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Web-Based Geographic Information Systems: Experience and Perspectives of Planners and the Implications for Extension

Abstract

Web-based geographic information system (GIS) technology, or web-based GIS, offers many opportunities for public planners and Extension educators who have limited GIS backgrounds or resources. However, investigation of its use in planning has been limited. The study described here examined the use of web-based GIS by public planning agencies. A 2013 web-based survey of 274 public planning agency staff throughout Wisconsin revealed that use of web-based GIS for planning tasks lags behind use of software-based GIS and that agency use is hampered by a number of barriers. The findings suggest that Extension professionals can help practitioners become more familiar and proficient with web-based GIS applications.

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Introduction

For years, many public planning agencies have lacked the resources to invest sufficiently in geographic information system (GIS) technology. However, recent advances have enabled agencies to combine GIS technology with the Internet, increasing its applications for planning practice without necessarily increasing the need for funding to invest in desktop, or software-based, GIS. For those in the general public and other stakeholders, web-based GIS technology (referred to as web-based GIS) provides easier access to geospatial data and a medium for sharing their perspectives, increasing the opportunities for public participation in planning efforts. For planners and Extension educators with limited GIS experience and agencies with limited budgets, web-based GIS also provides free or inexpensive opportunities to access planning-relevant data, conduct data analysis, and prepare maps to depict planning options.

For well over a decade, scholars have been writing about the role of the Internet in the future of GIS (e.g., Dragicevic, 2004; Li, Veenendaal, & Dragicevic, 2011; Verma, Verma, Singh, & Naik, 2012) and the future of GIS in planning (Drummond & French, 2008; Ferreira, 2008; Heikkila, 1998; Klosterman, 2008). Recently, countless web-based GIS applications have been developed that planners can easily use in their work. A 2011 study by the International City/County Management Association documented that two thirds of U.S. county and municipal governments provide GIS mapping and data online, a figure that represented a doubling over a 7-year period (International City/County Management Association, 2004, 2011). Web-based GIS applications span a wide range

of planning fields. Whereas some applications are intended for viewing only, others incorporate analytical capabilities, making spatial or statistical analysis possible.

Despite the thoughtful opinions of scholars (e.g., Drummond & French, 2008) and efforts at local, regional, state, and federal levels to develop web-based GIS applications, empirical evidence on web-based GIS use by planners is limited to case studies or to its use for public participation (Conroy & Evans-Cowley, 2006; Ganapati, 2011; Peng, 2001; Slotterback, 2011). Because web-based GIS provides additional opportunities for planning departments whose members may or may not have GIS expertise, it is important to investigate its use by public planning agencies. The purposes of the study reported here were to investigate the extent to which public planning agencies use web-based GIS and to determine whether their use of web-based GIS for planning functions differs from their use of locally installed software-based GIS for such functions. The study also investigated practitioner perspectives on the use of web-based GIS in public planning agencies and the perceived barriers to its use for planning. The findings have significant implications for Extension professionals, who have a vital role to play in teaching public agency planners how to use web-based GIS more widely and effectively. Learning how planners use web-based GIS—or why they do not—will help Extension professionals develop more effective programming.

Background

Web-Based GIS Applications for Planning

Local governments, state departments, federal agencies, nonprofit organizations, and universities have created numerous web-based geospatial technology applications spanning diverse fields. The most widespread applications involve local governments' making their GIS data layers available on the Internet for viewing. These applications typically have search and print capabilities, and users can turn on different layers to map. With these basic capabilities, users can easily access information such as parcel data and map a community's current conditions.

Agencies other than local governments have developed applications with similar mapping and information-accessing capabilities. The U.S. Department of Housing and Urban Development (HUD) created HUD Community Planning and Development Maps (http://egis.hud.gov/cpdmaps), which provides access to information on the consolidated planning process and housing needs assessments and allows users to view HUD grant programs and various indicators of community and economic development. NEPAssist (https://www.epa.gov/nepa/nepassist), from the U.S. Environmental Protection Agency (EPA), uses the EPA's GIS database to allow users to review environmental issues related to a particular community or project. Census Data Mapper (https://www.census.gov/geo/maps-data/maps/datamapper.html), a practical mapping tool provided by the U.S. Census Bureau, quickly displays county population and housing information.

