Towards a Public Participatory GIS-Based Framework for Municipal Solid Waste Management

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Abstract. Municipal solid waste management (MSWM) is a global controversial environmental challenge globally. Participatory approaches in planning and decision making have been advanced as part of the strategies in order to attain sustainable waste management systems. However, achieving meaningful public participation for such systems is still a challenge. The need therefore remains to explore different ways in which public participation in MSWM can be enhanced. The use of Public Participatory GIS (PPGIS) has a potential to increase public participation in MSWM. However, its use still face hurdles from the social, institutional and political aspects that limit "public participation". This paper reports on a study that explores the social, political and institutional challenges affecting public participation in MSWM problem in Uganda. An exploratory study was conducted in Uganda's central region with key stakeholders in MSWM. The results were analyzed using thematic analysis based on the Enhanced Adaptive Structuration Theory (EAST-2) framework. The results show that knowledge and awareness, participant attitudes, institutional practices, political will and legislation are important for successful MSWM participatory planning process.

Keywords: Public participation · Geographic information systems · Participatory planning · Municipal solid waste management · Framework

1 Introduction

Participatory approaches in environmental planning are popular due to their support for sustainable development. The shift from top-down to bottom–up approaches that are participatory is motivated by the need to take care of location-specific concerns of stakeholders in policy making in a bid to solve environmental, economic and social problems [1]. Participatory approaches are relevant because environmental problems cannot be solved by only authorities, but by engaging stakeholders in the causes and solutions so as to secure democratic legitimacy of decision-making as a critical factor for good environmental governance [2].

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Using ICTs to support public participation refers to e-participation [3]. ICTs motivate and widen the participation spectrum of citizens, broaden their involvement in the policy process, generate real time qualitative and accessible information [4], proactively change spheres of public involvement [3], and motivated the discovery of Geographic Information System (GIS) to enhance environment management [5]. However, GIS has been criticized as an 'elite' technology that lacks suitable tools to solicit public views for effective planning and decision making, hence the introduction of Public Participatory GIS – PPGIS [5, 6]. PPGIS is a set of methods for integrating public knowledge of places to inform land use planning and decision making [6]. PPGIS is one of the e-participation tools that specifically support public participation in planning [7] and environmental decision-making processes [8, 9]. PPGIS facilitate understanding of environmental problems and allow players to highlight their points of view on maps [10].

Municipal Solid Waste Management (MSWM) is one of the environment challenges whose planning process can be enhanced by use of participatory tools such as PPGIS [11]. PPGIS can enhance MSWM by supporting several executive, operational, environmental, social and managerial decisions such as the siting of waste processing and disposal units, selection of waste-treatment technologies, and allocation of waste flow to processing facilities and landfills [12]. Higgs [13] emphasizes that participative IT-based methods that combine GIS and multi-criteria evaluation techniques when involving the public in the decision-making process, support consensus building and reduce conflicts involved in siting waste facilities.

Although there has been commendable progress in developing methods to involve non-experts in planning and decision-making using PPGIS tools, the field still faces several challenges [14]. However, these challenges are not technological, but are social, economic and political; and call for the need to enhance PPGIS capabilities with conceptual theories on political, social and economic issues [15]. To address this need, Enhanced Adaptive Structuration theory version 2 (EAST-2) is adopted as the theoretical framework to investigate political, social and economic hindrances of public participation. This investigation was contextualized by using MSWM as a case study. Section 2 presents related work on public participation and PPGIS in MSWM. Section 3 presents the design of an exploratory survey on public participation in MSWM, Sect. 4 presents results, Sect. 5 concludes the paper.

2 Related Work

2.1 Municipal Solid Waste Management (MSWM)

MSWM is the control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials by developing sustainable waste management strategies [16]. However, its implementation and adoption varies across countries due to factors such as: population density, transportation infrastructure, social economics and environmental regulations [17].

