clark et al., 2013; Foster & Dunham, 2014).

It also has not been clear how would the broadened scale affect participation process. Localness is often considered as important to public participation, given that local communities are the primary sources of local knowledge and are more likely to be affected by decision outcomes (Sieber, 2006). The notion of localness also affects the trustworthiness of local spatial knowledge, as it is believed that local participants are more familiar with local circumstances and thus will provide more reliable and accurate information (Brabham, 2009; Brown & Kyttä, 2014). In the online environment, Wellman (2002) suggest that participation is composed of "intense local and extensive global interaction(s)"(Wellman, 2002 p.11). Accordingly, the notion of local might have changed as group relationships within the community have become "glocalized". Taking social media, the increasingly popular platform of government-citizen communication, as an example, a city's official account may have a significant portion of followers that are not local residents. Using Twitter's Friends/Followers API, we collected self-claimed locations of the followers of City of Waterloo's official Twitter account and found that 13.1% of them were out of the country, and additional 22.7% outside of the city/region. While self-claimed locations do not always accurately reflect users' physical locations, previous studies confirmed the roots of online social networks in physical communities (Stephens & Poorthuis, 2015). This estimate can shed some light on the globalized composition of public that is often beyond the city's jurisdiction.

The interactions between governments and the public on social media, however, suggest more localized patterns. Figure 2-5 presents government-citizen communication network generated based on the Region of Waterloo and the cities of Waterloo and Kitchener's Twitter accounts. The size of a node indicates how frequent the account represented by the node interacts (e.g., reposting a post and have direct dialogues) with the region and cities' accounts. Compared to the number of followers of the region and cities' accounts, only a relatively small group of local business and organizations is actively involved with online conversations. The presence of some physically distant Twitter users who are actively engaged with online conversations has indications on considering the "localness" of participation to be not only physically close but also socially proximate. That is, one that is physically outside of the community but remains connected with local communities and active involved with local affairs should still be considered to be local. However, it has not been clear how this alternative view of localness may affect the trustworthiness of citizen-generated data and accordingly government-citizen collaboration.

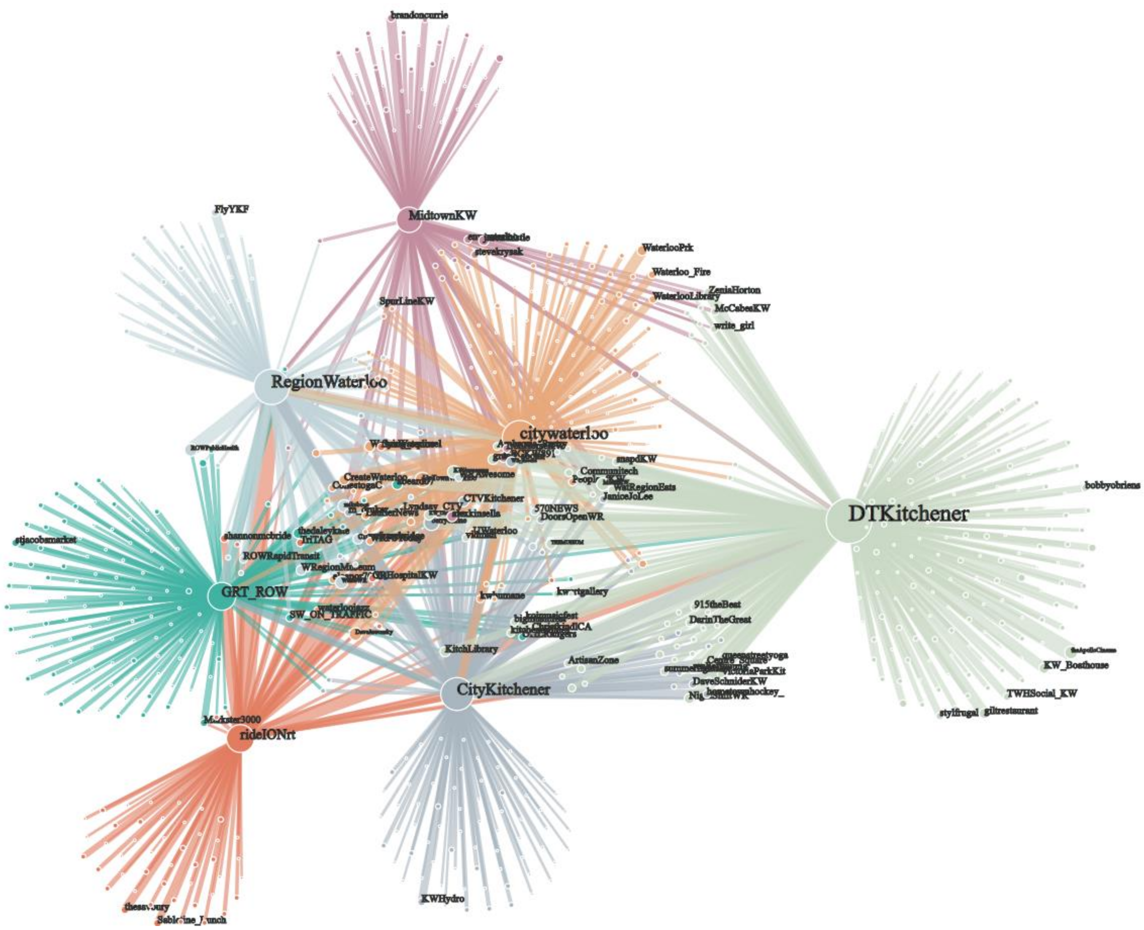


Figure 2-5 Networks of Region of Waterloo and Cities of Kitchener and Waterloo's Twitter Conversation

It is necessary for researchers and practitioners to further examine the social and spatial processes underpinning geo-participation. As suggested by Clark, Brudney, Jakobsen, & Andersen, (2013), understanding how technologies affect citizen participation is critical to assess the benefits and limitations of technologically-enabled government-citizen collaborations. GIS methods should be introduced to this investigation of social and spatial implications of geo-participation. Particularly, attention should be paid to exploring relationships between online and offline communities as well as associations of social and geographical connections. Traditional spatial models such as distance decay models may be useful for testing the assumption of distance effects on Internet-based participation. Methods such as social network analysis (SNA) may assist with exploration of the social dimension of localness. In fact, there is recent call for the integration of SNA into GIS systems to better understand the geography of communication and social interaction networks in GIS research (Andris, 2016). Synthesizing this research agenda with geo-participation context may advance our understanding of how the emerging geo-participation practices affect citizen participation.

2.7 Conclusion

The continued developments in ICTs are conducive to the proliferation of user-generated spatial data and new forms of geo-participation. To elucidate the diffusion of diverse concepts and practices related to geo-participation, this paper proposes an innovative typology for examining and implementing geo-participation. The intent of this typology is to clarify techniques, processes and outcomes associated with different geo-participation practices and establish connections between geo-participation and government operations. The typology along with examples demonstrated in the paper suggests emerging geo-participation practices that are conducive to enhanced public participation and improved government-citizen collaboration. Future research should further assess the identified potential and determine the best practices of utilizing emerging geo-participation practices in local government settings. More work is also needed to understand how the wider scale data generation affect public participation processes and change dynamics of government-citizen interactions.

Chapter 3: Understanding Public Opinions from Geosocial Media

Published As:

Zhang, S., & Feick, R. (2016). Understanding Public Opinions from Geosocial Media. *International Journal of Geo-Information*, 5(6), 74. https://doi.org/10.3390/ijgi5060074

3.1 Introduction

Engaging citizens and other stakeholders is considered as an essential step in government decision-making (Innes & Booher, 2004). While public input has been collected traditionally through in-person techniques such as public meetings, workshops, and interviews, computer-aided technology has been used to supplement traditional methods (Brown, 2015; Cinderby, 2010). More recent developments in Web 2.0 and mobile technologies have drawn attention from public agencies and research communities seeking easier and less expensive methods of citizen engagement (Lin, 2013b). Increasingly, local governments have been using social media platforms as additional communication channels to publish news and interact with citizens (Reddick & Norris, 2013). In addition, social media often contain information about public opinions and perceptions that is comparable to public comments collected through traditional public participation approaches (Massa & Campagna, 2014). It may potentially become a more convenient form of public participation as people are able to contribute information at any time from any location (Massa, 2015; Wukich & Mergel, 2016). Geotagged social media, also referred to as geosocial media (Croitoru, Wayant, Crooks, Radzikowski, & Stefanidis, 2014; Kim, Kojima, & Ogawa, 2016), contain both descriptive comments and location information and thus may assist in understanding what the public needs are and where solutions need to be developed (Dunkel, 2015; Gal-Tzur, Grant-Muller, Kuflik, et al., 2014). However, unlike citizen surveys or interviews, social media data are the outputs of users' communication. Hence, these data are unstructured, vary in quality, and often of unknown relevance to local governments' need (Campagna, Floris, & Massa, 2015). Further complications arise from the fact that only a small portion of social media are tagged with explicit geographic coordinates and that these data vary widely in their geographic representativeness within and across urban areas (Robertson & Feick, 2016). Their effectiveness to supporting public participation thus needs to be examined critically through empirical studies (Massa & Campagna, 2014).

This paper aims to empirically examine the usability of geosocial media for local governments through a case study carried out in the Region of Waterloo (Ontario, Canada). We modeled the text content of geosocial media to identify commonly expressed topics and explored the spatial patterns of these identified concerns and interests. We believe that the insights drawn from the case study has the value in advancing our understandings of potential opportunities and challenges of using geosocial media for citizen participation. To facilitate the empirical study, a web-based Text Filtering and Analysis (TFA) toolkit that integrates several text analysis methods into an easy-to-use package was developed to ease the technical challenges of filtering irrelevant information from geosocial media and analyzing text content (Grant-Muller et al., 2015).

The next section begins with a review of current studies related to geosocial media use for public participation and opinion mining in local governments. We then introduce the methods included in a toolkit designed for harvesting and analyzing text messages from geosocial media (Section 3.3), followed by a case study (Section 3.4). We conclude the paper with suggestions for future research opportunities (Section 3.5).

3.2 Literature review

3.2.1 Use of geosocial media in local governments

Public participation is recognized as important since it can aid transparency and accountability in government and empower citizens in decision-making processes (Carver et al., 2001; Innes & Booher, 2004; Rowe & Frewer, 2005). However, public participation has also been recognized as being a complex and contested process (Day, 1997; Higgs, Berry, Kidner, & Langford, 2008; Lowndes, Pratchett, & Stoker, 2001a). In particular, concerns have been centered upon issues including marginalized groups, effectiveness of participation approaches, and to what extent citizens are empowered in the participation process (Rhina Ghose, 2001; Rina Ghose, 2005; Irvin & Stansbury, 2004; King, Feltey, & Susel, 1998). The introduction of computer-based systems such as public participation GIS (PPGIS) was intended to address some of these challenges by providing integrated platforms for informing, creating, and sharing spatial knowledge (Hall et al., 2010; Sieber, 2006). Considerable effort has been made to develop mapping and visualization techniques that facilitate collecting and contextualizing spatial knowledge, identifying ways of enhancing collaborations among stakeholders, and engaging with marginalized populations using digital and Internet tools (Brown, Weber, & De Bie, 2014; Pocewicz, Nielsen-Pincus, Brown, & Schnitzer, 2012). In some instances, however, these systems are criticized for their over-reliance on technical skills and high cost for development and maintenance (Slotterback, 2011).

Social media have been increasingly used by local governments in recent years because they provide an easy and inexpensive method of communication, and expand social networks through which governments can potentially reach large numbers of citizens (Evans-Cowley & Griffin, 2011; Reddick & Norris, 2013; Vicente & Novo, 2014). Although some governments use social media primarily to publish news and information, there is a trend of governments interacting with citizen through social media (Khan, Yoon, Kim, & Park, 2013). According to Johannessen, Flak, & Sæbø, (2012), local governments ranked social media in terms of preferred communication methods after email and websites. A growing body of literature has further examined how sentiments expressed in social media can help improve communication between local governments and citizens (Bonsón, Royo, & Ratkai, 2015; Mossberger, Wu, & Crawford, 2013; Panagiotopoulos et al., 2014; Sandoval-Almazan & Ramon Gil-Garcia, 2014). Zavattaro, French, & Mohanty (2015), for example, suggested that social media sentiment is an effective indicator of successful interaction between local governments and citizens. Schweitzer (2014), similarly, identified strategies for transportation agencies to enhance their communication with the public through the analysis of transport planning-related tweets.

In addition to their communication functions, social media are also considered as platforms of recording lived experiences of their users (Silva, Vaz De Melo, Almeida, & Loureiro, 2013). That is, the way people tag place and events, check-in at venues, and comment leaves digital traces of their physical activities and reflect their personal opinions and sentiments (Li & Goodchild, 2012; Thelwall, Buckley, & Paltoglou, 2012). Another line of studies has thus focused on mining geosocial media data that are spontaneously contributed by users. Several spatial analysis and visualization methods have been developed to derive public perception toward local environment and planning issues from social media. Dunkel (2015), for example, developed a visualization tool to help planners explore perceived environment from geolocated Flickr data. Feick & Robertson (2015) proposed a multi-scale approach to identify commonality in how people define and delimit urban places in geotagged photo tags. Successful empirical studies of using geosocial media data for gauging public perceptions of disaster response, identifying events, and investigating human activities have also been documented (de Albuquerque et al., 2015; Panteras et al., 2014; Yin et al., 2012). In addition to the primary focus of mining spatial patterns, others suggested the need to further incorporate qualitative social media content (Campagna et al., 2015). Afzalan & Muller (2014), for example, found that informative dialogues are developed within online groups regarding local green infrastructure planning issues. Gal-Tzur, Grant-Muller, Kuflik, et al., (2014), similarly, suggested that useful information about transportation policy can be harvested from social media. The combination of qualitative and spatiotemporal analysis may, as suggested by Campagna et al., (2015), provide more insights into the geographies of public needs.

3.2.2 Challenges of utilizing geosocial media

Incorporating qualitative analysis of geosocial media content presents several challenges. As argued by Afzalan & Evans-Cowley (2015), the relatively large volume of social media data may increase the time and human costs of analyzing the data and thus make the new data source less valuable. As a result, a number of scholars have explored the use of computer-aided methods to harvest and analyze information related to local government decision-making from social media (Campagna et al., 2015; Schweitzer, 2014). Gal-Tzur, Grant-Muller, Kuflik, et al., (2014), for example, suggested that text analysis methods can improve the efficiency of harvesting transportation planning-related information from social media text. Campagna et al., (2015) similarly integrated basic text analysis functions such as generating tag clouds with spatiotemporal analysis to explore the use of location-based social media for spatial planning.

Notwithstanding these efforts, several challenges related to harvesting and analyzing locally specific social media remain (Massa, 2015). First, ontology-based information retrieval (IR) methods, which use concepts and their corresponding relationships to define domain-specific terminology and to recognize relevant text content, are used frequently to determine the relevance of a text message to topic (Wang & Stewart, 2015). However, they are not entirely suitable for identifying locally relevant geosocial media messages, because: (1) there are few universal ontologies available for local government or even more defined fields such as planning (El-Diraby & Osman, 2011), and (2) many topics are location specific and center on content that is relevant for a particular development plan or community.

Although developing an ontology based on local knowledge is possible, such an ontology will be limited to a specific local context. Other commonly used IR methods such as machine-learning approaches have similarly been criticized for not being generic because of their need for large and good quality training datasets (Kergosien, Laval, Roche, & Teisseire, 2014). Second, individual social media messages need to be aggregated so that major needs or concerns can be identified and be further used for decision-making (Grant-Muller et al., 2015). Despite the growing use of computational methods, such as topic modeling methods, to automate interpretation of text data (Adams & McKenzie, 2013; Dou, Wang, Skau, Ribarsky, & Zhou, 2012; Ríos & Muñoz, 2014), manual work is still often employed to understand and categorize public input (Afzalan & Muller, 2014; Schweitzer, 2014). Moreover, the reliance on computational knowledge to use these analytical methods can be a barrier to government adoption of social media as it may increase both financial and human cost (Johnson & Sieber, 2013).

Additionally, there are concerns about whether geosocial media data can meet local governments' needs. Because social media are networking and communication platforms at the core, their users are mostly contributing information without being aware that it might be used for other purposes (Stefanidis et al., 2013). Although this may result in less guarded recordings of user sentiment (Dunkel, 2015), much of the data may be irrelevant to local government needs. Further empirical studies of the nature and value of information that can be harvested from social media is therefore needed (Gal-Tzur, Grant-Muller, Kuflik, et al., 2014). Moreover, the geographic representativeness of geosocial media vary widely both among different cities and within cities (Robertson & Feick, 2016). Several studies have reported the geographical unevenness of volunteered geographic information, in that some areas may be represented by large amounts of data, while other areas very few (Graham, Straumann, & Hogan, 2015; Hardy, 2013; Hollenstein & Purves, 2010). Varying demographic profiles across geographic areas may also contribute to the geographical unevenness of user-generated content. As noted by Cavallo, Lynch, & Scull (2014), certain population groups may opt out of using new digital technologies. Although this unevenness should not mitigate the value of user-generated geographic information, the use of these data needs to be critically examined through context-specific analysis (Cavallo et al., 2014).

In this regard, local government adoption of geosocial media need solutions to alleviate technical challenges of utilizing the data as well as further recognitions of the local relevance and potential limitations of the data through critical examinations.

3.3 Methodology

Based upon previous sections, three components are essential for local government staff to harvest and analyze relevant information from social media (Figure 3-1). A web-based toolkit was developed to: (1) harvest geosocial media data from online sources; (2) identify text-based geosocial media messages that relate to local spatial planning issues; and (3) semi-automatically summarize the text content and explore main themes that appear from public input. These themes are delivered through an interactive visual design to help local authorities understand the data.

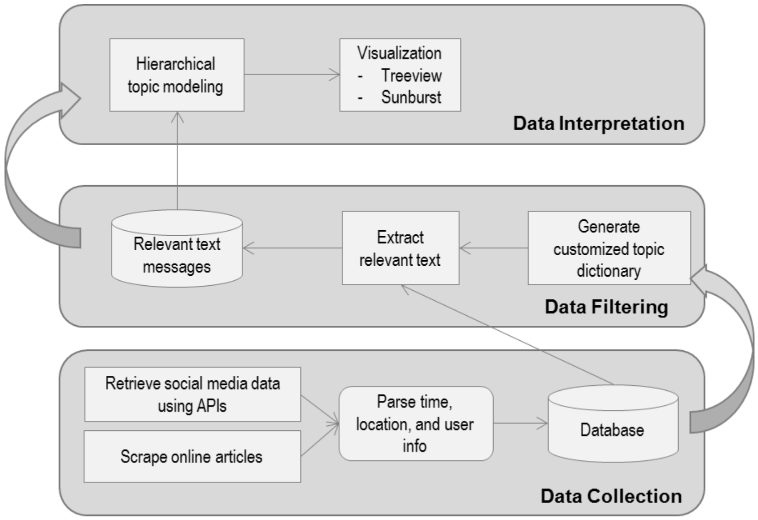


Figure 3-1 The workflow of collecting and analyzing social media data

3.3.1 Data collection

We chose Twitter as an exemplar social media service as it is one of the most popular micro-blogging services for users to post text messages, share images, tag locations, and interact with others. Twitter has a large user base—one in every ten American adults get news from Twitter (Schweitzer, 2014), and while its user community is skewed toward affluent and educated individuals, it is reportedly more diverse than is found on other social media platforms (Lenhart & Fox, 2009). Twitter data were collected using Twitter's Application Programming Interfaces (APIs) and an associated Python library Tweepy (http://www.tweepy.org/). Only data that contain valid geographic coordinates were collected for a local study area and were stored in PostgreSQL database after parsing time, spatial, and user information. For other sources of user-generated content such as online articles and citizen letters, Python scripts built with the scrapy library (http://scrapy.org/) were used to extract information directly from web pages. These text documents were also stored in the database with ancillary information such as the source and time.

3.3.2 Extraction of relevant geosocial media text messages

A two-step approach is used to identify social media messages that relate to local topics (Figure 3-2). As discussed in Section 3.2.2, one challenge associated with extracting text messages relevant to a local planning context is the need of locally specific resources (e.g., ontology, training datasets, *etc.*). A more generic approach is used here to build a local lexicon from local news, municipal reports, and articles based on the widely used *tf-idf* metric. This lexicon is then used as input to evaluate the relevance of the text messages based on a language modeling approach that is found to be effective for identifying relevant short text messages from social media (Tao, Abel, Hauff, & Houben, 2012).

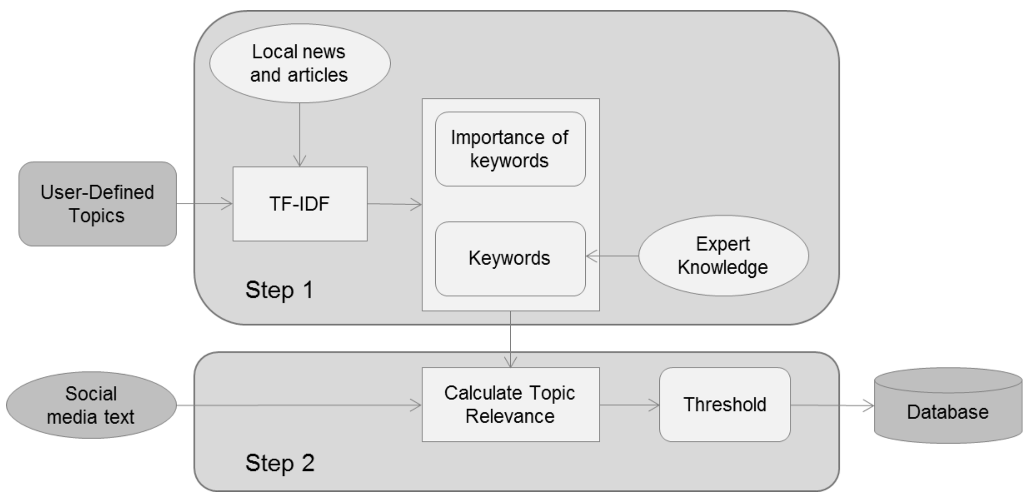


Figure 3-2 A two-step procedure to automatically identify relevant social media messages

3.3.2.1 Constructing Local Lexicon

A local lexicon composed of domain- and context- specific terms is built based on news postings, government documents, and articles that relate to a topic or issue of interest to a local government (e.g., public transportation, infrastructure, construction, *etc.*). In particular, the *tf-idf* measurement is applied to identify the most important words from collected articles. The method considers both the occurrence of a word in a document and the uniqueness of a word according to the number of documents it occurs within so that it can reduce the effect of common words, which are words that generally occur more often than others in a language (Rattenbury & Naaman, 2009). For each word in the corpus, a tf-idf value is calculated using Equation (1):

$$tf - idf = \frac{count(w,d)}{size(d)} \times log\left(\frac{n}{docs(w,D)}\right) \tag{1}$$

where a term frequency (*tf*) is first calculated using the number of times a word *w* occurs in a document *d (count (w, d))* and the total number of words the document *d* contains *(size(d))*. This *tf* value is then multiplied by an inverse document frequency (*idf*) value, which is an inverse fraction of the total number of documents *n* and the number of documents that contain word *w (docs (w, D))*, to get the *tf-idf* value for the word *w*. The higher the *tf-idf* score is, the more important the word *w* is.

A list of important words with high *tf-idf* scores is then used to generate a customized local lexicon based on the assumption that important words identified from planning-related documents are more likely to be related to planning topics (Gal-Tzur, Grant-Muller, Kuflik, et al., 2014). In addition to keywords derived from local documents (e.g., "parking"), their semantic variants (e.g., "parking lot", "parked", "parking garage") can be included in the lexicon to improve the accuracy of the IR (Abel, Celik, Houben, & Siehndel, 2011). Government professionals can thus use their expert knowledge to supplement or alter the auto-generated local lexicon.

3.3.2.2 Calculating Topic Relevance

We then evaluate the relevance of geosocial media messages based on the language model. According to Zhai and Lafferty (Zhai & Lafferty, 2001), a text message can be considered as a probability distribution over the words it contains. The relevance of a short message *t* to a query term *k* can then be calculated as maximum likelihood probability of a message t relating to query term k $R_{(t|k)}$ using a Bayes likelihood estimate (Equation (2)):

$$R_{(t|k)} = \frac{C(k,t) + uP(k|\theta_L)}{len(t) + u} \quad (2)$$

In the equation, $C(k,t)$ is the times the query k occurs in the message t; $P(k|\theta_L)$ is the probability of the query term k occurs in the whole corpus; $len\ (t)$ is the length of the message t; u is a smoothing parameter for Bayes estimate[5].

To evaluate the relevance of a text message to a topic, we consider each topic as a collection of query terms, which correspond to the keyword and its semantic variants as derived from the previous step. Therefore, a topic T can be represented as: T = <$k_1, k_2, k_3, \dots, k_n$>, where n is the total number of keywords identified for topic T. The relevance of a text message to a topic can then be evaluated using Equation (3):

$$R_{(t|T)} = \sum_{i=0}^{n} \frac{W(k_i|T)C(k_i,t) + uP(k_i|\theta_L)}{len(t) + u} \quad (3)$$

Here, the relevance of a message to a topic is considered as a sum of the message's relevance to each word in the topic dictionary. Each word is weighted using its *tf-idf* score to decrease the effect of less important or common words in the dictionary. Using this method, each message will receive a relevance score indicating its relevance to a topic T, with a higher score suggesting a higher possibility of being relevant.

A threshold is then determined to differentiate relevant messages from irrelevant ones by reviewing a sample of messages and their according scores. As shown in Table 3-1, although all the selected text messages refer to parking expressions, the first four with higher scores are potentially of more interest to

[5] After manually test a series of smoothing parameters, u=0.1 is used in the equation for the best accuracy of Bayes estimate.

planners, whereas the latter two relate more to personal feelings. A larger sample of Twitter tweets can be reviewed using the same method to determine the appropriate threshold for identifying parking-related text messages. Although somewhat subjective, reviewing a relatively small sample of the data allows local government staff to view more details about the data and bring in expert knowledge to the categorization procedure.

Table 3-1 Evaluating the relevance of a message to topic "parking"

Text	Score	Category
"This mcdonalds parking lot is so unnecessarily massive."	0.247	Relevant
"why does Waterloo parking charge so much for parking lots that are OBVIOUSLY over capacity everyday. open rim parking lots for f*** sake"	0.173	Relevant
"The freshco parking lots so d*** complicated. I'm almost prone to get into an accident"	0.132	Relevant
"Feels like the entire population of Waterloo is in this parking lot. can't find a place to park"	0.105	Relevant
"@570News turkey on the loose at Canadian Tire Weber Street parking lot! http://t.co/rXlmjXQvOZ"	0.076	Irrelevant
"I don't know why, but I always feel more comfortable parking next to other BMWs. So I've turned it into a game. I search them out"	0.036	Irrelevant

3.3.3 Understanding public input using hierarchical topic modeling

Having identified relevant geosocial media messages, a topic modeling approach is used to recognize latent sub-topics within message collections. Topic modeling is a suite of text mining methods for identifying semantic patterns within collections of natural language documents (Blei, 2012). The Latent Dirichlet Allocation (LDA) was selected because of its simple yet powerful nature (Adams & Janowicz, 2015; Adams & McKenzie, 2013; Blei, 2012). Each topic is associated with a list of keywords, based on which meanings of topics can be interpreted.

Within the context of this work, geosocial media messages related to a topic T are considered as a corpus, which the LDA method divides into a collection of sub-corpora. Assume topic T is "cycling", the above method would allow us to identify what aspects (e.g., cycling trails, shared-use path, and safety concerns) of "cycling" people are talking about. The same procedure can be repeated for these sub-topics to reveal more details from the text. Python scripting is used to automate this recursive procedure following the logic as shown in Figure 3-3. Topic models are first generated for the entire corpus. The words in the corpus are then reassigned to a set of new corpora based on their relationship with the topics. The procedure is repeated for each new corpus until the number of messages the corpus contains is less than a minimum threshold. As a result, texts are modeled as a topic hierarchy that is composed of various topic paths, which represents how one topic is broken down into several sub-topics.

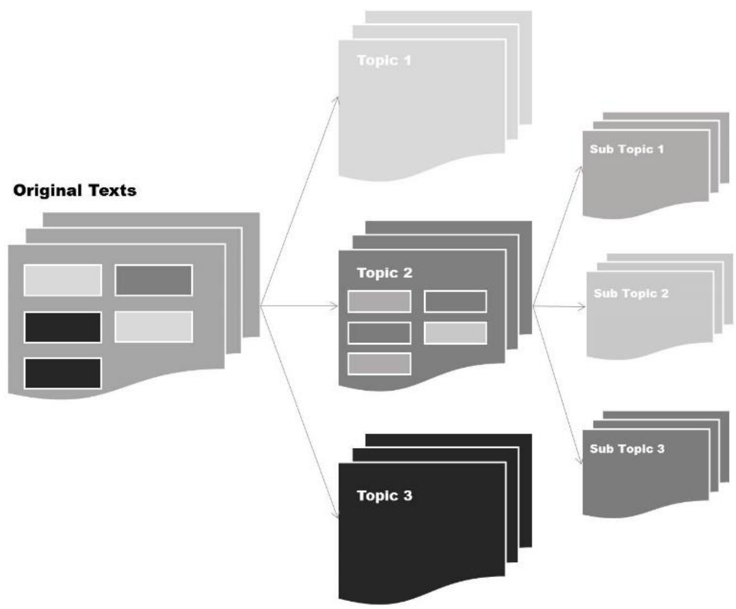


Figure 3-3 The logic of hierarchical LDA (hLDA) (adapted from (A. Smith, Hawes, & Myers, 2014))

3.3.4 Design and implementation of a web-based tool

The Django-based TFA toolkit was developed to provide an easy-to-use graphical interface that integrates IR and the topic modeling method. Django is a free and open source framework for web development (Django, n.d.). Figure 3-4 shows the system architecture of the application. On the backend, a PostgreSQL database is used to store parsed text messages as well as spatial and temporal information. On the server side, a series of models that process and analyze text data is developed using python scripts built from the open-source natural language processing (NLP) python library NLTK. GeoDjango handles the reading and storage of spatial data including locations of social media messages. On the browser side, map visualizations are generated using Leaflet and topic modeling results are visualized with the popular JavaScript-based D3 visualization library (see the D3 Gallery - https://github.com/mbostock/d3/wiki/Gallery).

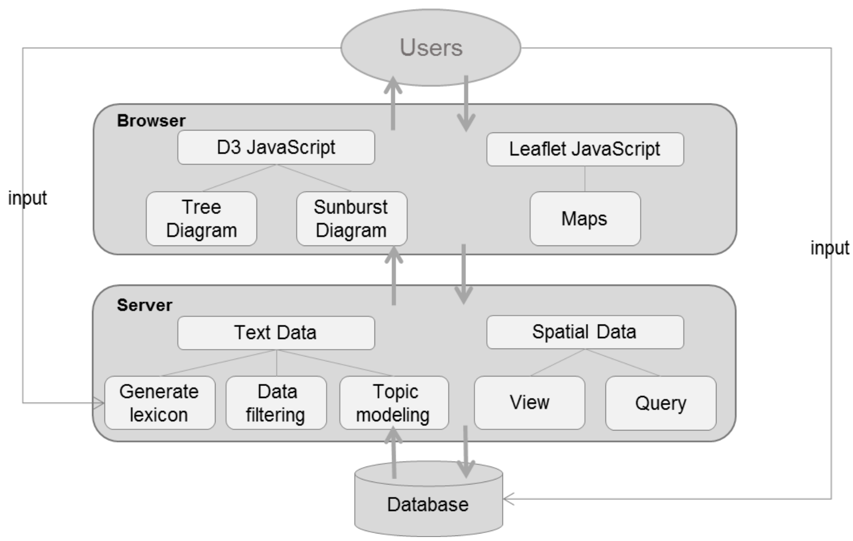


Figure 3-4 System design of TFA toolkit

Figure 3-5 shows several screenshots of the toolkit. Users can follow the steps on the left panel of the main interface to harvest and analyze text input (Figure 3-5a). Customized local lexicons can be created by selecting topic-related documents or by specifying online sources to scrape articles from (Figure 3-5b). Amendments can then be made to the auto-generated keyword list for identifying relevant text messages (Figure 3-5c). Clusters of relevant tweets are represented on the map using the Leaflet markercluster library (https://github.com/Leaflet/Leaflet.markercluster). Topic modeling results are then displayed as shown in Section 3.4.

