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## **A 10 Years Review and Classification of the Geographic Information Systems Impact Literature (1998-2008)**

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***Abstract.** Our objective in this paper is to review the literature on the impact of geographic information systems (GIS) in governmental and non-governmental organizations by analyzing 53 articles published between 1998 and 2008. The impacts of GIS are categorized in a taxonomy which designates GIS contributions to efficiency, effectiveness and societal well-being. According to this taxonomy, 38 articles are examined in-depth and their results reported. The focus of GIS impact research efforts in terms of research philosophies, methodologies and geographic focus is also presented. We suggest that the appropriate use of theories, concepts and testing of existing GIS evaluation frameworks could serve as building blocks for more rigorous studies on the impact of GIS, including Land Information Systems (LIS) and Spatial Data Infrastructure (SDI).*

***Key words:** GIS, evaluation*

### **1 Introduction**

The aim of this paper is to propose a series of considerations which may serve as a ‘lens’ for looking at GIS impact issues as reported in the academic literature published between 1998 and 2008. Our goal is to review the impact literature on GIS and ascertain the ‘level of attention’ paid to the categories designated in terms of GIS contributions to efficiency, effectiveness and societal well-being. In particular, we aim to extend the work of Nedović-Budić (1998) by providing a 10 years review and classification of the GIS impact literature as reflected in articles published until 2008 in five academic journals. The journals are *Environment and Planning B: Planning and Design*, *International Journal of Geographical Information Science*, *Urban and*

Regional Information Systems Association Journal, Transactions in GIS and Land Use Policy. We also show in the appendixes to this paper the focus of GIS impact research efforts in terms of research philosophies, methodologies and geographic focus.

Nedović-Budić (1998) reviewed the impact of GIS technology between 1990 and 1998 in planning agencies and local governments in the United States of America (USA), United Kingdom (UK) and Scandinavia. According to Nedović-Budić (1998; p 683) consideration for the societal impact of GIS is important “because the ultimate goal of all technologies introduced in public sector agencies is to benefit society”. Yet, Nedović-Budić’s (1998) research revealed mixed outcomes and conflicting empirical findings. For example, GIS had both positive and negative effects on society and it was also found that GIS could intensify existing societal problems. In the midst of these mixed indicators and contradictory findings, the need to explicitly address the role of GIS in their social context was recognized, especially with respect to the social implications of GIS

The rest of this paper is as follows. In the next section, we delineate our methodology; thereafter we discuss the nature of impact of GIS and degree of attention to GIS impact research. From prior literature, we offer an approach to classify GIS impact literature based on similarities of impact issues and present a review of the literature on the impacts of GIS. The penultimate section analyses and discusses our findings and outlines a classification of GIS impacts based on the literature reviewed followed by the conclusions and suggestions for future research.

## **2 Methods of survey of the GIS impact literature**

This section provides a concise discussion on the methods and techniques used and how these were applied in this paper. The initial technique consisted in a review and characterization of the literature, providing the foundation for our research through an output that enabled us to categorize reported impacts of GIS in the literature. Next, we examined the titles of 1,840 articles in all issues and volumes of the journals from January 1998 to July 2008. From the examination of titles, we selected 53 articles, which address GIS use and impacts. After a review of the abstracts, introduction and conclusion of the 53 pre-selected articles; we restricted our sample to 38 articles, which documented GIS impacts in governmental and non-governmental organizations mainly from primary sources of evidence. We conducted an in depth study and content analysis of the 38 articles, and assessed each of the articles reported contribution and attention to the taxonomic designations of efficiency, effectiveness and societal well being.

The last step was to conduct a thorough examination and sensible interpretation of the results of the 38 articles selected for this literature review.

The seven techniques used for this literature review are summarized in table 1. We define the techniques before the literature review to reduce subjective factors to a minimum and apply a replicable methodology for the review and classification GIS impacts.

