A Theoretical Framework for GIS-Enabled Public Electronic Participation in Municipal Solid Waste Management

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Abstract. Population growth, urbanization and industrialization are increasing the amounts of solid waste generated in municipalities globally. Municipal solid management (MSWM) is complex and requires active and broader stakeholder participation to achieve sustainable solutions. However, existing solutions to MSWM challenges lack public participation. Although public participatory geographic information systems (PPGIS) may be used to solicit stakeholders' views in planning for spatial environmental issues, there is a need to develop robust theoretical frameworks to guide their development and use. This study sought to extend the adaptive structuration theory-2 (EAST-2) to develop a comprehensive theoretical framework for the use of PPGIS applications to ensure effective public participation and social inclusion in MSWM. Additional constructs as suggested in literature were added to the existing EAST-2 framework. Data were collected cross-sectionally from MSWM stakeholders in central-Uganda and analyzed using partial least squares structural equation modelling. In the revised framework, participant influences, technology influences and task influences influence GIS-enabled participatory decision-making processes. The revised framework could be used to guide GIS-enabled participatory processes in different environmental problems in similar resource-constrained settings.

Keywords: Geographic information systems · Participatory planning · Municipal solid waste management · Uganda

1 Introduction

Globally, the high population growth, urbanization and industrialization have tremendously increased waste generation in municipalities. Annually, 2.01 billion metric tons of wastes are generated globally [1]. In Sub-Saharan Africa, 62 million tons of waste are generated annually [2]. Therefore, efficient, and effective municipal solid waste management (MSWM) is a global priority. However, current MSWM systems are not well planned [3] and are therefore inefficient and not effective [2].

Several strategies to address MSWM challenges have been proposed. These include Life Cycle Assessment [4], Cost-Benefit Analysis [5], Multi-criteria Decision Analysis (MCDA) [6], and MCDA integrated with Geographic Information Systems (GIS).

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Regardless of the strategy adopted, public participation is central to achieving sustainable solutions [7]. Public participation ensures that MSWM challenges are identified and addressed [8].

Public participation in government administrative process can be supported by different tools such as public hearings, focus groups, and public education, interviews, electronic mails, faxes, volunteered Geographic Information (VGI), PPGIS, discussion forums and chat rooms [9]. However, other participation methods, other than PPGIS, reach fewer participants and are ineffective for gathering useful information for planning [10]. PPGIS is one of the e-participation tools that have been specifically developed to support the solicitation of public views for planning purposes [11]. However, there are concerns that PPGIS lack theoretical and conceptual foundations [12]. Theoretical concepts and foundations help to reduce the complexity associated with GIS use in collaborative decision making [13].

This study sought to develop a comprehensive theoretical framework that supports the implementation of PPGIS in MSWM in resource-limited settings (RLS). To this end, the Enhanced Adaptive Structuration Theory (EAST-2) was adapted, and modifications made to increase public participation. The development and testing of the proposed framework were guided by design science. Design science is preferred over other methods of framework development because it clearly specifies the two major processes of "build" and "evaluate", which are important in developing frameworks [14]. Additionally, it is a flexible method which can be combined with other methods such as action research, case studies in order to enhance its contribution to theory [15].

After the introduction, the remainder of this paper is structured as follows. Section 2 covers the key literature review on MSWM, public participation, and theories for ICT-enabled collaborations. Section 3 explains the research methods for this study. Section 4 presents the study findings while Sect. 5 presents the discussion and the conclusions.

2 Related Work

2.1 Municipal Solid Waste Management in the Ugandan Context

Municipal solid waste management (MSWM) involves the control of generation, storage, collection, transport, processing and disposal of solid waste materials in a way that best ensures public health and environmental safety [16]. Therefore, MSWM is a core service that municipalities should offer to its inhabitants in order to minimize the potential health and environmental hazards [17].

In Uganda, the amount of waste generated is increasing due to rapid population growth and industrialization. The management of solid is a function of local government and urban councils (UCs); municipal authorities are therefore responsible for the collection, transportation and disposal of all waste [18]. However, MSWM is largely inefficient and ineffective due to limited funding and poor infrastructure [17]. Therefore, there is limited coverage of MSWM, waste transportation routes are not planned [19], and there is indiscriminate and illegal waste dumping [18, 20]. These gaps are compounded by inadequate public participation in MSWM decision making [19]. Therefore efficient MSWM approaches, including public participation, are needed for across municipalities [21, 22].