Several other applications allow users to visualize spatial information. The H+T Affordability Index (http://htaindex.cnt.org/map/), created by the Center for Neighborhood Technology, maps neighborhood affordability on the basis of census block statistics. Mapnificent (http://www.mapnificent.net) uses Google GTFS, a consolidated database of public transportation schedules and geographic information, to determine where a passenger can travel within a given time. NJ Flood Mapper (http://www.njfloodmapper.org/) helps users visualize the impacts of rising sea levels under different scenarios.

Whereas the aforementioned applications have built-in analysis, others enable users to conduct their own

analyses without having to download geospatial data or perform the analyses in GIS software. A notable example is the GIS of Waukesha County, Wisconsin (http://www.waukeshacounty.gov/defaultwc.aspx?id=39458). With almost 100 available data layers, it enables users to perform simple spatial analyses, such as those accomplished by creating buffers.

Many other applications have embedded analytical capabilities, eliminating the need for users to do analyses themselves. Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm), developed by the U.S. Department of Agriculture's Natural Resources Conservation Service, enables users to map the suitability of soils for different uses. In essence, the tool provides a simplified version of a land suitability analysis. The Long-Term Hydrological Impact Assessment (L-THIA) (https://engineering.purdue.edu/~lthia/), developed at Purdue University, estimates impacts of proposed land development on water quality and quantity by using actual rainfall, soil, and land use data, enabling users to evaluate alternative development scenarios. For additional examples, see http://urpl.wisc.edu/sites/urpl.wisc.edu/files/people/gocmen/Web%20based%20GIS%20applications%20for%20planners_gocmen%26levine.pdf and http://urpl.wisc.edu/sites/urpl.wisc.edu/files/people/gocmen/WebGIS_2nd%20vol_gocmen_rynish.pdf.

GIS in Wisconsin's Public Planning Agencies

The study described herein examined the use of web-based GIS in Wisconsin. Wisconsin has a rich history of land records modernization and GIS use in public agencies, dating back to the late 1970s. Several studies have documented county-based land records modernization through the Wisconsin Land Information Program (Day & Ghose, 2012; Hart, 2000; Kuhlman, 1994; Tulloch, 1997). Additional studies addressed barriers to GIS use in Wisconsin's public planning agencies, finding that most agencies used GIS primarily for administrative and routine tasks, such as keeping inventories and accessing information (Göçmen, 2013; Göçmen & Ventura, 2010).

Methods

The Survey

Between January and March 2013, I, along with a graduate assistant and another University of Wisconsin–Madison employee who assisted me, sent a web-based survey to staff in planning and GIS-related departments of regional and local governments in Wisconsin and to members of the Wisconsin chapter of the American Planning Association (APA-WI). Through personal communications and web searches, we sought contact information for planning staff in all regional planning commissions, all counties, and all municipalities with populations of at least 5,000. When we could not identify a planner, we searched for contact information for GIS professionals and sent them the survey. We also contacted APA-WI electronic mailing list members, which enabled us to capture planner representation from a greater number of agencies. In requesting participation from APA-WI members, we asked that only public agency planners respond; if others responded, we eliminated their entries from our final data set. We sent up to three reminders to nonrespondents and followed up with a subset of nonrespondents. Five hundred eighty-eight individuals responded to the survey, producing an approximately 36% response rate. It is difficult to know the exact response rate because the survey was sent to individuals in local and regional agencies who might have been listed as APA-WI members under alternative email addresses; thus, we suspect that the response rate was actually higher than 36%. We corresponded with a dozen nonrespondents. The most common reason for not participating was that another staff member in the agency had already completed the survey.

The survey included questions on the respondent's agency, GIS background and use, and familiarity with web-based GIS tools for planning as well as questions on the perceived benefits of and barriers to GIS use and the agency's use of web-based and software-based GIS for various planning functions. The Environmental Resources Center at the University of Wisconsin–Madison/Extension administered the survey, and the research assistant helped clean and recode the survey data.