**Table 1.** *Summary of literature review methodology*

<b>No.</b>	<b>Technique</b>	<b>Description</b>	<b>Output</b>
1	Literature review and characterization.	Study of academic literature on impacts of information systems, information technology and geographic/land information systems (G/LIS) for a scheme to catalogue G/LIS impacts.	An approach to categorize reported impacts of G/LIS.
2	Capturing of orientation of journals.	Survey of scope and focus of scholarly journals emphasizing G/LIS research to identify journals that report GIS use and impact issues.	Candidate journals. (Academic research outlets to explore for G/LIS impacts).
3	Examination of titles of articles.	Online review of titles of articles in each issue of the candidate journals and pre-selection of articles reflecting on G/LIS adoption, implementation and use.	Articles selected for further study.
4	Preliminary study of articles.	Review of abstracts, introduction and conclusion of pre-selected articles.	Articles with clear impacts issues, from mainly empirical investigations.
5	In-depth study and content analysis.	Content analysis of selected articles using the approach to categorize reported impacts of GIS derived from the first technique.	Thematic representation of reported G/LIS outcomes.
6	Assessment of 'contribution' and 'attention'.	Appraisals of reported G/LIS effects (contribution), academic papers of G/LIS impact issues (attention), approaches and focus of G/LIS impact research.	Contribution and attention under three taxonomic designations. Basis and focus of researches.
7	Scrutiny, interpretation and sense-making.	A thorough examination and sensible interpretation of results.	Enhanced research findings and indication of limitations.

### **2.1 Selection of journals and articles**

We started by studying a list of "some scholarly journals emphasizing GIS research" (Longley et al., 2001; p 27) and list of journals by Caron et al.

(2008) to identify journals relevant for this survey. We limit our selection to five journals based on our interpretation of aims, scopes, target audience and mission statements of the journals. The selected journals (see table 2) publish research covering applications of GIS in areas such as public health, crime analysis, housing and cadastral mapping in both developed and developing countries. They also focus on practical and theoretical issues influencing the development of GIS. One of the journals (Land Use Policy) aims to provide policy guidance to governments. The selected journals, number of articles examined for each journal during the period of review and the number of articles selected for review are in table 2. In appendix 1, we provide the list of articles reviewed in the five journals.

**Table 2.** Review period, and number of articles published in selected journals and number of articles selected for review

<b>Journal</b>	<b>Period</b>	<b>No. of articles</b>	<b>No of selected articles</b>
Environment and Planning B: Planning and Design	Volume 25 (1998), Issue 1 to Volume 35 (2008), Issue 6.	538	8
International Journal of Geographical Information Science	Volume 12 (1998), Issue 1 to Volume 22 (2008), Issue 8.	503	6
Land Use Policy	Volume 15 (1998), Issue 1 to Volume 25, (2008) Issue 4.	418	4
Transactions in GIS	Volume 3 (1999), Issue 1 to Volume 12 (2008), Issue 3	255	7
Urban and Regional Information Systems Association Journal	Volume 10 (1998), Number 1 Volume 19 (2007), Number 2	126	13
Total		1,840	38

### **2.2 In-depth study and content analysis**

The approaches applied in each article to ascertain impacts were analyzed by identifying their basis, methodology and level of analysis. By basis, we mean the framework of knowledge applied in an article, these are theory, framework, model, schema, concept, category, and non-framework based studies (Heeks and Bailur, 2007). We examine the methodologies used in each of the articles reviewed in this paper, which have used either positivist or interpretive approaches. The interpretive approaches of case study and ethnography are more frequent (76%) than the positivist approaches of experiment and surveys. The level of analysis considers an article’s object of study, which can be at different levels, such as “individual, group, organization, sector, national or international levels” (Sahay and Walsham,

1995; p 114). The majority of the researches (about 70%) were carried out at different levels in public service, such as country, state, local, academia, environment and military. The remaining 30% focused on non-governmental organizations and community based organizations.

### **2.3 Assessment of GIS documented impacts**

The assessment of the nature of the contribution of GIS included a consistent judgment of whether an article documents positive (+), mixed ( $\pm$ ) or negative (–) impact. We recognize that an observer can perceive the same impact as positive or successful and by another as negative or failure (Heeks, 2002). To attain consistency, we base our judgment of +,  $\pm$  and – on definitions from previous studies by Danziger and Andersen (2002) and Heeks (2002) as shown in table 3.