2.2 The Role of Public Participation in Municipal Solid Waste Management

Public participation in environmental decision making is one of the strongest pillars for sustainable development. Environmental issues are better handled by ensuring broader stakeholder participation [7, 24], including citizens at all levels [23]. Public participation ensures that popular decisions and policies are implemented [24]. However, public participation in MSWM has received less attention [25]. In Uganda, inadequate MSWM is attributable to the lack of public participation [20]. Therefore, public participation should be incorporated and evaluated at all stages of solid waste management [26].

2.3 Methods of Public Participation

Public participation in governmental administrative processes can be implemented using both traditional and ICT-enabled methods (E-participation). Traditional public participation involves the use of physical participatory mechanisms such as surveys, public meeting, and interviews [9]. On the other hand, E-participation involves using modern two-way modern techniques such as PPGIS, Web GIS, volunteered geographic information, social media, discussion forums and chat rooms, games, collaborative software, and 3D virtual animations [27]. E-participation enhances and is complementary to traditional participation activities [28].

2.4 Public Participatory Geographic Information Systems (PPGIS)

PPGIS involves the use of GIS for public participation [29]. Its goal is to ensure the participation of stakeholders who would have otherwise been left out by the traditional tools [30, 31]. PPGIS decision-making includes discussions between stakeholders to clarify and resolve existent spatial MSWM challenges. PPGIS integrates people, GIS data, exploratory tools in order to maximize the participation of all stakeholders [32].

2.5 Theories for Analyzing E-Participation

E-participation is best analyzed using structural frameworks [33]. Structural frameworks help to deconstruct the decision support system into components that can be accomplished by appropriate tools and technologies. Examples of structural frameworks used for e-participation include Adaptive Structuration Theory [34], Enhance Adaptive Structuration Theory (EAST) [35], and Enhanced Adaptive Structuration Theory (EAST-2) [36].

2.6 Enhanced Adaptive Structuration Theory (EAST-2)

In this study, EAST-2 was selected for modification because it was specifically developed for analyzing group decision making and use of PPGIS [36]. The framework comprises of constructs and aspects that describe participatory decision making. The constructs show the structure and aspects that address the content of participatory decision making [37]. The EAST-2 framework is divided into three construct categories that characterize the complex decision-making processes of public participatory GIS

(PPGIS). The construct categories are convening, process and the outcome constructs. In these three construct categories, eight influences are prescribed: social-institutional influences, group-participant influence, PGIS influence, appropriation, group process, emergent influence, task outcomes, and social outcomes [36]. Thus, EAST-2 categorizes 'participation' into 25 aspects, and eight constructs.

2.7 Extending the Adaptive Structuration Theory-2

As shown in Fig. 1, the EAST-2 framework was adapted to develop an extended version that provides a robust theoretical framework for PPGIS adoption in RLS. The aspects and constructs that have been previously been found to be important in GIS-enabled collaborative decision making were systematically included to the original EAST-2.

Task Influence was added on the existing three convening constructs. The influence of task on the utilization of technology in social interaction is well described [34] and considers the content of a task as a source of structures that affect the actual use of technology in participation. In addition, the nature of the task influences the choice of technology and its use [38].

To ensure spatial MSWM planning, reading background information, generating alternatives, evaluating alternative, 'discuss plan' and collaboration among participants were added to the original decision process construct [39]. In addition, the process of participation benefits from the dynamic capabilities orchestrated by ICTs [40]. The dynamic capabilities from the dynamic capabilities theory that are important for public participation - ubiquitous participation and monitoring of the process [40] were added onto the "decision process construct".

Organizational aspects that enhance PPGIS were identified from the literature and added on the "social-Institutional influence" construct. These include (1) availability of resources [41], (2) access to spatial data [42], (3) assess the impact and outcomes of PPGIS [12] and (4) procedures for integrating public input in the final decision [12]. The participant influence aspects that were added to this construct include motivation and incentives [43], skills and experience [41], collaboration and knowledge sharing [43] and perceptions of other peoples' knowledge [12].

EAST-2 does not consider aspects related to the evaluation of the decision outcomes [44]. Therefore the evaluation parameters of efficiency finance, equity, accountability, conformance to values and sustainability [45], were added to the decision outcome construct.

2.8 Study Hypotheses

Based on the nine constructs in the extended EAST-2 framework, eight null hypotheses were tested:

1. H_1: PPGIS influence has a positive significant effect on the appropriation of PPGIS in a participatory decision process.
2. H_2: Social-Institutional Influences have a positive significant effect on the appropriation of PPGIS influences in a participatory decision process.