The Respondents

The findings discussed in the rest of this article emerged from the views of 274 respondents (out of the original 588) who met the following conditions: The respondent was familiar with GIS; worked in a Wisconsin-based municipal, county, or regional government; and practiced in a planning, community development, or zoning department (hereafter "public planning agency").

About three quarters of the 274 respondents practiced in organizations with a long GIS history (over 20 years). Among the 274 respondents, 47% practiced in county governments and 40% in municipal governments. Furthermore, 29% practiced in planning agencies having a minimum of 10 nonclerical staff members. Respondents' GIS training backgrounds were roughly equally divided among formal training (extended classroom training), semiformal training (workshops and short trainings), and informal training (on-the-job training through interactions with coworkers).

Findings

Extent of Web-Based GIS Use in Wisconsin's Public Planning Agencies

In the survey, 89 respondents (32%) stated that their agencies used web-based GIS for at least one of the following 10 planning functions identified on the survey instrument:

- accessing of information,
- alternative scenario evaluation,
- impact assessment,
- land suitability analysis,
- sociodemographic analysis,
- other spatial analysis,
- mapping of current conditions,
- modeling,
- public participation, and
- visualization.

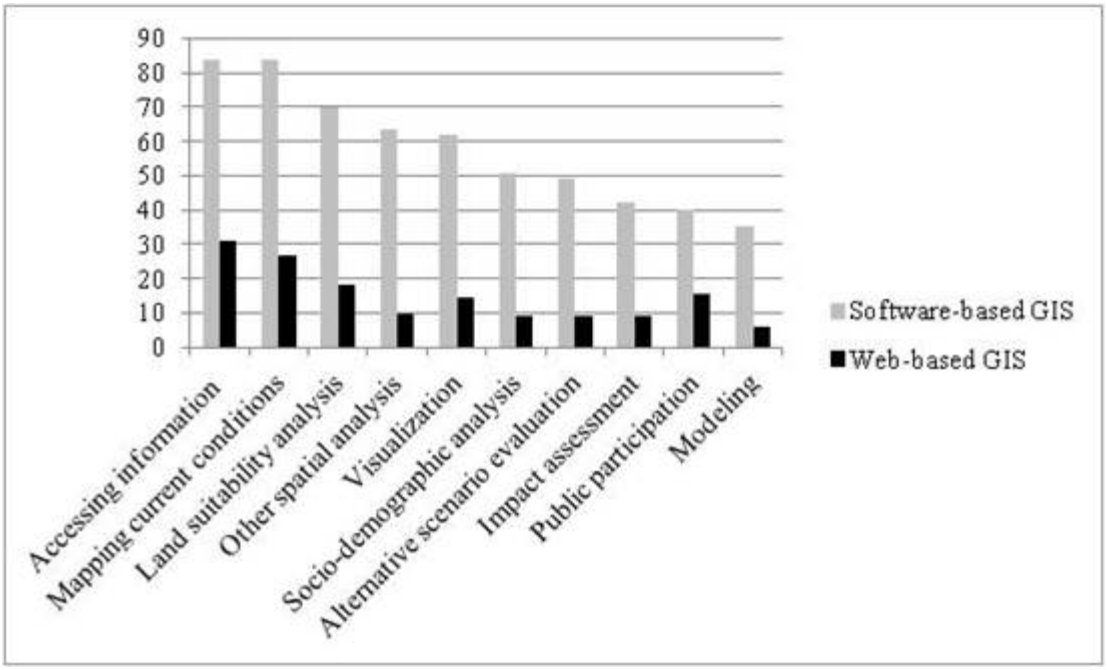
Although accessing of information and mapping of current conditions are common uses of GIS in planning agencies, they are rather rudimentary functions. The other functions listed above represent more sophisticated and effective implementation of GIS by planners during the decision-making process. In the survey, 74 respondents (27%) indicated that their agencies used web-based GIS for at least one task other than accessing information and mapping current conditions.