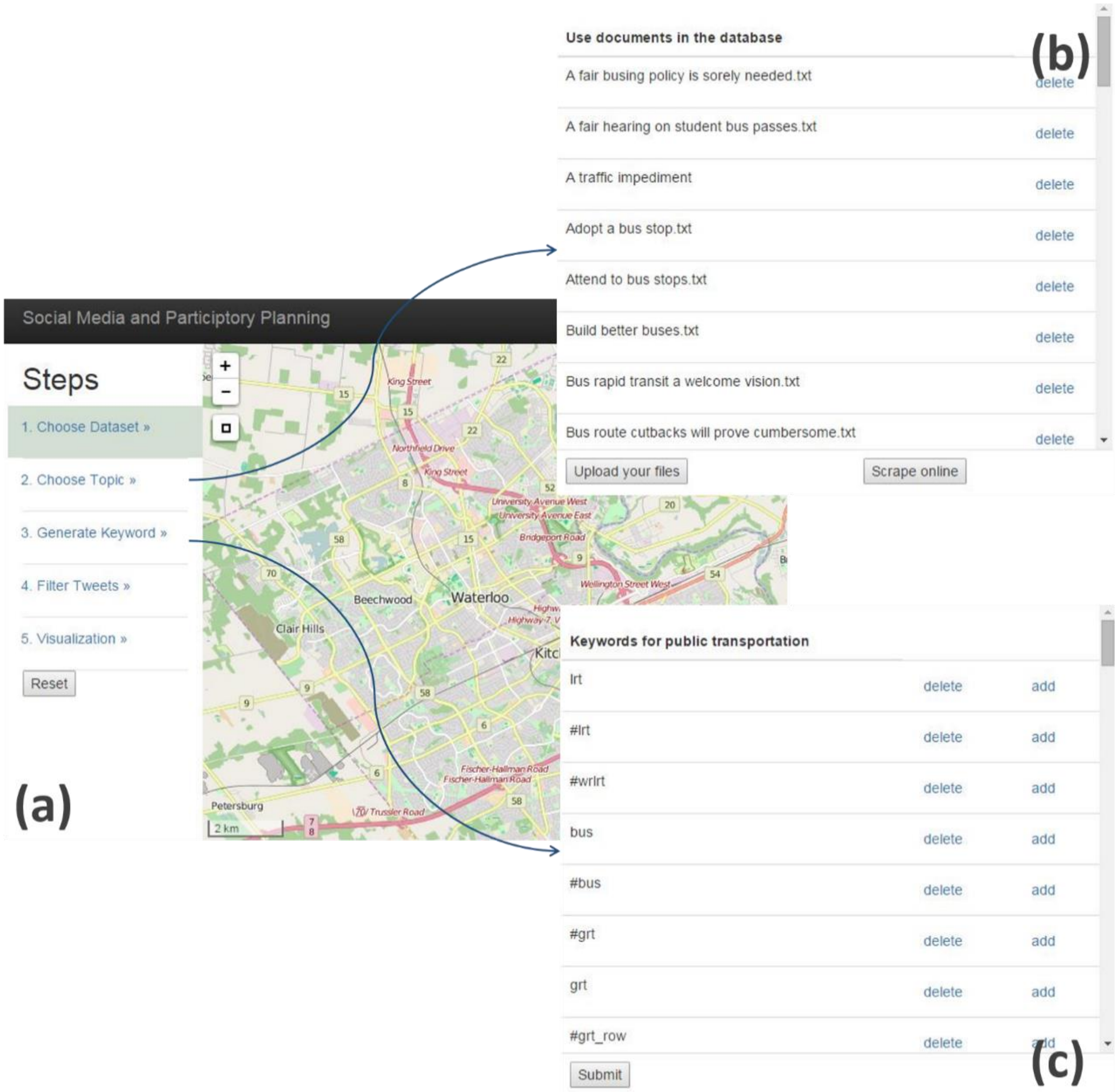


Figure 3-5 (a) the main interface of the TFA toolkit; (b) selecting documents for generating a customized topic lexicon; and (c) reviewing and modifying the auto-generated keyword list.

3.4 Case study

To demonstrate the possible value of topic modeling and mapping of geosocial media data, the toolkit described above was applied in the cities of Waterloo and Kitchener within the Region of Waterloo, Canada (Figure 3-6). The Region of Waterloo has consistently been ranked as one of the fastest growing communities in Canada and is forecast to increase in population from its current level of 568,500 to 729,000 by 2031 (Region of Waterloo, 2007). Consulting stakeholders is and will continuing to be an important function for local governments as the development unfolds. The ongoing construction of a new light rail transit (LRT) started in August 2014, has promoted public debate concerning issues such as congestion, urban intensification, and disruptions to existing neighborhoods. During the preparation of the project, both the regional and the city governments held public meetings to collect public opinions toward the transit plan at different stages of the project. Discussions about the project are continuing as the impacts of the LRT construction and associated intensification of urban forms become more apparent to local residents.

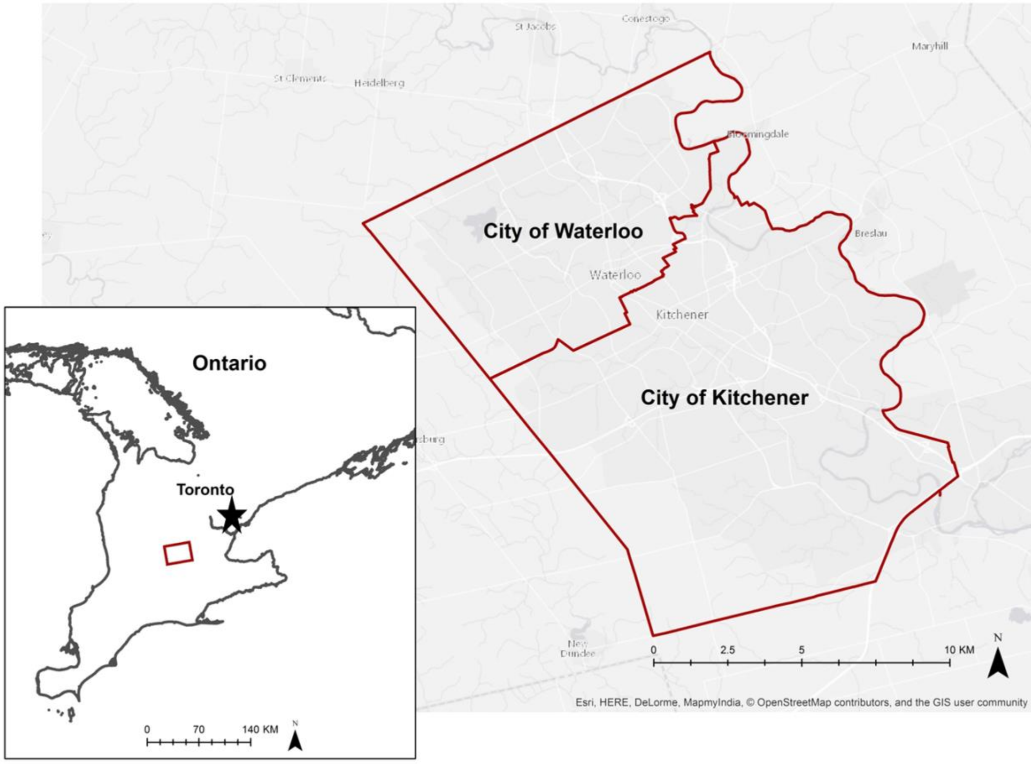


Figure 3-6 Study Area

3.4.1 Data

Twitter data with valid geographic coordinates were obtained in real time from March 2014 to July 2015, the time period when the Region started constructing the first stage of LRT, based on a fixed boundary for cities of Waterloo and Kitchener. It is important to note that although only some one percent of tweets can be obtained using public streaming API, the absolute quantity of the sample is still relatively large (Leetaru, Wang, Cao, Padmanabhan, & Shook, 2013). In the following analysis, we focus on transportation-related topics given the ongoing LRT project has elevated the issue of transportation within the Region and the general importance of transportation in many other locales (Gal-Tzur, Grant-Muller, Minkov, & Nocera, 2014).

A topic dictionary based on a purposely restrictive keyword set (LRT, light rail, bus, public transportation, GRT) was developed by scraping news and commentary articles from local media ("The Record" newspaper, http://www.therecord.com/waterlooregion/). Over 200,000 Twitter tweets with valid geographic coordinates were collected during the 16-month period. In total, 2777 and 2112 tweets were found to be relevant to the topics "public transportation" and "walking", respectively. This volume is similar to that was found in de Albuquerque et al. (de Albuquerque et al., 2015), where over 99% of Twitter tweets were found to be "off-topic".

To test the accuracy of the results, we manually classified a random sample (sample size = 120) for each topic and compared the results with computer-coded ones. We found 82.5% and 67.5% precision respectively for public transportation and walking. Interestingly, some messages about the TV show "The Walking Dead" were mistakenly classified as walking-related because the term "walking" has the highest weight in the lexicon. To improve this result, we adjusted the weight of the word "walking" and the relevance threshold of the topic accordingly. Testing of another randomly generated sample suggested that the precision of classification results increased to 80.83%, which is reasonable for IR of short text messages (Tao et al., 2012). We further examined the spatial distributions of these messages to draw insights into their locational context (Figure 3-7 and Figure 3-8). The maps shown here were reproduced in ArcGIS to add map elements such as legends, scales, and better-quality graphs. In addition to mapping individual locations of messages, clustering circles are also mapped with the size indicating the counts of tweets within the area. As expected, most tweets were posted nearby two universities (University of Waterloo and Wilfrid Laurier University), and the cores of Waterloo and Kitchener, as those are the busiest areas where most students and business are located.

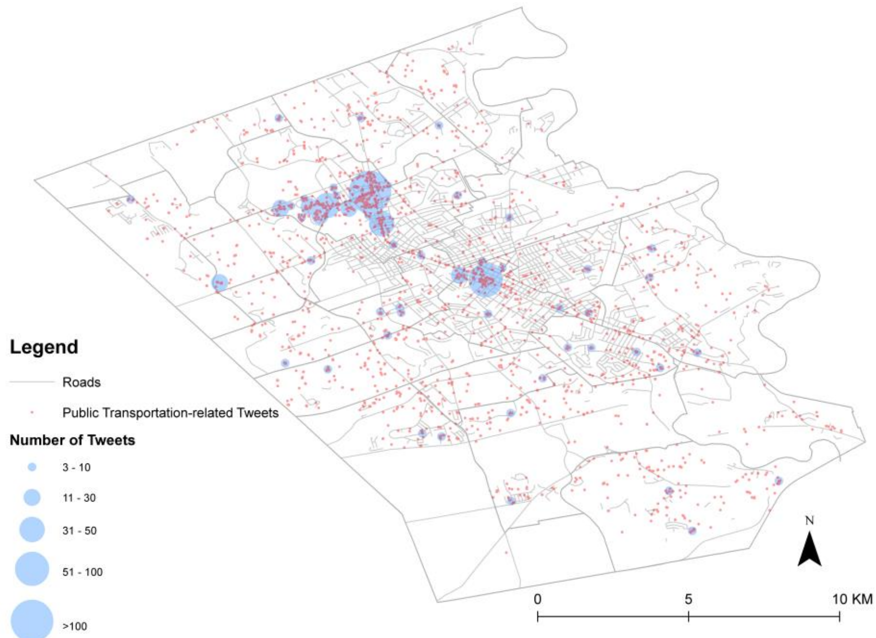


Figure 3-7 Spatial distributions of public transportation related tweets

Figure 3-8 Spatial distributions of walking related tweets

To further investigate the content of these messages, the topic modeling method was applied to find major topics of interest to Twitter users. The keyword list originally produced by LDA is shown in Table 3-2. While the relevance of some topics is evident, other terms shown in italics were less helpful and were removed from the topic hierarchy (Table 3-2).

Table 3-2 Examples of keyword list generated from LDA

Topic	***Personal Feelings***	***Long Distance***	***Schools and Kids***	***Schools and Kids***	***Irrelevant***	***Irrelevant***
Keyword	safety	walk	off	school	*nice*	*nice*
	comfort	far	school	walk	*love*	*respect*
	walking	school	kids	dont	*im*	*like*
	watch	away	snow	ice	*get*	*dont*
	like	campus	far	friendly	*places*	*soccer*
	lights	friendly	kitchener	back	*home*	*people*
	catch	minutes	traffic	ill	*hate*	*S***
	dog	class	hate	lights	*turning*	*got*
	good	snow	mom	waterloo	*guys*	*one*
	time	car	ice	cold	*tonight*	*weather*

3.4.2 Understanding public perception from geosocial media

Figure 3-9 shows a sunburst diagram generated based on topic modeling results of public transportation related messages. Five topics, including trains, bus services, Uptown Waterloo, Charles Terminal (shortened from Charles Street Bus Terminal), and LRT, are found at the top of the hierarchy (the second inner-most ring in Figure 3-9). Among these five topics, three are associated with public transportation modes (trains, bus, and LRT), the other two relate to two transit hub locations (Uptown Waterloo, Charles Terminal).

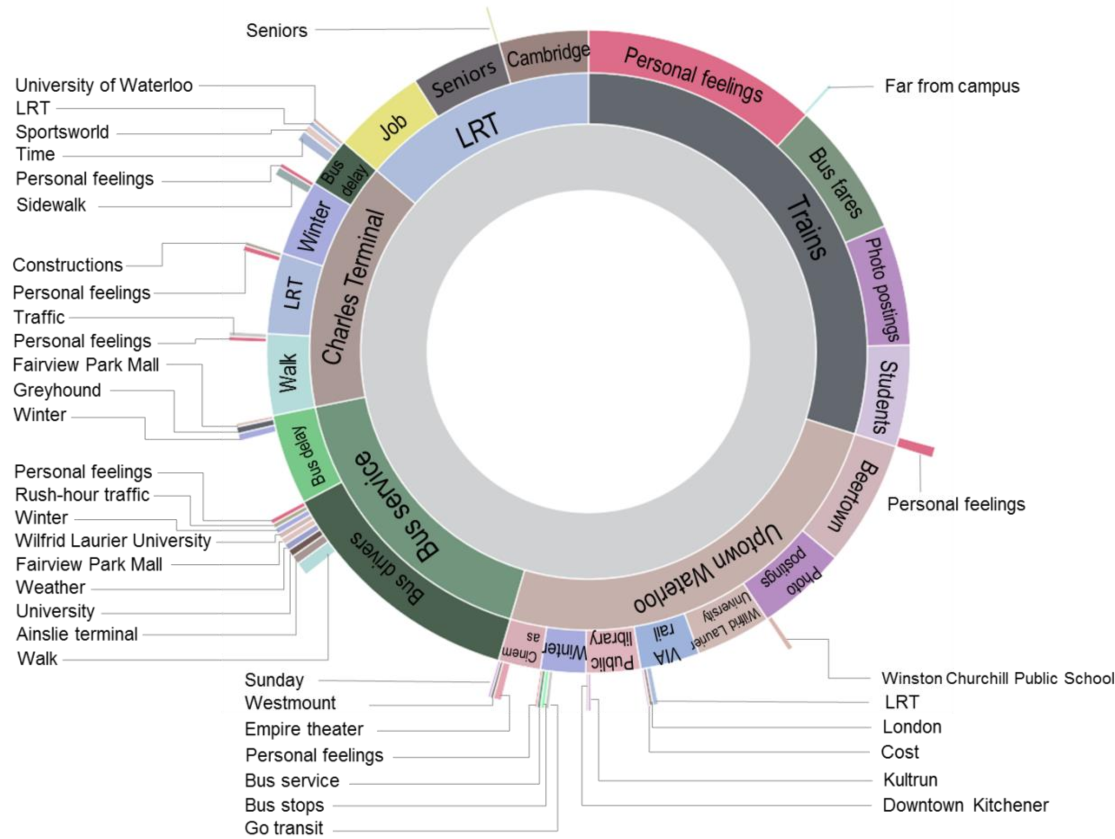


Figure 3-9 An overview of topic hierarchy generated from Twitter Tweets

While these topics generally provide a high-level overview of public transportation messages, more details are revealed at the next levels of the hierarchy. For example, the topic "bus service", located in the lower left of Figure 3-9, is split into "bus delay" and "bus drivers" topics. Given that a few studies have suggested that social media comments are more negative rather than positive (Schweitzer, 2014) and that "bus delay" itself is not a positive expression, it is reasonable to speculate that "bus delay" is the aspect that people have the most complaints about. In other instances, topics may occur multiple times in the hierarchy yet indicate different contexts. For example, "winter" appears under both "Charles Terminal" and" Uptown Waterloo" and relates to the infrastructure. Near Charles Terminal, people mentioned concerns with sidewalks in the surrounding area, largely because of ongoing construction (e.g., *"@CityKitchener can you please fix sidewalk bricks queen at King to Charles. I'm tired of twisting my ankles on missing bricks.*"). In Uptown Waterloo, "winter" was used more frequently to register a complaint about the lack of shelters at some bus stops (e.g., *"we need a shelter at bus stop #1908"*). This type of information is typical of what is reported through various open 311 applications that permit citizens to report concerns with city infrastructure and public services (Sieber & Johnson, 2015).

Text analysis results can also be combined with geolocations to examine where concerns or interests are expressed. Figure 3-10 shows major locations where tweets related to the topic "bus service" are posted. Spatial clusters were mapped using the proportion of bus service-related tweets to the total amounts of public transportation tweets within the same location in order to mitigate the effect of varying numbers of tweets in different locations. Not surprisingly, messages under this category are mostly concentrated around the University area as well as King Street, the central transit corridor in the Region. Several residential areas with concentrated rental housing in the northern Waterloo and southern Kitchener also appear to be significant, indicating high usages of bus service. General insights can be drawn from the map on where common concerns and needs are. For example, messages about bus drivers are consistently seen around Downtown Kitchener, indicating some pertinent traffic issues such as narrow road lanes and busy traffic in the area.

Figure 3-10 Spatial clustering of bus service-related tweets

Other locations may not appear to be significant using the data collected for the entire sixteen months but become more visible within certain time periods. For example, Figure 3-11 illustrates how road closures and changes in bus routes in June 2015 are reflected in bus service-related Tweets before and after June 2015. These changes were required at this time to permit a new LRT station to be constructed near the two tweet clusters close to the Parkside/Northfield intersection. While this is a specific example, it provides some indications of how geosocial media may help identify the dynamics of public opinions. Local governments can potentially use this data to examine the effects of planning and development projects on local people in a timelier manner.

Yet public opinions expressed through geosocial media mostly relate to public sentiment and perceptions toward their immediate environment. For example, although there is a growing trend of LRT-related tweets (from an average of 8% of all public transportation-related messages in 2014 to an average of 12% in 2015) because of the ongoing construction, the discussion of LRT mainly reflects users' experience with current traffic situation (e.g., "*On a jam-packed express bus—a good harbinger of ridership for the ION light rail line! Another reminder of how excited I am.*"). This also indicates the difference between geosocial media and traditional participation methods, which will be further examined in the next section.

Figure 3-11 The comparisons of bus service-related tweets before and after June 2015

3.4.3 Comparing different forms of citizen input

In addition to geosocial media, many traditional public participation methods, such as open house events, workshops, citizen letters, and surveys, also collect text and often geographically referenced input from citizens. This input can be analyzed in the same way as what was done for geosocial media messages. On a regular basis, The Record publishes citizen letters and comments that relate to public concerns. In total, 478 transportation-related citizen letters were obtained during the same time period as Twitter data were collected. These letters were processed following same procedure as shown in Figure 3-3. Figure 3-12 shows an overview of topics that emerged from the content of citizen letters.

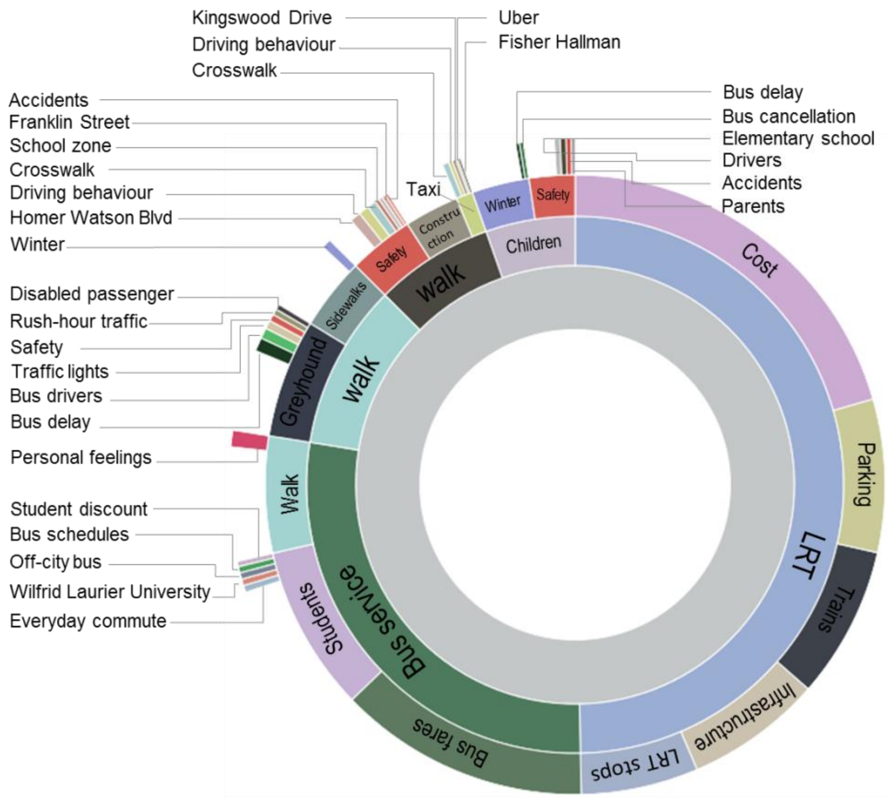


Figure 3-12 An overview of topic hierarchy generated from citizen letters

An initial examination of topic categories demonstrates marked differences between geosocial media messages and citizen letters. Some topics, such as roundabout, traffic lights, and disabled passengers, do not occur in social media messages, whereas social media messages have other unique topics which mostly are place-based (e.g., Fairview Park Mall, Ainslie Terminal, and Beertown—a restaurant) and event-oriented. Although both citizen letters and Twitter messages mention certain places, places mentioned in citizen letters more refer to general areas, such as school zones, university, etc., whereas more specific place names are mentioned in Twitter messages. This general versus specific distinction is comparable to what others found in comparison of walking and sedentary interviews (Evans & Jones, 2011). Similar to walking interviews, Twitter messages can better capture the dynamics of urban landscape as people often send messages when they are moving around the city. Citizen letters, analogous to sedentary interviews, serve as a more productive mode for narratives and an incubator of critical and deeper discussions on issues such as safety, urban design, and policy. Another unique characteristic of Twitter, or social media in general, is its capability to capture events and activities. In the topic hierarchy generated from Twitter messages, photo-posting activities appear to be associated with Uptown Waterloo and trains. Many messages in this category relates to an "IONUptown" challenge that was launched by Uptown Waterloo business improvement area (BIA) office (http://uptownwaterloobia.com/ionuptown-challenge/#). Many people, incentivized by the possibility of winning a prize, were willing to participate in the challenge by posting photos on Twitter about their work, play, or shopping activities around the Uptown area using hashtag *#ionuptown* and had a chance to win a prize. Methods demonstrated by Dunkel (2015) to examine the photo content in addition to the text tags are beyond the scope of this study, but could be used in future analysis to learn more about citizens' place perceptions and preferences.

Moreover, even topics that occur in both datasets may have completely different foci. While social media users mostly talked about bus delays and bus drivers regarding bus service, citizen letters demonstrate a quite divergent range of issues related to students, walking, and costs. These differences most likely can be traced to the different nature of the two input methods, one more temporally immediate and place-specific, the other favouring more contemplative and geographically generic, as discussed above (Gal-Tzur, Grant-Muller, Kuflik, et al., 2014). On the other hand, it provides an interesting lens to compare different public input, especially on the potential of social media in reaching younger demographics which are often under-represented in traditional public participation methods (Evans-Cowley & Griffin, 2011).

3.4.4 Implications for using geosocial media to understand public opinions

Public opinions that can be retrieved from social media relate to what Corburn (2003) considered as reflections of "actual sights, smells, and tastes, along with the tactil(e) and emotional experiences encountered in everyday life" (P.421). Knowledge of this kind is often not effectively captured by other data collection methods (McCall & Dunn, 2012) and thus makes geosocial media a potentially valuable source. The case study presented here suggests that geosocial media can help identify public concerns and needs about physical facilities and the quality of public services, and potentially be used as an additional citizen reporting mechanism. Moreover, as illustrated in the case study, messages about the LRT project appear shortly after the start of the construction, suggesting a potential use of geosocial media to capture the dynamics of public perception over space and time. In addition, public perception expressed through Twitter is often a reflection of people sensing and responding to their immediate environments and differs from public input collected from formal public participation procedures, which is usually given based on more considered thought and rational choice (Gal-Tzur, Grant-Muller, Kuflik, et al., 2014).

With regard to spatial bias in geosocial media, the uneven geographic distributions of tweets were not surprisingly found to be concentrated within university areas, city core areas, and the major transit corridor, while data points in other areas were relatively sparse. As suggested in other studies, this unevenness may limit the use of geosocial media to certain areas (Lawrence, Robertson, Feick, & Nelson, 2015; Shelton, Poorthuis, & Zook, 2015). However, we were able to identify places outside high-interaction areas that were associated with particular topics or emerged at specific time periods. To understand spatial bias in data of this type, some attention should be directed to exploring qualitative analysis at different spatial and temporal scales.

The comparison between geosocial media and citizen letters further investigates the differences between geosocial media and other methods of monitoring public sentiment. Although geosocial media may be limited in providing more in-depth discussion and comments in response to local government initiatives, they illustrate some potential of complementing other public participation methods as well as fostering new virtual interactions between government and citizens through online activities. These findings have several implications for citizen-government interactions. First, geosocial media may assist the study of "the relationship between what people say and where they say it" (Evans & Jones, 2011), which is found to be a challenging task because of the difficulty in identifying locational information from interviews (Elwood & Martin, 2000). While people are found to mention general areas more often in formally written comments such as citizen letters, whether geosocial media could supplement other methods by identifying where certain issues may worth further exploration. Second, the response to the IONUptown challenge suggests that there is a good potential to boost citizen contributions through entertaining place-based activities.

However, local government professionals' perspectives will be critical to evaluate these identified possibilities and challenges. In practice, government adoption of social media as a monitoring mechanism depends not only on whether valuable information can be identified from social media, but also various factors such as the trustworthiness of data contributors and the organization's culture with respect to adapting to new technologies (Grant-Muller et al., 2015; Wukich &

Mergel, 2016). Future work will examine the case study findings further by interviewing local government professionals.

3.5 Conclusions

This paper was intended to address challenges of utilizing geosocial media and assess the potential of these data sources as a new channel for gathering place-based public opinions. The potential uses and challenges identified from the case study contribute to an emerging body of literature on local governments' adoption of social media. The empirical study illustrates how geosocial media can provide topic- and location-specific types of public input that differ subtly from what might be found in complementary data sources. Second, based on the inevitable geographic unevenness of geosocial media data, our study suggests that such an unevenness should be explored further by incorporating qualitative analysis at different spatial and temporal scales. Additionally, different from many geosocial media studies focusing on metropolitan cities, we purposefully chose cities of Waterloo and Kitchener to shed light on whether perceived opportunities of geosocial media are applicable to medium-sized cities. Finally, the TFA toolkit facilitated the study by alleviating technical challenges for harvesting and analyzing social media content. Designed for social media messages, this toolkit can be used for other text-based public input, such as that collected from surveys, public meetings, online forums, and different social media platforms. Further user study is needed to test the functionality and user-friendliness of the toolkit in order to broaden its usage.

There are several ways where the use of geosocial media in local government context can be further explored. First, our analysis focuses on Twitter, which is only one of the most popular social media platforms. It will be worthwhile to examine whether an integration of various types of social media would allow different subpopulations to be represented and different aspects of behavior and interaction to be captured. Second, a relatively small proportion of social media have encoded geographic coordinates. Georeferencing implicit spatial information such as place names may enrich data volume and increase the potential to glean useful information from social media. Finally, future work should further combine spatiotemporal analysis with ancillary information such as user profiles to uncover the representativeness of geosocial media and advance our understanding of how geosocial media may complement other participation methods.

Chapter 4: A Geospatial Data Perspective to Evaluating Opportunities and Challenges of using Geosocial Media for Non-Emergency Reporting

4.1 Introduction and background

4.1.1 Evolving government-citizen interactions

Driven by developments in ICTs, increasing openness of public sector information, and pervasive uses of digital devices, the world has witnessed transforming actions of government-citizen relationships (United Nations, 2016). The role of citizens has been at least partially transformed from data and service consumers to co-producers of government data and services (Sieber & Johnson, 2015). While the idea of citizens being co-producers of government service is not new (Levine & Fisher, 1984), Web 2.0 tools have made data and service production more accessible to average citizens (Linders, 2012). Advances in social networking capabilities have further provided opportunities for government-citizen collaboration through multi-directional and more dynamic communications (Mergel, 2013). There is some promise held that governments can augment and improve their services delivery by reaching out to collective citizen efforts (Khan, 2015).

Using geospatial technologies (e.g. location-aware devices including smart phones and GPS-enabled sensors, location-based services), citizens can more directly contribute new types of geo-referenced data and communicate place-based issues with governments. For example, citizens may actively contribute to government mapping initiatives (Statistic Canada, n.d.) or passively generate geospatial information that sheds light on human movements and perceived environments (Deville et al., 2014; Dunkel, 2015). With citizens constantly generating geospatial data about urban environments, urban dynamics may be monitored and understood at finer-resolutions and in real-time (Kitchin, 2014b).

These developments provide potential for governments to improve the delivery of non-emergency services. Governments provide important non-emergency services, handling issues like graffiti, parking enforcement, noise complaints and potholes. To enable these citizen requests for service, governments have expanded available communication channels to include mobile reporting applications and social media (Nam & Pardo, 2014b). Using geo-enabled tools such as geosocial media, citizens may conveniently send a request to government and include location information, helping governments improve service delivery and optimize government resources (Wiseman, 2014). The public may also increase their situational awareness of time-critical situations where there might be a lack of authoritative data via social media (e.g. road/sidewalk conditions, safety concerns) (Linders, 2012).

Despite this potential, there are significant challenges of using citizen-contributed geospatial data, most notably the uncertain quality of this data. Lack of supervision in data collection processes, anonymous data authors, inconsistent data formats, and biased representation are common challenges identified in previous studies (Elwood, 2010; Robertson & Feick, 2016; Sieber et al., 2016). For governments, adopting citizen-contributed geospatial data may raise issues including trustworthiness and liability.

4.1.2 Non-emergency reporting in local governments

Given the large volumes of non-emergency citizen requests local governments receive (e.g. City of Chicago receives about 3.9 million phone calls a year), innovative government-citizen collaboration is necessary for local governments (Wiseman, 2014). Growing numbers of North American municipalities have established 311 customer service centers (i.e. the abbreviated telephone number for non-emergency contact with local governments in the U.S. and Canada). Originating from local phone-based systems in the 1990s, 311 services have been expanded to emails, websites, and mobile applications that offer citizens easier access to the service 24-hours, 7-days-a-week (Nam & Pardo, 2014b; Sieber &

Johnson, 2015). Web and mobile applications, particularly, are increasingly adopted to make reporting more convenient for citizens. Good-quality reports coming from the reporting applications can be directly integrated into back-end systems (e.g. Customer Relationship Management (CRM) system) for processing and can thus improve the responsiveness of municipalities (Foth, Schroeter, & Anastasiu, 2011; Lu, 2017).

Yet reporting applications have two main disadvantages. First, the relatively low adoption rate is one challenge for wider scale usages of web and mobile applications (Desouza & Bhagwatwar, 2012). Requirements of possessing a smartphone, data plan, and application installation seem to be too much effort for some citizens, especially occasional reporters (Lu, 2017). Second, some non-emergency issues relate to time-critical situations. Although a problem can be reported to government immediately using reporting applications, the information is not accessible to other citizens who may need the information (Peixoto & Fox, 2016).

Comparatively, social media has large user base and is widely adopted by local governments. According to Oliveira & Welch (2013), 88% of local governments in the United States use social media. Moreover, social media allows open and timely interaction. A range of studies have examined geosocial media as a source of volunteered or ambient geographic information and suggested its usefulness for understanding dynamic environments (Arribas-Bel, 2014; Crooks et al., 2015). These characteristics presented the potential of geosocial media being a supplementary reporting mechanism.

However, the uncertain quality of geosocial media may raise concern for its use (Reddick, Chatfield, & Ojo, 2017; Tilly, Fischbach, & Schoder, 2015). Different from other reporting methods, people are not asked specific questions about a reported issue when reporting through social media. The extent to which geosocial media with unstructured content and inconsistent formats can fit into official non-emergency reporting programs is thus questionable. Additionally, geosocial media information is found to be geographically uneven and thematically dispersed (Poorthuis, Zook, Shelton, Graham, & Stephens, 2014; Robertson & Feick, 2016). While successful examples have been reported on the usefulness of geosocial media for improving situational awareness of emergency situations (Crooks et al., 2013; L. Smith, Liang, James, & Lin, 2015), how relevant and useful it is for citizens to understand urban environments needs to be further investigated. In this regard, understanding the usefulness of geosocial media for sharing and reporting non-emergency issues needs to explore both citizen and government perspectives.