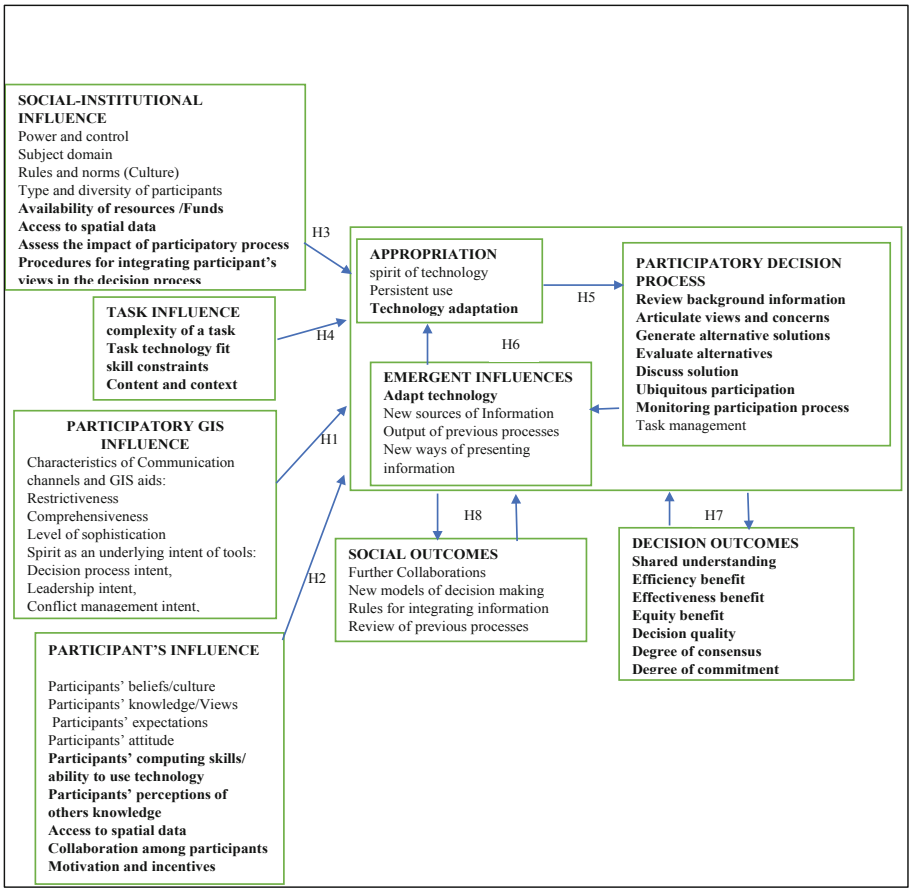

Fig. 1. Proposed extended EAST-2 framework* Note: the constructs which were added to the revised framework are in bold.

3. H_3: Public Participant Influences have a positive significant effect on the appropriation of PPGIS influences in a participatory decision process.
4. H_4: Task influence has a positive significant effect on the appropriation of PPGIS Influence in a participatory decision process.
5. H_5: Appropriation has a positive significant effect on the participatory decision process.
6. H_6: participatory decision process has a positive significant effect on the social outcomes of a participatory decision process.
7. H_7: Appropriation has a positive significant effect on the decision outcomes of a participatory decision process.
8. H_8: Appropriation has a positive significant effect on the social outcomes of a participatory decision process.

3 Methodology

3.1 Study Design and Survey Participants

A cross-sectional survey was conducted among stakeholders in MSWM in Uganda's rapidly growing urban areas of Kampala, Wakiso, Entebbe, Mukono, Mbarara and Busia. In the Ugandan context, stakeholders included residents, solid waste officers, health inspectors, environmental officers, landfill officers, waste recyclers, physical planners, and waste pickers.

3.2 Data Collection and Data Collection Tools

A Likert scale-based self-administered questionnaire was used to collect data to measure the nine latent variables. The questionnaire consisted of two parts. The first part consisted of questions on the nine variables in the proposed framework. Questions were arranged basing on the constructs in the proposed framework. The scale had 5 points, 1 (strongly disagree) to 5 (strongly agree). An option for 'not sure' was provided to avoid forced responses. The questionnaire was pretested on 15 respondents to determine reliability and validity and the suggested improvements were made before the survey. The second part of the questionnaire collected respondent demographics, including gender, age, the highest level of education and years of experience.