*Table 3. Definitions of positive, negative and mixed impacts of GIS*

	<b>Positive (+)</b>	<b>Mixed (<math>\pm</math>)</b>	<b>Negative (–)</b>
<b>Heeks (2002)</b>	Success: most stakeholder groups attain their major goals and do not experience significant undesirable outcomes.	Partial failure <sup>1</sup> : major goals are not accomplished or significant unfavorable outcomes.	Failure: initiative never implemented or implemented but immediately abandoned.
<b>Danziger and Andersen (2002)</b>	Enhance the provision of public goods and services.	Both positive and negative impacts on the same category of outcome.	Opposite effect of positive impact, for example worsen the provision of public goods and services.

Set against these considerations, we categorize impacts reported as major goals achieved, for example by enhancing the provision of public goods and services without significant undesirable outcomes as +. In contrast, impacts reported with significant undesirable outcomes and do not achieve their major goals are in the category of – impacts, for example, a GIS that is never fit for proper functioning and latter collapsed. Impacts reported with desired and adverse effects are in the category of  $\pm$  impacts.

### **2.4 Contribution of GIS to efficiency, effectiveness and societal well-being**

The nature of contribution (+,  $\pm$  or –) of GIS varies across the three taxonomic designations.

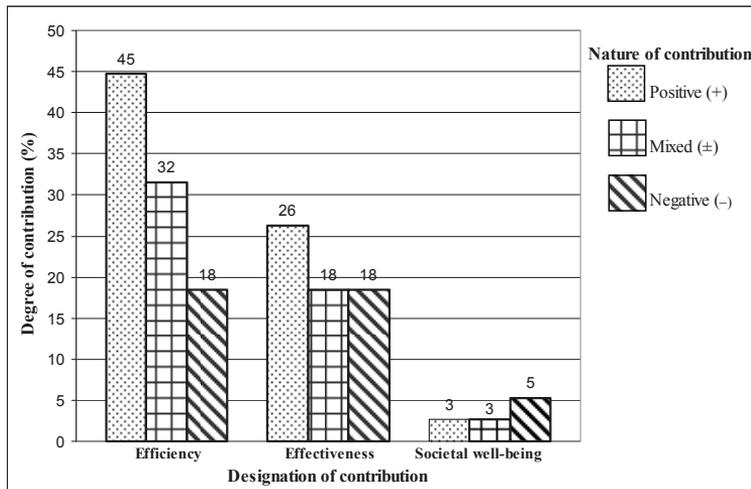
Efficiency is typically a ratio of outputs to inputs, which can be expressed in terms cost savings, cost avoidance, or productivity gains

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<sup>1</sup> This can also mean partial success.

(Nedovic-Budic, 1999). Tulloch and Epstein (2002; p 197) described effectiveness as “improvement in the performance of an organization's fundamental duties or activities because of the organization's use of GIS”. Contribution to societal well-being draws on how GIS technology has transformed society and its way of dealing with human problems. The review of the contribution of GIS to societal well-being is necessary because, technology in general has been described as a set of tools, machines, materials that has transformed or holds the potential for transforming society in positive directions (Berman and Tetley, 2001; Prakash and De, 2007).

Figure 1 illustrates our findings. About 45% of the articles in our review reported positive contributions to efficiency impact issues, 32% are mixed, 18% are negative and the remaining articles do not report on efficiency aspects of GIS. The percentage of articles that reported positive contribution of GIS to effectiveness issues is 26%. We analyzed 18% of the impacts reported as mixed and another 18% as negative and the rest do not pay attention to effectiveness impact. The positive and mixed contributions of GIS to societal well-being are 3% and we considered 5% as negative contribution to societal well-being.