4.1.3 Research objectives

This study aims to assess the usefulness of geosocial media for sharing and reporting non-emergency issues and critically explore what are the opportunities and challenges of using geosocial media for government reporting. These objectives are addressed by an empirical study of citizens sharing sidewalk conditions using geosocial media and a series of interviews with Canadian municipalities. Results of empirical studies aim to provide generalizable insights on the opportunities and challenges of government adopting geosocial data.

4.2 Methods

4.2.1 Research design

Figure 4-1 represents the workflow of this study. Citizen and local governments' perspectives of the usefulness of geosocial media for non-emergency reporting were first collected using a two-part data collection approach. In the first stage, we surveyed the public about usefulness of geosocial media through a case study of citizens using geosocial media to share and report on sidewalk conditions. A study website entitled Smart Sidewalks was developed to solicit public opinions toward the usefulness of geosocial media for understanding changing environments and reporting non-emergency issues. In the second stage, we interviewed municipal government staff about how they currently handle citizen reports and what are their perspectives of opportunities and challenges of adopting geosocial media reporting using a combination of multiple choices and open-ended questions.

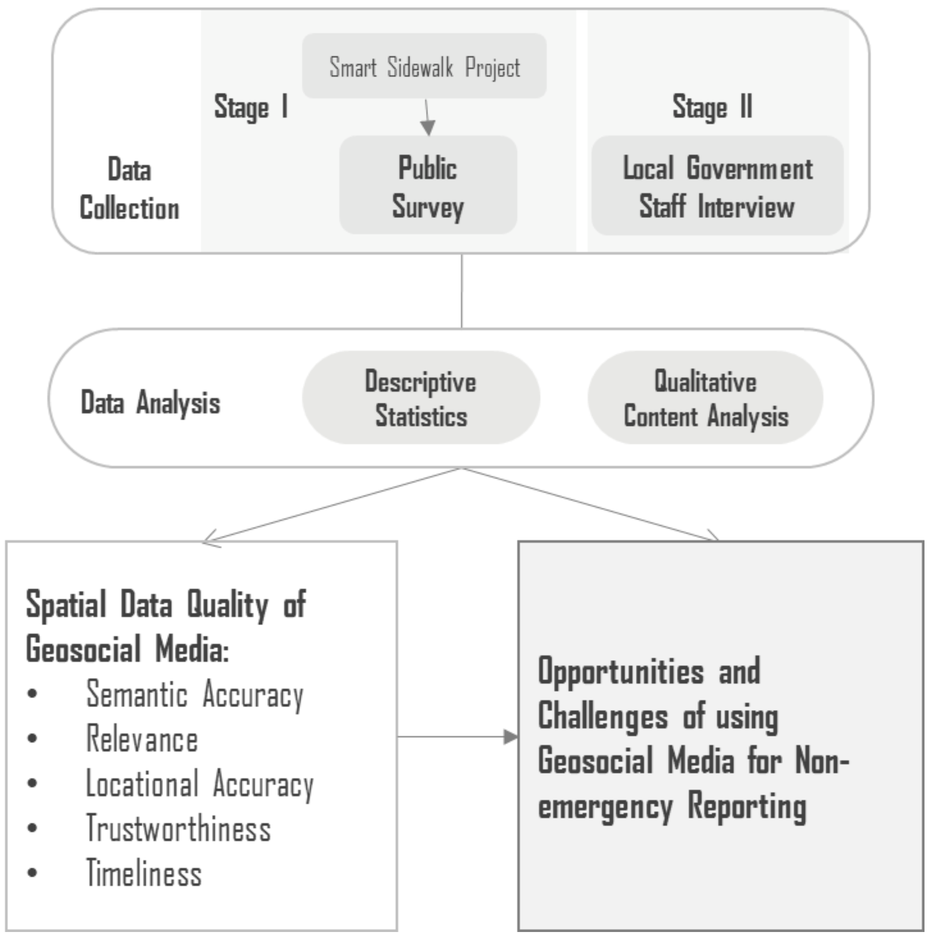


Figure 4-1 Research Design

Results of public survey and local government staff interview were then analyzed using descriptive statistics and qualitative content analysis. Survey responses from citizens were analyzed based on the percentage of the total number of participants that agree or disagree with each given statement regarding spatial data quality of geosocial media and the usefulness of geosocial media reporting. For local government interviews, answers to multiple choices were also analyzed using descriptive statistics. Answers to open-ended questions were first transcribed and then manually coded by summarizing common themes emerged from the data.

The analysis focuses on spatial data quality of geosocial media and usefulness of geosocial media reporting respectively. For the former, the evaluation focuses on five spatial data quality aspects including relevance, semantic accuracy, locational accuracy, trustworthiness, and timeliness, as they are most addressed quality aspects of contributed spatial data in literature (Olteanu-Raimond et al., 2017). Based on citizen and government's evaluations of the quality of geosocial media, opportunities and challenges of geosocial media reporting are further investigated.

4.2.2 Citizen evaluation of geosocial media reporting

To help citizens understand the idea of using geosocial media for non-emergency reporting, a case study of sharing and reporting sidewalk conditions via geosocial media was implemented. Sidewalk maintenance is an important mandate of local governments. According to minimum maintenance standards in Ontario, sidewalk inspections have to be carried out at least once per year (Ontario, n.d.). In City of Kitchener, Ontario, the municipality spends up to $750,000 for sidewalk inspections and identifies 2800 new sidewalk defects in average every year (City of Kitchener, n.d.). Yet it is challenging for local governments to capture dynamics of sidewalk conditions by regular inspections. For example, a sidewalk may temporarily be blocked by an obstacle (e.g. construction, poor surface conditions, and vehicles driving on the sidewalk) and be inaccessible for pedestrians. This information is important for both municipalities and citizens important as they may form potential trip obstacles and raise safety risks.

4.2.2.1 Case study

The case study was implemented in the downtown of City of Kitchener, Canada (Figure 4-2). As one of the fastest growing communities in Canada, the City of Kitchener has been endeavoring to pioneer innovative government strategies and improving its service delivery to over 200,000 residents (The City of Kitchener, n.d.).

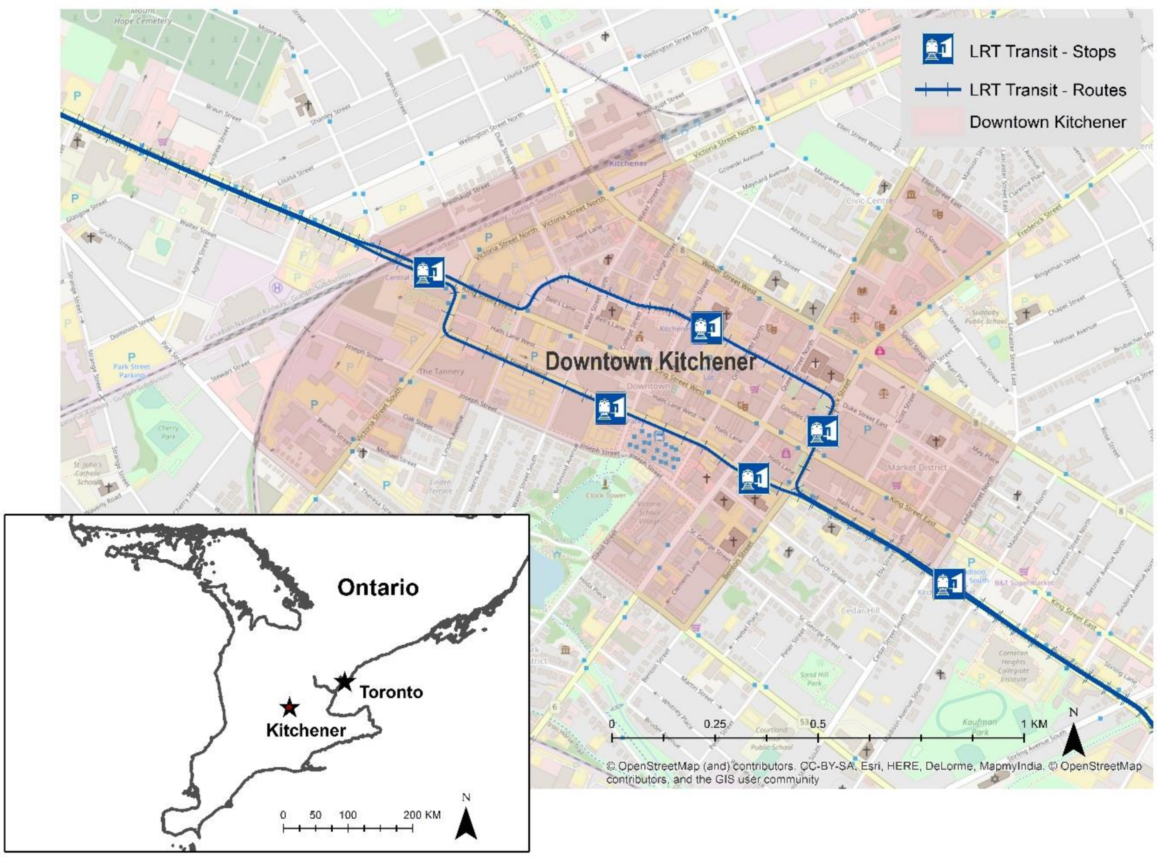
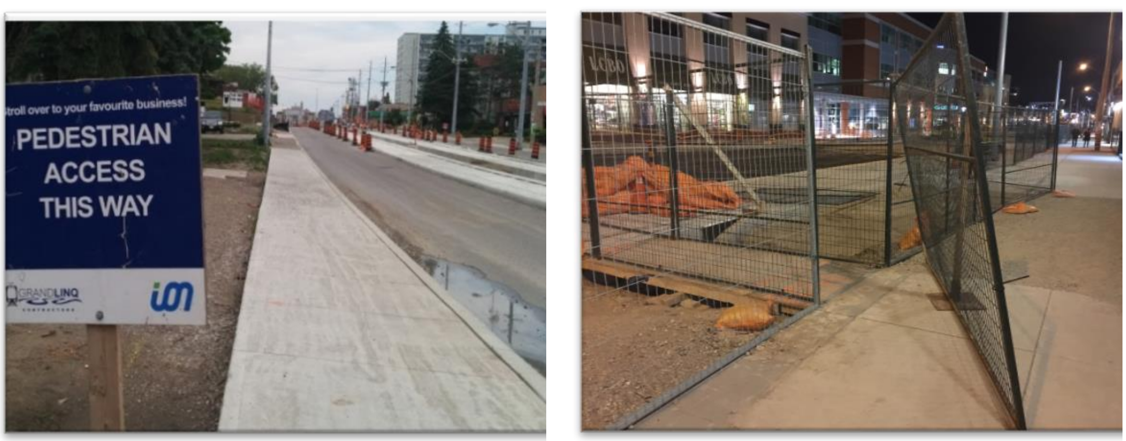


Figure 4-2 Study Area

During the time of the study, the construction of a Light Rail Transit (LRT) in the City of Kitchener added extra complexity to already dynamic sidewalk situations. The two-year construction of the first stage of the project installed 19km of LRT tracks and 5.6km of new sidewalks. From December 2016 to March 2017, there were 13 major road closures according to official construction updates, with varying closing times ranging from a day to a few months. However, these updates mainly focused on road closures that were not always the same as sidewalk closures. Pedestrians could hardly know the accessibility of the sidewalk without going to the place. Moreover, proper signage to warn pedestrians with potential barriers and hazards were not always posted in time due to rapidly-changing sidewalk conditions (Bueckert, 2016). The signage shown in Figure 4-3a was reported to be misleading as it directed pedestrians down a blocked street and forced pedestrians to the street (Bueckert, 2016). This brought up serious safety concerns for pedestrians maneuvering construction sites, especially for those with mobility challenges. Situations of temporary pedestrian paths being accessible only to able-bodied pedestrians (Figure 4-3b) often occurred as well with the construction.



(a) (b)

Figure 4-3 Examples of sidewalk issues in the City of Kitchener: (a) a misleading signage for pedestrian access (source: Bueckert (2016)) (b) a temporary pedestrian path that was too narrow for wheelchair users

4.2.2.2 Participant recruitment

Study participants were recruited during mid-December 2016 to March 2017 through 1) on-street recruitment and 2) contacting municipalities and local organizations. Three on-street recruitments activities were carried out at the City of Kitchener's Farmers Market, one of the major business locations in the study site for distributing project flyers. We also contacted the City of Kitchener and local community organizations working on accessibility related issues to help broadcast project information through flyers and social media. The study was open to participants with a minimum age of 14 years old without restrictions on their own locale. However, given that the public involvement is local in nature (Kidney, 2002), participants were mostly local residents.

4.2.2.3 Participation process

Participants were asked to access the study website Smart Sidewalk at their own time and location. Participants would follow the step-by-step guidance on the website to understand how they may use geosocial media for sharing and reporting sidewalk conditions and complete the survey accordingly.

First, participants examined at least five Twitter messages and five Flickr photos within a selected construction area of interest on the map and determined how relevant these message and photos to sidewalk conditions (Figure 4-4). Twitter and Flickr are used as examples of geosocial media considering that they both are popular platforms but have different focuses (i.e. Twitter is a timely communication platform, whereas Flickr focuses on photo-sharing). The messages and photos displayed on the map were harvested based on keywords (LRT, sidewalk) and geographic locations (City of Kitchener) using the Twitter and Flickr public APIs.

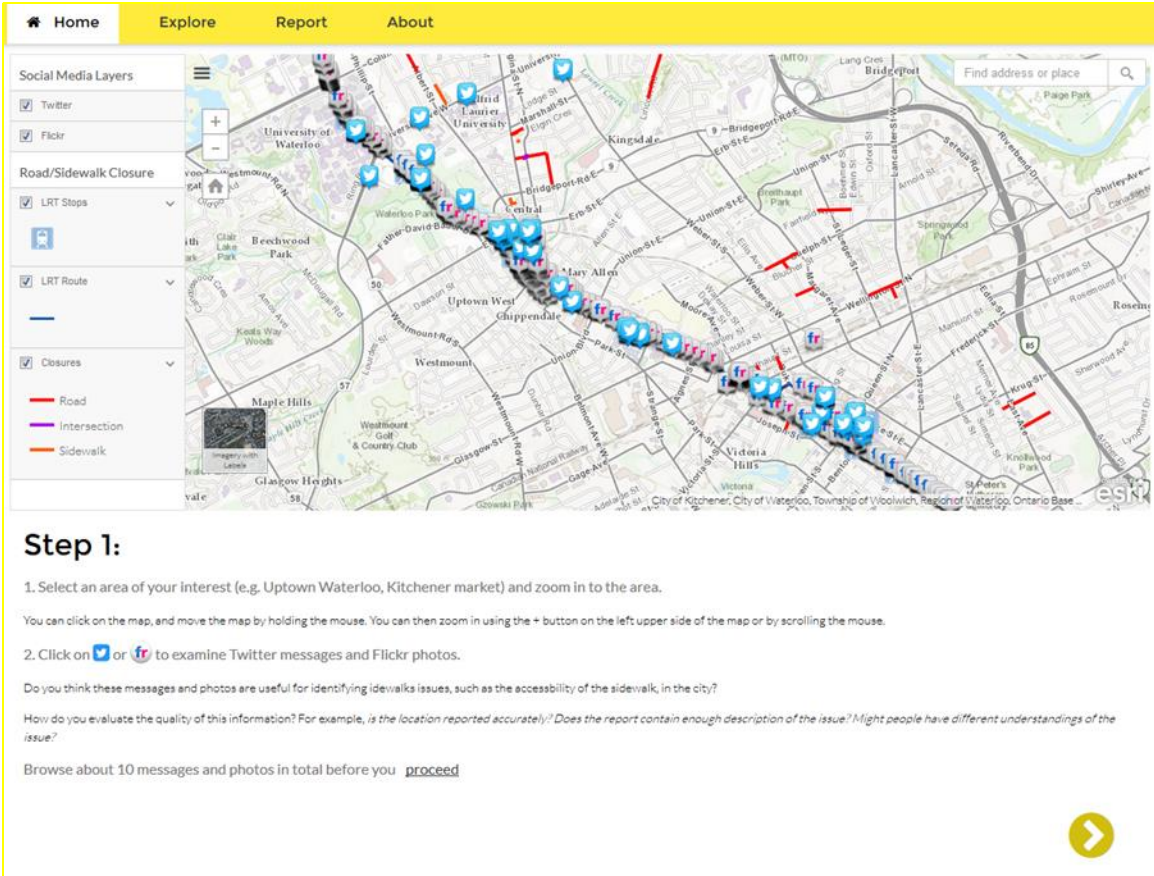
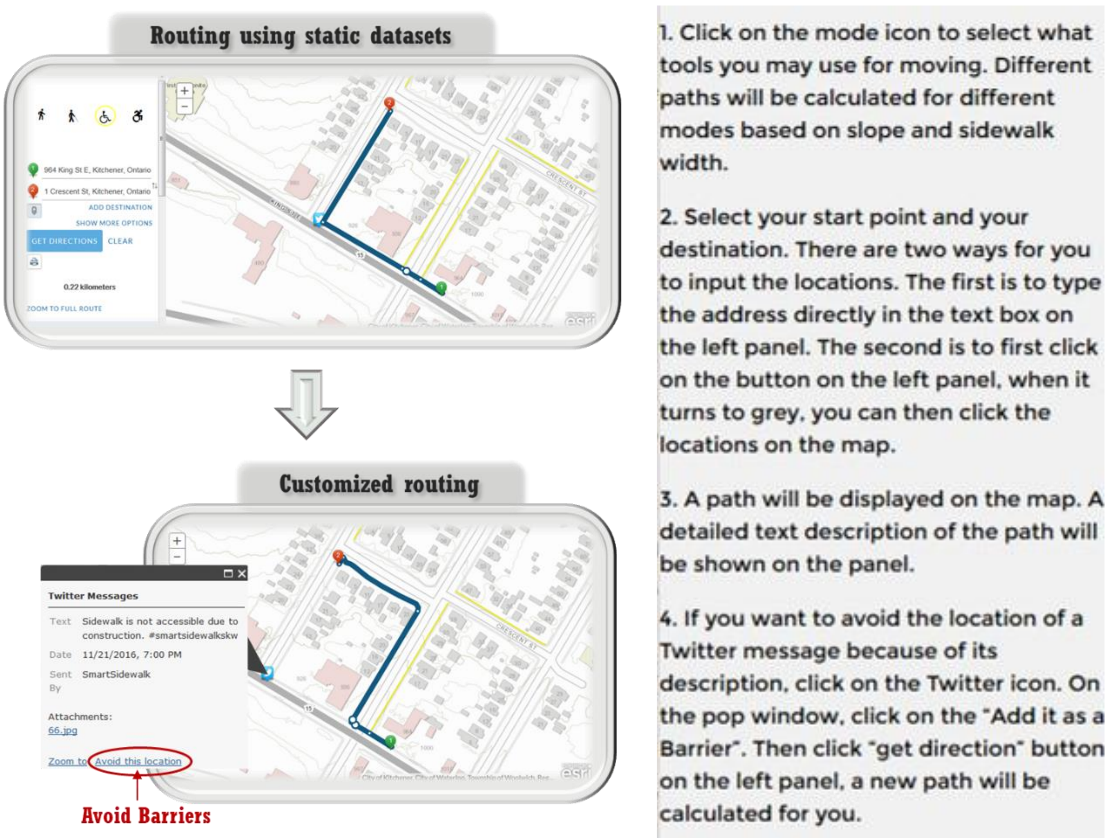


Figure 4-4 Study Website: Map display of Twitter messages and Flickr photos

Second, participants used a customized pedestrian routing services to examine if and how geosocial media is useful for them to maneuver around construction sites (Figure 4-5). The proof-of- concept service allowed participants to examine geosocial media messages on the map and add perceived barriers to routing choices. The service would then find users an alternative route that avoid perceived barriers.



(a) (b)

Figure 4-5 (a) Proof-of-concept service: Social media messages as aids to plan pedestrian routes (b) Instruction for participants

Participants would then complete the online survey held on SurveyMonkey about the usefulness of geosocial media for understanding dynamic urban environment regarding its semantic accuracy, relevance, locational accuracy, trustworthiness, and timeliness. The survey also asked participants general questions regarding their experiences with citizen reporting and their perceived opportunities and challenges of geosocial media reporting (Appendix E: Survey Questions).

4.2.3 Local government staff interviews

To compare citizen evaluation of geosocial media with governments' willingness and capacity of using geosocial media for their operation, we further interview local government staff about the general procedures for handling citizen reports and opportunities and challenges of adopting geosocial media as a non-emergency reporting mechanism.

Given that social media are widely used by municipal governments and that municipalities with different sizes and organizational culture may have different experiences with adopting social media, we interviewed the staff from the City of Kitchener, as well as other municipal governments across Canada. To make the interview sample representative, we contacted 42 municipalities with various population sizes that cover each range of 30,000 to 50,000, 50,000 to 150,000, and over 150,000, using the classification of Canadian municipalities suggested by El-diraby, Kinawy, & Piryonesi (2015) (Appendix D: Cities Contacted for Interviews). Municipalities with a population less than 30,000 were excluded because rural municipalities are found to have different technological needs from urban municipalities and will be considered in a forthcoming study (Seo & Bernsen, 2016). At least one municipality was contacted from each province in Canada to ensure the geographical representativeness of selected sample. Staff who are in charge of or involved with communication, 311 center management and operations were contacted in the selected cities.

The interview was composed of two sets of questions (Appendix B: Interview Questions). The first set of questions focused on 1) what citizen reporting methods are currently used by municipal governments, 2) how do municipal governments process and validate citizen reports, and 3) how government staff evaluate the quality of citizen reports for each reporting method. The second set of questions focused on how municipal governments validate geosocial media reports and what opportunities and challenges municipal governments have encountered with or anticipated for geosocial media reporting.

4.3 Results

4.3.1 Study sample

A total of 47 participants completed the assigned tasks and survey questions. Nearly half of the participants (45.9%) fell into the 25-35 years age group, and 20.5% of participants were between 35 and 45. The other age groups have very similar shares of total participants, with 11.5% of participants under 25, 9.1% aged between 45 and 55, and 11.3% over 55. The distribution of male and female participants was almost equal (44.4% and 48.9% respectively, the rest 6.7% participants would not like to disclose their gender information).

For local government interviews, fourteen local government staff from twelve Canadian municipalities across five provinces were interviewed. These cities include Kitchener, Waterloo, Toronto, Burlington, Mississauga, Stratford, St John's, Vancouver, Langley, Regina, Moose Jaw, and Calgary. Among them, six interviewees work at a corporate service department, three work at information division, one works at Operations, and three work at a municipal call center. For the rest of the cities contacted, five indicated that they do not currently use social media reporting and thus would not participate; others indicated they could not participate due to busy schedules.

4.3.2 Spatial data quality of geosocial media

4.3.2.1 Citizen evaluation of geosocial media for understanding sidewalk conditions

4.3.2.1.1 Relevance

After reviewing Twitter messages and Flickr photos, 62.22% of participants (n=28) considered Twitter messages being helpful for them to identify potential sidewalk obstacles (Table 4-1). As one participant stated, "If there is a traffic or accident, or the roads are closed, then it is useful to know this information before actually going in." In contrast, fewer participants (n=12) considered Flickr photos useful.

Table 4-1 Usefulness of Twitter posts and Flickr images for people to understand sidewalk conditions

	Not useful at all	Not useful	Neutral	Useful	Very Useful	Response Count
Twitter Posts	8.89%	4.44%	24.44%	48.89%	13.33%	45
Flickr Images	16.67%	7.14%	47.62%	26.19%	2.38%	42

A few participants mentioned in the comments that more specific information, such as how long the delay is, is needed for sidewalk navigation. The unevenness of geosocial media reports was brought up by some participants, as certain locations do not have enough posts for them to determine sidewalk conditions.

4.3.2.1.2 Semantic Accuracy

Participants raised the issue of the subjectivity of geosocial media. As one participant said in the comments, geosocial media might be too prone to subjective commentary of text messages, or selective composition of photos. One of our retrieved tweets said that "intersection at (street A and B) is not accessible for wheelchair users". It is yet unknown whether this intersection is accessible for able-bodied people or cane users.

Twenty-six participants indicated that they are more likely to consider a post that has photo attachments to be useful. Five participants suggested in comments that pictures are more useful for them to understand real world circumstances, whereas text descriptions are sometimes less informative or less accurate.

4.3.2.1.3 Locational Accuracy

The location information associated with social media posts was considered a valuable asset. Twenty-eight participants believed that the geotagging function allows accurate communication of the locations of sidewalk problems. However, answers to the question "What challenges do you find when adding location information to social media posts?" suggested that near half (48.8%) of the participants do not want to share their location information. This concern with privacy is not new (Elwood & Leszczynski, 2011). Previous studies have similarly suggested that smartphone users either did not know about geotagging function or would not like to disclose their location information (Ricker, Schuurman, & Kessler, 2015). Accordingly, insufficient numbers of people sharing geo-located information about sidewalks can be a challenge for using geosocial media as a dynamic source of understanding urban environment. Moreover, half of the ten participants aged over 45 claimed that they do not know how to add location information to social media. While social media is often considered easy to use, our results suggest that certain functions of social media such as geotagging may not be well accepted by all of the population groups.

4.3.2.1.4 Trustworthiness

The issue of reliability of geosocial media was raised by participants. 72.3% of the participants (n=34) claimed that they are more likely to trust the posts coming from official accounts (e.g. local government). In the comments, some participants stated that they regularly check @570 Traffic, a Twitter account operated by a local radio station that updates local road conditions on an hourly basis. Participants suggested that a similar method of assembling Twitter messages would increase the reliability of the information as well as reduce the effort of looking for specific information.

4.3.2.1.5 Timeliness

According to 75% of the participants (n=32), timeliness is an important indicator for them to evaluate the usefulness of geosocial media reports. Not being timely is a major factor that makes Flickr less useful, as it is a photo-sharing website where users do not always post at the time and location of a photo is taken. whereas Twitter is more used for immediate communication.

4.3.2.2 Local government staff evaluation

The interviewees were asked to evaluate the quality of citizen reports collected from six primary channels of non-emergency reporting. Figure 4-6 shows the average scores interviewees gave to each quality aspect of citizen reports from each reporting channel. Overall, the quality of geosocial media reporting was considered the poorest. In particular, the semantic and location accuracy, relevance, and trustworthiness of geosocial media reports are considered low. Only timeliness of geosocial media reporting is comparable to other reporting methods.

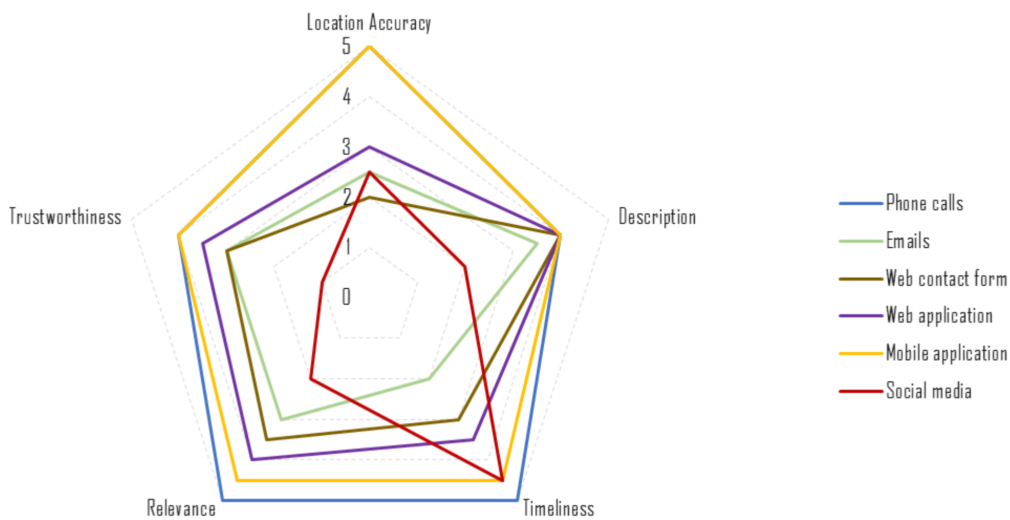


Figure 4-6 Comparison of the quality of citizen reports collected from different channels

4.3.2.2.1 Relevance

Interviewees suggested that many of the social media comments are only general complaints that do not reflect on actual problem that requires attention. As indicated by Participant B:

"They (social media messages) are not specific about what the issue is. And then sometimes people just want to 'chill' the city, they want to make comments or be provocative."

Moreover, interviewees raised the issue that social media conversations often go beyond the scope of the original issue. According to participants C and D, the open and continuing dialogs on social media makes it difficult for government staff to track the origin of an issue and decide whether the issue is relevant to the jurisdiction of the municipality or individual department. In the similar vein, the majority of our interviewees considered crowdsourcing methods as not helpful for improving the locational accuracies of citizen reports, as there might be too much irrelevant information.

4.3.2.2.2 Semantic Accuracy

Interviewed staff suggested that unlike web and mobile reporting applications where people answer a list of pre-defined questions when reporting an issue, people use their own words to describe an issue when using social media. Yet the descriptions often do not provide enough details that are necessary for government operations, according to interviewees. Moreover, there is the issue of semantic ambiguity that different people may describe the same issue differently. Similar to citizens' perspectives, all of the interviewees considered photos as better representatives of real-world circumstances.

4.3.2.2.3 Locational Accuracy

In a separate question about how much geosocial media reports have implicit or explicit geographic information, all of the interviewees indicated that only less than 5% of social media reports has exact geographic information such as geotags and addresses. Therefore, municipalities are not collecting nor using geotags associated with social media reports. Instead, they would identify the location of an issue based on reporter's description. Yet the description is often ambiguous. Participant E gave an example of people referring to an intersection of two streets even though those streets cross several times along their length and have multiple intersections. Participant C also pointed out that different locations with same or similar names make it difficult for government staff to determine where the problem is and whether it is within the jurisdiction. According to participants I and J, the staff often need to use maps and their own knowledge to validate the location.

Preferably, the automatic geotagging function of geosocial media can be used similarly to location services embedded in web and mobile applications. All of the interviewees agreed that geotagging and reverse geocoding (i.e. matching an input address to a map location) functions could help improve locational accuracy of reports. Yet three questions were brought up. First, local government may need specific parcel information for handling service request that is often not provided by public map service (e.g. google map). As a result, government staff need to take additional steps to match user-provided location information with parcel information used in government systems. Second, when people use their current location to report an issue, this location may not be the location of the issue. Participant L gave an example of reporting potholes where the reporter is unlikely to stand at the pothole location when geotagging. Participant I also pointed out that the GPS of a mobile device is often not sufficiently accurate for operators to find out the location of a reported issue. Third, current mapping or geotagging approaches only provide the staff with location information (x, y) but not height information (z). According to participant K, it is time-consuming for staff to locate a reported issue that happens at a multi-story building without the height information.

4.3.2.2.4 Trustworthiness

Because of these quality issues, government staff are concerned by the trustworthiness of geosocial media reporting. As pointed by participant A:

"… there is a concern that if we send our staff out but we can't find it because it wasn't geotagged or, you know, we didn't get to ask them the questions of exactly what it was, then we waste staff resources if we assign staff based on social media."

The anonymity of social media users further exacerbated such concern. Participants A and D claimed that not having contact information of reporters makes further inquiry and validation of a reported issue more difficult. Moreover, participants A and E raised the concern that people may say whatever they want to say behind the veil of anonymity and send negative messages that do not always hold the truth. Participants D, H and K had similar observations that some frequent reporters repeatedly complain about the same or similar issues.

Staff have to rely on their personal knowledge or "common sense" to determine the validity of a report. According to participant E, the staff may look up reporter's social media account to ensure credibility of the reporter. This is similar to the findings with general online content. That is, determining the trustworthiness of online content is mostly subjective (Banerjee, Bhattacharyya, & Bose, 2017).

4.3.2.2.5 Timeliness

Despite the concerns of spatial data quality, interviewees agreed that social media reporting is timely for citizens. According to participant E, people are more likely to report with social media immediately after they see the issue, whereas the likelihood of people seeing the issue and reporting later using other methods is much lower.

4.3.3 Usefulness of geosocial media for non-emergency reporting

4.3.3.1 Citizen evaluation

4.3.3.1.1 Opportunities of geosocial media reporting

With regard to geosocial media reporting, participants had very positive attitude, considering geosocial media provides an easy form of reporting and can stimulate effective and open communication (Table 4-2).