Stratified random sampling approach was used to select participants. The prospective study population was divided into municipal staff, the staff of agencies contracted for MSWM and the public. The study participants were then randomly from these groups.

3.3 Data Processing and Analysis

Partial least squares structural equation modelling (SEM) using SmartPLs 3.2.8 [46], was used to test the relationships between the measures and to fit the final structural model. Variables with loadings and path coefficients lower than the recommended values were omitted from the final model. Path coefficients for the trimmed model were then tested. Internal consistency was measured by Cronbach alpha and the recommended acceptable value (0.70) was used [47]. Convergent validity was measured by the average variance extracted (AVE) and a validity threshold of 0.50 used. The structural model included unobservable latent variables and their theoretical relationships [48].

4 Results

4.1 Characteristics of the Participants

Overall, 500 participants were enrolled, the majority of whom were male (65.2%), with at least diploma level education (58.3%). However, 97% had working experience for less than 10 years (Table 1).

Table 1. Demographics of participants (n = 500)

Characteristics	Frequency	Per cent
Gender		
Female	105	34.8
Male	195	65.2
Level of education		
Primary	39	12.9
Secondary	87	28.8
Diploma	86	28.5
Degree and above	90	29.8
Years of experience		
0-10 years	293	97.0
10-20 years	7	2.5
≥20 years	2	0.7

Table 2. Reliability results

Constructs	Cronbach's alpha	Composite reliability	AVE
Appropriation	0.724	0.844	0.644
Emergent structures	0.779	0.858	0.602
Organizational influence	0.880	0.907	0.582
Participatory decision process	0.774	0.848	0.529
Decision outcomes	0.856	0.888	0.499
Participant influence	0.850	0.883	0.487
Social outcomes	0.769	0.852	0.591
Task influence	0.767	0.851	0.588
Technology influence	0.806	0.861	0.510

4.2 Measurement Model

Overall, there was high internal consistency. The values of Cronbach's alpha, composite reliability, and AVE for the nine latent variables ranged from 0.724 to 0.856, 0.844 to 0.907, and 0.510 to 0.644, respectively (Table 2).

Additionally, the square roots of the AVEs were greater than the off-diagonal elements in their corresponding column (Table 3). Thus, most of the constructs in this study were valid.

Table 3. Discriminant validity

Construct	Appropriation	Emergent structures	Institutional influence	Participatory decision process	Decision outcomes	Participant	Social outcomes	Task	Tech influence
Appropriation	0.802								
Emergent structures	0.631	0.776							
Organizational influence	0.491	0.592	0.763						
Participatory decision process	0.697	0.748	0.575	0.727					
Decision outcomes	0.647	0.714	0.590	0.734	0.706				
Participant influence	0.510	0.606	0.724	0.542	0.610	0.698			
Social outcomes	0.575	0.660	0.572	0.633	0.727	0.545	0.769		
Task influence	0.527	0.643	0.535	0.607	0.557	0.560	0.524	0.767	
Technology influence	0.582	0.670	0.665	0.658	0.665	0.625	0.600	0.549	0.714

4.3 Structural Model

Coefficient of Determination (R2): Figure 2 shows the validated structural model, with the path coefficients and coefficient of determination (R2). The path coefficients indicate the strength of the relationships between the variables. Together, participant technology, task and institutional explain 46.1% of the variance in the appropriation of technology. All path coefficients were positive. Technology appropriation explains 64.3% of the variance in the participatory decision-making process. Also, participatory decision-making process explains 40.0% and 53.9% variances in social outcomes and participatory decision-making task outcomes, respectively.

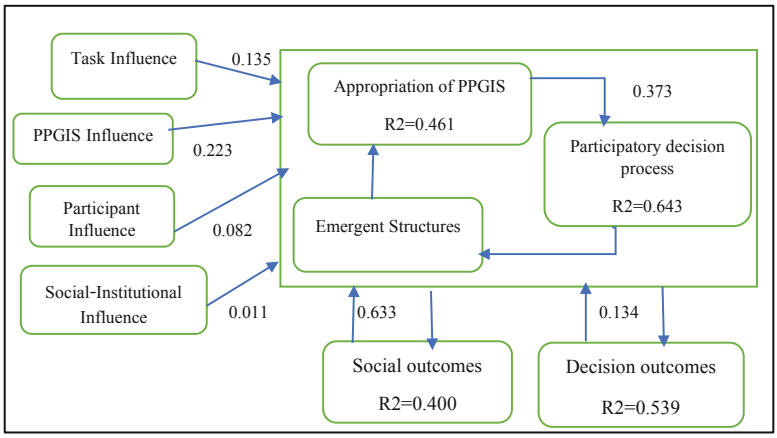

Fig. 2. Structural model

Significance of Factors and Path Coefficients: To test for the significance of path coefficient, we used bootstrapping and two-tailed test to generate estimates of t-values and p-values for the indicators and path coefficients (Table 4).