2.2 Public Participation in Municipal Solid Waste Management

Public participation in MSWM is crucial because everyone generates waste and they are affected indirectly or directly by poor waste management. However, citizens are normally regarded passive recipients of government services which inhibit their ability to explore the different roles in government service delivery [18]. Amidst complex MSWM challenges faced by municipalities in developing countries, citizen participation is a necessary component of the remedy. Public involvement in waste strategy and planning helps to transform traditional consultation techniques to incorporate deliberative and participatory activities that involve lay communities in decision making [19]. According to Garnett and Cooper [20] changing existing waste management practices and behaviors that are inherent in communities requires broader public participation in decision making. Public participation in waste management in crucial because: (1) landfill space is now scarce and yet the communities also are less likely to accept landfills to be sited near their habitation for environmental and health reasons, (2) systematic sorting of waste at the different stages right from the source to the disposal sites is inadequate, (3) manner in which waste is disposed of especially in the developing world may only suit participation of the public in order to reverse the effects of poor solid waste disposal, (4) public participation helps to build trust and avoid controversy over decisions, (5) public support is needed to implement policies [21–23].

Although public participation is important for the success of any waste management system, it is faced with many challenges. Several studies [22, 24, 25] report challenges faced for public participation in waste management. Other studies [22, 23] classify these challenges. Besides the classifications used by these scholars, in this study we adopt a classification based on EAST-2 constructs as presented in Table 1.

Table 1. Challenges for public participation in MSWM

Classification based on EAST-2 convening constructs	Challenges reported in literature under each classification
Social-Institutional Influence includes issues associated with laws and regulations, institutional arrangements and resource distribution	• Inadequate funding that limits resources for public participation in waste management [25] • Lack of structures and clear policies [20] • Public institutions are not willing to involve the public in planning for waste management [22] • Poor waste management infrastructure [26, 27]
Public Participant Influence includes issues associated with public knowledge, trust, and interest in waste management initiatives	• Poor attitude towards public participation in MSWM [23, 28] • Limited Public knowledge and awareness about different waste practices [28–30]
PPGIS/technology influence involves ability to use technology, access to data, and the functionalities offered by ICT systems	• Limited use of ICTs in waste management [31] • Inadequate ICT waste infrastructure [29] • Low technology access [29]

2.3 PPGIS Support for Public Participation in MSWM

Modern Participatory processes are quite often associated with interactive platforms such as discussion forums, collaborative software, web-GIS/internet-GIS and PPGIS to promote two-way interaction among the citizens and local authorities [10]. However, PPGIS is the commonly used platform in environmental planning [10]. Planning for MSWM can benefit from the implementation and uptake of PPGIS because MSWM issues have locational attribute [32]. Thus, public participation should be focused on the locational aspects of waste management aided by PPGIS [32, 33]. Idris and Mohd [21] also noted that PPGIS enables citizen to record and follow up their feelings and spatial knowledge regarding main problems of the city such as MSWM. In addition, PPGIS can tackle several factors simultaneously which need to be considered while planning waste management [34].

The potential of PPGIS to support public participation in planning and decision making is widely recognized in literature [35–37]. However, the actual use of PPGIS still faces many obstacles that go beyond the technology aspects [15, 38]. Babelon et al. [15] noted that a theoretical understanding of the social-technical aspects associated with the implementation and use of PPGIS is crucial. These aspects include:

- Tool design and affordances are concerned with the design, application and use values of PPGIS applications. Affordances are influenced by the functionalities of the tool.
- Organizational capacity concerns financial resources and skilled staff to facilitate uses participatory planning.
- Organizational capacity which is determined by parameters such as incentives, resource allocation, knowledge and experience sharing, early PPGIS application in the planning stages and PPGIS adaptability in all planning stages.
- Governance issues such as municipal governance structures and context are crucial for the design and implementation of PPGIS applications.

According to Brown and Kyatta [14] technical, social and political issues affect the implementation and uptake of PPGIS and these include: (1) Understanding and increasing participation rates, (2) Evaluating the effectiveness of PPGIS (the focus has been largely put on evaluating the technology not the process outcomes), and (3) Improving "PP" in PPGIS.

Sieber [6] developed a framework for analyzing PPGIS implementations. It considers coproduction of PPGIS as an integration of several aspects such as:

- Place and people dimension considers cultural influences, stakeholder relations and influences important for PPGIS implementation and subsequent acceptance.
- Technology and data dimension considers accessibility of data, representation of data, the cost of hardware and software and the extent of GIS technology for operationalization of PPGIS.
- Process outcome and evaluation considers discursive goals such as empowerment, social capacity and inclusion, equity and redistribution and expanded participation.