Although public planning agencies use web-based GIS for a range of planning-related tasks, use of web-based GIS lagged behind use of software-based GIS for all items identified in the survey (Figure 1). The proportions of respondents who reported using software-based GIS for various tasks ranged from 35% for modeling to 84% for accessing information and mapping current conditions, whereas the range for web-based GIS was between 6% for modeling and 31% for accessing information. Like software-based GIS, web-based GIS was used most commonly for accessing information and mapping current conditions and least commonly for modeling.

Figure 1.

Uses of Software-Based and Web-Based GIS in Wisconsin Planning Agencies

(Percentages of Respondents, *N* = 274)



The survey revealed the following information relative to the 89 respondents who stated that their agencies used web-based GIS for at least one planning function:

- Seventy respondents (79%) stated that their agencies used web-based GIS more frequently than or as frequently as software-based GIS for at least one of the 10 functions included in the survey. Another 18 respondents (20%) indicated that their agencies used web-based GIS more frequently than or as frequently as software-based GIS for at least five of the 10 functions.

- Eight agencies that did not have in-house GIS capabilities used web-based GIS. In these agencies, web-based GIS was most commonly used for accessing of information (*n* = 8), mapping of current conditions (*n* = 6), and land suitability analysis (*n* = 5).

- Relative to software-based GIS, web-based GIS was used more frequently by small agencies (those having

fewer than five staff members) than by large agencies for six functions, including various types of analysis, mapping of current conditions, and visualization.

- One fifth of the respondents stated that their agencies used their own web-based GIS, and a quarter of the municipal respondents stated that they used county-based web services.

- Over half of the respondents (58%) stated that their departments had experienced an increase of GIS users due to the availability of web-based applications.

- Around two thirds of the respondents stated that their departments' planning-related GIS needs were somewhat met by present web-based GIS applications, and 6% stated that such needs were completely met.

- Although 10 respondents (11%) believed that their agencies' planning staffs had the right amount of GIS and planning experience, they were concerned about staff members' inability to implement web-based applications due to "lack of awareness of all that is available" and lack of time to keep up with new applications, which are rapidly being developed and evolving. These respondents also expressed concerns about their agencies' not being able to do required tasks using web-based applications even when planners had the background needed to take advantage of available web-based GIS applications.

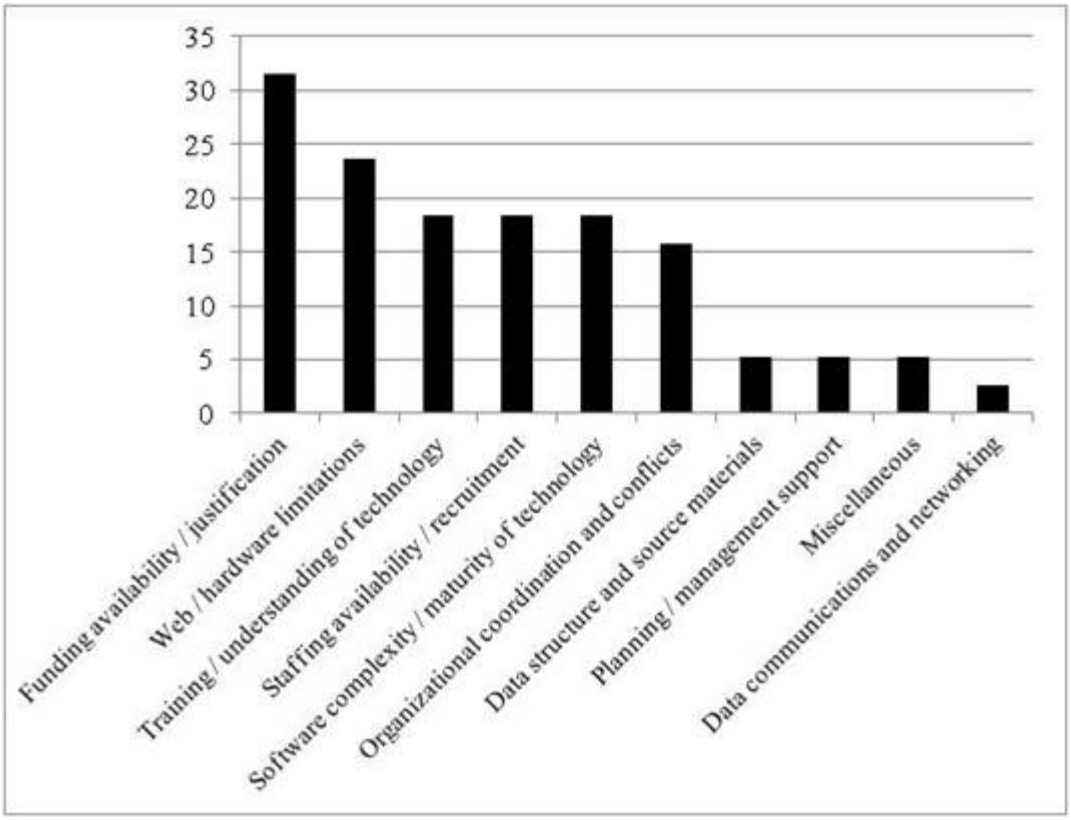
An agency might experience an increased number of GIS users because web-based GIS provides opportunities to nonexperts, but it is not unusual for an agency with an established GIS and planning staff trained in GIS to make more extensive use of software-based GIS. Software-based GIS provides more consistent access to data (because there are fewer web-related delays and crashes), greater control over the appearance of output when mapping current conditions, and many additional capabilities (for instance, related to analyzing geospatial data). My review of many local and other web-based GIS services and tools revealed that the analytical capabilities of these applications were inadequate for most planning work and decision making; they were mostly limited to creating buffers, calculating distances, and displaying choropleth maps. Much planning analysis (e.g., comprehensive land suitability analysis) goes beyond these simple operations, requiring the overlay of multiple layers that have restrictions and a range of suitability criteria for different development purposes. It is not surprising, then, that only 6% of respondents believed their agencies' planning-related needs were completely met by current web-based applications. Still, web-based applications are likely to evolve rapidly and provide greater functionality in the near future.