4.4 Hypothesis Testing Results

Overall, there was statistically a significant relationship between Appropriation and Participatory decision process (*p-value* < 0.001). Similarly, there was statistically a significant relationship between emergent structures and participatory decision process (*p-value* < 0.001) and appropriation (*p-value* < 0.001). Similarly, there is a statistically significant relationship between participatory decision process and decision outcomes (*p-value* < 0.001) as well as social outcomes (*p-value* < 0.001). In addition, there was a statistically significant relationship between technology influence and appropriation (*p-value* < 0.002). However, there was no statistically significant relationship between the appropriation of technology and participant influence (*p-value* $= 0.220$), as well as with organizational influence (*p-value* $= 0.882$). Additionally, there was a weak but not statistically significant relationship between task influence and appropriation of technology, but this relationship was not statistically significant (*p-value* $= 0.066$).

Table 4. Significance of path coefficient

Relationship between variables	SD	t-statistic	P-value
Appropriation → Participatory decision process	0.047	8.02	<0.001
Emergent structures → Appropriation	0.079	4.27	<0.001
Emergent structures → Participatory decision process	0.050	10.23	<0.001
Organizational influence → Appropriation	0.072	0.15	0.882
Participatory decision process → Decision outcomes	0.034	21.90	<0.001
Participatory decision process → Social outcomes	0.039	16.06	<0.001
Participant influence → Appropriation	0.066	1.23	0.220
Task influence → Appropriation	0.073	1.84	0.066
Technology Influence → Appropriation	0.072	3.11	0.002

Note: SD means standard deviation

5 Discussion and Conclusion

This study developed a comprehensive theoretical framework for guiding the implementation of GIS-enabled participatory processes to support planning and decision making in MSWM. The developed framework extended the EAST-2 framework to include the spatial planning process, decision outcome, evaluation, and social aspects. These aspects have previously been reported to influence the use of PPGIS in governmental administrative process. Nine relationships between variables were tested, six of which were statistically significant. This study validated the impact of technology influence on appropriation. Similarly, the impact of emergent structures on appropriation and participatory decision process was validated. In addition, the impact of participatory decision process on social and decision outcomes was also validated. Finally, there was also a relationship between appropriation and the participatory decision process. However, the social aspects such as those related to the individual participants, institutions and task influence did not have an impact on the appropriation of technology in a participatory decision process. This is potentially due to the infancy stage of utilization of technology to support participatory MSWM processes.

5.1 Relationships Among Variables

This study suggests that the characteristics and intent of a technology have a direct bearing on how the participatory process is conducted and ultimately on the outcomes. This finding is consistent with prior research. Schmitz *et al.* [49] found that the use and adaptation of technology enhance job performance. Similarly, technology enhances decision making in virtual teams and ultimately increases the amount of work accomplished [50].

Concerning Task influence, our study found a positive relationship between the nature of a task and the technology used. These findings are in line with Zigurs and Buckland [51] who supported the argument that task characteristics, such as complexity, are important in Group decision support systems.

Regarding the appropriation of PPGIS influences, there was a significant relationship between participatory decision process and decision outcomes. This finding is consistent with previous literature findings which have shown that ICT is necessary for group decision making [52]. The ICT tools that can potentially enhance group decision making include groupware, decision support systems (DSS), and telecommunications that are needed for quick and yet sustainable decision making. ICTs improve group and individual performance [53], quality and type of decisions [35, 54].

Regarding social outcomes, we found a relationship between Appropriation of PPGIS in a participatory decision process and the social outcomes. Group decision processes not only result in task-related outcomes but also for the strong ties between participants and organizations responsible for these processes [36, 55].

However, the study was unable to find a relationship between Social-institutional influence and appropriation in a participatory decision process This finding is inconsistent with prior literature that suggests that social influences affect uptake and utilization of technology in group support systems (GSS) and within an organization [37, 56]. Additionally, the literature suggests that social-institutional influences affect the use of technology in collaborative processes [35, 56]. The lack of relationship between social-Institutional influence and appropriation in this study may be attributed to the differences MSWM in most RLS and developed countries. Whereas public participation could be in advance stages in developed countries, developing countries are yet to embrace citizen engagement in governmental decision making [57].