Table 4-2 Percentages of participants that consider the following statements to be the advantages of using geosocial media reporting

Answer Options	Response Percentage
An easy form of reporting	
Citizens can report issues at any time	84.8%
Citizens can report issues from anywhere	78.3%
It is easy to add pictures to social media to help city staff to understand the problem	80.4%
It is easy to add exact locations to social media so that citizens can report the location of issues easily and precisely	63.0%
The cost of reporting via social media is low	69.6%
Citizens do not need to find contact information of the city to report	63.0%
Effective and open communication	
City staff can get most up-to-date reports and thus may respond more efficiently	73.9%
Many people are using social media so that city staff can get more feedback from citizens	60.9%
Social media is an open communication platform so that citizens can see each other's reports as well as city staff's response	65.2%

Not surprisingly, participants considered that reporting via social media might be easier than reporting via phone calls or reporting applications. 84.8% and 78.3% of the participants believed that social media allows them to report non-emergency issues at any time and location respectively. Participants also believed that they can easily add pictures and location information to help city staff identify what and where a reported issue is. 63% of participants considered direct contact with city being convenient for them to report issues, as they do not need to look for specific reporting methods (e.g., phone numbers, website). When asked about whether they have reported issues to the city before in a separate question, 47.4% of the participants claimed that they have never reported non-emergency issues. Among them, 54.2% indicated that reporting was too much effort for them. The ease of social media reporting can potentially mobilize these people to increase reporting rates.

Among those participants who have reported to the city before, 23.2% claimed that they were not satisfied or extremely not satisfied with their reporting experience. Slow response from governments, in particular, was the most mentioned reason that dissatisfied people. In contrast, citizens anticipated social media reporting to be more efficient. A majority of the participants (73.9%) believed that being able to receive up-to-date reports from citizens allows governments to react more promptly. In addition, 65.2% of the participants considered the openness of social media as advantageous for expanding government-citizen communication to citizen-citizen information sharing. As suggested by Linders (2012), this greater interactivity may enhance citizen participation and foster innovative forms of collaboration.

4.3.3.1.2 Challenges of geosocial media reporting

Comparatively, a smaller portion of participants (less than 50%) agreed with statements regarding challenges of using geosocial media reporting (Table 4-3).

Table 4-3 Percentages of participants that consider the following statements to be the challenges of using geosocial media reporting

Answer Options	Response Percentage
Official Acceptance	
It is not an official reporting method, and government officials may not respond	42.2%
It is not an official reporting method, and government officials may not treat these reports the same way as reports coming from other methods	44.4%
The city will need to devote more personnel to processing and monitoring social media, and is less likely to consider social media as a reporting method	40.0%
I do not know how to report via social media (e.g. use what format, keywords, hashtags)	15.6%
Quality Issues	
People often post emotional messages rather than describe what issues are on social media, therefore the reports may not be as trustworthy as reports coming from other methods	42.2%
Sometimes the situation is too complicated to describe within a word limit (e.g. each Twitter message can only have 140 words maximum).	35.6%
Citizens' personal smartphone GPS may not be sufficiently precise, thus locations reported to city staff may not be accurate	22.2%
Privacy	
I do not want to make my report viewable to the public	15.6%
I don't want to add location information, because I don't want other people know where I am.	17.2%
Others	
I am more used to other reporting methods (e.g. phone, email) and would like to continue using them	11.1%

The major concern participants had with geosocial media reporting is that it is not an official reporting method, and that government officials may not respond to geosocial media reports or not respond similarly to they would do with reports from other channels. Along a similar line, 42.2% of the participants agreed that the often too emotional tone of social media messages could make geosocial media reporting less trustworthy compared to other reporting methods. Other participants indicated that the details and locations of non-emergency issues may not be communicated clearly and precisely through social media.

Answers to privacy concerns revealed some interesting results. Only 15.6% and 17.2% of the participants claimed that they would not like to make their report viewable to public or disclose their location information, respectively. These results support citizen participants' beliefs that geosocial media provide an open environment for efficient communication. However, it contrasts to the answers regarding challenges of using geosocial media, for which nearly half of the participants claimed that they do not want to share their locations. These seemingly contradictory results have some indications that the understanding of privacy is context-dependent. While people may not want to share personal location information such as their home addresses, they may not have issues with adding location information when reporting an issue at public places.

While only five participants that they would prefer to continue using reporting methods that they have used before, 60% of them were in the age group of above 55. Consistent with other studies about digital divide (Corbett, 2013), this result can shed light on the possibility that different population groups may accept geosocial media reporting differently.

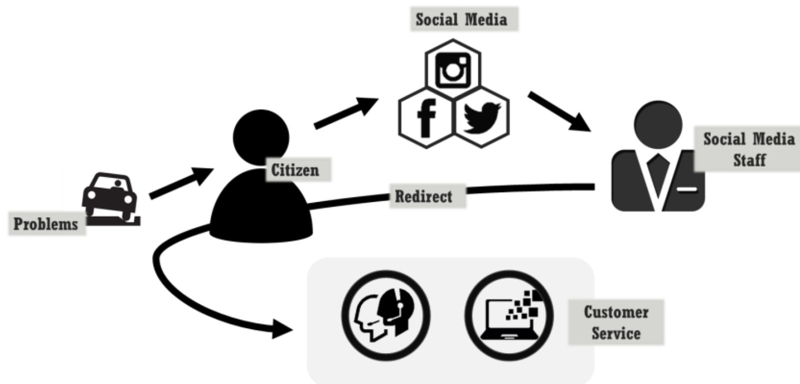
4.3.3.2 Local government staff evaluation

4.3.3.2.1 Local government adoption of geosocial media reporting

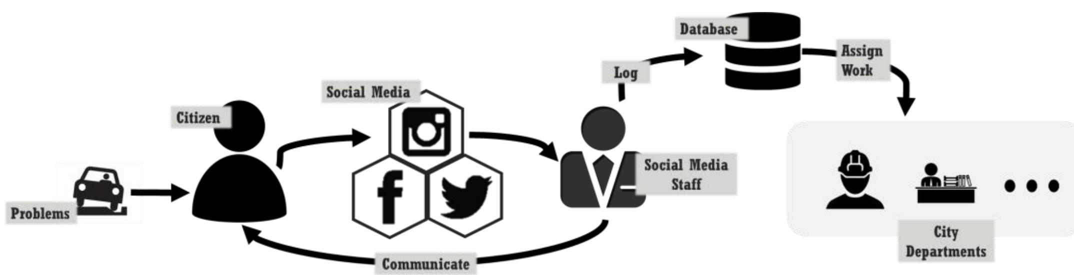
As stated in section 4.3.2.2, local government interviewees considered the quality of geosocial media poor and suggested adopting geosocial media reporting is challenging. Three out of twelve interviewed municipalities do not currently use geosocial media reporting because of this quality concern. Yet the municipality receives complaints from citizens, as citizens feel "that (social media) is how they should report". In these cases, the communication staff will redirect reporters to other reporting methods (e.g., phone calls and emails) (Figure 4-7a).

Among the rest nine municipalities that adopt geosocial media reporting, five handle social media reports as part of their social media communication mandates (Figure 4-7b). In these municipalities, the social media staff are in charge of communication of reported issues. Usually, the staff first contact the reporter through the social media platform where the issue is reported and then send the report to relevant departments for processing after necessary information is collected. The same social media platform is used for further inquiries or updates of the report.

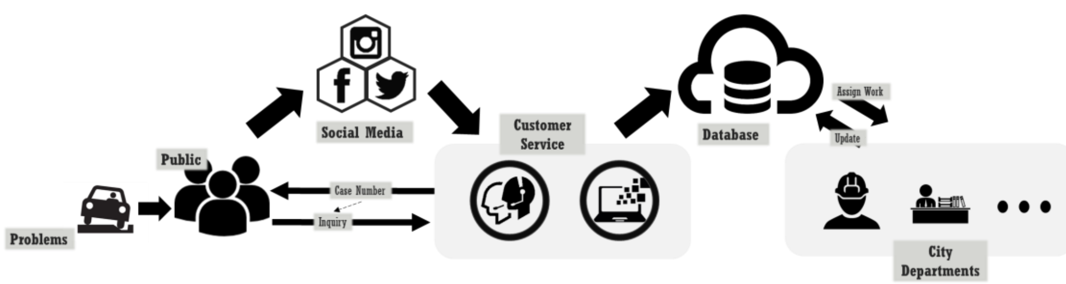
The other four municipalities have centralized customer services or non-emergency contact programs (e.g., 311) that take care of citizen reports from various channels, including geosocial media (Figure 4-7c). Staff of service center, similarly, communicate with citizens if important information about the issue is missing in the report. The staff will send the report to responsible departments if necessary and assign a case number to the report for further inquiry once the report is validated.



(a) Redirect model



(b) Stand-alone model



(c) Integrated model

Figure 4-7 Current practices of handling geosocial media reporting in Canadian municipalities

4.3.3.2.2 Challenges of geosocial media reporting

Given the poor quality of geosocial media reports, the major challenge facing local governments adopt geosocial media reporting is validating the reports. For governments, validating citizen reports is required for further processing through work orders and permit requests. Currently, validating geosocial media reports is primarily based on government staff's communication with citizen reporters and staff's personal knowledge. For example, the staff would ask the type and the location of the issue if certain information is not clear in the report. Yet differences in spatial knowledge possessed by officials and the public may generate confusions. According to participants B and C, knowledge about local geography is included in their staff training to assist staff identify the location of the issue when given vague place descriptions. However, the public may use different place names or describe location differently from official records. Participant B mentioned an example that newcomers of the city may not know the name of a place but instead use an uncommon reference that is difficult for officials to identify the location.

With the stand-alone model, an additional challenge is the lack of formalized guidelines for report validation. According to participant D, their staff are sometimes not sure about to which department they should forward the issue, and what information the other department would need to handle the issue. Lack of an integrated management system or database may also result in repeated work within governments as whether a reported issue has already been handled is not automatically tracked. Moreover, the communication through private messages of social media is not always efficient. Government staff often need to manually search the communication history to find the reporter for follow-ups, yet the reporter may not always respond timely. As such, developing centralized processes for handling citizen reports from different channels may help government improve the efficiency of processing geosocial media reports.

As a result, governments need longer time to process geosocial media reports compared to other reporting methods. According to participant B, their staff may spend twice as much as the time and effort needed for reports from other channels.

4.3.3.2.3 Opportunities of geosocial media reporting

Despite the significant challenges facing local governments, 12 out of 14 interviewees acknowledged the importance of social media as a communication channel and believed that municipalities should adopt reporting methods favored by the public. As suggested by participant G, local governments should take the main responsibility of handling unstructured citizen reports and encourage citizens to report in their preferred methods, instead of asking citizens to go through multiple steps to report or restricting citizens to specific reporting channels. As such, local governments seek solutions to improve the efficiency of their communication with citizens and tackling with data quality issues of geosocial media. In our interviews, four interviewed municipalities have already deployed social media management software, such as HootSuite and Sprout, to help social media communication. The software can alert government staff when a social media message is directed to the municipality and manage communication history to help staff track previous conversations, determine the trustworthiness of the reporter, and make the communication more efficient.

According to participant G, local governments should adopt automated methods of pre-processing and validating citizen reports to improve the efficiency of municipalities' customer service. Developing integrated program of municipal reporting could also improve government efficiency, as four municipalities in our interviews that deploy integrated model of citizen reporting have fewer issues of unclear or overlapped responsibilities of multiple departments. According to participant H, improving governments' technical capacities of tackling with quality issues have benefits for not only geosocial media reports but also other types of citizen reports. Given that handling with citizen reports from any channels often involve manual validation, an automated and integrated method of pre-processing and validating citizen reports could improve the efficiency of municipalities’ customer service and reduce the risk of generating errors when manually handling citizen reports.

4.4 Discussion and conclusions

4.4.1 Spatial data quality of geosocial media

Our study reveals contradictory views of municipalities and citizens on spatial data quality of geosocial media. To ensure the efficiency and lower the cost of government operations, governments need accurate and often specific information (e.g. parcel information and height information) about citizens’ service requests. They may consider a location reported using geotags insufficiently accurate for their operations due to hardware deficiency or human errors, yet citizens often believe that a geotagged location is sufficiently accurate. This mismatch of organizational needs and citizen contribution is not unique to geosocial media, but is found common with VGI reporting (Brandeis & Nyerges, 2016). Training the public is often recommended to address this gap. For example, empirical studies suggested that data quality of non-expert contributions for land use mapping may evolve over time and eventually be close to that of expert contributions (See et al., 2013). In the context of geosocial media reporting, public education can be challenging given that most municipalities have not established formal procedures and standards for geosocial media reporting. Moreover, restricting users to specific reporting routine (e.g. specific reporting format and content) may contradict to the intention of providing citizens with flexibility of reporting via geosocial media.

Our study also suggests some common challenges of using geosocial data. One is the inherent bias of geosocial data (Graham & Zook, 2011; Poorthuis et al., 2014). In our study, despite the extensive recruitment efforts, the sample size of survey participants is small. The small sample is limited in representing the broader population, yet it exhibits the often skewed representation of participants as found in other VGI studies (Haworth et al., 2016). In addition, the uneven spatial distribution of geosocial media posts harvested from Twitter and Flickr indicates the selective representation of geosocial data as suggested in other studies (Zook, 2017). As suggested by Mooney, Sun, & Yan (2011), crowdsourced data is almost by default related to personal interests and experiences. In our study, half of the participants are between 25-35; people aged over 55 showed less likelihood of using geotagging function because of privacy concerns and limited experiences with the technology. As a result, geosocial media information may only show interests of certain population groups and are limited by geographic locations that are valued by individuals who are more frequent users of social media.

The second is the privacy issue, a major concern facing local government adoption of geosocial media (Zook, 2017). In addition to commonly expressed concern of disclosing personal trajectories, our study has implications that the understanding of privacy is context-specific. People are more willing to provide geolocation information when they know the information is used for sharing and reporting non-emergency issues. According to Christin, Reinhardt, Kanhere, & Hollick, (2011), lacking knowledge about privacy is one factor that prevents people from using online participatory services. Ricker et al., (2015) also suggested that the public is willing to use the technology when perceived benefits outweigh potential risks. In line with these comments, we may develop strategies of alleviating public's privacy concerns, such as providing participants with details of benefits and risks associated with sharing location information and develop location-based services that are directed to specific uses, to encourage participation.

4.4.2 Opportunities and challenges of geosocial media reporting

Our study suggests that municipal governments' adoption of geosocial media reporting is mainly driven by public pressure and by the intention of utilizing social media to improve citizen participation. Municipal governments acknowledged the importance of participating in social media, as it will improve their communication with participation and enhance transparency (Picazo-Vela, Gutiérrez-Martínez, & Luna-Reyes, 2012). However, municipal governments are struggling with extra time and human capital needed to validate and process geosocial media reports, which makes geosocial media reporting an inefficient and not preferred reporting method. Moreover, municipal governments face challenges of not meeting citizens' expectations of real-time reporting and problem solving. In fact, the gap between citizen expectation and limited governments' capacity to handle citizen requests is not uncommon. With increasing usages of citizen reporting apps, governments are overwhelmed with increasing demands from citizens (Desouza & Bhagwatwar, 2012). To strengthen the benefits of social media for communication and participation, municipal governments should leverage organizational capacities and establish clear strategies of adopting geosocial media for particular uses such as citizen reporting (Oliveira & Welch, 2013). For example, some municipalities may opt for the re-direct model of utilizing geosocial media reporting if they do not have enough human and technical resources. Other municipalities may further tackle with quality challenges of geosocial media to improve the efficiency of geosocial media reporting and make it an integrated part of official reporting program.

This study also has indications on the "distinction between the ways in which ICT platforms mediate the relationship between citizens and service providers"

(Peixoto & Fox, 2016 p.2). That is, citizens reporting issues to governments and collective information sharing among citizens should be considered separately. From the geospatial data perspective, citizens find geosocial media helpful for wayfinding albeit a few deficiencies. This suggests the potential of developing an immediate and collaborative form of civic action that avoids rigorous quality assessment procedures required by governments. Rather, citizens can determine the usefulness of information based on their own criteria and needs. To some extent, this collective information sharing may extend government services as citizens can act upon the information without the discretion of governments and generate their own services outside of government mandate (Linders, 2012).

4.4.3 Future considerations

This paper identifies opportunities and challenges of using geosocial media for non-emergency reporting and contributes to the broad discussions of quality issues of geosocial data and evolving government-citizen relationships. Building upon our research findings, we envision several directions that worth further investigations.

First, previous study suggested that it is necessary to investigate social effects of how government adoption of new information technology on service provision, particularly the generation of new digital divides or exacerbation of existing ones (Clark et al., 2013). While our study touches upon the divisions in how people use geosocial media, further empirical evidence is necessary to untangle the relationship between demographic characteristics and usage patterns of geosocial media. This will help practitioners evaluate whether geosocial media has the potential of outreaching to previously underrepresented groups (e.g. young people) or not.

Second, our study suggests the potential of citizen developing their own services considering the differences between how governments and citizens use information. To further explore this potential, we may also consider how citizens will use information differently. That is, data contributed by one person may only be of value to a group of users that share similar interests or have similar needs. While citizen collaboration has the potential of delivering personalized information that is tailored to individual needs, how skewed representation of users may affect the delivery of personalized service needs to be further unraveled in future studies.

Chapter 5: Conclusion

The dissertation begins by introducing the contemporary need of local governments enhancing public participation. The changing practice of how geospatial information is generated and disseminated is one emerging thread for such effort. Chapter 1 presents the significant potential presented by geo-participation for local governments to enhance public participation and identifies issues that need to be further addressed to fulfill the potential.

In this light, the overall objective of the dissertation is to identify and assess how can emerging geo-participation practices provide local governments with new tools and approaches to better address and serve public needs. Collectively, three related works in this dissertation make significant conceptual, empirical and practical contributions to this goal. Conceptually, the proposed typology classifies geo-participation practices by differentiating the tools, methods and outcomes of geo-participation and identifies opportunities and challenges of researching and implementing geo-participation. Empirically, this dissertation tells a story of opportunities and challenges that sheds light on how local governments can use geosocial media as: 1) a data source for soliciting citizen input and, 2) a tool for sharing and reporting issues related to routine government services and enabling new forms of government-citizen interaction. Practically, this dissertation develops a tool of processing text-based citizen input and suggests models of implementing geosocial media reporting that can help local government develop appropriate strategies of adopting geosocial media. The following paragraphs further reflect on key findings of this dissertation with reference to three main research questions.

5.1 Empirical findings and contributions: Revisiting research questions

To address the first research question: "In general, how can geo-participation practices be classified? What implications does this classification have for researching and implementing geo-participation?", Chapter 2 puts forward a holistic view of how advances in geospatial technologies have given rise to evolving government-citizen relationships. Geo-participation practices are classified into three types, with enabling technologies and data and participation outcome of each type of geo-participation identified. Opportunities for local governments to solicit public input and collaborate with citizens using emerging geo-participation practices are illustrated. The typology is then applied to both academic literature and government programs to demonstrate the use of the typology. The classification of academic literature suggests that different types of geo-participation are associated with varying research focuses. In practice, different types of geo-participation are associated with different participation processes and outcomes. However, generated geospatial data can be used across different geo-participation practices and facilitate government operations and government-citizen collaboration. Chapter 2 ends with discussions on potential areas that need further research.

The second question "As an example of geo-participation, how useful is geosocial media as a data source for mining public needs?" aims to investigate the usefulness of geosocial media as a data source for understanding public needs. The empirical study presented in Chapter 3 suggests that geosocial media can provide topic- and location-specific types of public input that differ from what might be found in complementary data sources. Particularly, some of the public input collected from geosocial media is relevant to physical infrastructure and quality of public services. This input is akin to citizen requests for public service, which are usually handled by customer service programs of municipalities. The finer temporal resolution of geosocial media data provides governments with opportunities to probe into changes in public perceptions and to monitor dynamic urban environments.

From a geospatial data perspective, Chapter 3 demonstrates that the use of geosocial data is most likely to be limited by spatial, temporal, and semantic relevance. Contesting with the notion that VGI studies should primarily focus on the volume of information (Brown, 2017), data that are relevant to a particular study may only be a small subset of the big raw data. As suggested by Poorthuis & Zook (2017), social and urban researchers may often need to carefully extract a small subset of the big data and obtain in-depth insights on social and spatial phenomena using the small data. As such, analyzing geosocial data often requires a mixture of quantitative and qualitative methods (Shelton, Poorthuis, Graham, & Zook, 2014). As presented in Chapter 3, quantitative methods can help extract, categorize, and understand the general patterns of the data, whereas qualitative interpretation is necessary to obtain deeper insights from the data.

Chapter 4 addresses the third question "From the perspective of both local governments and citizens, how useful is geosocial media for citizen reporting non-emergency issues? What are the opportunities and challenges of adopting geosocial media for municipal reporting?". Citizen survey and local government interviews suggest some common data quality issues related to biased representation of geosocial data, particularly the uneven spatial distribution and skewed representation of data contributors. One interesting finding of the study is that citizens consider privacy issue differently according to the context of data usage. Previous studies suggest that concerns of privacy may prevent people from contributing location data and result in scarcity or incompleteness of contributed data (Elwood & Leszczynski, 2013). This study suggests that citizen participants have fewer privacy concerns for providing location information when they know the use of the information. This finding has implications for alleviating participants' privacy concerns and encourage participation by providing participants with details of what contributed data are used for and how.

Another significant finding of this study is that government staff and citizens have contradictory views on spatial data quality of geosocial media, which have implications for the opportunities and challenges of local government adopting geosocial media for municipal reporting. Local governments face significant challenges of adopting geosocial media considering its poor quality, as they need to invest extra time and human capital to process and validate geosocial media reports. Accordingly, local governments are less likely to meet citizen expectations of having immediate response from local governments. Developing integrated and automated methods is necessary for local governments to make efficient uses of geosocial media reporting and to improve their operational efficiencies of handling citizen requests in the long term. In practice, local governments should determine the proper practice of adopting geosocial media reporting based on their needs and current capacities. Models of implementing geosocial media reporting suggested in Chapter 4 have practical contributions to government operations, as it provides local governments with a reference of implementing geosocial media reporting for municipal reporting programs. Citizens, on the other hand, find geosocial media reports sufficiently accurate for them to understand dynamic urban environments. This suggests the potential of developing collaborative civic actions of citizens sharing non-emergency issues outside the mandate of governments. Resonating with "Do-it-Yourself" model as suggested by Linders (2012), citizens may develop their own public services and use contributed geospatial data based on their own information needs. From the data perspective, differences in how citizens and local government staff perceive the quality of geosocial data present the need of addressing users' information needs when evaluating the quality of VGI. While data quality is considered important to VGI studies, how perceived qualities of VGI may differ among different groups of users have not been well addressed in the current literature.

5.2 Implications for local governments: Geospatial data as conduits for government-citizen collaboration

This dissertation suggest that significant opportunities have emerged from mass geospatial data generation for local governments to better address public needs and enhance government-citizen collaboration. First, this research demonstrates the potential for local government to use data-driven approaches to solicit public opinions from passively generated geosocial data. While the concept of citizen sensing is not new, its application in local government decision-making has not been widely studied. Further integration of citizen sensing with routine government service may help local governments improve service response time and deliver services that are better tailored to citizen needs (Lee & Kwak, 2012; Linders, Liao, & Wang, 2015). Second, this research suggests that collective data contribution can serve as a conduit for facilitating public participation and spurring innovative forms of collaboration. Chapter 2 suggests the potential of citizens collaboratively sharing information in supplement to government services. Chapter 4 further assesses this potential from a geospatial data perspective and validates the usefulness of geosocial data for citizens to understand dynamic environments. Potentially, geospatial information may not only be transmitted between citizens and governments, but also be shared among citizens so that citizens can use the information for their own needs.

However, local governments face significant challenges to take advantage of these emerging opportunities. Tensions arise through increased citizen demands and limited local government resources to handle citizen input. In particular, the uncertain quality and accordingly high costs of handling citizen requests will likely to be a continuing threat to local government adoption of contributed data. Local governments do not always have the capacity (e.g. financial and human resources, technical capacities) to capitalize on technical developments including adopting new tools and methods of processing citizen requests.

In practice, the process of diffusing technological innovation is affected not only by technological developments but also by other organizational and administrative factors (Mustonen-Ollila & Lyytinen, 2003). According to the well-established theory of diffusion of innovation, perceived advantage or improvement of using a new idea, approach or system over existing ones will motivate individuals or organizations to adopt innovations (Rogers, 1983). Yet adopters will also consider other characteristics of an innovation including compatibility, trialability, complexity, and observability (Rogers, 1983).

In the government context, compatibility refers to how well an innovation aligns with existing procedures and norms in the organization (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). Trialability refers to how easy the organization can test the innovation and assess the impacts of innovations on the organization (Lundblad, 2003). According to Weber (1947), operations in a bureaucratic organization such as governments need to follow “a set of formal, explicit, comprehensive and stable rules that are impersonally enforced in decision making and lead to predictable and determinate results” (Cordella & Tempini, 2015 p.280). Therefore, governments usually carry out repeated and deliberative processes to ensure the smooth transition of government operations and to minimize the possibility of having negative consequence (Bertot et al., 2016).

Janowski (2015) suggested that innovation in governments would usually encompass several steps (Figure 5-1). Governments often seek to adopt new digital technologies when facing economic, social, or political challenges. While the new technology may only be applied in response to a short-term pressure at the first time, it will be applied and improved repeatedly before it becomes a standard practice embedded in government operations. Eventually, the institutionalized practice should follow the bureaucratic legislative, policy, and administrative principles, and enforce "democratic values of impartiality, fairness and equality" (Cordella & Tempini, 2015 p.280). Making a digital innovation become a standard government practice should therefore take holistic approaches that account for a variety of technological, administrative, policy, and institutional factors.

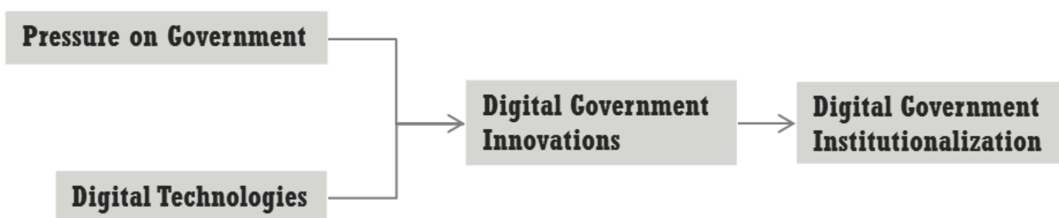


Figure 5-1 Digital government innovation flow. Adapted from Janowski (2015)

Complexity and observability of an innovation are also important to determining the adoption rate of the innovation (Rogers, 1983). Complexity refers to how easy adopters could understand and use an innovation. Observability refers to how visible is an innovation to adopters. Influenced by these factors, the extent to which an organization is willing to adopt innovation and to change its familiar practices vary (Sahin, 2006). Rogers (1983) categorized adopters into innovators, early adopters, early majority, late majority and laggards. Often, innovators and early adopters would take the leadership roles in adopting new ideas and in providing information and advice about the innovation (Sahin, 2006). Early majority often follow early adopters but do not take the leadership role in the innovation diffusion process. Late majority and laggards usually are more skeptical about the innovation and its according outcomes. They tend to decide whether to adopt innovation after they see successful adoption examples from other adopters. In accordance with Roger's categorization, the interviews of Chapter 4 showed that the adoption rates of municipalities vary significantly. Some municipalities have integrated geosocial media reporting with their citizen reporting systems, while others have not. Some of the interviewed municipalities that have not used geosocial media reporting expressed the desire of learning from others' experiences to determine whether or not they would adopt geosocial media reporting. According to Rogers (1983), networking among adopters may help reduce the uncertainty of innovation adoption and help late adopters to feel more safe about adopting innovation. It is therefore helpful for cities that led technological changes to share their experiences of implementing technology-driven initiatives so that other cities could better understand the processes and outcomes of implementing an innovation (Johnson & Sieber, 2013).

5.3 Implications for geo-participation research

The implications of this study for geo-participation research are twofold. From a data perspective, an important thread throughout the empirical studies is that the participatory paradigm of spatial data generation may give rise to a deluge of unstructured, georeferenced data that require new validating and interpreting methods (Miller & Goodchild, 2015). Since geosocial data are rich in content and unstructured, qualitative data analysis methods (e.g. text-analytics) and standardized frameworks for managing geosocial data are necessary. The TFA toolkit presented in Chapter 3 makes methodological contribution to automating the processing of unstructured qualitative citizen data (Brooker, Barnett, & Cribbin, 2016). Research should also further develop conceptual understandings of the data (Kitchin, 2014a). Much of the citizen-generated geospatial data relate to their perceptions and experiences with local environments that are subject to time and people (Roche & Feick, 2012). According to Goodchild (2011), space-based conceptualization and methods are often limited in representing and analyzing these data with vague and contextual information; the concept of place should be used instead to conceptualize implicit geographic information that is rich in everyday lived experiences. Other ethical (e.g. privacy) and scientific challenges (e.g. idiographic versus nomothetic knowledge; sampling of the data) should also be further studied.

From a participation perspective, this dissertation advances the understanding of geo-participation by classifying geo-participation practices and identifying the application of each type of geo-participation in local government settings. The empirical studies examined two participation practices (passive and transactional geo-participation). From the viewpoint of tool development, these emerging participation methods generate needs for new tools for data analysis that support the specific needs of government officials (e.g., extracting exact locations from ambiguous place descriptions, identifying height and parcel information for non-emergency reporting). From the viewpoint of implementing public participation, this dissertation suggests that practices such as passive VGI and citizen sensing can be used for participatory uses. While some scholars argue that VGI is not participatory (Brown, 2017; McCall, Martinez, & Verplanke, 2013), this study suggests that the practice of citizen generating geospatial data and the according data outcomes can be repurposed to help local government with decision-making and facilitate government-citizen collaboration. In particular, the work presented in this dissertation demonstrates the potential for local governments to enhance their capabilities of soliciting public input, which lay the foundation for governments to promote open participation by utilizing the public input (Lee & Kwak, 2012) and to develop citizen-centric services that are better tailored to citizen needs (Reddick, Chatfield, & Ojo, 2016). However, neither geosocial media nor passive VGI in general could be standalone approaches for collecting public input. The study suggests the limitations of geosocial data in terms of their biased representation as reported elsewhere (Zook, 2017). Chapter 3 suggests that public input collected from geosocial media and user letters reveal different interests and concerns of the public. It is necessary to develop integrated participatory approaches that can elicit public input from different channels and obtain comprehensive views of public needs.

5.4 Ethical issues of passive geo-participation

There are also several ethical issues associated with passive geo-participation that need to be further addressed both in research and in practice. Kitchin (2016) suggested that the ubiquitous data collection through sensors, the Internet, telecommunication, GPS devices have posited several privacy concerns. That is, information about people's identity, communication, transaction, location and movement might be accessed, shared and used without people's knowledge or consent. The challenge is that people are often not aware of what data are gathered and how the data will be used, and therefore do not have the opportunity to consent or refuse the data collection and uses (Crawford & Finn, 2015). Solove (2013) argued that the design of web and mobile applications often provides users with little power to bargain regarding their privacy. That is, users often have no choice but to consent with the application's user terms in order to use the application. As a result, the data may be collected regardless of users' preferences. Moreover, the data or the collection of data may include personally identifying information (Kar & Ghose, 2014). Montjoye, Radaelli, & Singh (2012) showed an example that customers' personal information could become identifiable from anonymous transactional records when the records are combined with Instagram photos. The misuse of this information may raise unintended consequences such as safety concerns (Olteanu, Castillo, Diaz, & Kiciman, 2016).

Context is important to the understanding of people's privacy preferences. Crawford & Finn (2015) pointed out that people's choices of whether to disclose personal information or not may shift according to the circumstances. As shown in Chapter 4, people are more willing to disclose their locational information when they know the information is used for specific purposes. This result has indications that people may have fewer privacy concerns when perceived benefits outweigh risks (Ricker et al., 2015). However, we should be cautious about arbitrary and sometimes falsified gauges of perceived benefits and risks. For example, Tene & Polonetsky (2012) stated that "where the benefits of prospective data use clearly outweigh privacy risks, the legitimacy of processing should be assumed even if individuals decline to consent" (p.67). Crawford & Finn (2015) criticized such statement by asking "who gets to decide when the benefits outweigh the risks?" (p.499).

There is a considerable skepticism about the legitimacy of using citizen contributed data if the decisions of using the data are not determined by the communities or individuals who contribute the data. In the context of crisis management, Crawford & Finn(2015) suggested that although mining information from data sources such as geosocial media is beneficial for understanding and assessing disaster situations, it is inappropriate to put less considerations on privacy and ethical considerations because of these benefits. Rather, the benefits and risks of a data use should be carefully deliberated by considering the context of data uses and the preferences of data contributors.

With regard to location privacy, methodological developments may also assist with protecting users' privacy. Kar & Ghose (2014) suggested four computational approaches for protecting users' location privacy, including anonymity, aggregation, obfuscation, and encryption. Anonymity refers to making a user's location anonymous by using one's location that is shared with other users. Personal location can also become unidentifiable by aggregating individual locations to groups. Obfuscation refers to methods of introducing noises to locational data so that the accuracy of data will be reduced. A true location may also be encrypted or fudged so that it cannot be identified. While the technical details and applications of these computational approaches are beyond the scope of this discussion, these methods shed light on the use of users' locational data. For instance, depending on the characteristics of a locational dataset, certain computational approaches may be applied to the dataset to ensure that personal location information is not disclosed.