2.4 Applications of EAST 2

Public participation can be framed using complex decision situation. Enhanced Adaptive Structuration Theory EAST [39] and EAST-2 [40] are the frameworks that have been used to analyse and understand technology use in large group decision making situations. EAST-2 includes eight constructs that characterize complex decision. These constructs are categorised as convening, process and outcome. All EAST-2 constructs helps us to understand that information technology use in public participation is influenced by rather broad-based set of issues. Chang and Li [41] critiqued EAST 2 for not being robust to explain real-time synchronous geo-collaborations and suggested that participant profiles, task information, access to information and communication among participants are important for real time geo-collaborations. Porwol et al. [42] suggested that public participation process and real time geo-collaborations can benefit from dynamic capabilities orchestrated by the World Wide Web (WWW) such as ubiquitous participation and remote monitoring. Wang [43] applied EAST 2 to analyse Volunteered Geographical reporting systems and concluded that Participant's trust, beliefs (public participants influence aspects) and the role of convenor (social-institutional aspects) are not crucial. Modifications advanced [41–43] have been considered to adapt EAST-2 framework shown in Fig. 1.

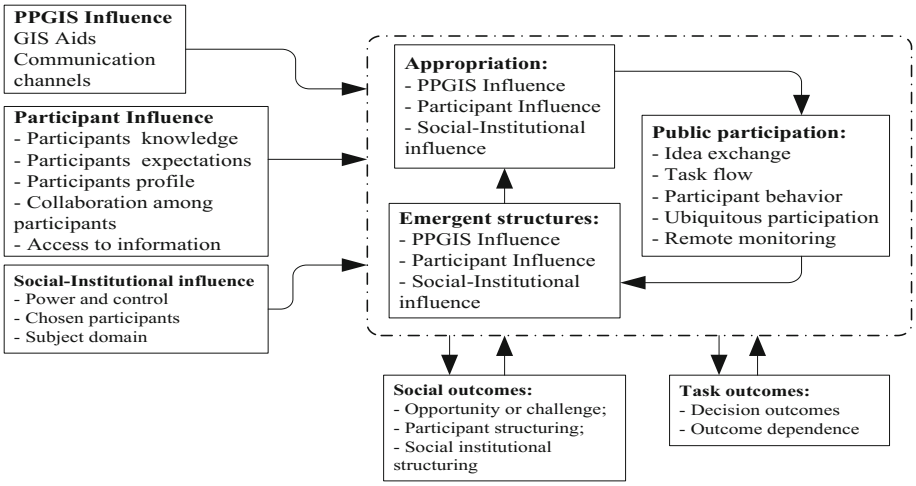

Fig. 1. Conceptual Framework PPGIS implementation in MSWM (Extension of EAST-2 by Jankowski and Nyerges [38])

3 Set up of the Exploratory Survey

The study sought to establish the factors influencing public participation in a participatory planning process for MSWM in Uganda. Qualitative exploratory study was done through conductive interviews with key stakeholders involved in planning for MSWM. The Interviews were conducted between January and March 2018. Table 2 shows key factors that were considered when designing the exploratory survey.

Table 2. Design of the exploratory interviews on challenges of public participation in MSWM

#	Parameter	Instantiations of the parameter in the study
1	Target population	• Solid waste officers, environmental officers, physical planners, field/landfill officers, managers and directors of waste collection contracted officers and landfill operators • The respondents were from Mukono, Entebbe and Kampala capital city Authority
2	Sample size	• Permission to conduct an exploratory study on public participation in MSWM was sought • The principle of saturation point in qualitative studies was based on to select 25 participants
3	Sampling method	Purposive sampling was used. Selection criteria for subjects that participated in the interviews were: • The availability or willingness of a respondent to allocate time to respond to Interview questions through a face-to-face dialog with the researcher • Having knowledge on waste management and also being involved in planning for MSWM
4	Data collection instrument	• A semi-structured interview guide to keep the researcher consistent with the flow of the questions • Face to face interviews were conducted (between the researcher and each respondent)
5	Data analysis	Thematic analysis was used to analysis [44] • Transcriptions were used to identify, name and categorize phrases and words in order to develop the initial codes • From the initial codes, themes were developed which were iteratively revisited to develop the final themes • Final themes were refined and named with EAST-2 view and matched with the convening constructs

4 Results

This section presents analyzes study findings using components of EAST 2.