Regarding participant influence, we did not find a significant effect of appropriation of PPGIS influence in a participatory process. This finding is inconsistent with prior literature that has reported the relationships between individual characteristics and technology use when executing a task [58]. The null finding in this study may be explained by the poor attitude towards MSWM initiatives by citizens and limited adoption of technology in MSWM process [25].

5.2 Application of the Extended EAST-2 Framework

The field of PPGIS is still evolving and faces social, political, and economic challenges, especially in RLS. Thus, the salient social, political, and economic factors identified in this study have a potential to contribute to the successful adoption and implementation of PPGIS applications in RLS. Also, the recent developments including COVID-19 pandemic make traditional PPGIS approaches unfeasible. The identified factors include establishing guidelines and procedures for evaluating public participation, access to spatial information, integrating generated data, and solicitation of financial and human resources.

The results of this study suggest that municipalities and cities intending to involve the public in MSWM should ensure equitable access to information, training, public participation, formulation of guidelines for conducting and evaluating participatory process.

5.3 Limitations

This study was conducted in urban areas therefore the performance of the framework should be investigated in rural settings. However, across many RLS, waste management is more challenging in urban settings. Additionally, in most RLS the use of spatial technologies and other ICT in MSWM is still in the infancy phase. Therefore, there is a need to study the adoption process and establish a clear understanding of the different stages, activities, expertise, and the social-economic dynamics of the field. This study relied on data from a survey among stakeholders. The results should be validated through a field experiment.

5.4 Conclusion

This study developed and tested a framework to support GIS-enabled public participation implementations for MSWM especially in RLS. The study validated the positive relationships between hitherto investigated aspects and PPGIS. The revised EAST-2 framework may comprehensively ensure public participation in MSWM. The findings of this study contribute to the implementation of PPGIS especially in RLS where PPGIS is in infancy stages. The revised framework could accelerate the adoption of PPGIS in RLS amidst the ongoing COVID-19 epidemic that has threatened traditional public participation avenues in most developing countries.

References

1. Kaza, S., Yao, L., Bhada-Tata, P., Van Woerden, F.: What a waste 2.0: a global snapshot of solid waste management to 2050 (2018). https://doi.org/10.1596/978-1-4648-1329-0
2. Kawai, K., Tasaki, T.: Revisiting estimates of municipal solid waste generation per capita and their reliability. J. Mater. Cycles Waste Manag. **18**(1), 1–13 (2015). https://doi.org/10.1007/s10163-015-0355-1
3. Vergara, S.E., Tchobanoglous, G.: Municipal solid waste and the environment: a global perspective. Annu. Rev. Environ. Resour. **37**, 277–309 (2012). https://doi.org/10.1146/annurev-environ-050511-122532
4. Tulokhonova, A., Ulanova, O.: Assessment of municipal solid waste management scenarios in Irkutsk (Russia) using a life cycle assessment-integrated waste management model. Waste Manag. Res. **31**, 475–484 (2013). https://doi.org/10.1177/0734242X13476745
5. Zhou, C., Gong, Z., Hu, J., Cao, A., Liang, H.: A cost-benefit analysis of landfill mining and material recycling in China. Waste Manag. **35**, 191–198 (2015). https://doi.org/10.1016/j.wasman.2014.09.029
6. Soltani, A., Hewage, K., Reza, B., Sadiq, R.: Multiple stakeholders in multi-criteria decision-making in the context of municipal solid waste management: a review. Waste Manag. **35**, 318–328 (2015). https://doi.org/10.1016/j.wasman.2014.09.010
7. 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). https://doi.org/10.1016/j.wasman.2017.04.022
8. Ndururi, J., Muriithi, J., Ochola, S.: The influence of stakeholder participation strategies on domestic waste management in Biashara residential area, RUIRU. ijssit.com (2019)
9. Kingston, R.P.: Public participation in local policy decision-making: the role of Web-based mapping. Cartogr. J. **44**, 138–144 (2007). https://doi.org/10.1179/000870407X213459