Passive geo-participation builds upon the assumption that collecting dynamic and fine-grained data about aspects of urban life could inform evidence-based decisions and enable effective modes of governance (Kitchin, 2014b). It is necessary to further consider and improve regulations on dissemination and application of data. Kitchin (2014) warned us that the lack of regulated enforcement may raise significant resistance of data-driven city governance concerning the abuses of data. Citizen-generated data and other forms of sensor data collection may raise new challenges to data-related ethical and legal issues concerning intellectual property, liability, privacy and licensing (Scassa, 2013). For instance, the recent openings of real-time trajectory data introduce complexity to the issue of data licensing given that the licensing of such dynamic data is not consistent with the licensing of static data (Scassa & Diebel, 2017). Moreover, inconsistent regulations among different levels of governments further complicate the issue of data regulation (Scassa & Diebel, 2017). That is, while the use of a dataset meets the requirement of one level of government, it may not meet the requirement of another.

Attention should also be paid to inherent challenges associated with data-driven and algorithm-based approaches (Janssen & Kuk, 2016). For example, algorithms shape how data are collected, processed and interpreted (Kwan, 2016). For instance, Twitter offers different levels of access to retrieving user feeds through its APIs. What tweets can be harvested from Twitter API is influenced by Twitter's algorithms (Joseph, Landwehr, & Carley, 2014). Using different data collection methods (e.g. adopting geosocial media collection software vs. "ad hoc" data collection via the open source API libraries) may also result in different datasets (Poorthuis & Zook, 2017). The resulting dataset can only represent a selective sample of whole Twitter users, yet how the sample is selected is often left unknown. How data are analyzed and interpreted also have significant impacts on what insights are obtained from the data. The widely cited paper by Lazer, Kennedy, King, & Vespignani (2014) pointed out the errors in flu prediction based on Google flu trend (i.e., the big data over-fitted the small number of cases) and warned us of the trap in big data analysis. That is, ad hoc analysis methods are often adopted without careful model calibrations and evaluations of the replicability of data analysis.

The conclusions drawn from data analysis are also subject to the assumption made for the analysis. For instance, a range of studies have used geosocial media for analyzing human mobility patterns and people's preferences for using city places (Chen et al., 2017; Liu et al., 2014). These studies provided city planners with evidence on measuring the quality of city design and services for satisfying citizens' needs of transportation, public infrastructure and services. Such evidence should be used cautiously, however, as it may reflect only one artifact of city life (Kitchin, 2014b). For example, how people use city spaces might be constrained by how the city is currently designed and other cultural and policy factors and may not always be the equivalent to how people would like to use city space. The muddle of the two may overlook factors that should be accounted for in city planning.

Practitioners therefore should be attentive to the control possessed by data and algorithms over what information is included or excluded and over what conclusions are drawn (Janssen & Kuk, 2016). Particularly, attention should be paid to what questions can be answered by the data, the extent to which the algorithms impact the representation of different social groups, if and how different algorithms may result in different conclusions, and the validity and replicability of algorithms that are used for collecting and analyzing the data (Kwan, 2016). Failure to address these questions in the context of city governance may lead to improper understandings of public perceptions (e.g., the over- or under-representation of certain social groups) or reinforcement of undesired practices (Janssen & Kuk, 2016). As suggested by Vayena, Salathé, Madoff, & Brownstein (2015), ensuring the robustness of algorithms for data analysis should not only be scientific inquires but should also be ethical requirements.

Algorithm-based approaches for governance also raise concerns about the transparency and accountability of governments. Algorithms behind how data are processed and used have become increasingly autonomous and invisible (Fink, 2017). Communicating complex algorithms is often challenging, and only few experts may understand algorithms for data analysis (Sandvig, 2015). Accordingly, the lack of transparency and complexity may deprive the public's capabilities of understanding and scrutinizing decisions made by the governments (Coletta & Kitchin, 2017). Janssen & Kuk (2016) suggest that this challenge indicates higher requirements on decision-makers' skills and expertise to ensure the validity of algorithms used for making decisions. Issues that shape and arise from the use of algorithms in governance should also be further explored both in research and in practice (Coletta & Kitchin, 2017).

5.5 Limitations and future research

While this dissertation makes substantial contributions to understanding geo-participation as a thread of current government efforts to enhance public participation, it demonstrates a few shortcomings. First, the empirical study presented in Chapter 4 is limited by who participated in the citizen survey. The study sample of citizen participants tends to over-represent people who are aged between 25 and 35. Other studies have characterized the majority of social media users as young, well-educated and more affluent and suggested the potential of social media as channel of engaging young population who are often under-represented in participatory projects (Schweitzer, 2014). Yet this potential needs to be further validated using qualitative data that provide evidence on the representativeness of geosocial data. This is also important to addressing the potential of using data-driven approaches to mine public opinions as presented in Chapter 3. It is necessary to further assess whether the presented approach, or more broadly automatic citizen sensing from various sources, can address issues of citizen participation including low participation rates and under-representation of certain population groups.

Second, while this dissertation primarily focuses on technological and organizational aspects of implementing geo-participation, the social processes embedded in geo-participation require further attention. Chapter 2 points to the needs of reconsidering the notion of "local" in citizen participation. This issue should be further investigated by identifying how ICTs change social and power relationships among governments and citizens and what implications these changing relationships have on digital divide, social disparity and citizen participation (Haworth, 2017).

Moreover, empirical studies in the dissertation provide in-depth examinations of geosocial media, which is only one popular channel of citizen contributing geospatial data. It would be advantages to examine citizen contributions from other ICT-based channels and in other contexts. I envision following key areas for further scientific investigation.

First, it would be beneficial to carry out comparative studies to investigate the similarities and differences among multiple ICT-based channels. Chapter 3 demonstrates differences in public input elicited from different channels. Further investigation along this line may shed light on if and how different participatory approaches may supplement each other and whether an integrated participatory approach could be developed accordingly. Moreover, with continuing developments of web technologies and Internet of Things (IoT), it would be interesting to examine the extent to which automated citizen sensing from various physical and human sensors may help soliciting public input or even substitute methods of purposively collecting public input from human participants. Additionally, Bright & Margetts (2016) raised the issue that since people are passively contributing data, they may not expect their opinions to be integrated into decision-making processes. This contrasts with traditional public participation approaches, where people consciously give voices and make choices. It is necessary to further investigate how the conceptualization of participation may change accordingly.

Second, with the increasing heterogeneous geospatial data generated by the public, spatial data quality must be addressed from a multi-user perspective. While this study suggests different perspectives of users (i.e., citizens and governments) toward spatial data quality (Chapter 4), it is necessary to examine how perspectives of different citizen groups vary with respect to their needs. Such investigation is necessary for developing customized public services, similar to the proof-of-concept service of citizens collaboratively contributing sidewalk information as demonstrated Chapter 2. For example, how do people perceive accessibility differently? Accordingly, how should spatial data quality of sidewalk information be evaluated differently? Future studies should focus on developing spatial data quality measurements that are tailored to users' needs.

Reference

Abel, F., Celik, I., Houben, G. J., & Siehndel, P. (2011). Leveraging the semantics of tweets for adaptive faceted search on twitter. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7031 LNCS*(PART 1), 1–17. http://doi.org/10.1007/978-3-642-25073-6_1

Abelson, J., Forest, P. G., Eyles, J., Smith, P., Martin, E., & Gauvin, F. P. (2003). Deliberations about deliberative methods: Issues in the design and evaluation of public participation processes. *Social Science and Medicine*, *57*(2), 239–251. http://doi.org/10.1016/S0277-9536(02)00343-X

Adams, B., & Janowicz, K. (2015). Thematic signatures for cleansing and enriching place-related linked data. *International Journal of Geographical Information Science*, *29*(4), 556–579. http://doi.org/10.1080/13658816.2014.989855

Adams, B., & McKenzie, G. (2013). Inferring thematic places from spatially referenced natural language descriptions. In D. Z. Sui, S. Elwood, & M. F. Goodchild (Eds.), *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice* (pp. 201–221). Houten, The Netherlands: Springer. http://doi.org/10.1007/978-94-007-4587-2

Afzalan, N., & Evans-Cowley, J. (2015). Planning and social media: Facebook for planning at the neighbourhood scale. *Planning Practice & Research*, (August), 1–16. http://doi.org/10.1080/02697459.2015.1052943

Afzalan, N., & Muller, B. (2014). The role of social media in green infrastructure planning: A case study of neighborhood participation in park siting. *Journal of Urban Technology*, *21*(3), 67–83. http://doi.org/10.1080/10630732.2014.940701

Al-Kodmany, K. (1999). Using visualization techniques for enhancing public participation in planning and design: process, implementation, and evaluation. *Landscape and Urban Planning*, *45*(1), 37–45. http://doi.org/10.1016/S0169-2046(99)00024-9

Aladalah, M., Cheung, Y., & Lee, V. (2015). Enabling Citizen Participation in Gov 2.0: An Empowerment Perspective. *Electronic Journal of E-Government*, *13*(2), 77–93.

Andris, C. (2016). Integrating social network data into GISystems. *International Journal of Geographical Information Science*, *8816*(March), 1–23. http://doi.org/10.1080/13658816.2016.1153103

Anthopoulos, L., Reddick, C. G., Giannakidou, I., & Mavridis, N. (2014). Why e-government projects fail? An analysis of the Healthcare.gov website. *Government Information Quarterly*, *33*(1), 161–173. http://doi.org/10.1016/j.giq.2015.07.003

Arnstein, S. R. (1969). A Ladder Of Citizen Participation. *Journal of the American Institute of Planners*, *35*(4), 216–224. http://doi.org/10.1080/01944366908977225

Arribas-Bel, D. (2014). Accidental, open and everywhere: Emerging data sources for the understanding of cities. *Applied Geography*, *49*, 45–53. http://doi.org/10.1016/j.apgeog.2013.09.012

Atzmanstorfer, K., Resl, R., Eitzinger, A., & Izurieta, X. (2014). The GeoCitizen-approach: community-based spatial planning – an Ecuadorian case study. *Cartography and Geographic Information Science*, *41*(3), 248–259. http://doi.org/10.1080/15230406.2014.890546

Aubry, E., Silverston, T., Lahmadi, A., & Festor, O. (2014). CrowdOut: A mobile crowdsourcing service for road safety in digital cities. In *2014 IEEE International Conference on Pervasive Computing and Communication Workshops, PERCOM WORKSHOPS 2014* (pp. 86–91). http://doi.org/10.1109/PerComW.2014.6815170

Bakillah, M., Liang, S., Zipf, A., & Arsanjani, J. (2013). Semantic Interoperability of Sensor Data with Volunteered Geographic Information: A Unified Model. *ISPRS International Journal of*

Geo-Information, *2*, 766–796. http://doi.org/10.3390/ijgi2030766
Banerjee, S., Bhattacharyya, S., & Bose, I. (2017). Whose online reviews to trust ? Understanding reviewer trustworthiness and its impact on business. *Decision Support Systems*, *96*, 17–26. http://doi.org/10.1016/j.dss.2017.01.006
Basiouka, S., & Potsiou, C. (2012). VGI in Cadastre: a Greek experiment to investigate the potential of crowd sourcing techniques in Cadastral Mapping. *Survey Review*, *44*(325), 153–161. http://doi.org/10.1179/1752270611Y.0000000037
Bertot, J. C., Estevez, E., & Janowski, T. (2016). Universal and contextualized public services: Digital public service innovation framework. *Government Information Quarterly*, *33*(2), 211–222. http://doi.org/10.1016/j.giq.2016.05.004
Blei, D. M. (2012). Introduction to probabilistic topic modeling. *Communications of the ACM*, *55*, 77–84. http://doi.org/10.1145/2133806.2133826
Bonsón, E., Royo, S., & Ratkai, M. (2015). Citizens' engagement on local governments' Facebook sites. An empirical analysis: The impact of different media and content types in Western Europe. *Government Information Quarterly*, *32*(1), 52–62. http://doi.org/10.1016/j.giq.2014.11.001
Brabham, D. C. (2009). Crowdsourcing the Public Participation Process for Planning Projects. *Planning Theory*, *8*(3), 242–262. http://doi.org/10.1177/1473095209104824
Brandeis, M. W., & Nyerges, T. (2016). Assessing Resistance to Volunteered Geographic Information Reporting within Local Government. *Transactions in GIS*, *20*(2), 203–220. http://doi.org/10.1111/tgis.12168
Bright, J., & Margetts, H. (2016). Big Data and Public Policy : Can It Succeed Where E-Participation Has Failed ? *Policy and Internet*, *8*(3), 218–224.
Brooker, P., Barnett, J., & Cribbin, T. (2016). Doing social media analytics, (December), 1–12. http://doi.org/10.1177/2053951716658060
Brown, G. (2009). Public Participation GIS : A New Method for Use in National Forest Planning. *Forest Science*, *55*(2), 166–182.
Brown, G. (2012). Public Participation GIS (PPGIS) for regional and Environmental Planning : reflections on a decade of Empirical research. *URISA Journal*, *25*(2), 7–18.
Brown, G. (2015). Engaging the wisdom of crowds and public judgement for land use planning using public participation geographic information systems. *Australian Planner*, *52*(3), 199–209. http://doi.org/10.1080/07293682.2015.1034147
Brown, G. (2017). A Review of Sampling Effects and Response Bias in Internet Participatory Mapping (PPGIS/PGIS/VGI). *Transactions in GIS*, *21*(1), 39–56. http://doi.org/10.1111/tgis.12207
Brown, G., & Brabyn, L. (2012). The extrapolation of social landscape values to a national level in New Zealand using landscape character classification. *Applied Geography*, *35*(1–2), 84–94. http://doi.org/10.1016/j.apgeog.2012.06.002
Brown, G., Kelly, M., & Whitall, D. (2014). Which "public"? Sampling effects in public participation GIS (PPGIS) and volunteered geographic information (VGI) systems for public lands management. *Journal of Environmental Planning and Management*, *57*(2), 190–214. http://doi.org/10.1080/09640568.2012.741045
Brown, G., & Kyttä, M. (2014). Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Applied Geography*, *46*, 126–136. http://doi.org/10.1016/j.apgeog.2013.11.004
Brown, G., & Raymond, C. (2007). The relationship between place attachment and landscape values: Toward mapping place attachment. *Applied Geography*, *27*(2), 89–111. http://doi.org/10.1016/j.apgeog.2006.11.002

Brown, G., & Weber, D. (2011). Public Participation GIS: A new method for national park planning. *Landscape and Urban Planning*, *102*(1), 1–15. http://doi.org/10.1016/j.landurbplan.2011.03.003

Brown, G., Weber, D., & De Bie, K. (2014). Assessing the value of public lands using public participation GIS (PPGIS) and social landscape metrics. *Applied Geography*, *53*, 77–89. http://doi.org/10.1016/j.apgeog.2014.06.006

Budhathoki, N. R., Bruce, B. (Chip), & Nedovic-Budic, Z. (2008). Reconceptualizing the role of the user of spatial data infrastructure. *GeoJournal*, *72*(3–4), 149–160. http://doi.org/10.1007/s10708-008-9189-x

Bueckert, K. (2016, June 19). Pedestrian safety near LRT construction sites galls residents. Retrieved July 31, 2017, from http://www.cbc.ca/news/canada/kitchener-waterloo/kitchener-waterloo-lrt-construction-sites-pedestrian-safety-concern-1.3640705

Bugs, G., Granell, C., Fonts, O., Huerta, J., & Painho, M. (2010). An assessment of Public Participation GIS and Web 2.0 technologies in urban planning practice in Canela, Brazil. *Cities*, *27*(3), 172–181. http://doi.org/10.1016/j.cities.2009.11.008

Burke, E. M. (1979). *A participatory approach to urban planning*. Human Sciences Press.

Callies, D. (1981). Public Participation in the United States. *Town Planning Review*, *52*(3), 286. http://doi.org/10.3828/tpr.52.3.10818l2422673763

Campagna, M., Floris, R., & Massa, P. (2015). The role of social media geographic information (SMGI) in spatial planning. In S. Geertman (Ed.), *Planning Support Systems and Smart Cities, Lecture Notes in Geoinformation and Cartography* (pp. 41–60). Springer International Publishing Switzerland. http://doi.org/10.1007/978-3-319-18368-8

Cao, J., Zeng, K., Wang, H., & Cheng, J. (2014). Web-Based Traffic Sentiment Analysis : Methods and Applications. In *IEEE Transactions on Intelligent Transportation Systems* (Vol. 15, pp. 844–853).

Carver, S., Evans, A., Kingston, R., & Turton, I. (2001). Public participation, GIS, and cyberdemocracy: evaluating on-line spatial decision support systems. *Environment and Planning B: Planning and Design*, *28*(6), 907–921. http://doi.org/10.1068/b2751t

Cavallo, S., Lynch, J., & Scull, P. (2014). The digital divide in citizen-initiated government contacts: A GIS approach. *Journal of Urban Technology*, *21*(4), 77–93. http://doi.org/10.1080/10630732.2014.942167

Chen, Y., Liu, X., Li, X., Liu, X., Yao, Y., Hu, G., … Pei, F. (2017). Delineating urban functional areas with building-level social media data: A dynamic time warping (DTW) distance based k-medoids method. *Landscape and Urban Planning*, *160*, 48–60. http://doi.org/10.1016/j.landurbplan.2016.12.001

Christin, D., Reinhardt, A., Kanhere, S. S., & Hollick, M. (2011). A survey on privacy in mobile participatory sensing applications. *Journal of Systems and Software*, *84*(11), 1928–1946. http://doi.org/10.1016/j.jss.2011.06.073

Cinderby, S. (2010). How to reach the "hard-to-reach": the development of Participatory Geographic Information Systems (P-GIS) for inclusive urban design in UK cities. *Area*, *42*(2), 239–251. http://doi.org/10.1111/j.1475-4762.2009.00912.x

City of Kitchener. (n.d.). Roads and sidewalks. Retrieved August 15, 2017, from https://www.kitchener.ca/en/livinginkitchener/RoadsAndSidewalks.asp

Clark, B. Y., Brudney, J. L., Jakobsen, M., & Andersen, S. C. (2013). Coproduction of Government Services and the New Information Technology: Investigating the Distributional Biases. *Public Administration Review*, *73*(5), 704–713. http://doi.org/10.1111/puar.12092.Coproduction

Coleman, D. J., Rajabifard, A., & Kolodziej, K. W. (2016). Expanding the SDI environment: comparing current spatial data infrastructure with emerging indoor location-based services.

International Journal of Digital Earth, *8947*(January), 1–19. http://doi.org/10.1080/17538947.2015.1119207
Coletta, C., & Kitchin, R. (2017). Algorhythmic governance: Regulating the "heartbeat" of a city using the Internet of Things. *Big Data & Society*, *4*(2), 205395171774241. http://doi.org/10.1177/2053951717742418
Collins, L., Swart, R., & Zhang, B. (2013). *The rise of future finance: The UK alternative finance benchmarking report*.
Colombo, C. (2010). e-Participation experiences and local government in Catalonia: An explanatory analysis. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 6229 LNCS, pp. 82–94). http://doi.org/10.1007/978-3-642-15158-3_7
Connor, D. M. (1988). A new ladder of citizen participation. *National Civic Review*, *77*(3), 249–257. http://doi.org/10.1002/ncr.4100770309
Corbett, J. (2013). "I Don't Come from Anywhere": Exploring the Role of the Geoweb and Volunteered Geographic Information in Rediscovering a Sense of Place in a Dispersed Aborignial Community. In *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice* (pp. 223–241). http://doi.org/10.1007/978-94-007-4587-2
Corbett, J., Cochrane, L., & Gill, M. (2016). Powering Up: Revisiting Participatory GIS and Empowerment. *The Cartographic Journal*, *53*(4), 1–6. http://doi.org/10.1080/00087041.2016.1209624
Corburn, J. (2003). Bringing Local Knowledge into Environmental Decision Making. *Journal of Planning Education and Research*, *22*, 420–433. http://doi.org/10.1177/0739456X03253694
Cordella, A., & Tempini, N. (2015). E-government and organizational change: Reappraising the role of ICT and bureaucracy in public service delivery. *Government Information Quarterly*, *32*(3), 279–286. http://doi.org/10.1016/j.giq.2015.03.005
Craglia, M., Ostermann, F., & Spinsanti, L. (2012). Digital Earth from vision to practice: making sense of citizen-generated content. *International Journal of Digital Earth*, *5*(5), 398–416. http://doi.org/10.1080/17538947.2012.712273
Cranshaw, J., Hong, J. I., & Sadeh, N. (2012). The Livehoods Project : Utilizing Social Media to Understand the Dynamics of a City. In *Proceedings of the Sixth International AAAI Conference on Weblogs and Social Media* (pp. 58–65).
Crawford, K., & Finn, M. (2015). The limits of crisis data: analytical and ethical challenges of using social and mobile data to understand disasters. *GeoJournal*, *80*(4), 491–502. http://doi.org/10.1007/s10708-014-9597-z
Criado, J. I., Sandoval-Almazan, R., & Gil-Garcia, J. R. (2013). Government innovation through social media. *Government Information Quarterly*, *30*(4), 319–326. http://doi.org/10.1016/j.giq.2013.10.003
Croitoru, A., Wayant, N., Crooks, A., Radzikowski, J., & Stefanidis, A. (2014). Linking cyber and physical spaces through community detection and clustering in social media feeds. *Computers, Environment and Urban Systems*. http://doi.org/10.1016/j.compenvurbsys.2014.11.002
Crooks, A., Croitoru, A., Stefanidis, A., & Radzikowski, J. (2013). #Earthquake: Twitter as a Distributed Sensor System. *Transactions in GIS*, *17*(1), 124–147. http://doi.org/10.1111/j.1467-9671.2012.01359.x
Crooks, A., Pfoser, D., Jenkins, A., Croitoru, A., Stefanidis, A., Smith, D., … Lamprianidis, G. (2015). Crowdsourcing urban form and function. *International Journal of Geographical Information Science*, *29*(5), 720–741. http://doi.org/10.1080/13658816.2014.977905

Crutcher, M., & Zook, M. (2009). Placemarks and waterlines: Racialized cyberscapes in post-Katrina Google Earth. *Geoforum*, *40*(4), 523–534. http://doi.org/10.1016/j.geoforum.2009.01.003

Day, D. (1997). Citizen participation in the planning process: An essentially contested concept? *Journal of Planning Literature*, *11*(3), 421–434. http://doi.org/10.1177/088541229701100309

de Albuquerque, J. P., Herfort, B., Brenning, A., & Zipf, A. (2015). A geographic approach for combining social media and authoritative data towards identifying useful information for disaster management. *International Journal of Geographical Information Science*, *29*(4), 667–689. http://doi.org/10.1080/13658816.2014.996567

De Longueville, B., Annoni, A., Schade, S., Ostlaender, N., & Whitmore, C. (2010). Digital Earth's Nervous System for crisis events: real-time Sensor Web Enablement of Volunteered Geographic Information. *International Journal of Digital Earth*, *3*(3), 242–259. http://doi.org/10.1080/17538947.2010.484869

Degbelo, A., Granell Granell, C., Trilles Oliver, S., Bhattacharya, D., Casteleyn, S., & Kray, C. (2016). Opening up Smart Cities: Citizen-Centric Challenges and Opportunities from GIScience. *ISPRS International Journal of Geo-Information*, *5*(2), 16. http://doi.org/10.3390/ijgi5020016

Desouza, K. C., & Bhagwatwar, A. (2012). Citizen Apps to Solve Complex Urban Problems. *Journal of Urban Technology*, *19*(3), 107–136.

Deuze, M. (2006). Participation, Remediation, Bircolage: Considering Principle Components of Digital Culture. *The Information Society*, *22*(2), 63–75.

Deville, P., Linard, C., Martin, S., Gilbert, M., Stevens, F. R., Gaughan, A. E., … Tatem, A. J. (2014). Dynamic population mapping using mobile phone data. *Proceedings of the National Academy of Sciences*, *111*(45), 15888–15893. http://doi.org/10.1073/pnas.1408439111

Django. (n.d.). The Overview of Django Framework. Retrieved January 9, 2016, from https://www.djangoproject.com/start/overview/

Dorcey, A. H. J. (1994). *Public involvement in government decision making: choosing the right model: a report of the B.C. Round Table on the environment and the economy.* Victoria, B.C.

Dou, W., Wang, X., Skau, D., Ribarsky, W., & Zhou, M. X. (2012). LeadLine: Interactive visual analysis of text data through event identification and exploration. In *IEEE Conference on Visual Analytics Science and Technology 2012, VAST 2012 - Proceedings* (pp. 93–102). http://doi.org/10.1109/VAST.2012.6400485

Dunkel, A. (2015). Visualizing the perceived environment using crowdsourced photo geodata. *Landscape and Urban Planning*, *142*, 173–186. http://doi.org/10.1016/j.landurbplan.2015.02.022

Dunkel, A. (2016). Assessing the perceived environment through crowdsourced spatial photo content for application to the fields of landscape and urban planning, (August).

El-diraby, T. E., Kinawy, S. N., & Piryonesi, M. (2015). *Analyzing Approaches Used by Ontario Municipalities to Develop Road Asset Management Plans : Initial Insights Report*.

El-Diraby, T. E., & Osman, H. (2011). A domain ontology for construction concepts in urban infrastructure products. *Automation in Construction*, *20*(8), 1120–1132. http://doi.org/10.1016/j.autcon.2011.04.014

Elwood, S. (2010). Geographic information science: emerging research on the societal implications of the geospatial web. *Progress in Human Geography*, *34*(3), 349–357. http://doi.org/10.1177/0309132509340711

Elwood, S., & Ghose, R. (2011). PPGIS in Community Development Planning: Framing the Organizational Context. In *Classics in Cartography: Reflections on Influential Articles from Cartographica* (pp. 83–105). http://doi.org/10.1002/9780470669488.ch8

Elwood, S., & Leszczynski, A. (2011). Privacy, reconsidered: New representations, data practices, and the geoweb. *Geoforum*, *42*(1), 6–15. http://doi.org/10.1016/j.geoforum.2010.08.003

Elwood, S., & Leszczynski, A. (2013). New spatial media, new knowledge politics. *Transactions of the Institute of British Geographers*, *38*(4), 544–559. http://doi.org/10.1111/j.1475-5661.2012.00543.x

Elwood, S., & Martin, D. G. (2000). "Placing" interviews: Location and scales of power in qualitative research. *The Professional Geographer*. http://doi.org/10.1111/0033-0124.00253

Etzioni-Halevy, E. (2013). *Bureaucracy and democracy: A political dilemma*. *Bureaucracy and Democracy: A Political Dilemma* (Vol. 7). http://doi.org/10.4324/9780203707890

Evans-Cowley, J. S., & Griffin, G. (2011). Micro-participation: The role of microblogging in planning. *SSRN Electronic Journal*, 1–38. http://doi.org/10.2139/ssrn.1760522

Evans, J., & Jones, P. (2011). The walking interview: Methodology, mobility and place. *Applied Geography*, *31*(2), 849–858. http://doi.org/10.1016/j.apgeog.2010.09.005

Fagence, M. (1977). *Citizen Participation in Planning*. *Citizen Participation in Planning*. http://doi.org/10.1016/B978-0-08-020398-0.50009-7

Fearon, J. D. (1998). Deliberation as discussion. In *Deliberative Democracy* (pp. 44–68). http://doi.org/10.1017/CBO9781139175005.004

Feick, R., & Robertson, C. (2015). A multi-scale approach to exploring urban places in geotagged photographs. *Computers, Environment and Urban Systems*, *53*, 96–109. http://doi.org/10.1016/j.compenvurbsys.2013.11.006

Fink, K. (2017). Opening the government's black boxes: freedom of information and algorithmic accountability. *Information Communication and Society*, *4462*(May), 1–19. http://doi.org/10.1080/1369118X.2017.1330418

Fischer, F. (1993). Citizen participation and the democratization of policy expertise: From theoretical inquiry to practical cases. *Policy Sciences*, *26*(3), 165–187. http://doi.org/10.1007/BF00999715

Foster, A., & Dunham, I. M. (2014). Volunteered geographic information, urban forests, & environmental justice. *Computers, Environment and Urban Systems*, *53*, 65–75. http://doi.org/10.1016/j.compenvurbsys.2014.08.001

Foth, M., Schroeter, R., & Anastasiu, I. (2011). Fixing the city one photo at a time: mobile logging of maintenance requests. *The 22nd Australasian Conference on Computer-Human Interaction*, 126–129. http://doi.org/10.1145/2071536.2071555

Gagliardi, D., Schina, L., Sarcinella, M. L., Mangialardi, G., Niglia, F., & Corallo, A. (2015). Information and communication technologies and public participation: Interactive maps and value added for citizens. *Government Information Quarterly*, *34*(1), 153–166. http://doi.org/10.1016/j.giq.2016.09.002

Gal-Tzur, A., Grant-Muller, S. M., Kuflik, T., Minkov, E., Nocera, S., & Shoor, I. (2014). The potential of social media in delivering transport policy goals. *Transport Policy*, *32*, 115–123. http://doi.org/10.1016/j.tranpol.2014.01.007

Gal-Tzur, A., Grant-Muller, S. M., Minkov, E., & Nocera, S. (2014). The impact of social media usage on transport policy: Issues, challenges and recommendations. *Procedia - Social and Behavioral Sciences*, *111*, 937–946. http://doi.org/10.1016/j.sbspro.2014.01.128

Gao, S., Janowicz, K., Montello, D. R., Hu, Y., Yang, J., McKenzie, G., … Yan, B. (2017). A data-synthesis-driven method for detecting and extracting vague cognitive regions. *International Journal of Geographical Information Science*, *31*(6), 1245–1271. http://doi.org/10.1080/13658816.2016.1273357

Garnett, R., & Kanaroglou, P. (2016). Qualitative GIS: An Open Framework Using SpatiaLite and Open Source GIS. *Transactions in GIS*, *20*(1), 144–159. http://doi.org/10.1111/tgis.12163

Gaye, M., & Diallo, F. (1997). Community participation in the management of the urban environment in Rufisque (Senegal). *Environment and Urbanization*, *9*(1), 9–30. http://doi.org/10.1177/095624789700900110

Ghose, R. (2001). Use of information technology for community empowerment: Transforming geographic information systems into community information systems. *Transactions in GIS*, *5*(2), 141–163. http://doi.org/10.1111/1467-9671.00073

Ghose, R. (2005). The complexities of citizen participation through collaborative governance. *Space and Polity*, *9*(1), 61–75. http://doi.org/10.1080/13562570500078733

Goodchild, M. F. (2007). Citizens as sensors: the world of volunteered geography. *GeoJournal*, *69*(4), 211–221. http://doi.org/10.1007/s10708-007-9111-y

Goodchild, M. F. (2011). Formalising Place in Geographic Information Systems. *Communities, Neighborhoods, and Health: Expanding the Boundaries of Place*, 1–22. http://doi.org/10.1007/978-1-4419-7482-2

Gottwald, S., Laatikainen, T. E., & Kyttä, M. (2016). Exploring the usability of PPGIS among older adults: challenges and opportunities. *International Journal of Geographical Information Science*, *30*(12), 2321–2338. http://doi.org/10.1080/13658816.2016.1170837

Graham, M., Straumann, R. K., & Hogan, B. (2015). Digital divisions of labor and informational magnetism: Mapping participation in Wikipedia. *Annals of the Association of American Geographers*, *5608*(September), 1–21. http://doi.org/10.1080/00045608.2015.1072791

Graham, M., & Zook, M. (2011). Visualizing Global Cyberscapes: Mapping User-Generated Placemarks. *Journal of Urban Technology*, *18*(1), 115–132. http://doi.org/10.1080/10630732.2011.578412

Grant-Muller, S. M., Gal-Tzur, A., Minkov, E., Kuflik, T., Nocera, S., & Shoor, I. (2015). Transport policy: Social media and user-generated content in a changing information paradigm. In S. Nepal (Ed.), *Social Media for Government Services* (pp. 325–366). Springer International Publishing. http://doi.org/10.1007/978-3-319-27237-5

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank …*, *82*(4), 581–629. http://doi.org/10.1111/j.0887-378X.2004.00325.x

Grönlund, Å. (2009). ICT is not participation is not democracy - eParticipation development models revisited. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *5694 LNCS*, 12–23. http://doi.org/10.1007/978-3-642-03781-8_2

Hall, G. B., Chipeniuk, R., Feick, R. D., Leahy, M. G., & Deparday, V. (2010). Community-based production of geographic information using open source software and Web 2.0. *International Journal of Geographical Information Science*, *24*(5), 761–781. http://doi.org/10.1080/13658810903213288