4.1 Social-Institutional Influence on Participatory Planning Process

Results relating to social-institutional influence include: availability of resources, institutional practices and norms, legislation and mandate and political will.

Institutional practices and norms have an impact on public participation. Current municipal practices and norms in regard to planning for MSWM do not cater for involvement of stakeholders. "*It is a common practice with institutions not to involve stakeholders; however, there is a change where majority stakeholders are being brought on board"* (solid waste officer 1).

Availability of resources has an effect on Public participation in MSWM. Time, funds and human resources are needed to conduct successful participatory planning process. "*It is time consuming and costly to involve the stakeholders*" (solid waste officer 3). Availability of resources has an effect on a participatory planning and the subsequent outcomes because it has an impact on the number of stakeholders that can be involved in the process "*Budget constraints limit us on the number of stakeholders to involve in council meetings*" (solid officer 3).

Legislation and guidelines – A set of well established guidelines and procedures are needed prior to establishing a participatory planning process. Guidelines and legislations held to demonstrate the relevancy of stakeholders at each stage in planning and the premises of participation. At least 13 respondents reported lack of guidelines as one of the reasons for not involving stakeholders in planning for MSWM.

Political will – Municipal authorities are reluctant to involve stakeholders in the planning processes. "*Public participation hinders development so most institutions are not ready to involve the public and other stakeholders*" (solid waste officer 1).

4.2 Participant Influence on Participatory Planning Process

Results show that participant's knowledge and awareness of the existing MSWM practices has an influence on the participatory planning process. Participants give views based on the knowledge and experience they have. However, solid waste 2 and 4 noted that. "*Some stakeholders are at times not ware of existing MSWM practices and initiatives and some lack knowledge of MSWM principles*" In addition, public attitude towards municipal solid waste management initiatives and projects has an effect on participatory planning process. The public resist municipal solid waste initiatives. Thus, sensitization campaigns and negotiations have to be first carried out in order to prepare the public for change. "*Most people think that handling municipal waste is not their responsibility so they are not concerned*" (Field officer 1).

4.3 PPGIS and the Participatory Planning

Respondents reported limited application of ICTs especially GIS in MSWM practices; although ICTs are necessary component of any sound municipal solid waste system. "*ICTs such as GIS are rarely used. The entire process is still manual*" (solid waste officer 1). Also, views were collected on the awareness of the roles of GIS in waste management. All the 23 respondents agreed that they were aware of the roles GIS plays in municipal solid waste management processes especially in the selection of suitable sites for waste disposal, route scheduling and optimization, waste disposal site monitoring and management.

5 Discussions and Conclusions

The study investigated the social, institutional and technology aspects that affect participatory planning processes. The key aspects are legislation, institutional practices and norms, political will, knowledge and awareness challenges and attitude. Results show that the current institutional practices and norms do not favor participatory planning process. The current practice is that institutions make decisions without involving stakeholders especially the general public. These results are in line with findings of Minn et al. [27] who noted that decisions regarding planning and implementation of waste management strategies are made by municipalities without taking into consideration the concerns of the general public. In addition, results show that there is lack of knowledge on the general principles and practices in MSWM needed for public participation. Mukama et al. [25] also found that practices, concerns, and attitudes of residents in slum areas indicate lack of sufficient knowledge about good waste practices and their responsibilities in MSWM.

From the findings, participant's attitude towards a participatory planning process affects the process itself and the subsequent outcomes. The public feel it is the mandate of municipal authorities to handle all the municipal solid waste aspects and hence they are not interested in participating in any of the initiatives. Minn et al. [25] findings show people have indifferent attitude towards keeping public places clean and they too lack interest in participating in the drive for sustainable MSWM. Thus, change in attitude and behavior is critical for the success of public participation initiatives for MSWM.

We conclude that PPGIS implementations for successful public participation in MSWM require: sensitization of public on waste management practices, setting up ICT infrastructure and advocate for adoption of ICTs in MSWM, equip staff with skills to conduct participatory processes, allocate funds to conduct citizen participation projects and establish procedures for recruiting participants. At this preliminary stage, the study did not consider views of citizens so as to enrich views of institutions responsible for MSWM. Hence a limitation, that is to be explored in future work.