10. 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**, 195–214 (2016). https://doi.org/10.1080/02697459.2015.1104203
11. 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 and Spatial Information Sciences - ISPRS Archives, pp. 115–121. International Society for Photogrammetry and Remote Sensing (2017). https://doi.org/10.5194/isprs-archives-XLII-2-W7-115-2017
12. 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). https://doi.org/10.1016/j.apgeog.2013.11.004
13. Nyerges, T., Jankowski, P.: Enhanced adaptive structuration theory: a theory of GIS-supported collaborative decision making. Geogr. Syst. **4**, 225–260 (1997)
14. Järvinen, P.: Action research is similar to design science. Qual. Quant. **41**, 37–54 (2007). https://doi.org/10.1007/s11135-005-5427-1
15. Weber, S.: Design science research: paradigm or approach? In: AMCIS 2010 Proceedings (2010)
16. Environmental Protection Agency: Waste classification (2014)
17. 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). https://doi.org/10.1155/2016/6830163
18. Nyakaana, J.B.: solid waste management in urban centers: the case of Kampala city—Uganda. East Afr. Geogr. Rev. **19**, 33–43 (1997). https://doi.org/10.1080/00707961.1997.9756235
19. 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). https://doi.org/10.1016/j.wasman.2015.04.012
20. NEMA: State of the Environment Report for Uganda 2006/2007. Environment (2007)
21. Ministry of Water and Environment: Water and environment sector performance report 2013, Kampala (2013)
22. Garnett, K., Cooper, T.: Effective dialogue: enhanced public engagement as a legitimising tool for municipal waste management decision-making. Waste Manag. **34**, 2709–2726 (2014). https://doi.org/10.1016/j.wasman.2014.08.011
23. Macnaghten, P., Jacobs, M.: Public identification with sustainable development. Glob. Environ. Chang. **7**, 5–24 (1997). https://doi.org/10.1016/s0959-3780(96)00023-4
24. Wiedemann, P.M., Femers, S.: Public participation in waste management decision making: analysis and management of conflicts. J. Hazard. Mater. **33**, 355–368 (1993). https://doi.org/10.1016/0304-3894(93)85085-S
25. Okot-Okumu, J., Nyenje, R.: Municipal solid waste management under decentralisation in Uganda. Habitat Int. **35**, 537–543 (2011). https://doi.org/10.1016/j.habitatint.2011.03.003
26. Kirunda, M.P.: A case of Kira town council, Uganda: public participation in solid waste management: challenges and prospects. Master thesis Public Particip. Solid Waste Management Challenges Prospect (2009). https://doi.org/10.3389/fmicb.2011.00098
27. Liu, T.: Internet-based public participation GIS in environmental management. Community Reg. Plan. Progr. Student Proj. Theses (2013)
28. Macintosh, A.: Characterizing e-participation in policy-making. In: Proceedings of the Hawaii International Conference on System Sciences (2004). https://doi.org/10.1109/hicss.2004.1265300
29. Steinmann, R., Krek, A., Blaschke, T.: Can online map-based applications improve citizen participation? In: Böhlen, Michael, Gamper, Johann, Polasek, Wolfgang, Wimmer, Maria A. (eds.) TCGOV 2005. LNCS (LNAI), vol. 3416, pp. 25–35. Springer, Heidelberg (2005). https://doi.org/10.1007/978-3-540-32257-3_3