Hardy, D. (2013). The geographic nature of Wikipedia authorship. In D. Sui, S. Elwood, & M. Goodchild (Eds.), *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice* (pp. 175–200). Houten, The Netherlands: Springer. http://doi.org/10.1007/978-94-007-4587-2

Harris, T., & Weiner, D. (1998). Empowerment, Marginalization, and “Community-integrated” GIS. *Cartography and Geographic Information Systems*, *25*(2), 67–76. http://doi.org/10.1559/152304098782594580

Haworth, B. (2017). Implications of Volunteered Geographic Information for Disaster Management and GIScience: A More Complex World of Volunteered Geography. *Annals of the American Association of Geographers*, *4452*(July), 1–15. http://doi.org/10.1080/24694452.2017.1321979

Haworth, B., Whittaker, J., & Bruce, E. (2016). Assessing the application and value of participatory mapping for community bushfire preparation. *Applied Geography*, *76*, 115–127. http://doi.org/http://dx.doi.org/10.1016/j.apgeog.2016.09.019

Higgs, G. (2006). Integrating multi-criteria techniques with geographical information systems in waste facility location to enhance public participation. *Waste Management and Research*, *24*(2), 105–117. http://doi.org/10.1177/0734242X06063817

Higgs, G., Berry, R., Kidner, D., & Langford, M. (2008). Using IT approaches to promote public participation in renewable energy planning: Prospects and challenges. *Land Use Policy*, *25*(4), 596–607. http://doi.org/10.1016/j.landusepol.2007.12.001

Ho, A. T. (2002). Reinventing Local Governments and the E-Government Initiative. *Public Administration Review*, *62*(4), 434–444. http://doi.org/10.1111/0033-3352.00197

Hollenstein, L., & Purves, R. (2010). Exploring place through user-generated content: Using Flickr to describe city cores. *Journal of Spatial Information Science*, *1*(1), 21–48. http://doi.org/10.5311/JOSIS.2010.1.3

Hong, S. (2013). Who benefits from Twitter? Social media and political competition in the U.S. House of Representatives. *Government Information Quarterly*, *30*(4), 464–472. http://doi.org/10.1016/j.giq.2013.05.009

Housley, W., Procter, R., Edwards, a., Burnap, P., Williams, M., Sloan, L., … Greenhill, a. (2014). Big and broad social data and the sociological imagination: A collaborative response. *Big Data & Society*, *1*(2), 1–15. http://doi.org/10.1177/2053951714545135

Hu, Y., & Li, W. (2017). Spatial Data Infrastructure. In J. P. Wilson (Ed.), *The Geographic Information Science & Technology Body of Knowledge*. Retrieved from http://dx.doi.org/10.22224/gistbok/2017.2.1

Hughes, A. L., & Palen, L. (2009). Twitter adoption and use in mass convergence and emergency events. *International Journal of Emergency Management*, *6*(3/4), 248. http://doi.org/10.1504/IJEM.2009.031564

IAP2. (n.d.). Public Participation Spectrum. Retrieved September 8, 2017, from http://iap2canada.ca/page-1020549

Innes, J. E., & Booher, D. E. (2004). Reframing public participation: strategies for the 21st century. *Planning Theory & Practice*, *5*(4), 419–436. http://doi.org/10.1080/1464935042000293170

Irvin, R. a., & Stansbury, J. (2004). Citizen participation in decision making: Is it worth the effort? *Public Administration Review*, *64*(1), 55–65. http://doi.org/10.1111/j.1540-6210.2004.00346.x

Jankowski, P., Czepkiewicz, M., Młodkowski, M., & Zwoliński, Z. (2016). Geo-questionnaire: A Method and Tool for Public Preference Elicitation in Land Use Planning. *Transactions in GIS*, *20*(6), 903–924. http://doi.org/10.1111/tgis.12191

Janowski, T. (2015). Digital government evolution : From transformation to contextualization. *Government Information Quarterly*, *32*(3), 221–236. http://doi.org/10.1016/j.giq.2015.07.001

Janssen, M., & Kuk, G. (2016). The challenges and limits of big data algorithms in technocratic governance. *Government Information Quarterly*, *33*(3), 371–377. http://doi.org/10.1016/j.giq.2016.08.011

Johannessen, M. R., Flak, L. S., & Sæbø, Ø. (2012). Choosing the right medium for municipal eParticipation based on stakeholder expectations. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7444 LNCS*, 25–36. http://doi.org/10.1007/978-3-642-33250-0_3

Johnson, P. A. (2016). Models of direct editing of government spatial data: challenges and constraints to the acceptance of contributed data. *Cartography and Geographic Information Science*, *406*(May), 1–11. http://doi.org/10.1080/15230406.2016.1176536

Johnson, P. A., & Sieber, R. E. (2012). Motivations driving government adoption of the Geoweb. *GeoJournal*, *77*(5), 667–680. http://doi.org/10.1007/s10708-011-9416-8

Johnson, P. A., & Sieber, R. E. (2013). Situating the Adoption of VGI by Government. In D. Sui, S. Elwood, & M. Goodchild (Eds.), *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice* (pp. 65–81). Houten, The Netherlands: Springer. http://doi.org/10.1007/978-94-007-4587-2

Johnson, P. A., Sieber, R. E., Scassa, T., Stephens, M., & Robinson, P. (2017). The Cost(s) of Geospatial Open Data. *Transactions in GIS*, *21*(3), 434–445. http://doi.org/10.1111/tgis.12283

Joseph, K., Landwehr, P. M., & Carley, K. M. (2014). Two 1%s Don't make a whole: Comparing simultaneous samples from Twitter's Streaming API. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 8393 LNCS, pp. 75–83). http://doi.org/10.1007/978-3-319-05579-4_10

Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of Social Media. *Business Horizons*, *53*(1), 59–68. http://doi.org/10.1016/j.bushor.2009.09.003

Kar, B., & Ghose, R. (2014). Is my information private? Geo-privacy in the World of Social Media. *CEUR Workshop Proceedings*, *1273*(Webster), 28–31.

Kar, B., Sieber, R. E., Haklay, M., & Ghose, R. (2016). Public Participation GIS and Participatory GIS in the Era of GeoWeb. *The Cartographic Journal*, *53*(4), 296–299. http://doi.org/10.1080/00087041.2016.1256963

Kassen, M. (2013). A promising phenomenon of open data: A case study of the Chicago open data project. *Government Information Quarterly*, *30*(4), 508–513. http://doi.org/10.1016/j.giq.2013.05.012

Kergosien, E., Laval, B., Roche, M., & Teisseire, M. (2014). Are opinions expressed in land-use planning documents? *International Journal of Geographical Information Science*, *28*(4), 739–762. http://doi.org/10.1080/13658816.2013.872823

Khan, G. F. (2015). The Government 2.0 utilization model and implementation scenarios. *Information Development*, *31*(2), 135–149. http://doi.org/10.1177/0266666913502061

Khan, G. F., Yoon, H. Y., Kim, J., & Park, H. W. (2013). From e-government to social government: Twitter use by Korea's central government. *Online Information Review*, *38*(1), 95–113. http://doi.org/10.1108/OIR-09-2012-0162

Khan, G. F., Yoon, H. Y., & Park, H. W. (2014). Social media communication strategies of government agencies: Twitter use in Korea and the USA. *Asian Journal of Communication*, *24*(1), 60–78. http://doi.org/10.1080/01292986.2013.851723

Kidney, T. C. (2002). *Public Involvement and Civic Rationalism in Local Authority Planning and Decision Making*. University of Wales.

Kim, K.-S., Kojima, I., & Ogawa, H. (2016). Discovery of local topics by using latent spatio-temporal relationships in geo-social media. *International Journal of Geographical Information Science*, *8816*(March), 1–24. http://doi.org/10.1080/13658816.2016.1146956

King, C. S., Feltey, K. M., & Susel, B. O. (1998). The question of participation: Toward authentic public participation in public administration. *Public Administration Review*, *58*(4), 317–326. http://doi.org/10.2307/977561

Kingston, R. (2007). Public Participation in Local Policy Decision-making: The Role of Web-based Mapping. *The Cartographic Journal*, *44*(2), 138–144. http://doi.org/10.1179/000870407X213459

Kingston, R., Carver, S., Evans, A., & Turton, I. (2000). Web-based public participation geographical information systems: an aid to local environmental decision-making. *Computers, Environment and Urban Systems*, *24*(2), 109–125. http://doi.org/10.1016/S0198-9715(99)00049-6

Kitchin, R. (2014a). The Data Revolution. *SAGE Publications Ltd*. http://doi.org/10.1017/CBO9781107415324.004

Kitchin, R. (2014b). The real-time city? Big data and smart urbanism. *GeoJournal*, (June). Retrieved from http://link.springer.com/article/10.1007/s10708-013-9516-8

Kitchin, R. (2016). *Getting smarter about smart cities : Improving data privacy and data security*.

Kwan, M. P. (2016). Algorithmic geographies: Big data, algorithmic uncertainty, and the production of geographic knowledge. *Annals of the American Association of Geographers*, *106*(2), 274–282. http://doi.org/10.1080/00045608.2015.1117937

Kyttä, M., Broberg, A., Tzoulas, T., & Snabb, K. (2013). Towards contextually sensitive urban densification: Location-based softGIS knowledge revealing perceived residential environmental quality. *Landscape and Urban Planning*, *113*, 30–46. http://doi.org/10.1016/j.landurbplan.2013.01.008

Lawrence, H., Robertson, C., Feick, R., & Nelson, T. (2015). Identifying optimal study areas and apatial aggregation units for point-based VGI from multiple sources. In F. Harvey & Y. Leung (Eds.), *Advances in Spatial Data Handling and Analysis* (pp. 65–84). Springer. http://doi.org/10.1007/978-3-319-19950-4_5

Layne, K., & Lee, J. (2001). Developing fully functional E-government: A four stage model. *Government Information Quarterly*, *18*(2), 122–136. http://doi.org/10.1016/S0740-624X(01)00066-1

Lazer, D., Kennedy, R., King, G., & Vespignani, A. (2014). The Parable of Google Flu: Traps in Big Data Analysis. *Science*, *343*, 1203–1205. http://doi.org/10.1126/science.1248506

Lee, G., & Kwak, Y. H. (2012). An Open Government Maturity Model for social media-based public engagement. *Government Information Quarterly*, *29*(4), 492–503. http://doi.org/10.1016/j.giq.2012.06.001

Leetaru, K. H., Wang, S., Cao, G., Padmanabhan, A., & Shook, E. (2013). Mapping the global Twitter heartbeat: The geography of Twitter. *First Monday*, *18*(5), 1–12. http://doi.org/10.5210/fm.v18i5.4366

Lenhart, A., & Fox, S. (2009). Twitter and status updating. *Methodology*, *Retrieved*(December 2008), 1–6. Retrieved from http://www.pewinternet.org/Reports/2009/Twitter-and-status-updating.aspx

Lev-On, A., & Steinfeld, N. (2015). Local engagement online: Municipal Facebook pages as hubs of interaction. *Government Information Quarterly*, *32*(3), 299–307. http://doi.org/10.1016/j.giq.2015.05.007

Levine, C. H., & Fisher, G. (1984). Citizenship and Service Delivery: The Promise of Coproduction. *Source: Public Administration Review*, *4482174130*, 178–189. http://doi.org/10.2307/975559

Li, L., & Goodchild, M. F. (2012). Constructing places from spatial footprints. In *Proceedings of the 1st ACM SIGSPATIAL International Workshop on Crowdsourced and Volunteered Geographic Information - GEOCROWD '12* (pp. 15–21). New York, New York, USA: ACM Press. http://doi.org/10.1145/2442952.2442956

Lin, W. (2013a). Situating performative neogeography: tracing, mapping, and performing "Everyone's East Lake." *Environment and Planning A*, *45*(1), 37–54. http://doi.org/10.1068/a45161

Lin, W. (2013b). When web2.0 meets public participation GIS (PPGIS): VGI and spaces of participatory mapping in China. In D. Sui, S. Elwood, & M. Goodchild (Eds.), *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice* (pp. 83–103). Dordrecht: Springer Science + Business Media B.V. http://doi.org/10.1007/978-94-007-4587-2

Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly*, *29*(4), 446–454. http://doi.org/10.1016/j.giq.2012.06.003

Linders, D., Liao, C. Z., & Wang, C. (2015). Proactive e-Governance : Flipping the service delivery model from pull to push in Taiwan. *Government Information Quarterly*. http://doi.org/10.1016/j.giq.2015.08.004

Liu, Y., Liu, X., Gao, S., Gong, L., Kang, C., Zhi, Y., … Shi, L. (2015). Social Sensing: A New Approach to Understanding Our Socioeconomic Environments. *Annals of the Association of American Geographers*, *105*(3), 512–530. http://doi.org/10.1080/00045608.2015.1018773

Liu, Y., Sui, Z., Kang, C., & Gao, Y. (2014). Uncovering patterns of inter-urban trip and spatial interaction from social media check-in data. *PloS One*, *9*(1), e86026. http://doi.org/10.1371/journal.pone.0086026

Longueville, B. De, & Smith, R. S. (2009). " OMG , from here , I can see the flames !": a use case of mining Location Based Social Networks to acquire spatio- temporal data on forest fires. In *ACM LBSN* (pp. 73–80). New York, NY, USA. http://doi.org/10.1145/1629890.1629907

López-Ornelas, E., & Zaragoza, N. M. (2014). Social media participation: A narrative way to help planners. In *Social Computing and Social Media* (pp. 48–54). http://doi.org/10.1007/978-3-319-07632-4

Lowndes, V., Pratchett, L., & Stoker, G. (2001a). Trends in public participation: part 1 – local government perspectives. *Public Administration*, *79*(1), 205–222. http://doi.org/10.1111/1467-9299.00253

Lowndes, V., Pratchett, L., & Stoker, G. (2001b). Trends in public participation: Part 2 - citizens' perspectices. *Public Administration*, *79*(2), 445–455.

Lu, Q. (2017). *Smartphone Applications in Government : Characterizing and Evaluating Municipal Smartphone Applications for Service Requests*. University of Waterloo. Retrieved from https://uwspace.uwaterloo.ca/bitstream/handle/10012/11151/Lu_Qing.pdf?sequence=1&isAllowed=y

Lundblad, J. P. (2003). A Review and Critique of Rogers â€™ Diffusion of Innovation Theory as it Applies to Organizations. *Organization Development Journal*, *21*(4), 50–64.

Magro, M. J. (2012). A Review of Social Media Use in E-Government. *Administrative Sciences*, *2*(2), 148–161. http://doi.org/10.3390/admsci2020148

Massa, P. (2015). *Social Media Geographic Information (SMGI): opportunities for spatial planning and governance*. Università Degli Studi Di Cagliari Scuola.

Massa, P., & Campagna, M. (2014). Social media geographic information: Recent findings and opportunities for smart spatial planning. *TeMA Journal of Land Use Mobility and Environment INPUT*, 645–658.

McCall, M. K., & Dunn, C. E. (2012). Geo-information tools for participatory spatial planning: Fulfilling the criteria for "good" governance? *Geoforum*, *43*(1), 81–94. http://doi.org/10.1016/j.geoforum.2011.07.007

McCall, M. K., Martinez, J., & Verplanke, J. (2013). Shifting Boundaries of Volunteered Geographic Information Systems and Modalities: Learning from PGIS. *An International E-Journal for Critical Geographies*, 1–36.

McCarthy, J. D., & Zald, M. (2001). *The Enduring Vitality of the Resource Mobilization Theory of Social Movements*. http://doi.org/10.1007/0-387-36274-6_25

McCarthy, J. D., & Zald, M. N. (1977). Resource Mobilization and Social Movements: A Partial Theory. *American Journal of Sociology*, *82*(6), 1212–1241. http://doi.org/10.1086/226464

McKinsey Center for Government. (2017). *Government Productivity: Unlocking the $3.5 trillion opportunity*.

Medaglia, R. (2012). EParticipation research: Moving characterization forward (2006-2011). *Government Information Quarterly*, *29*(3), 346–360. http://doi.org/10.1016/j.giq.2012.02.010

Mergel, I. (2013). A framework for interpreting social media interactions in the public sector.

Government Information Quarterly, *30*(4), 327–334. http://doi.org/10.1016/j.giq.2013.05.015
Middleton, S. E., Middleton, L., & Modafferi, S. (2014). Real-time crisis mapping of natural disasters using social media. In *IEEE Intelligent Systems* (Vol. 29, pp. 9–17). http://doi.org/10.1109/MIS.2013.126
Miller, H. J., & Goodchild, M. F. (2015). Data-driven geography. *GeoJournal*, (October 2014), 449–461. http://doi.org/10.1007/s10708-014-9602-6
Misra, A., Gooze, A., Watkins, K., Asad, M., & Le Dantec, C. (2014). Crowdsourcing and Its Application to Transportation Data Collection and Management. *Transportation Research Record: Journal of the Transportation Research Board*, *2414*, 1–8. http://doi.org/10.3141/2414-01
Mitchell, L., Frank, M. R., Harris, K. D., Dodds, P. S., & Danforth, C. M. (2013). The Geography of Happiness: Connecting Twitter Sentiment and Expression, Demographics, and Objective Characteristics of Place. *PLoS ONE*, *8*(5), e64417. http://doi.org/10.1371/journal.pone.0064417
Montjoye, Y. De, Radaelli, L., & Singh, V. K. (2012). Unique in the shopping mall: On the reidentifiability of credit card metadata. *Identity and Privacy*.
Mooney, P., Sun, H., Corcoran, P., & Yan, L. (2011). Citizen-generated spatial data and information: Risks and opportunities. *Proceedings of 2011 IEEE International Conference on Intelligence and Security Informatics*, 232–232. http://doi.org/10.1109/ISI.2011.5984087
Mooney, P., Sun, H., & Yan, L. (2011). VGI as a dynamically updating data source in location-based services in urban environments. *… of the 2Nd International Workshop on …*, 1027–1036. http://doi.org/10.1145/1357054.1357213
Mossberger, K., Wu, Y., & Crawford, J. (2013). Connecting citizens and local governments? Social media and interactivity in major U.S. cities. *Government Information Quarterly*, *30*(4), 351–358. http://doi.org/10.1016/j.giq.2013.05.016
Mustonen-Ollila, E., & Lyytinen, K. (2003). Why organizations adopt information system process innovations: a longitudinal study using Diffusion of Innovation theory. *Info Systems J*, *13*, 275–297. http://doi.org/10.1046/j.1365-2575.2003.00141.x
Nam, T., & Pardo, T. a. (2014a). Understanding Municipal Service Integration: An Exploratory Study of 311 Contact Centers. *Journal of Urban Technology*, *21*(1), 57–78. http://doi.org/10.1080/10630732.2014.887933
Nam, T., & Pardo, T. A. (2014b). The changing face of a city government: A case study of Philly311. *Government Information Quarterly*, *31*(SUPPL.1), S1–S9. http://doi.org/10.1016/j.giq.2014.01.002
Neis, P., & Zielstra, D. (2014). Recent Developments and Future Trends in Volunteered Geographic Information Research: The Case of OpenStreetMap. *Future Internet*, *6*(1), 76–106. http://doi.org/10.3390/fi6010076
O'Brien, D. T., Offenhuber, D., Baldwin-Philippi, J., Sands, M., & Gordon, E. (2017). Uncharted Territoriality in Coproduction: The Motivations for 311 Reporting. *Journal of Public Administration Research and Theory*, 320–335. http://doi.org/10.1093/jopart/muw046
O'Reilly, T. (2005). O'Reilly: What Is Web 2.0. Retrieved from http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html
OECD. (2001). *citizen as partners: information, consultation and public participation in policy-making*.
Oliveira, G. H. M., & Welch, E. W. (2013). Social media use in local government: Linkage of technology, task, and organizational context. *Government Information Quarterly*, *30*(4), 397–405. http://doi.org/10.1016/j.giq.2013.05.019
Olteanu-Raimond, A.-M., Hart, G., Foody, G. M., Touya, G., Kellenberger, T., & Demetriou, D. (2017). The Scale of VGI in Map Production: A Perspective on European National Mapping Agencies. *Transactions in GIS*, *21*, 74–90. http://doi.org/10.1111/tgis.12189
Olteanu, A., Castillo, C., Diaz, F., & Kiciman, E. (2016). Social Data: Biases, Methodological

Pitfalls, and Ethical Boundaries. *SSRN Electronic Journal*, 1–47. http://doi.org/10.2139/ssrn.2886526
Ontario. (n.d.). ONTARIO REGULATION 239/02: MINIMUM MAINTENANCE STANDARDS FOR MUNICIPAL HIGHWAYS.
Open Knowledge. (n.d.). Open Definition. Retrieved March 14, 2018, from http://opendefinition.org/
Overeem, A., R. Robinson, J. C., Leijnse, H., Steeneveld, G. J., P. Horn, B. K., & Uijlenhoet, R. (2013). Crowdsourcing urban air temperatures from smartphone battery temperatures. *Geophysical Research Letters*, *40*(15), 4081–4085. http://doi.org/10.1002/grl.50786
Panagiotopoulos, P., Bigdeli, A. Z., & Sams, S. (2014). Citizen–government collaboration on social media: The case of Twitter in the 2011 riots in England. *Government Information Quarterly*, *31*(3), 349–357. http://doi.org/10.1016/j.giq.2013.10.014
Panteras, G., Wise, S., Lu, X., Croitor, A., Crooks, A., & Stefanidis, A. (2014). Triangulating social multimedia content for event localization using Flickr and Twitter. *Transactions in GIS*, *19*(5), 694–715. http://doi.org/10.1111/tgis.12122
Parker, B. (2006). Constructing community through maps? Power and praxis in community mapping. *Professional Geographer*, *58*(4), 470–484. http://doi.org/10.1111/j.1467-9272.2006.00583.x
Peixoto, T., & Fox, J. (2016). When Does ICT-Enabled Citizen Voice Lead to Government Responsiveness? *IDS Bulletin*, *41*(1), 23–39. http://doi.org/10.19088/1968-2016.104
Picazo-Vela, S., Gutiérrez-Martínez, I., & Luna-Reyes, L. F. (2012). Understanding risks, benefits, and strategic alternatives of social media applications in the public sector. *Government Information Quarterly*, *29*(4), 504–511. http://doi.org/10.1016/j.giq.2012.07.002
Pickles, J. (2004). *A History of Spaces: Cartographic Reason, Mapping and the Geo-coded World*. New York: Routledge.
Plieninger, T., Dijks, S., Oteros-Rozas, E., & Bieling, C. (2013). Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy*, *33*, 118–129. http://doi.org/10.1016/j.landusepol.2012.12.013
Pocewicz, A., Nielsen-Pincus, M., Brown, G., & Schnitzer, R. (2012). An evaluation of Internet versus paper-based methods for Public Participation Geographic Information Systems (PPGIS). *Transactions in GIS*, *16*(1), 39–53. http://doi.org/10.1111/j.1467-9671.2011.01287.x
Poorthuis, A., & Zook, M. (2017). Making Big Data Small: Strategies to Expand Urban and Geographical Research Using Social Media. *Journal of Urban Technology*, pp. 1–21. Taylor & Francis. http://doi.org/10.1080/10630732.2017.1335153
Poorthuis, A., Zook, M., Shelton, T., Graham, M., & Stephens, M. (2014). Using Geotagged Digital Social Data in Geographic Research. *Key Methods in Geography (Forthcoming)*.
Prandi, F., Soave, M., Devigili, F., & Amicis, R. De. (2014). Collaboratively collected geodata to support routing service for disabled people, (November), 26–28.
Rana, R. K., Chou, C. T., Kanhere, S. S., Bulusu, N., & Hu, W. (2010). Ear-Phone : An End-to-End Participatory Urban Noise Mapping System. *Proceedings of the International Conference on Information Processing in Sensor Networks IPSN*, 105–116. http://doi.org/10.1145/1791212.1791226
Rattenbury, T., & Naaman, M. (2009). Methods for extracting place semantics from Flickr tags. *ACM Transactions on the Web*, *3*(1), 1–30. http://doi.org/10.1145/1462148.1462149
Reddick, C. G., Chatfield, A. T., & Ojo, A. (2016). A social media text analytics framework for double-loop learning for citizen-centric public services: A case study of a local government Facebook use. *Government Information Quarterly*, *34*, 1–16. http://doi.org/10.1016/j.giq.2016.11.001

Reddick, C. G., Chatfield, A. T., & Ojo, A. (2017). A social media text analytics framework for double-loop learning for citizen-centric public services: A case study of a local government Facebook use. *Government Information Quarterly*, *34*(1), 110–125. http://doi.org/10.1016/j.giq.2016.11.001

Reddick, C. G., & Norris, D. F. (2013). Social media adoption at the American grass roots: Web 2.0 or 1.5? *Government Information Quarterly*, *30*(4), 498–507. http://doi.org/10.1016/j.giq.2013.05.011

Region of Waterloo. (2007). A Blueprint for Shaping Growth in Waterloo Region. Retrieved May 16, 2016, from http://www.regionofwaterloo.ca/en/doingBusiness/resources/BlueprintShapingGrowth.pdf

Remmen, A. (2004). *Images of e-Government – Experiences from the Digital North Denmark*. Aalborg University.

Rice, R. M., Aburizaiza, A. O., Rice, M. T., & Qin, H. (2016). Position Validation in Crowdsourced Accessibility Mapping. *Cartographica: The International Journal for Geographic Information and Geovisualization*, *51*(2), 55–66. http://doi.org/10.3138/cart.51.2.3143

Ricker, B., Schuurman, N., & Kessler, F. (2015). Implications of smartphone usage on privacy and spatial cognition: academic literature and public perceptions. *GeoJournal*, *80*(5), 637–652. http://doi.org/10.1007/s10708-014-9568-4

Rinner, C. (2006). Argumentation Mapping in Collaborative Spatial Decision Making, 1–14.

Rinner, C., Keßler, C., & Andrulis, S. (2008). The use of Web 2.0 concepts to support deliberation in spatial decision-making. *Computers, Environment and Urban Systems*, *32*(5), 386–395. http://doi.org/10.1016/j.compenvurbsys.2008.08.004

Ríos, S., & Muñoz, R. (2014). Content patterns in topic-based overlapping communities. *The Scientific World Journal*, *2014*, 1–11. http://doi.org/10.1155/2014/105428

Robertson, C., & Feick, R. (2016). Bumps and bruises in the digital skins of cities: unevenly distributed user-generated content across US urban areas. *Cartography and Geographic Information Science*, *43*(4), 283–300. http://doi.org/10.1080/15230406.2015.1088801

Roche, S. (2014). Geographic Information Science I: Why does a smart city need to be spatially enabled? *Progress in Human Geography*. http://doi.org/10.1177/0309132513517365

Roche, S., & Feick, R. (2012). Wiki-place: Building place-based GIS from VGI, (2007), 2007–2009.

Roeder, S., Poppenborg, A., Michaelis, S., Märker, O., & Salz, S. R. (2005). "Public Budget Dialogue" – An Innovative Approach to E-Participation. In *E-Government: Towards Electronic Democracy* (Vol. 3416, pp. 48–56). http://doi.org/10.1007/978-3-540-32257-3_5

Rogers, E. M. (1983). *Diffusion of Innovations*. *Book*. Retrieved from http://books.google.com.sg/books?id=zw0-AAAAIAAJ&hl=en

Ross, H., Baldwin, C., & Carter, R. W. B. (2016). Subtle implications: public participation versus community engagement in environmental decision-making. *Australasian Journal of Environmental Management*, *23*(2), 123–129. http://doi.org/10.1080/14486563.2016.1194588

Rowe, G., & Frewer, L. J. (2000). Public Participation Methods: A Framework for Evaluation. *Science, Technology & Human Values*, *25*(1), 3–29. http://doi.org/10.1177/016224390002500101

Rowe, G., & Frewer, L. J. (2005). A typology of public engagement mechanisms. *Science, Technology & Human Values*, *30*(2), 251–290. http://doi.org/10.1177/0162243904271724

Sahin, I. (2006). Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology: Related Studies Based on Rogers' Theory. *The Turkish Online Journal of Educational Technology*, *5*(April 2006), 14–23. http://doi.org/10.1287/mnsc.43.7.934

Sandoval-Almazan, R., & Ramon Gil-Garcia, J. (2014). Towards cyberactivism 2.0? Understanding the use of social media and other information technologies for political activism and social movements. *Government Information Quarterly*, *31*(3), 365–378.

http://doi.org/10.1016/j.giq.2013.10.016
Sandström, P., Granqvist Pahlén, T., Edenius, L., Tømmervik, H., Hagner, O., Hemberg, L., … Egberth, M. (2003). Conflict Resolution by Participatory Management: Remote Sensing and GIS as Tools for Communicating Land-use Needs for Reindeer Herding in Northern Sweden. *AMBIO: A Journal of the Human Environment*, *32*(8), 557–567. http://doi.org/10.1579/0044-7447-32.8.557
Sandvig, C. (2015). Seeing the Sort: The Aesthetic and Industrial Defense of "The Algorithm." *Media-N: Journal of the New Media Caucus*, 1–20.
Sawicki, D. S., & Peterman, D. R. (1996). Surveying the extent of PPGIS practice in the United States.
Scassa, T. (2013). Legal issues with volunteered geographic information. *Canadian Geographer*, *57*(1), 1–10. http://doi.org/10.1111/j.1541-0064.2012.00444.x
Scassa, T., & Diebel, A. (2017). *Open or Closed ? Open Licensing of Real- Time Public Sector Transit Data*.
Schade, S., Díaz, L., Ostermann, F., Spinsanti, L., Luraschi, G., Cox, S., … Longueville, B. (2013). Citizen-based sensing of crisis events: sensor web enablement for volunteered geographic information. *Applied Geomatics*, *5*(1), 3–18. http://doi.org/10.1007/s12518-011-0056-y
Schlossberg, M., & Shuford, E. (2005). Delineating "Public" and "Participation" in PPGIS. *URISA Journal*, *16*(2), 15–26. Retrieved from https://scholarsbank.uoregon.edu/xmlui/handle/1794/1343
Schweitzer, L. (2014). Planning and social media: A case study of public transit and stigma on Twitter. *Journal of the American Planning Association*, *80*(3), 218–238. http://doi.org/10.1080/01944363.2014.980439
See, L., Comber, A., Salk, C., Fritz, S., van der Velde, M., Perger, C., … Obersteiner, M. (2013). Comparing the Quality of Crowdsourced Data Contributed by Expert and Non-Experts. *PLoS ONE*, *8*(7), 1–11. http://doi.org/10.1371/journal.pone.0069958
See, L., Mooney, P., Foody, G. M., Bastin, L., Comber, A., Estima, J., … Laakso, M. (2016). Crowdsourcing, Citizen Science or Volunteered Geographic Information? The Current State of Crowdsourced Geographic Information, (April), 1–10. http://doi.org/10.3390/www.mdpi.com/journal/ijgi
Seeger, C. J. (2008). The role of facilitated volunteered geographic information in the landscape planning and site design process. *GeoJournal*, *72*(3–4), 199–213. http://doi.org/10.1007/s10708-008-9184-2
Senaratne, H., Mobasheri, A., Ali, A. L., Capineri, C., & Haklay, M. (2017). A review of volunteered geographic information quality assessment methods. *International Journal of Geographical Information Science*, *31*(1), 139–167. http://doi.org/10.1080/13658816.2016.1189556
Seo, D. B., & Bernsen, M. (2016). Comparing attitudes toward e-government of non-users versus users in a rural and urban municipality. *Government Information Quarterly*, *33*(2), 270–282. http://doi.org/10.1016/j.giq.2016.02.002
Shelton, T., Poorthuis, A., Graham, M., & Zook, M. (2014). Mapping the data shadows of Hurricane Sandy: Uncovering the sociospatial dimensions of "big data." *Geoforum*, *52*, 167–179. http://doi.org/10.1016/j.geoforum.2014.01.006
Shelton, T., Poorthuis, A., & Zook, M. (2015). Social media and the city: Rethinking urban socio-spatial inequality using user-generated geographic information. *Landscape and Urban Planning*, *142*, 198–211. http://doi.org/10.1016/j.landurbplan.2015.02.020
Sieber, R. E. (2006). Public participation geographic information systems: A literature review and framework. *Annals of the Association of American Geographers*, *96*(3), 491–507. http://doi.org/10.1111/j.1467-8306.2006.00702.x

Sieber, R. E., & Johnson, P. A. (2015). Civic open data at a crossroads: Dominant models and current challenges. *Government Information Quarterly*, *32*(3), 308–315. http://doi.org/10.1016/j.giq.2015.05.003

Sieber, R. E., Robinson, P. J., Johnson, P. A., & Corbett, J. M. (2016). Doing Public Participation on the Geospatial Web. *Annals of the American Association of Geographers*, *106*(5), 1030–1046. http://doi.org/10.1080/24694452.2016.1191325

Silva, T. H., Vaz De Melo, P. O. S., Almeida, J. M., & Loureiro, A. a F. (2013). Social media as a source of sensing to study city dynamics and urban social behavior: Approaches, models, and opportunities. In M. Atzmueller (Ed.), *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 8329 LNAI, pp. 63–87). Springer-Verlag Berlin Heidelberg. http://doi.org/10.1007/978-3-642-45392-2_4

Simão, A., Densham, P. J., & Haklay, M. (2009). Web-based GIS for collaborative planning and public participation: An application to the strategic planning of wind farm sites. *Journal of Environmental Management*, *90*(6), 2027–2040. http://doi.org/10.1016/j.jenvman.2007.08.032

Sivarajah, U., Weerakkody, V., Waller, P., Lee, H., Irani, Z., Choi, Y., … Glikman, Y. (2015). The role of e-participation and open data in evidence-based policy decision making in local government. *Journal of Organizational Computing and Electronic Commerce*, *26*(1–2), 64–79. http://doi.org/10.1080/10919392.2015.1125171

Slotterback, C. S. (2011). Planners' perspectives on using technology in participatory processes. *Environment and Planning B: Planning and Design*, *38*(3), 468–485. http://doi.org/10.1068/b36138

Smith, A., Hawes, T., & Myers, M. (2014). Hierarchie: Interactive visualization for hierarchical topic models. *Acl2014*, 71–78.