References

1. Sabatier, P.A., Leach, W.D., Lubell, M., Pelkey, N.W.: Theoretical frameworks explaining partnership success. In: Swimming Upstream Collaborative Approaches to Watershed Management, pp. 173–200 (2005). R, F.: Article title. Journal **2**(5), 99–110 (2016)
2. Bulkeley, H., Mol, A.P.: Participation and environmental governance: consensus, ambivalence and debate. Environ. Values **12**(2), 143–154 (2003)
3. Tambouris, E., Liotas, N., Kaliviotis, D., Tarabanis, K.: A framework for scoping eParticipation. In: 8th Annual International Conference on Digital Government Research, Bridging Disciplines & Domains, pp. 288–289 (2006)
4. Islam, M.S.: Towards a sustainable e-Participation implementation model. Eur. J. e-Pract. **5**(10), 1–12 (2008)
5. Butt, M.A., Li, S.: Developing a web-based, collaborative PPGIS prototype to support public participation. Appl. Geomat. **4**(3), 197–215 (2012)

6. Sieber, R.: Public participation geographic information systems a literature review and framework. Ann. Assoc. Am. Geogr. **96**(3), 491–507 (2006)
7. Nooshery, N.R., Taleai, M., Kazemi, R., Ebadi, K.: Developing a web-based PPGIS, as an environmental reporting service. In: International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, p. 42 (2017)
8. Brown, G.: An empirical evaluation of the spatial accuracy of public participation GIS (PPGIS) data. Appl. Geogr. **34**, 289–294 (2012)
9. Floreddu, P., Cabiddu, F., Pettinao, D.: Public participation in environmental decision-making: the case of PPGIS. In: Information Technology and Innovation Trends in Organizations, pp. 37–44 (2011)
10. Jankowski, P.: Towards participatory geographic information systems for community-based environmental decision making. J. Environ. Manage. **90**(6), 1966–1971 (2009)
11. Al-Shehhi, A., Aung, Z., Woon, W.L.: Argument visualization and narrative approaches for collaborative spatial decision making and knowledge construction: a case study for an offshore wind farm project. In: Woon, W.L., Aung, Z., Madnick, S. (eds.) DARE 2015. LNCS (LNAI), vol. 9518, pp. 135–154. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-27430-0_10
12. Ghiani, G., Laganà, D., Manni, E., Musmanno, R., Vigo, D.: Operations research in solid waste management: a survey of strategic and tactical issues. Comput. Oper. Res. **44**, 22–32 (2014)
13. Higgs, G.: Integrating multi-criteria techniques with geographical information systems in waste facility location to enhance public participation. Waste Manage. Res. **24**(2), 105–117 (2006)
14. Brown, G., Kyttä, M.: Key issues and research priorities for public participation GIS (PPGIS): a synthesis based on empirical research. Appl. Geogr. **46**, 122–136 (2014)
15. Babelon, I., Ståhle, A., Balfors, B.: Toward Cyborg PPGIS: exploring socio-technical requirements for the use of web-based PPGIS in two municipal planning cases, Stockholm region, Sweden. J. Environ. Plan. Manage. **60**(8), 1366–1390 (2017)
16. Environmental Protection Agency: Waste Classification (2014). http://www.epa.ie/waste/municipal/wasteclass. Accessed 02 Aug 2017
17. Sakai, S.: Municipal solid waste management in Japan. Waste Manag. **16**, 5–6 (1996)
18. Tadesse, S.: The economic value of regulated disclosure: evidence from the banking sector. J. Account. Public Policy **25**(1), 32–70 (2006)
19. Cotton, M.: Shale gas—community relations: NIMBY or not? Integrating social factors into shale gas community engagements. Nat. Gas Electr. **29**(9), 8–12 (2013)
20. Garnett, K., Cooper, T., Longhurst, P., Jude, S., Tyrrel, S.: A conceptual framework for negotiating public involvement in municipal waste management decision-making in the UK. Waste Manag. **66**, 210–221 (2017)
21. Idris, A., Mohd, N.: Overview of waste disposal and landfills/dumps in Asian countries. J. Mater. Cycles Waste Manage. **6**(2), 104–110 (2004)
22. Mukisa, P.K.: Public participation in solid waste management: challenges and prospects: a case of Kira Town council, Uganda. Master's thesis, Universitetet i Agder, University of Agder (2007)
23. Mukama, T., et al.: Practices, concerns, and willingness to participate in solid waste management in two urban slums in central Uganda. J. Environ. Public Health **2016**, 7 pages (2016)
24. Gorsevski, P.V., Torregrosa, A.M.: Android-based multi-criteria evaluation approach for enhancing public participation for a wind farm site selection. In: Sarjakoski, T., Santos, M.Y., Sarjakoski, L.T. (eds.) Geospatial Data in a Changing World. LNGC, pp. 87–103. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-33783-8_6