Barriers to Web-Based GIS Use

Of the 89 respondents who stated that their agencies used web-based GIS for at least one planning function, 38 (43%) indicated that they had experienced barriers to web-based GIS use for planning purposes. Categories of barriers and associated data are shown in Figure 2.

Figure 2.

Barriers to Web-Based GIS Use for Planning Purposes



Notes: Categories of barriers are adapted from Göçmen and Ventura (2010) and Croswell (1991). In this study, I created a separate category for web and hardware limitations.

Funding-related barriers, identified by close to one third of the respondents, were the most common. As one respondent commented, "No one wants to budget any money that doesn't have tangible deliverables."

The second set of significant barriers related to an agency's Internet capabilities, available hardware, or operating a GIS on the web; these challenges were identified by nearly one quarter of the respondents. This category included responses such as "Firewall," "low-loading," and "It is difficult to print from the web." One respondent commented that the online version of a particular software program did not allow users to upload large files, thereby restricting the use of planning-related GIS data and applications on the web.

Another type of barrier identified by practitioners related to lack of training needed to maintain skills and lack of knowledge of what is available on the web (i.e., training/understanding of technology). One respondent stated, "We don't have any planners specifically trained in GIS; it's been on-the-job learning. We are having trouble utilizing GIS to its full capacity." Although less than one fifth of the users cited training-related barriers, other findings of the study suggest that lack of familiarity with various applications may be a more significant barrier to using already-developed web-based GIS applications for planning. Only 21% of the 274 study respondents indicated familiarity with any web applications, and the numbers were lower for applications developed by the state (7%) or any organization other than local or county governments (4%).

Practitioners identified many additional barriers. Staffing-related issues comprised the next most commonly indentified type of barrier. One respondent remarked, "The workloads of staff prevent us from quickly taking that next leap in the use of web-based GIS and widening its use." Respondents also frequently cited as a barrier the

limited functionality of web-based GIS as opposed to software-based GIS, particularly related to analytical functions (i.e., software complexity/maturity of technology).