Smith, L., Liang, Q., James, P., & Lin, W. (2015). Assessing the utility of social media as a data source for flood risk management using a real-time modelling framework. *Journal of Flood Risk Management*, n/a-n/a. http://doi.org/10.1111/jfr3.12154

Smith, P. D., & McDonough, M. H. (2001). Beyond public participation: Fairness in natural resource decision making. *Society and Natural Resources*, *14*(3), 239–249. http://doi.org/10.1080/08941920120140

Solove, D. J. (2013). Introduction: Privacy self-management and the consent dilemma. *Harvard Law Review*, *126*(7), 1880–1903. http://doi.org/10.1525/sp.2007.54.1.23.

Spinsanti, L., & Ostermann, F. (2013). Automated geographic context analysis for volunteered information. *Applied Geography*, *43*, 36–44. http://doi.org/10.1016/j.apgeog.2013.05.005

St. Martin, K., & Hall-Arber, M. (2008). The missing layer: Geo-technologies, communities, and implications for marine spatial planning. *Marine Policy*, *32*(5), 779–786. http://doi.org/10.1016/j.marpol.2008.03.015

Statistic Canada. (n.d.). Mapping your community through crowdsouring. Retrieved November 21, 2017, from https://www.statcan.gc.ca/eng/crowdsourcing

Stefanidis, A., Crooks, A., & Radzikowski, J. (2013). Harvesting ambient geospatial information from social media feeds. *GeoJournal*, *78*(2), 319–338. http://doi.org/10.1007/s10708-011-9438-2

Stephens, M., & Poorthuis, A. (2015). Follow thy neighbor: Connecting the social and the spatial networks on Twitter. *Computers, Environment and Urban Systems*, *53*(September), 87–95. http://doi.org/10.1016/j.compenvurbsys.2014.07.002

Tang, Z., & Liu, T. (2015). Evaluating Internet-based public participation GIS (PPGIS) and volunteered geographic information (VGI) in environmental planning and management. *Journal of Environmental Planning and Management*, (August 2015), 1–18. http://doi.org/10.1080/09640568.2015.1054477

Tao, K., Abel, F., Hauff, C., & Houben, G. (2012). What makes a tweet relevant for a topic? *CEUR Workshop Proceedings*, *838*, 49–56.
Tene, O., & Polonetsky, J. (2012). Privacy in the Age of Big Data: A Time for Big Decisions. *Stanford Law Review Online*, *64*, 63. http://doi.org/10.5121/ijgca.2012.3203
The City of Kitchener. (n.d.). *Kitchener's strategic plan 2015-2018*. Retrieved from https://www.kitchener.ca/en/resourcesGeneral/Documents/CAO_2015-2018_Strategic_plan.pdf
Thelwall, M., Buckley, K., & Paltoglou, G. (2012). Sentiment strength detection for the social web. *Journal of the American Society for Information Science and Technology*, *63*(1), 163–173. http://doi.org/10.1002/asi.21662
Thomas, J. C. (1995). *Public Participation in Public Decisions*. San Francisco, CA: Jossey-Bass.
Tilly, R., Fischbach, K., & Schoder, D. (2015). Mineable or messy? Assessing the quality of macro-level tourism information derived from social media. *Electronic Markets*, *25*(3), 227–241. http://doi.org/10.1007/s12525-015-0181-2
Tulloch, D. L. (2008). Is VGI participation? From vernal pools to video games. *GeoJournal*, *72*(3–4), 161–171. http://doi.org/10.1007/s10708-008-9185-1
Turner, A. J. (2006). *Introduction to Neogeography*. *OReilly Short Cuts*. Retrieved from http://books.google.com/books?hl=en&lr=&id=oHgDv4feV-8C&oi=fnd&pg=PA24&dq=Introduction+to+Neogeography&ots=wYr7RESSeW&sig=HTani7IqwF0NQmiqf8jZigkFguQ
United Nations. (2008). *United Nations e-Government Survey 2008: From e-Government to Connected Governance*. *New York*.
United Nations. (2016). *United Nations e-government survey 2016: E-Government in support of sustainable development*.
UNPAN. (n.d.). UN Public Administration Glossary. Retrieved May 31, 2018, from http://www.unpan.org/Directories/Glossary/tabid/1398/language/en-US/Default.aspx
Unsworth, K., Forte, A., & Dilworth, R. (2014). Urban Informatics: The Role of Citizen Participation in Policy Making. *Journal of Urban Technology*, *21*(4), 1–5. http://doi.org/10.1080/10630732.2014.971527
Vasardani, M., Winter, S., & Richter, K.-F. (2013). Locating place names from place descriptions. *International Journal of Geographical Information Science*, *27*(12), 2509–2532. http://doi.org/10.1080/13658816.2013.785550
Vayena, E., Salathé, M., Madoff, L. C., & Brownstein, J. S. (2015). Ethical Challenges of Big Data in Public Health. *PLoS Computational Biology*, *11*(2), 1–7. http://doi.org/10.1371/journal.pcbi.1003904
Veljković, N., Bogdanović-Dinić, S., & Stoimenov, L. (2014). Benchmarking open government: An open data perspective. *Government Information Quarterly*, *31*(2), 278–290. http://doi.org/10.1016/j.giq.2013.10.011
Verplanke, J., McCall, M. K., Uberhuaga, C., Rambaldi, G., & Haklay, M. (2016). A Shared Perspective for PGIS and VGI. *The Cartographic Journal*, *7041*(September), 1–10. http://doi.org/10.1080/00087041.2016.1227552
Vicente, M. R., & Novo, A. (2014). An empirical analysis of e-participation. The role of social networks and e-government over citizens' online engagement. *Government Information Quarterly*, *31*(3), 379–387. http://doi.org/10.1016/j.giq.2013.12.006
Wang, W., & Stewart, K. (2015). Spatiotemporal and semantic information extraction from Web news reports about natural hazards. *Computers, Environment and Urban Systems*, *50*, 30–40. Retrieved from http://www.sciencedirect.com/science/article/pii/S0198971514001252
Weber, M. (1947). *The theory of social and economic organization*. *Book* (Vol. 57).

http://doi.org/10.2307/2181723
Weinreb, A. R., & Rofè, Y. (2013). Mapping Feeling: An Approach to the Study of Emotional Response to Built Environment and Landscape. *Journal of Architectural and Planning Research*, *30*(2), 127–145.
Wellman, B. (2002). Little Boxes, Glocalization, and Networked Individualism From Little Boxes to Social Networks. *Digital Cities*, 10–25. http://doi.org/10.1007/3-540-45636-8_2
Werts, J. D., Mikhailova, E. a, Post, C. J., & Sharp, J. L. (2012). An integrated WebGIS framework for volunteered geographic information and social media in soil and water conservation. *Environmental Management*, *49*(4), 816–32. http://doi.org/10.1007/s00267-012-9818-5
Wiedemann, P. M., & Femers, S. (1993). Public participation in waste management decision making : Analysis and management of conflicts. *Journal of Hazardous Materials*, *33*, 355–368.
Wiseman, J. (2014). *Can 311 call centers improve service delivery? Lessons from New York and Chicago*.
Wukich, C., & Mergel, I. (2016). Reusing social media information in government. *Government Information Quarterly*, *33*(2), 305–312. http://doi.org/10.1016/j.giq.2016.01.011
Xie, B., & Jaeger, P. T. (2008). Older adults and political participation on the internet: A cross-cultural comparison of the USA and China. *Journal of Cross-Cultural Gerontology*, *23*(1), 1–15. http://doi.org/10.1007/s10823-007-9050-6
Yearley, S., Cinderby, S., Forrester, J., Bailey, P., & Rosen, P. (2003). Participatory modelling and the local governance of the politics of UK air pollution: A three-city case study. *Environmental Values*, *12*(2), 247–262. http://doi.org/10.3197/096327103129341315
Yin, J., Lampert, A., Cameron, M., Robinson, B., & Power, R. (2012). Using social media to enhance emergency situation awareness. *IEEE Intelligent Systems*, *27*(6), 52–59. http://doi.org/10.1109/MIS.2012.6
Zavattaro, S. M., French, P. E., & Mohanty, S. D. (2015). A sentiment analysis of U.S. local government tweets: The connection between tone and citizen involvement. *Government Information Quarterly*, *32*(3), 333–341. http://doi.org/10.1016/j.giq.2015.03.003
Zhai, C., & Lafferty, J. (2001). A study of smoothing methods for language models applied to Ad Hoc information retrieval. In *Proceedings of the 24th annual international ACM SIGIR conference on Research and development in information retrieval - SIGIR '01* (pp. 334–342). New York, NY, USA: ACM. http://doi.org/10.1145/383952.384019
Zhang, S., & Feick, R. (2016). Understanding Public Opinions from Geosocial Media. *ISPRS International Journal of Geo-Information*, *5*(6), 74. http://doi.org/10.3390/ijgi5060074
Zhou, X., Xu, C., & Kimmons, B. (2015). Detecting tourism destinations using scalable geospatial analysis based on cloud computing platform. *Computers, Environment and Urban Systems*, *54*, 144–153. http://doi.org/10.1016/j.compenvurbsys.2015.07.006
Zook, M. (2017). Crowd-sourcing the smart city : Using big geosocial media metrics in urban governance. *Big Data & Society*, *4*(1), 1–13. http://doi.org/10.1177/2053951717694384

Appendix A: Code for Chapter 3

Python code of automatically scraping online articles using Python Scrapy library (An example):

```
from scrapy.selector import HtmlXPathSelector
from scrapy.spider import BaseSpider
from scrapy.http import Request
from scrapy.utils.url import urljoin_rfc
from tutorial.items import DmozItem

class recordSpider(BaseSpider):
   name = "record"
   allowed_domains = [domain_url]
   start_urls = [domain_search + query]

   def start_requests(self):
      for i in range (50):
         yield Request(domain_search + query)

   def parse2(self, response):
      # hxs = HtmlXPathSelector(response)
      hxs = HtmlXPathSelector(text=response.body)
      item = response.meta['item']
      items = []
      contents = hxs.xpath('//div[@itemprop="articleBody"]')
      item['content'] = contents.xpath('p/text()').extract()
      items.append(item)
      return items

   def parse(self,response):
      hxs = HtmlXPathSelector(text=response.body)
      items = []
      title = hxs.select(xpath_title).extract()
      url = hxs.select(xpath_body).extract()

      for i in range(len(url)-1):
         print i
         item = DmozItem()
         print url[i]
         item['link'] = urljoin_rfc(domain_url, url[i])
         item['title'] = title[i][:]
         items.append(item)
      for item in items:
         yield
Request(item['link'],meta={'item':item},callback=self.parse2)
```

Python code of classifying newspaper articles using SVM classification

```
from sklearn.feature_extraction.text import TfidfVectorizer
import codecs
import numpy as np

X_train = np.array([''.join(el) for el in train_data[:]])
y_train = np.array([el for el in train_labels[:]])

X_test = np.array([''.join(el) for el in texts[:]])

vectorizer = TfidfVectorizer(min_df=2,
 ngram_range=(1, 2),
 stop_words='english',
 strip_accents='unicode',
 norm='l2')

test_string = unicode(train_data[0])


X_train = vectorizer.fit_transform(X_train)
X_test = vectorizer.transform(X_test)

## SVM
from sklearn.svm import LinearSVC

svm_classifier = LinearSVC().fit(X_train, y_train)
y_svm_predicted = svm_classifier.predict(X_test)
print y_svm_predicted

print "MODEL: Linear SVC\n"

fwrite = codecs.open(outputfile,'a')
for i, value in enumerate(y_svm_predicted):
   print i, value
   fwrite.write(str(value)+'\t')
   fwrite.write(lines2[i]+'\n')
```

<u>Python code of calculating *tf-idf* value for words in articles related to topics of public transportation and walking respectively.</u>

```
import os, os.path, string, re, codecs, math
import nltk
from decimal import Decimal
from textblob import TextBlob as tb

##Define functions for calculating tf-idf value
def tf(word, blob):
    return blob.words.count(word) / len(blob.words)

def n_containing(word, bloblist):
    return sum(1 for blob in bloblist if word in blob)

def idf(word, bloblist):
    return math.log(len(bloblist) / (1 + n_containing(word, bloblist)))

def tfidf(word, blob, bloblist):
    return tf(word, blob) * idf(word, bloblist)


## For topics of public transportation and walking,
## loop through articles relevant to each of the topic,
## remove stop words and numbers,
## add all the rest of the words to the topic list

docList = []
for topic in topicList:
        directory = rootdir+'/'+topic
        text = ''
        words = []

        for files in os.walk(directory):
                print files[2]
                for filename in files[2]:

                        filePath = directory + '/'+filename
                        fopen = codecs.open(filePath,'r','utf-8')
                        lines = fopen.read().split('\n')
                        for line in lines:
                                text = text + line

        words = text.split(' ')
        words = [word.lower() for word in words]
        words = filter(lambda word: not word.isdigit(), words)
        words = filter(lambda word: not word in stopwords_en, words)
        words = filter(lambda word: not word in stoplist, words)
        texts = ''

        for word in words:
            texts = texts +' '+ word
        doc = tb(texts)
```

```
        docList.append(doc)

## For topics of public transportation and walking,
## calculate the tf-idf value of each word within the topic list

for i, doc in enumerate(docList):
        print ("Top words in topic " + topicList[i])
        scores = {word: tfidf(word,doc,docList) for word in doc.words}
        sorted_words = sorted(scores.items(),key = lambda x:
x[1],reverse = True)

        for word, score in sorted_words[:50]:
                print("\t{}, {}".format(word,round(score,5)))
```

Python code of calculating the relevance of each Twitter message to topics of public transportation and walking respectively

```
import codecs

u = 0.1

fopen = codecs.open(tweetFile,"r","utf-8")
fwrite = codecs.open(resultFile,'w','utf-8')


class topic (object):
    def __init__(self,id, keyword,p):
        self.id = id
        self.keywordList = keyword
        self.pList = p

class tweetScore(object):
    def __init__(self,id,text,score,finalScore):
        self.id = id
        self.text = text
        self.score = score
        self.finalScore = finalScore


## Read Twitter messages from file
lines = fopen.read().split('\n')
tweets =[]
for line in lines:
    tweets.append(line.split('\t'))

def readAllTweets():
    words = []
    for tweet in tweets:
        words.append(tweet[1].split())

    return words

## Calculate the frequency of each keyword occuring
## in the collection of language model (all tweets)
def readTopics():
    topics = []
    allwords = readAllTweets()

    for one_topic in topic_list:
        print "reading topics {}".format(one_topic)
        keywordList = []
        probList = []
        fread = codecs.open(one_topic+'.txt','r','utf-8')
        lines = fread.read().split('\n')
        for line in lines:
            temp = line.split('\t')
            keywordList.append(temp[0])
```

```
            prob = allwords.count(temp[0])/len(allwords)
            probList.append(prob)
        newTopic = topic(one_topic,keywordList,probList)
        topics.append(newTopic)
    print "finished reading topics"

    return topics

## Go through all the tweets and calculate the probability score
def calProbTweet():
    topics = readTopics()
    tweetScores = []

    for tweet in tweets:
        words = tweet[1].split()
        words = [word.lower() for word in words]
        rele_score = []
        finalScore = 0
        for topic in topics:
            relevance = 0
            i = 0
            for keyword in topic.keywordList:
                count = words.count(keyword)
                pi = (count + u*topic.pList[i])/(len(words)+u)
                i = i + 1
                relevance = relevance + pi
            # relevance = math.log(relevance)
            finalScore = finalScore + relevance
            rele_score.append(relevance)
        newTweetScore =
tweetScore(tweet[0],tweet[1],rele_score,finalScore)
        tweetScores.append(newTweetScore)

    print "Finished calculating relevance score, start exporting..."
    writetofile(tweetScores)

## Write results to the file
def writetofile(tweetScores):
    for record in tweetScores:

        fwrite.write(record.id + '\t'+record.text+'\t')
        for score in record.score:
            fwrite.write (str(round(score,5))+'\t')
        fwrite.write(str(round(record.finalScore,5))+'\n')


if __name__=='__main__':
    calProbTweet()
```

Python code of LDA topic modeling:

```
import random

alpha = 0.1
beta = 0.1
K = 10
iter_num = 50
top_words = 20


class Document(object):
    def __init__(self):
        self.words = []
        self.length = 0

class Dataset(object):
    def __init__(self):
        self.M = 0
        self.V = 0
        self.docs = []
        self.word2id = {}     # <string,int> dictionary
        self.id2word = {}     # <int, string> dictionary

    def writewordmap(self):
        with open(wordmapfile, 'w') as f:
            for k,v in self.word2id.items():
                f.write(k + '\t' + str(v) + '\n')

class Model(object):
    def __init__(self, dset):
        self.dset = dset

        self.K = K
        self.alpha = alpha
        self.beta = beta
        self.iter_num = iter_num
        self.top_words = top_words

        self.wordmapfile = wordmapfile
        self.trnfile = trnfile
        self.modelfile_suffix = modelfile_suffix

        self.p = []         # double type, store temp variants from
sampling
        self.Z = []         # M*doc.size(), topic-words distribution of
the words
        self.nw = []        # V*K, the distribution of word i on topic j
        self.nwsum = []     # K, # of words topic j has
        self.nd = []        # M*K, # of words doc i has that belong to
topic j
```

```
        self.ndsum = []     # M, # of words topic i has
        self.theta = []     # doc - topic distribution
        self.phi = []       # topic - word distribution

    def init_est(self):
        self.p = [0.0 for x in xrange(self.K)]
        self.nw = [ [0 for y in xrange(self.K)] for x in
xrange(self.dset.V) ]
        self.nwsum = [ 0 for x in xrange(self.K)]
        self.nd = [ [ 0 for y in xrange(self.K)] for x in
xrange(self.dset.M)]
        self.ndsum = [ 0 for x in xrange(self.dset.M)]
        self.Z = [ [] for x in xrange(self.dset.M)]
        for x in xrange(self.dset.M):
            self.Z[x] = [0 for y in xrange(self.dset.docs[x].length)]
            self.ndsum[x] = self.dset.docs[x].length
            for y in xrange(self.dset.docs[x].length):
                topic = random.randint(0, self.K-1)
                self.Z[x][y] = topic
                self.nw[self.dset.docs[x].words[y]][topic] += 1
                self.nd[x][topic] += 1
                self.nwsum[topic] += 1
        self.theta = [ [0.0 for y in xrange(self.K)] for x in
xrange(self.dset.M) ]
        self.phi = [ [ 0.0 for y in xrange(self.dset.V) ] for x in
xrange(self.K)]

    def estimate(self):
        print 'Sampling %d iterations!' % self.iter_num
        for x in xrange(self.iter_num):
            print 'Iteration %d ...' % (x+1)
            for i in xrange(len(self.dset.docs)):
                for j in xrange(self.dset.docs[i].length):
                    topic = self.sampling(i, j)
                    self.Z[i][j] = topic
        print 'End sampling.'
        print 'Compute theta...'
        self.compute_theta()
        print 'Compute phi...'
        self.compute_phi()
        print 'Saving model...'
        self.save_model()

    def sampling(self, i, j):
        topic = self.Z[i][j]
        wid = self.dset.docs[i].words[j]
        self.nw[wid][topic] -= 1
        self.nd[i][topic] -= 1
        self.nwsum[topic] -= 1
        self.ndsum[i] -= 1

        Vbeta = self.dset.V * self.beta
        Kalpha = self.K * self.alpha

        for k in xrange(self.K):
            self.p[k] = (self.nw[wid][k] + self.beta)/(self.nwsum[k] +
```

```
Vbeta) * \
                         (self.nd[i][k] + alpha)/(self.ndsum[i] +
Kalpha)
        for k in range(1, self.K):
            self.p[k] += self.p[k-1]
        u = random.uniform(0, self.p[self.K-1])
        for topic in xrange(self.K):
            if self.p[topic]>u:
                break
        self.nw[wid][topic] += 1
        self.nwsum[topic] += 1
        self.nd[i][topic] += 1
        self.ndsum[i] += 1
        return topic

    def compute_theta(self):
        for x in xrange(self.dset.M):
            for y in xrange(self.K):
                self.theta[x][y] = (self.nd[x][y] + self.alpha) \
                                   /(self.ndsum[x] + self.K *
self.alpha)

    def compute_phi(self):
        for x in xrange(self.K):
            for y in xrange(self.dset.V):
                self.phi[x][y] = (self.nw[y][x] + self.beta)\
                                 /(self.nwsum[x] + self.dset.V *
self.beta)

    def save_model(self):
        with open(self.modelfile_suffix+'.theta', 'w') as ftheta:
            for x in xrange(self.dset.M):
                for y in xrange(self.K):
                    ftheta.write(str(self.theta[x][y]) + ' ')
                ftheta.write('\n')
        with open(self.modelfile_suffix+'.phi', 'w') as fphi:
            for x in xrange(self.K):
                for y in xrange(self.dset.V):
                    fphi.write(str(self.phi[x][y]) + ' ')
                fphi.write('\n')
        with open(self.modelfile_suffix+'.twords','w') as ftwords:
            if self.top_words > self.dset.V:
                self.top_words = self.dset.V
            for x in xrange(self.K):
                ftwords.write('Topic '+str(x)+'th:\n')
                topic_words = []
                for y in xrange(self.dset.V):
                    topic_words.append((y, self.phi[x][y]))
                #quick-sort
                topic_words.sort(key=lambda x:x[1], reverse=True)
                for y in xrange(self.top_words):
                    word = self.dset.id2word[topic_words[y][0]]

ftwords.write('\t'+word+'\t'+str(topic_words[y][1])+'\n')
        with open(self.modelfile_suffix+'.tassign','w') as ftassign:
            for x in xrange(self.dset.M):
                for y in xrange(self.dset.docs[x].length):
```

```
ftassign.write(str(self.dset.docs[x].words[y])+':'+str(self.Z[x][y])+'
')
                ftassign.write('\n')
        with open(self.modelfile_suffix+'.others','w') as fothers:
            fothers.write('alpha = '+str(self.alpha)+'\n')
            fothers.write('beta = '+str(self.beta)+'\n')
            fothers.write('ntopics = '+str(self.K)+'\n')
            fothers.write('ndocs = '+str(self.dset.M)+'\n')
            fothers.write('nwords = '+str(self.dset.V)+'\n')
            fothers.write('liter = '+str(self.iter_num)+'\n')

def readtrnfile():
    print 'Reading train data...'
    with open(trnfile, 'r') as f:
        docs = f.readlines()

    dset = Dataset()
    items_idx = 0
    for line in docs:
        if line != "":
            tmp = line.strip().split('\t')
            #genereate a document object
            doc = Document()
            for item in tmp:
                if dset.word2id.has_key(item):
                    doc.words.append(dset.word2id[item])
                else:
                    dset.word2id[item] = items_idx
                    dset.id2word[items_idx] = item
                    doc.words.append(items_idx)
                    items_idx += 1
            doc.length = len(tmp)
            dset.docs.append(doc)
        else:
            pass
    dset.M = len(dset.docs)
    dset.V = len(dset.word2id)
    print 'There are %d documents' % dset.M
    print 'There are %d items' % dset.V
    print 'Saving wordmap file...'
    dset.writewordmap()
    return dset

def lda():
    dset = readtrnfile()
    model = Model(dset)
    model.init_est()
    model.estimate()

if __name__=='__main__':
    lda()
```

JavaScript code of creating sunburst diagram

```
// Dimensions of sunburst.
var width = 750;
var height = 600;
var radius = Math.min(width, height) / 2;

// Breadcrumb dimensions: width, height, spacing, width of tip/tail.
var b = {
  w: 150, h: 30, s: 3, t: 10
};


// Total size of all segments; we set this later,
// after loading the data.
var totalSize = 0;

var vis = d3.select("#chart").append("svg:svg")
    .attr("width", width)
    .attr("height", height)
    .append("svg:g")
    .attr("id", "container")
    .attr("transform", "translate(" + width / 2 + "," + height / 2 +
")");

var partition = d3.layout.partition()
    .size([2 * Math.PI, radius * radius])
    .value(function(d) { return d.size; });

var arc = d3.svg.arc()
    .startAngle(function(d) { return d.x; })
    .endAngle(function(d) { return d.x + d.dx; })
    .innerRadius(function(d) { return Math.sqrt(d.y); })
    .outerRadius(function(d) { return Math.sqrt(d.y + d.dy); });

// Use d3.text and d3.csv.parseRows so that we do not need to have a
// header row, and can receive the csv as an array of arrays.
d3.text("ttree_tweet_2.csv", function(text) {
  var csv = d3.csv.parseRows(text);
  var json = buildHierarchy(csv);
  createVisualization(json);
});

// Main function to draw and set up the visualization
function createVisualization(json) {

  initializeBreadcrumbTrail();
  drawLegend();
  d3.select("#togglelegend").on("click", toggleLegend);


  vis.append("svg:circle")
      .attr("r", radius)
      .style("opacity", 0);
```

```
  var nodes = partition.nodes(json)
      .filter(function(d) {
      return (d.dx > 0.005);
      });

  var path = vis.data([json]).selectAll("path")
      .data(nodes)
      .enter().append("svg:path")
      .attr("display", function(d) { return d.depth ? null : "none"; })
      .attr("d", arc)
      .attr("fill-rule", "evenodd")
      .style("fill", function(d) {
        if (d.name in colors){return colors[d.name];
          } else {return colors['Others'];}})
      .style("opacity", 0.3)
      .on("mouseover", mouseover);

  d3.select("#container").on("mouseleave", mouseleave);
  totalSize = path.node().__data__.value;
 };

// Fade all but the current sequence,
// and show it in the breadcrumb trail.
function mouseover(d) {

  var percentage = (100 * d.value / totalSize).toPrecision(3);
  var percentageString = percentage + "%";
  if (percentage < 0.1) {
    percentageString = "< 0.1%";
  }
  // var percentageString = d.value

  d3.select("#percentage")
      .text(percentageString);

  d3.select("#explanation")
      .style("visibility", "");

  var sequenceArray = getAncestors(d);
  updateBreadcrumbs(sequenceArray, percentageString);

  d3.selectAll("path")
      .style("opacity", 0.3);

  vis.selectAll("path")
      .filter(function(node) {
                return (sequenceArray.indexOf(node) >= 0);
              })
      .style("opacity", 0.8);
}

// Restore everything to full opacity when
// moving off the visualization.
function mouseleave(d) {

  d3.select("#trail")
      .style("visibility", "hidden");
```

```
  d3.selectAll("path").on("mouseover", null);

  d3.selectAll("path")
      .transition()
      .duration(1000)
      .style("opacity", 0.8)
      .each("end", function() {
              d3.select(this).on("mouseover", mouseover);
            });

  d3.select("#explanation")
      .style("visibility", "hidden");
}

// Given a node in a partition layout, return an array of all of its
// ancestor nodes, highest first, but excluding the root.
function getAncestors(node) {
  var path = [];
  var current = node;
  while (current.parent) {
    path.unshift(current);
    current = current.parent;
  }
  return path;
}

function initializeBreadcrumbTrail() {
  // Add the svg area.
  var trail = d3.select("#sequence").append("svg:svg")
      .attr("width", width)
      .attr("height", 50)
      .attr("id", "trail");

  trail.append("svg:text")
    .attr("id", "endlabel")
    .style("fill", "#000");
}

// Generate a string that describes the points of a breadcrumb polygon.
function breadcrumbPoints(d, i) {
  var points = [];
  points.push("0,0");
  points.push(b.w + ",0");
  points.push(b.w + b.t + "," + (b.h/2));
  points.push(b.w + "," + b.h);
  points.push("0," + b.h);
  if (i > 0) {
    points.push(b.t + "," + (b.h / 2));
  }
  return points.join(" ");
}

// Update the breadcrumb trail to show the current
// sequence and percentage.
function updateBreadcrumbs(nodeArray, percentageString) {
```

```
  var g = d3.select("#trail")
      .selectAll("g")
      .data(nodeArray, function(d) { return d.name + d.depth; });

  var entering = g.enter().append("svg:g");

  entering.append("svg:polygon")
      .attr("points", breadcrumbPoints)
      .style("fill", function(d) { return colors[d.name]; });

  entering.append("svg:text")
      .attr("x", (b.w + b.t) / 2)
      .attr("y", b.h / 2)
      .attr("dy", "0.35em")
      .attr("text-anchor", "middle")
      .text(function(d) { return d.name; });

  // Set position for entering and updating nodes.
  g.attr("transform", function(d, i) {
    return "translate(" + i * (b.w + b.s) + ", 0)";
  });

  // Remove exiting nodes.
  g.exit().remove();

  // Move and update the percentage at the end.
  d3.select("#trail").select("#endlabel")
      .attr("x", (nodeArray.length + 0.5) * (b.w + b.s))
      .attr("y", b.h / 2)
      .attr("dy", "0.35em")
      .attr("text-anchor", "middle")
      .text(percentageString);

  // Make the breadcrumb trail visible, if it's hidden.
  d3.select("#trail")
      .style("visibility", "");

}

function drawLegend() {
  // Dimensions of legend item: width, height, spacing,
  // radius of rounded rect.
  var li = {
    w: 150, h: 30, s: 3, r: 3
  };

  var legend = d3.select("#legend").append("svg:svg")
      .attr("width", li.w)
      .attr("height", d3.keys(colors).length * (li.h + li.s));

  var g = legend.selectAll("g")
      .data(d3.entries(colors))
      .enter().append("svg:g")
      .attr("transform", function(d, i) {
              return "translate(0," + i * (li.h + li.s) + ")";
           });
```

```
  g.append("svg:rect")
      .attr("rx", li.r)
      .attr("ry", li.r)
      .attr("width", li.w)
      .attr("height", li.h)
      .style("fill", function(d) { return d.value; });

  g.append("svg:text")
      .attr("x", li.w / 2)
      .attr("y", li.h / 2)
      .attr("dy", "0.35em")
      .attr("text-anchor", "middle")
      .text(function(d) { return d.key; });
}

function toggleLegend() {
  var legend = d3.select("#legend");
  if (legend.style("visibility") == "hidden") {
    legend.style("visibility", "");
  } else {
    legend.style("visibility", "hidden");
  }
}

// Take a 2-column CSV and transform it into a hierarchical structure
// suitable for a partition layout.
function buildHierarchy(csv) {
  var root = {"name": "root", "children": []};

  for (var i = 0; i < csv.length; i++) {
    var sequence = csv[i][0];
    var size = +csv[i][1];

    if (isNaN(size)) {
      continue;
    }

    var parts = sequence.split("-");
    var currentNode = root;

    for (var j = 0; j < parts.length; j++) {
      var children = currentNode["children"];
      var nodeName = parts[j];
      var childNode;
      if (j + 1 < parts.length) {
        var foundChild = false;
        for (var k = 0; k < children.length; k++) {
                if (children[k]["name"] == nodeName) {
                        childNode = children[k];
                        foundChild = true;
                        break;
                }
        }

   if (!foundChild) {
        childNode = {"name": nodeName, "children": []};
        children.push(childNode);
```

```
        }
        currentNode = childNode;
      }
        else
        {
                childNode = {"name": nodeName, "size": size};
                children.push(childNode);
        }
    }
  }

  return root;
};
```

Appendix B: Interview Questions

<u>**Section 1:**</u> This section asks about the process of how your organization gathers 311 reports from the public and how your organization validates and processes 311 reports.

1. How valuable are the following methods for your organization to collect 311 reports from the public?

Phone calls	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Used
Emails	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Used
Web contact form	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Used
Web applications	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Used
Mobile application (e.g. Open 311)	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Used
Social media (such as Twitter, Flickr, Facebook)	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Used

2. Does your organization use other methods that are not listed above to collect 311 reports? If so, please list them.
3. Once a 311 report is received, how do you determine the validity of the report?
4. Please rank the quality of the following aspects of citizen reports in a range of 1 to 5 (with 1 representing the poorest quality and 5 representing the best quality).