25. Amasuomo, E., Tuoyo, O.J.A., Hasnain, S.A.: Analysis of public participation in sustainable waste management practice in Abuja. Nigeria Environ. Manag. Sustain. Dev. **4**(1), 180 (2015)
26. Kinobe, J.R., Gebresenbet, G., Niwagaba, C.B., Vinnerås, B.: Reverse logistics system and recycling potential at a landfill: a case study from Kampala City. Waste Manag. **42**, 82–92 (2015)
27. Okot-Okumu, J., Nyenje, R.: Municipal solid waste management under decentralization in Uganda. Habitat Int. **35**(4), 537–543 (2011)
28. Shukor, F.S.A., Mohammed, A.H., Sani, S.I.A., Awang, M.: A review on the success factors for community participation in solid waste management. In: Proceeding of International Conference on Management, Penang, Malaysia (2015)
29. Kaza, Y., Mrkgraf, C.: Five ways to increase citizen participation
30. Hannan, M.A., Al Mamun, M.A., Hussain, A., Basri, H., Begum, R.A.: A review on technologies and their usage in solid waste monitoring and management systems: issues and challenges. Waste Manage. **43**, 509–523 (2015)
31. Minn, Z., Laohasiriwong, W.: Promoting people's participation in solid waste management in Myanmar. Res. J. Environ. Sci. **4**(3), 209–222 (2010)
32. Ganapati, S.: Uses of public participation geographic information systems applications in e-government. Public Adm. Rev. **71**(3), 425–434 (2011)
33. Labib, S.M.: Volunteer GIS (VGIS) based waste management: a conceptual design and use of web 2.0 for smart waste management in Dhaka City. In: Research in Computational Intelligence and Communication Networks (ICRCICN), Third International Conference 2017, pp. 137–141. IEEE (2017)
34. Ahmed, A.: Field Testing Volunteer Geographic Information Collection–The Viability of Community Mapping (2011)
35. Mansourian, A., Taleai, M., Fasihi, A.: A web-based spatial decision support system to enhance public participation in urban planning processes. J. Spat. Sci. **56**(2), 269–282 (2011)
36. Kahila-Tani, M., Broberg, A., Kyttä, M., Tyger, T.: Let the citizens map—public participation GIS as a planning support system in the Helsinki master plan process. Plan. Pract. Res. **31**(2), 195–214 (2016)
37. Simao, A., Densham, P.J., Haklay, M.M.: Web-based GIS for collaborative planning and public participation: an application to the strategic planning of wind farm sites. J. Environ. Manage. **90**(6), 2027–2040 (2009)
38. Bugs, G., Granell, C., Fonts, O., Huerta, J., Painho, M.: An assessment of Public Participation GIS and Web 2.0 technologies in urban planning practice in Canela, Brazil. Cities **27**(3), 172–181(2010)
39. Nyerges, T.L., Jankowski, P.: Enhanced adaptive structuration theory: a theory of GIS-supported collaborative decision making. Geogr. Syst. **4**, 225–260 (1997)
40. Jankowski, P., Nyerges, T.: Toward a framework for research on geographic information-supported participatory decision-making. URISA J. **15**(1), 9–17 (2003)
41. Chang, Z., Li, S.: Geo-social model: a conceptual framework for real-time geo-collaboration. Trans. GIS **17**(2), 182–205 (2013)
42. Porwol, L., Ojo, A., Breslin, J.G.: An ontology for next generation e-Participation initiatives. Gov. Inf. Q. **33**(3), 583–594 (2016)
43. Wang, M.: Volunteer geographic information reporting system: a cross-case comparison, Doctoral dissertation (2015)
44. Braun, V., Clarke, V.: Using thematic analysis in psychology. Qual. Res. Psychol. **3**, 77–101 (2006)