Apart from funding, the significant barriers that Wisconsin planners reported having experienced when using software-based GIS several years ago (Göçmen and Ventura, 2010) appeared to be less prominent for users of web-based GIS in 2013. It is not surprising to find that many of the barriers identified in the earlier study are no longer as prominent. Because web-based applications are much more limited than software-based GIS and because "people are more familiar with Internet browsers than actual GIS software" (as one respondent remarked), public agency planners may not need continual training on most of the currently available applications. Someone working in a municipal or county government that has web services may be able to access geospatial data created by other departments or other local governments much more easily than someone working in an organization without web services could. With web services, the desired geospatial data are usually just "a click away," whereas in the absence of local web services, a practitioner would have to identify and contact the right data source and then wait to receive the data. Furthermore, the use of web-based GIS in an organization forces departments with varying needs to use the same data formats and thus decreases barriers associated with data structure and source material. While technology-related barriers also are not as prominent, their importance relative to other barriers has remained the same among Wisconsin's public planners. This finding is in line with others' conjectures: Li et al. (2011) identified technology-related obstacles as one of the top three barriers to web-based GIS that developers and professional and public users will continue to experience.

Implications for Extension Professionals

Prior research has highlighted the importance of web-based GIS in planning efforts as well as the importance of Extension professionals in educating practitioners about geospatial tools (Göçmen, 2013; Merry, Bettinger, & Hubbard, 2008a, 2008b; Milla, Lorenzo, & Brown, 2005; Watermolen, Andrews, & Wade, 2009). For instance, Merry et al. (2008a, 2008b) found that the majority of Georgia's planners and Extension educators valued web-based access to maps in their efforts to evaluate and model land cover change. Watermolen et al. (2009) argued that web-based GIS can mitigate the "widened digital divide" (Milla et al., 2005) faced by Extension professionals with limited understanding of rapidly developing geospatial technologies and applications. The authors stressed that web-based GIS tools can support Extension professionals' programming efforts related to land use planning. Their survey of Extension professionals in Wisconsin showed that Extension educators valued tools that contain data and are web based, free, scalable, customizable, and intuitive (Watermolen et al., 2009).

Many web-based GIS applications meet these requirements and can indeed be useful in Extension programming. Many communities throughout the United States rely on Extension professionals for help with community-based planning efforts. For communities with limited staff and resources, assistance provided to the staff as well as to the public can be invaluable. Extension educators can help these groups access community-based data, perform analyses, and prepare maps—activities all made possible through the use of GIS. Because most Extension educators lack extensive GIS experience, keeping up with web-based rather than software-based GIS would be more feasible, and more effective relative to their programming efforts.

With heightened awareness of and competency in web-based GIS applications, Extension educators and specialists could play a critical role in transforming the use of GIS by planning agencies, but obstacles such as funding and staff time must be addressed. Planners in local agencies often lack awareness of geospatial tools that can be used for a variety of planning functions (Göçmen, 2013); indeed, the study reported here reveals very low levels of familiarity with web-based GIS applications relevant to planning. As one respondent stated, "We have

the skills, but perhaps not the awareness of all that is available."

Extension professionals can play an essential role in familiarizing planners with the available web-based GIS applications and functionalities and in training them to use and critically evaluate these tools. Extension educators can collaborate with specialists in conducting needs assessment studies to identify potentially useful tools for their community planners, in developing and improving such tools, and in preparing and delivering training aimed at increasing familiarity and proficiency with different, particularly basic, tools. Targeting smaller agencies that have limited resources likely will yield greater success in encouraging the use of GIS for planning applications other than administrative tasks and basic work because larger agencies, which are more likely to have in-house GIS and a GIS specialist on staff, can take advantage of the fully developed software-based GIS options. Like software-based GIS, web-based GIS likely will evolve quickly and provide many advanced analytical and other opportunities for local governments. Gaining familiarity and proficiency with different web-based applications will be vital for planning agencies in the coming years, and Extension professionals have a vital role to play in helping them achieve that familiarity and proficiency.

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References

Conroy, M. M., & Evans-Cowley, J. (2006). E-participation in planning: An analysis of cities adopting on-line citizen participation tools. *Environment and Planning C: Government and Policy*, *24*(3), 371–384.

Croswell, P. L. (1991). Obstacles to GIS implementation and guidelines to increase the opportunities for success. *Journal of the Urban Regional Information Systems Association*, *3*(1), 1–15.