	Location Accuracy	Description	Timeliness	Relevance	Trustworthiness
Phone calls					
Emails					
Web contact form					
Web application					

Mobile application	
Social media	

5. Please elaborate your answers to question 4.
6. Are there any other important aspects in determining the validity or relevance of a 311 report? If so, please list them.
7. In the table below, please estimate what percentages of 311 reports contain no geographic information, approximate geographic locations, and exact geographic references of the reported issue.

	Phone calls	Emails	Web contact form	Web application	Mobile application	Social media
No geographic information (e.g. no locations mentioned or only references to an entire municipality)						
Approximate geographic information (references to general or vague locations [e.g. near City Hall, west side of town] or areas that lack formal boundaries or locations [e.g. downtown])						
Exact geographic information (e.g. addresses, intersections, postal codes, geotags)						

8. What challenges have you encountered when using geographic information associated with 311 requests to locate a reported issue?
9. Have you found or do you believe that the following methods may be helpful for validating location information or improving imprecise location descriptions?

Citizens pinpoint the location on a digital map.	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Sure
Citizens add auto-detected geolocations using GPS-enabled mobile devices.	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Sure
Citizens search for place/location using geocoding services (similar to the search function of Google Maps).	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Sure
Citizens use crowdsourcing approach (e.g. one may agree/disagree with another's report).	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Sure
Government staff use a mapping application to input the location and manage requests.	(Not Valuable)	1	2	3	4	5	(Very Valuable)	Not Sure

10. Are there any other methods which might be helpful for validating/improving the quality of geographic information? If so, please list them.
11. What are the potential barriers of using these methods?
12. Once a 311 report is validated, what is the procedure for dealing with the reported issue?

<u>**Section 2:**</u> This section asks you questions about using social media as a channel to communicate 311 requests.

13. If your organization uses social media to communicate 311 issues with the public, what social media platforms do you use?

14. Is the procedure of validating a social media report different from that of validating reports received from other channels? If so, what are the differences?
15. What challenges have you encountered with validating social media reports?
16. What is the approximate percentage of social media reports that use geotags?
17. Have you found or do you think that the usage of geotags helps you identify the location of a reported issue? Why or why not?
18. What challenges have you encountered with logging and tracking a social media report?
19. In general, what are the advantages of using social media compared to other methods?

Citizens can report issues at any time.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Citizens can report issues from any location.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Citizens can report to the city directly by @ city's official account	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
The cost of reporting via social media is low.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
It is easy to add photographs to social media to help city staff understand the problem.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
It is easy to add exact locations to social media so that citizens can report the location of issues easily and precisely.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Government staff can access the most up-to-date reports and thus respond more efficiently.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Social media is an open communication platform	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

where citizens can view each other's reports as well as the responses of city staff members.					
Many people use social media so that city staff can receive more feedback from citizens.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

20. Do you have additional comments for question 19?
21. In general, what are the challenges of using social media compared to other methods?

Citizens may not be aware that they could report via social media.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Citizens may not know how to report via social media in terms of format, keywords, and hashtags.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Citizens may not want to make their reports viewable to the public.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Sometimes the situation is too complex to describe within a set word limit (e.g. each Twitter message can only have 140 words maximum).	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Citizens may not want to share location information (e.g. their property information or their personal location).	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Citizens' personal smartphone GPS may not be sufficiently precise, thus locations reported to city staff may not be accurate.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
People often post emotional messages on social media rather than accurately describing the issue, therefore	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

the reports on social media may not be as trustworthy as reports coming from other methods.					
The city will need to devote more personnel to processing and monitoring social media.	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
It is more difficult to manage social media reports (e.g. track the status of the request and save the request into the database).	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

22. Do you have additional comments for question 21?
23. Please share any suggestions you may have on how local government can make better use of social media to communicate 311 requests.

Appendix C: Interview Recruitment Materials

Email contact to local municipalities

To whom it may concern,

This is a letter written to invite you to participate in a research project ***Citizen Reporting through Geosocial Media: Opportunities and Barriers***. This project is part of my PhD degree in the *Department of Geography and Environment Management at the University of Waterloo*, Ontario, under the supervision of Dr. Rob Feick. This project is part of Geothink, a 5-year partnership research grant funded by SSHRC (one of only 20 grants awarded in the year) that is partnered with City of Montreal.

The objective of the study is to explore the potential of citizens using geo-located social media to report issues to local governments. As a participant, you will be asked to an interview about how your organization currently validates and processes non-emergent citizen reports (e.g. 311 reports) and how you evaluate the quality and usefulness of geosocial media information for reporting. The interview will combine a number of ***multiple choice questions and open-ended questions*** and will be approximately **40 minutes** in length.

Participation in this study is **voluntary**. The interview will take place in a mutually agreed upon location or via phone. You may decline to answer any of the interview questions that you do not wish to answer. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview, a copy of the transcript will be sent to you so that you can confirm the accuracy of our conversation and add or clarify any points that you think are needed.

We would like to assure you that all of the information you provide will be kept **confidential**. Your name will not appear in any thesis or report resulting from this study, however, anonymous quotations may be used with your permission. The data, with no personal identifiers, collected from this study will be maintained on a password-protected computer database in a restricted access area of the university. This data will be electronically archived after completion of the study and maintained for a minimum of five years and then erased.

This study has been reviewed and received *ethics clearance* through a University of Waterloo Research Ethics Committee (ORE#21727). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact **Shanqi Zhang**, s72zhang@uwaterloo.ca, or **Dr. Rob Feick**, Robert.feick@uwaterloo.ca. Further, if you would like to receive a copy of the results of this study, please contact either investigator.

I hope that the results of my study will be help local governments understand opportunities and challenges of using geosocial media for citizen reporting, and develop strategies to better adopt the new reporting method. I very much look forward to speaking with you and thank you in advance for your assistance with this project.

Sincerely,

Shanqi (Ashley) Zhang

PhD Candidate

Department of Geography and Environment Management

University of Waterloo

Information letter

You are invited to participate in a research study conducted by Shanqi Zhang, a PhD Candidate at the Department of Geography and Environmental Management, under the supervision of Dr. Rob Feick of the University of Waterloo, Canada. The study is for a PhD thesis.

The objective of the study is to explore the potential of citizens using geo-located social media to report 311 issues to local governments.

As a participant, you will be asked to an interview about how your organization currently validates and processes 311 reports and how you evaluate the quality and usefulness of geosocial media information for 311 reporting. The interview will combine a number of multiple choice questions and open-ended questions and will be approximately 40 minutes in length.

Participation in this study is voluntary. The interview will take place in a mutually agreed upon location. You may decline to answer any of the interview questions that you do not wish to answer. Further, although no negative impacts are anticipated, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview, a copy of the transcript will be sent to you so that you can confirm the accuracy of our conversation and add or clarify any points that you think are needed.

We would like to assure you that all of the information you provide will be kept confidential. Your name will not appear in any thesis or report resulting from this study. However, I may indicate which municipalities participated in the study. Given the small number of individuals who could reasonably speak to these issues within your office, a motivated individual may attempt to discern your identity. Further, anonymous quotations may be used with your permission.

The data, with no personal identifiers, collected from this study will be maintained on a password-protected computer database in a restricted access area of the university. This data will be electronically archived after completion of the study and maintained for a minimum of five years and then erased.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#21727). If you have questions for the Committee, contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

For all other questions contact Shanqi Zhang, s72zhang@uwaterloo.ca, or Dr. Rob Feick, Robert.feick@uwaterloo.ca. Further, if you would like to receive a copy of the results of this study, please contact either investigator.

Thank you for considering participation in this study.

Consent Form

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Shanqi Zhang at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

I have been informed that I may withdraw my consent at any time without penalty by advising the researcher.

I have been informed that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee and that questions that I may have for the Committee may be directed to Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

I have been informed that if I have any additional questions or comments about the study, I may contact Shanqi Zhang, s72zhang@uwaterloo.ca, or Dr. Rob Feick, Robert.feick@uwaterloo.ca.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study. YES NO

I agree to have my interview audio recorded. YES NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research. YES NO

Participant Name: ____________________________ (Please print)

Participant Signature: ____________________________

Witness Name: ________________________________ (Please print)

Witness Signature: ______________________________

Date: ____________________________

Appendix D: Cities Contacted for Interviews

City/County	Province	Population
City of Saskatoon	Saskatchewan	222,189
City of Regina	Saskatchewan	216,528
City of Moose Jaw	Saskatchewan	33,274
City of Moncton	New Brunswick	72,321
City of Fredericton	New Brunswick	56,224
City of Halifax	Nova Scotia	390,096
City of St. John's	Newfoundland	100,645
City of Charlottetown	Prince Edward Island	34,562
City of Calgary	Alberta	1,096,833
Strathcona County	Alberta	92,490
City of Edmonton	Alberta	928,182
City of Airdrie	Alberta	42,564
City of Red Deer	Alberta	100,418
City of Vancouver	British Columbia	603,502
City of Langley	British Columbia	104,177
City of Prince George	British Columbia	73,004
City of North Vancouver	British Columbia	84,412
City of Port Moody	British Columbia	32,975
City of Kelowna	British Columbia	117,312
City of Vernon	British Columbia	38,150
City of Winnipeg	Manitoba	663,617

City/County	Province	Population
City of Toronto	Ontario	2,615,060
City of Kitchener	Ontario	219,153
City of Waterloo	Ontario	98,780
Town of Oakville	Ontario	182,520
City of Oshawa	Ontario	149,607
Town of Milton	Ontario	84,362
City of Guelph	Ontario	121,688
City of Kingston	Ontario	123,363
City of St. Catharines	Ontario	131,400
City of Niagara Falls	Ontario	82,997
City of Cambridge	Ontario	126,748
City of Sault Ste. Marie	Ontario	75,141
City of Burlington	Ontario	193,871
Greater Sudbury	Ontario	165,175
City of Stratford	Ontario	31,465
City of Hamilton	Ontario	551,751
City of Barrie	Ontario	145,544
City of Mississauga	Ontario	781,057
City of Brampton	Ontario	570,290
City of Ottawa	Ontario	947,031
City of Montreal	Quebec	1,741,000

* interviewed cities

Appendix E: Survey Questions

This survey asks you questions about how do you evaluate the usefulness of geo-located social media information and how do you think local governments (e.g. City of Wateloo, City of Kitchener, and Region of Waterloo) could benefit from using geosocial media as a reporting method.

This survey will take you about 10-15 minutes. We appreciate your taking time to complete the survey.

<u>Section I: Motivation and Experience</u>

This section asks you questions about your experience with reporting issues (e.g. traffic, infrastructure, garbage, etc.) to the city (i.e. the City of Waterloo, the City of Kitchener, the Region of Waterloo).

1. Have you ever reported issues to the city before? Please check all the issues you have reported, and add other issues you have reported but are not listed here.

- ☐ Infrastructure (e.g. Pot holes, trail surface, sidewalk trip hazard) Traffic
- ☐ Garbage collection, Park litter
- ☐ Graffiti
- ☐ Parking
- ☐ Issues related to LRT construction

Other

2. What methods have your used to report issues to the city? And how would you rank your satisfaction with these methods? Please check all that apply.

	Extremely not satisfied	Not satisfied	Neutral	Satisfied	Extremely satisfied	Never Used
telephone / call city directly	○	○	○	○	○	○
send email	○	○	○	○	○	○
in-person (go to the city's office and talk to a representative)	○	○	○	○	○	○
post comments on city's website	○	○	○	○	○	○
post comments on city's official social media page or mentioning city's official social media account	○	○	○	○	○	○
using mobile application such as Ping Street	○	○	○	○	○	○

Other:

3. If you are not pleased with your previous experience with reporting to the city, why not?

4. If you have never reported issues to the city before, why not? Please check all that apply.

- ☐ Most issues do not seem too pressing
- ☐ I do not know how to report issues to the city
- ☐ Reporting issues seem to be too much effort
- ☐ Others:

5. Do you use social media such as Twitter, Facebook, and Flickr? If so, how often do you us them?

	Every day	A couple of times a week	A couple of times a month	Do not use at all
Twitter	○	○	○	○
Facebook	☐	☐	☐	☐
Flickr	○	○	○	○
Other	☐	☐	☐	☐

6. When you post information (i.e message and/or photos), do you add location information?

☐ Yes, very often

☐ Yes, sometimes

☐ Not at all

If you answered "not at all", why?

Section II: Usefulness of citizen reporting to the city

This section asks about your opinion on the usefulness of social media as a reporting mechanism.

7. How useful do you think the social media posts displayed on the map are for you to understand current conditions of roads and sidewalks?

	Not useful at all	Not useful	Neutral	Useful	Very Useful
Twitter Posts	○	○	○	○	○
Flickr	○	○	○	○	○

8. What methods did you use to judge the usefulness of these posts concerning road and sidewalk conditions?

- ☐ Whether the description matches with my knowledge
- ☐ Whether the post comes from a local government account (e.g. City of Waterloo, City of Kitchener)
- ☐ Whether the post comes from an official organisation account (e.g. Grand River Hospital, CBC news)
- ☐ Whether the post comes from people that I know (e.g. friends)
- ☐ Whether they are recent posts
- ☐ Whether there are photos associated with the post
- ☐ Whether the style of message is appropriate (e.g. no inappropriate words or short forms)

Other (please specify):

9. In general, what do you think are the advantages of using geo-located social media to report to the city? Please check all that apply.

- ☐ Citizens can report issues at any time
- ☐ Citizens can report issues from anywhere
- ☐ City staff can get most up-to-date reports and thus may respond more efficiently
- ☐ Citizens do not need to find contact information of the city to report
- ☐ The cost of reporting via social media is low
- ☐ It is easy to add pictures to social media to help city staff to understand the problem
- ☐ It is easy to add exact locations to social media so that citizens can report the location of issues easily and precisely
- ☐ Social media is a open communication platform so that citizens can see each other's reports as well as city staff's response
- ☐ Many people are using social media so that city staff can get more feedback from citizens
- ☐ Other:

10. In general, what concern you might have with reporting issues to the city using geo-located social media? Please check all that apply.

- ☐ It is not an official reporting method, and government officials may not respond
- ☐ It is not an official reporting method, and government officials may not treat these reports the same way as reports coming from other methods
- ☐ I do not know how to report via social media (e.g. use what format, keywords, hashtags)
- ☐ I do not want to make my report viewable to the public
- ☐ Sometimes the situation is too complicated to describe within a word limit (e.g. each Twitter message can only have 140 words maximum).
- ☐ I am more used to other reporting methods (e.g. phone, email) and would like to continue using them
- ☐ I don't want to add location information, because I don't want other people know where I am.
- ☐ Citizens' personal smartphone GPS may not be sufficiently precise, thus locations reported to city staff may not be accurate
- ☐ People often post emotional messages rather than describe what issues are on social media, therefore the reports may not be as trustworthy as reports coming from other methods
- ☐ The city will need to devote more personnel to processing and monitoring social media, and is less likely to consider social media as a reporting method
- ☐ Other:

Background

Please tell us a little about yourself. All of the information will be kept confidential.

11. Please choose your age group:

- ○ 18 - 25 years
- ○ 25 -35 years
- ○ 35 - 45 years
- ○ 45 - 55 years
- ○ 55 - 65 years
- ○ > 65 years
- ○ Prefer not to answer

12. Please choose your gender:

- ◯ Female
- ◯ Male
- ◯ Other
- ◯ Prefer not to answer

Thank you for participating in our study! Your feedback is extremely valuable.

If you would like a copy of the results, please leave your email in the following text box. The results will be sent to you by email at the address you provided by 2017/05/31.

We would like to assure you that this project has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. Should you have any comments or concerns resulting from your participation in this study, please contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

If you have any general comments or questions related to this study, please contact Shanqi Zhang, s72zhang@uwaterloo.ca, or Dr. Rob Feick, Robert.feick@uwaterloo.ca.

Appendix F: Survey Recruitment Materials

Social media recruitment

Shortened version (for Twitter with a word limitation):

"Check out Smart Sidewalks: http://rhea.uwaterloo.ca/smartsidewalks/! Find out how geo-located social media can be used to identify sidewalk issues."

Complete version:

"Check out Smart Sidewalks: http://rhea.uwaterloo.ca/smartsidewalks/. Find out how geo-located social media can be used to identify sidewalk issues and tell us about how do you evaluate the quality of geosocial media reports. This application is part of the research project "Citizen reporting through geosocial media: opportunities and barriers" implemented by Shanqi Zhang, PhD student at University of Waterloo, to explore the usefulness of geosocial media as a citizen-government reporting mechanism."

Recruitment Poster & Front page of Recruitment Flyer

Back page of Recruitment Flyer

What do we do?

Our research project *Citizen Reporting through GeoSocial Media: Opportunities and Barriers* aims to explore the potential of citizens using geo-located social media (i.e. social media post with locational information) to report issues to local governments. Citizens reporting sidewalk issues is used as a case study, and we are interested in how do you evaluate the quality of geo-located social media information in representing sidewalk issues.

Why should you participate?

As part of the research project, **Smart Sidewalks** maps sidewalk and LRT related social media messages and photos harvested from Twitter and Flickr. With more people sharing their observations, we hope that people can find up-to-date information about sidewalk conditions and avoid hazards when finding a pedestrian path.

Your input will be critical for us to evaluate the *quality and usefulness* of geosocial media information to be used for this purpose.

What do participants need to do?

A volunteer participant will be asked to complete two tasks.

First, follow the instruction on the web site and get an idea of what geo-located social media is and how can geosocial media be used.

Second, complete a **10-15-minute online survey** about how do you evaluate the usefulness of communicating social media information to local governments.

Who can participate?

Anyone with a minimum age of 14 can participate!

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision to participate is yours.

Verbal script for street recruitment

Hello, my name is Shanqi Zhang and I am a PhD student in the Department of Geography. I am inviting you to participate in my thesis research project entitled Citizen Reporting through Geosocial Media: Opportunities and Barriers. Citizens can report location-based issues to local governments using social media. The purpose of this study is to understand potential benefits and challenges for citizens using social media to report to local governments. I am using a case study of citizen reporting sidewalk issues, as frequently changing sidewalk conditions due to construction and unexpected hazards may raise issues of accessibility and safety.

If you volunteer as a participant in this study, you will be asked to use a web map application entitled Smart Sidewalks. You will browse geo-located social media messages and photos related to sidewalk/road conditions and LRT construction and evaluate their usefulness. You will then be asked to complete a short online anonymous survey related to the usefulness of geosocial media as a citizen-government reporting mechanism.

As a further option, you may choose to share your own observations of sidewalk conditions using your social media account(s). In doing so, you may help others to move around more easily and make Waterloo more pedestrian-friendly!

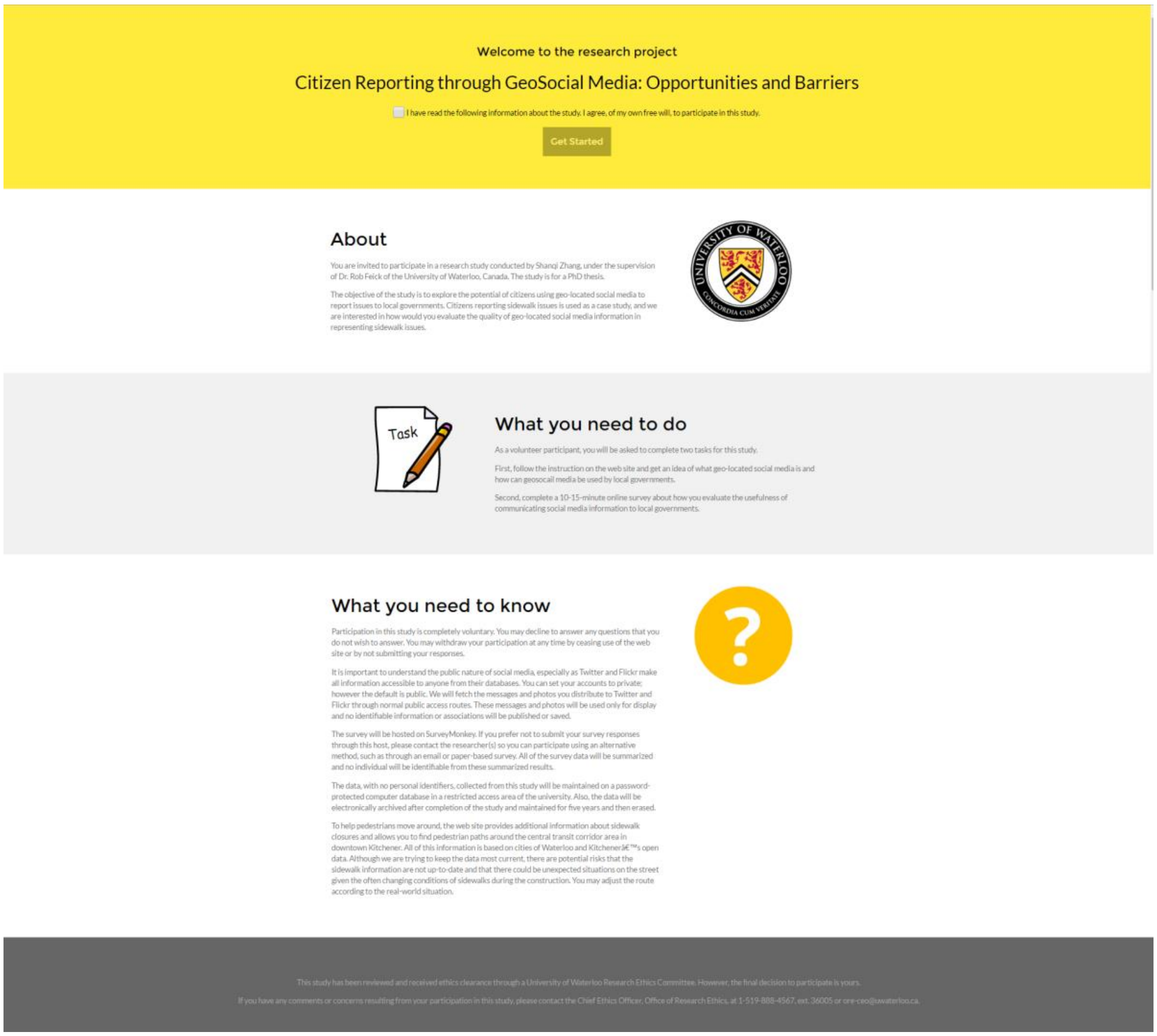
I would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours.

If you are interested in participating, please visit our website

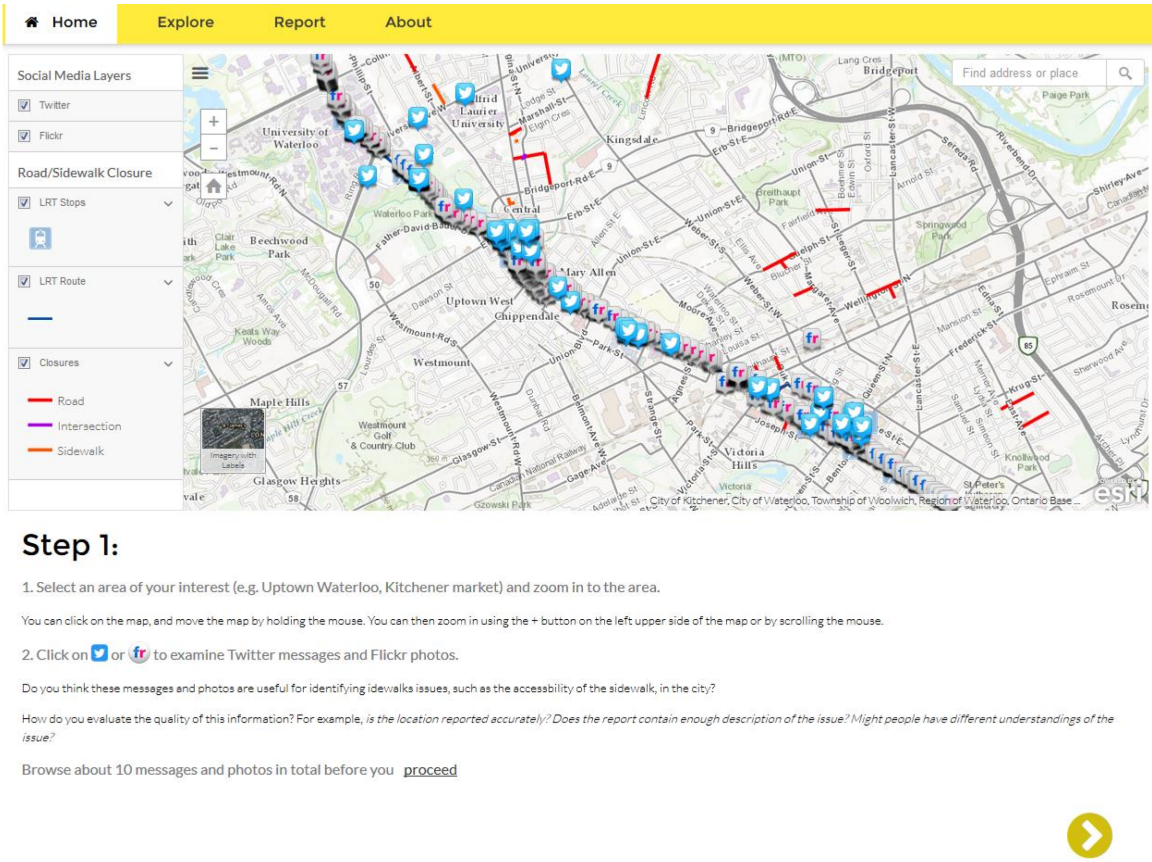
Thank you.

Appendix G: Screenshots of study website

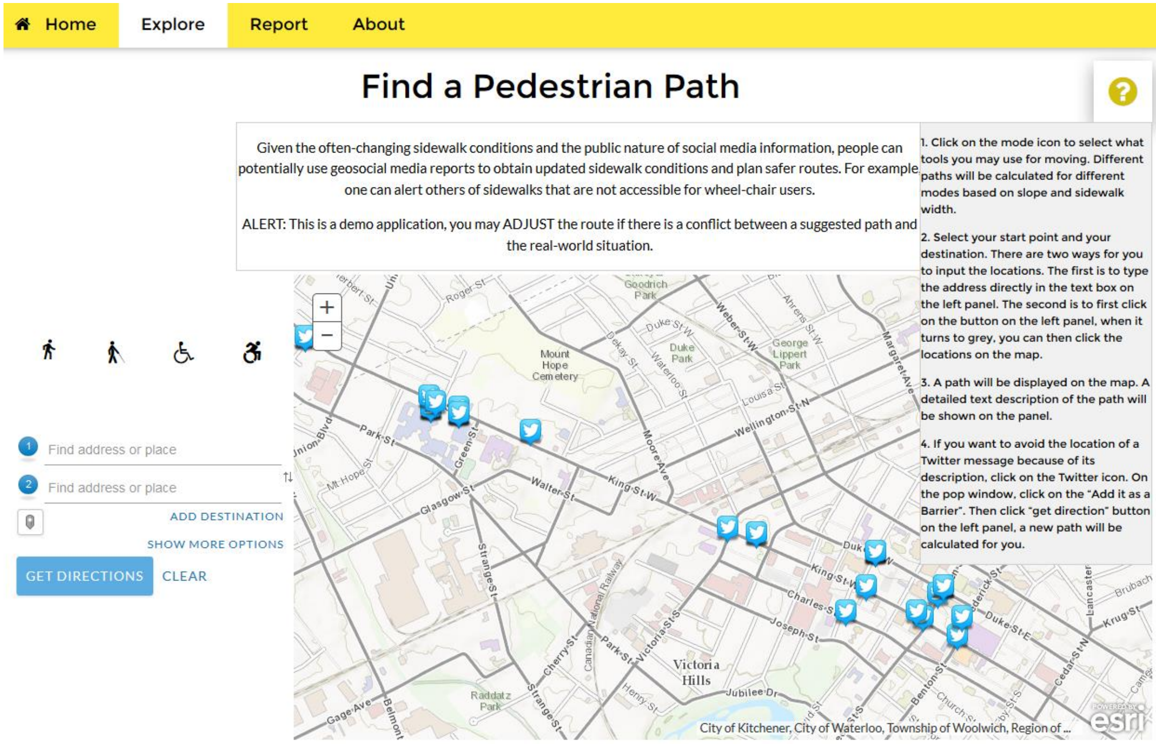
Landing page: Information Letter and Consent Form



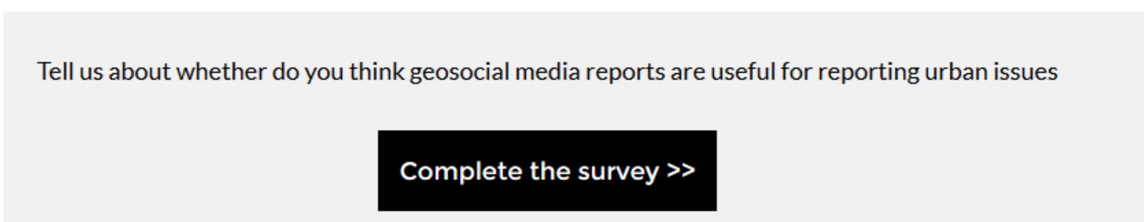
Step 1: Map interface that displays geo-located social media messages and photos



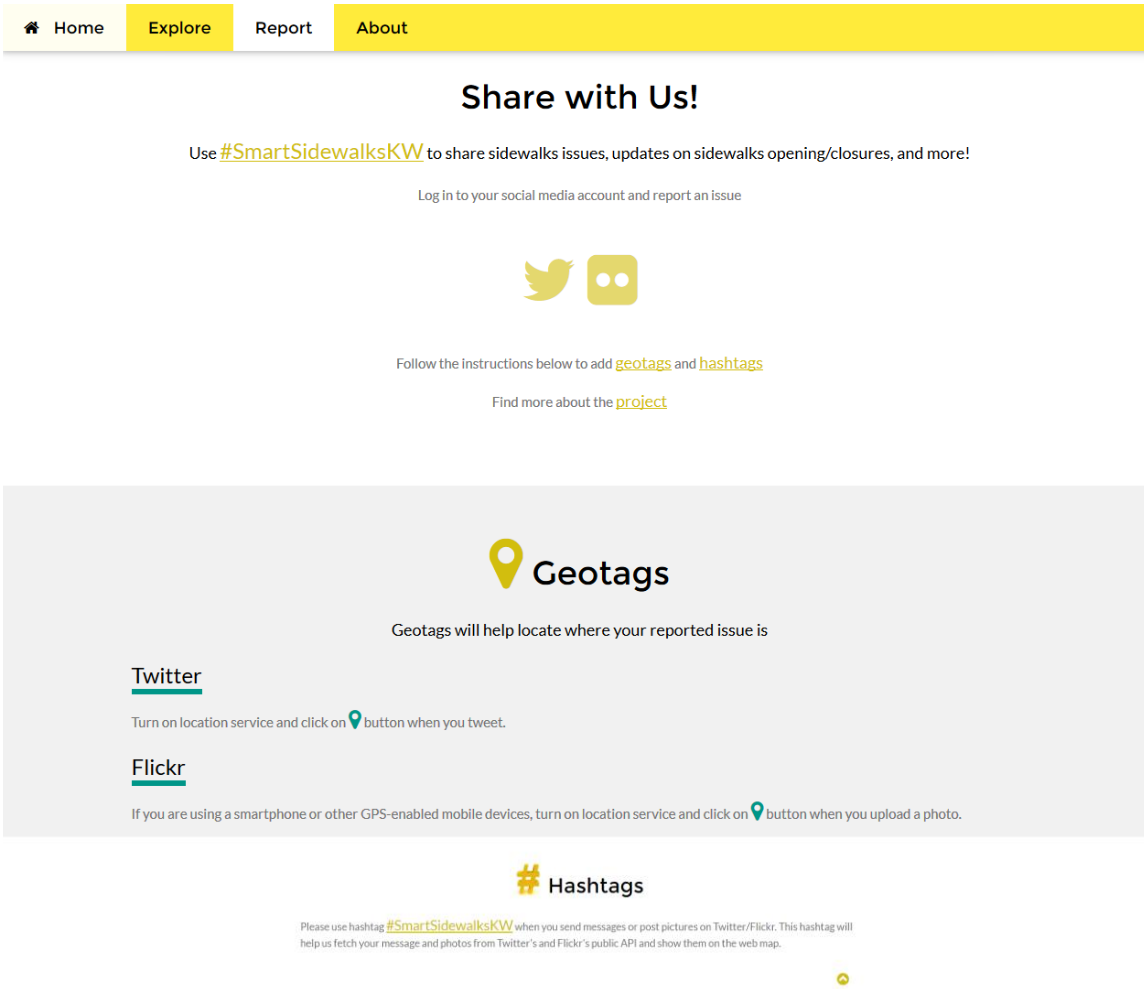
Step 2: Viewing potential application of geosocial media reports



Step 3: The interface that guides participants to the online survey



Introduction of how to add geotags to social media posts.



About page for frequently asked questions