30. Radil, S.M., Jiao, J.: Public participatory GIS and the geography of inclusion. Prof. Geogr. **68**, 202–210 (2016). https://doi.org/10.1080/00330124.2015.1054750
31. Floreddu, P., Cabiddu, F., Pettinao, D.: Public participation in environmental decision-making: the case of PPGIS. In: Information Technology and Innovation Trends in Organizations - ItAIS: The Italian Association for Information Systems, pp. 37–44. Physica-Verlag (2011). https://doi.org/10.1007/978-3-7908-2632-6_5
32. Wang, X., Yu, Z., Cinderby, S., Forrester, J.: Enhancing participation: experiences of participatory geographic information systems in Shanxi province China. Appl. Geogr. **28**, 96–109 (2008). https://doi.org/10.1016/j.apgeog.2007.07.007
33. Metla, J.A.: Participation technologies: a framework for the development of an online interactive GIS application (2008)
34. DeSanctis, G., Poole, M.S.: Capturing the complexity in advanced technology use: adaptive structuration theory. Organ. Sci. **5**, 121–147 (1994). https://doi.org/10.1287/orsc.5.2.121
35. Nyerges, T.L., Jankowski, P.: Enhanced adaptive structuration theory: a theory of GIS-supported collaborative decision making. Geogr. Syst. **4**, 225–260 (1997)
36. Jankowski, P.T.N., Nyerges, T.L.: Toward a framework for research on geographic information-supported participatory decision-making. URISA J. **15**, 9–17 (2003)
37. Jankowski, P., Nyerges, T.: GIS-supported collaborative decision making: results of an experiment. Ann. Assoc. Am. Geogr. **91**, 48–70 (2001). https://doi.org/10.1111/0004-5608.00233
38. Strong, D.M., Dishaw, M.T., Brent Bandy, D.: Extending task technology fit with computer self-efficacy. Data Base Adv. Inf. Syst. **37**, 96–107 (2006). https://doi.org/10.1145/1161345.1161358
39. Simão, 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. Manag. **90**, 2027–2040 (2009). https://doi.org/10.1016/j.jenvman.2007.08.032
40. Porwol, L., Ojo, A., Breslin, J.G.: An ontology for next generation e-participation initiatives. Gov. Inf. Q. **33**, 583–594 (2016). https://doi.org/10.1016/j.giq.2016.01.007
41. Reynard, D.: Five classes of geospatial data and the barriers to using them. Geogr. Compass **12**, e12364 (2018). https://doi.org/10.1111/gec3.12364
42. Sieber, R.: Public Participation Geographic Information Systems: A Literature Review and Framework. Wiley, Hoboken (2006). https://doi.org/10.1111/j.1467-8306.2006.00702.x
43. Brown, G.: An empirical evaluation of the spatial accuracy of public participation GIS (PPGIS) data. Appl. Geogr. **34**, 289–294 (2012). https://doi.org/10.1016/j.apgeog.2011.12.004
44. Walker, B.B., Rinner, C.: A qualitative framework for evaluating participation on the Geoweb. URISA J. **25**, 15–24 (2013)
45. Nigussie, Z., et al.: Applying Ostrom's institutional analysis and development framework to soil and water conservation activities in north-western Ethiopia. Land Use Policy **71**, 1–10 (2018). https://doi.org/10.1016/j.landusepol.2017.11.039
46. Hair, J.F., Ringle, C.M., Sarstedt, M.: PLS-SEM: indeed a silver bullet. J. Mark. Theory Pract. **19**, 139–152 (2011). https://doi.org/10.2753/MTP1069-6679190202
47. Jr. Hair, J.F.: Essentials of Business Research Methods (2015). https://doi.org/10.4324/9781315704562
48. Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E.: Multivariate Data Analysis (2010). https://doi.org/10.1016/j.ijpharm.2011.02.019
49. Schmitz, K.W., Teng, J.T.C., Webb, K.J.: Capturing the complexity of malleable IT use: adaptive structuration theory for individuals. MIS Q. Manag. Inf. Syst. **40**, 663–686 (2016). https://doi.org/10.25300/MISQ/2016/40.3.07
50. Nordbäck, E.: The influence of emergent technologies on decision making process in virtual teams. In: 19th Americas Conference on Information Systems, AMCIS 2013 - Hyperconnected World: Anything, Anywhere, Anytime (2013)

51. Zigurs, I., Buckland, B.K.: A theory of task/technology fit and group support systems effectiveness. MIS Q. Manag. Inf. Syst. **22**, 313–334 (1998). https://doi.org/10.2307/249668
52. Karehka, R.: The Role of Information Technology in Group Decision Making (2014). https://useoftechnology.com/role-information-technology-group-decision-making/
53. Schmitz, K., et al.: Impact of lay health worker programmes on the health outcomes of mother-child pairs of HIV exposed children in Africa: a scoping review. PLoS One **14**, e0211439 (2019)
54. Cano, A.R.: Effects of technological support on decision making performance of distributed groups (1997)
55. Gopal, A., Bostrom, R.P., Chin, W.: Modelling the process of GSS use: an adaptive structuration perspective. In: Proceedings of the Hawaii International Conference on System Science (1992). https://doi.org/10.1109/hicss.1992.183432
56. Nyerges, T.L., Ramsey, K.S., Wilson, M.W.: Design considerations for an Internet portal to support public participation in transportation improvement decision making. In: Collaborative Geographic Information Systems (2006). https://doi.org/10.4018/978-1-59140-845-1.ch012
57. Denhardt, J., Terry, L., Delacruz, E.R., Andonoska, L.: Barriers to citizen engagement in developing countries. Int. J. Public Adm. **32**, 1268–1288 (2009). https://doi.org/10.1080/01900690903344726
58. Goodhue, D.L., Thompson, R.L.: Task-technology fit and individual performance. MIS Q. Manag. Inf. Syst. **19**, 213–236 (1995). https://doi.org/10.2307/249689