Day, P., & Ghose, R. (2012). E-planning through the Wisconsin Land Information Program: The contexts of power, politics, and scale. *International Journal of E-Planning Research*, *1*(1), 75–89.

Dragicevic, S. (2004). The potential of Web-based GIS. *Journal of Geographical Research*, *6*, 79–81.

Drummond, W. J., & French, S. P. (2008). The future of GIS in planning: Converging technologies and diverging interests. *Journal of the American Planning Association*, *74*(2), 161–174.

Ferreira, J. Jr. (2008). Comment on Drummond and French: GIS evolution: Are we messed up by mashups? *Journal of the American Planning Association*, *74*(2), 177–179.

Ganapati, S. (2011). Uses of public participation geographic information systems applications in e-government. *Public Administration Review*, *71*(3), 425–434.

Göçmen, Z. A. (2013). GIS use in public planning agencies: Extension opportunities. *Journal of Extension*, *51*(4) Article 4FEA5. Available at: http://www.joe.org/joe/2013august/a5.php

Göçmen, Z. A., & Ventura, S. J. (2010). Barriers to GIS use in planning. *Journal of the American Planning Association*, *76*(2), 172–183.

Hart, D. (2000). *Building a horizontally and vertically integrated coastal GIS using local government spatial data: The case of coastal erosion hazards on the Lake Michigan coast of Wisconsin.* Doctoral dissertation, University of Wisconsin-Madison.

Heikkila, E. J. (1998). GIS is dead; long live GIS! *Journal of the American Planning Association*, *64*(3), 350–360.

International City/County Management Association. (2004). *Electronic government 2004 survey results*. Retrieved from http://icma.org/en/Search?s=electronic%2Bgovernment%2B2004

International City/County Management Association. (2011). *E-government 2011 survey summary*. Retrieved from http://icma.org/en/Search?s=electronic%2Bgovernment

Klosterman, R. E. (2008). Comment on Drummond and French: Another view of the future of GIS. *Journal of the American Planning Association*, *74*(2), 174–176.

Kuhlman, K. (1994). Measuring the influences on land records modernization in Wisconsin counties. Unpublished master's thesis, University of Wisconsin–Madison.

Li, S., Veenendaal, B., & Dragicevic, S. (2011). Advances, challenges and future directions in web-based GIS, mapping services and applications. In S. Li, S. Dragicevic, & B. Veenendaal (Eds.), *Advances in web-based GIS, mapping services and applications*. London, UK: Taylor & Francis Group.

Merry, K. L., Bettinger, P., & Hubbard, W. G. (2008a). Back to the future part I: Surveying geospatial technology needs of Georgia land use planners. *Journal of Extension*, *46*(3) Article 3RIB6. Available at: http://www.joe.org/joe/2008june/rb6.php

Merry, K. L., Bettinger, P., & Hubbard, W. G. (2008b). Back to the future part II: Surveying geospatial technology needs of agriculture and natural resources Extension professionals. *Journal of Extension*, *46*(4) Article 4RIB1. Available at: http://www.joe.org/joe/2008august/rb1.php

Milla, K. A., Lorenzo, A., & Brown, C. (2005). GIS, GPS, and remote sensing technologies in Extension services: Where to start, what to know. *Journal of Extension*, *43*(3) Article 3FEA6. Available at: http://www.joe.org/joe/2005june/a6.php

Peng, Z. (2001). Internet GIS for public participation. *Environment and Planning B: Planning and Design*, *28*(6), 889–905.

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

Tulloch, D. L. (1997). *A theoretical model of the life cycle of community multipurpose land information systems development*. Doctoral dissertation, University of Wisconsin–Madison.

Verma, S., Verma, R. K., Singh, A., & Naik, N. S. (2012). Web-based GIS and desktop open source GIS software: An emerging innovative approach for water resources management. *Advances in Computer Science, Engineering, and Applications, 167*, 1061–1074.

Watermolen, D. J., Andrews, E., & Wade, S. (2009). Extension educators can use Internet GIS and related technologies. *Journal of Extension*, *47*(5) Article 5FEA2. Available at: http://www.joe.org/joe/2009october/a2.php