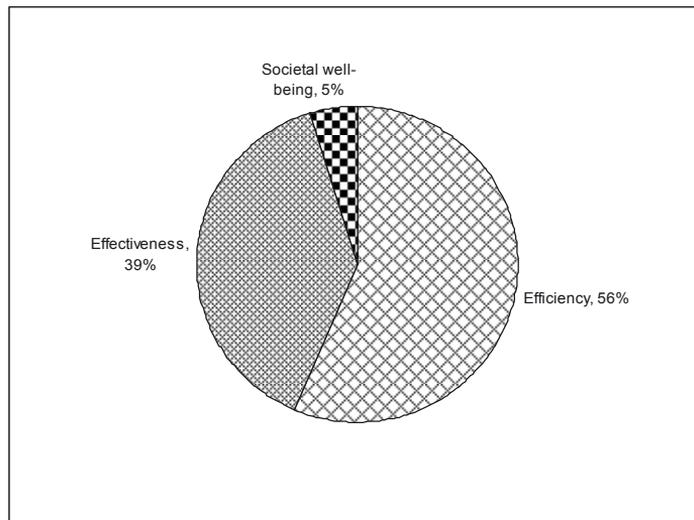


**Figure 1.** Nature of contribution of GIS

**2.5 Attention to efficiency, effectiveness and societal well-being aspects of GIS**

From figure 1, we see that the level of positive, mixed and negative contributions of GIS to societal well-being is very low. The near absence of a clear positive contribution in this designation corroborates this comment. The

proportion of attention to each taxonomic designation is analyzed across the articles and illustrated graphically in figure 2.



*Figure 2. Level of attention to GIS impact research*

## **2.6 Limitations**

Our methodology, of course has some limitations. The restriction of our review to five journals is a limitation. However, it provides a population from which to draw samples and give all the members of that population equal chance of selection based on a predetermined condition of use and applications of GIS. This can also enhance generalisability and replicability. In a similar way, the exclusion of non G/LIS academic outlets such as Public Administration Review, Journal of Management Information Systems and MIS Quarterly, reduced the coverage of our review. We also excluded other sources, such as working papers and international agencies' reports, which are usually joined at the hip of sponsors. The journals reviewed are published in developed countries in English language, thus producing already an Anglo-Saxon biased review and neglecting local publications in developing countries and non-English publications. In addition, this paper does not review the contributions of integration of location based services and internet search engines, such as the Google Earth and MapQuest. Only one of the articles reviewed – Campagna and Deplano (2004) – discussed the impact of Web-based application. However, most of the findings in the articles reviewed are based on evidence gathered by the authors from real-life experiences or observations (Kumar, 2005), suggesting a positive impression on conclusions drawn in this paper from their findings.

**Table 4.** A classification of GIS impact literature based on similarities of impact issues

<b>Taxonomic designation</b>	<b>Definition</b>	<b>Impact issue</b>
Contribution to efficiency	The degree to which GIS operates with minimum waste, duplication, and expenditure of resources (Stone, 2002).	<ol style="list-style-type: none"> <li>1. Availability and accessibility to products and services</li> <li>2. Cost (monetary and nonmonetary costs associated with utilizing a service or buying a product)</li> <li>3. Coverage and completeness</li> <li>4. Data acquisition capability</li> <li>5. Data storage capability</li> <li>6. Time-saving</li> </ol>
Contribution to effectiveness	The extent to which GIS has contributed to the satisfaction of information needs, in adequate quantity and quality of data and decision-making process.	<ol style="list-style-type: none"> <li>1. Adequacy of service relative to need</li> <li>2. Improved planning, coordination and cooperation</li> <li>3. Improved products and services</li> <li>4. Job satisfaction</li> <li>5. Potentials for conflict resolution</li> <li>6. Support for quicker, more explicit articulation of decisions (improved decision support)</li> <li>7. User satisfaction</li> </ol>
Contribution to societal well-being	The degree to which GIS helps in the realization of collective goals of a society or impact of GIS on broad societal objectives such as “individual integrity, social justice, distribution of wealth and fulfillment of human aspirations” (Clapp et al., 1989; p42).	<ol style="list-style-type: none"> <li>1. Citizen-public sector interactions (participation)</li> <li>2. Economic benefits</li> <li>3. Enhancement of principles of a democratic society, for example, freedom from constraints such as corruption</li> <li>4. Improved standard of health and safety</li> <li>5. Protection of legal rights, such as privacy (surveillance and confidentiality)</li> <li>6. Social justice: fair treatment and a just share of benefits, for example equal availability of information to citizens when needed and equal ease of access</li> </ol>

Based on Clapp et al. (1989) and Danziger and Anderson (2002)

### 3 Classification of the GIS impact literature

To advance the knowledge on the impacts of GIS we lay out a plan in table 4, which will be used later for the literature review. Traditionally, the use of a Cost and Benefits Analysis (CBA) an assessment of the advantages of a specific GIS application and allows matching benefits of a GIS to organizational goals and to determine the potentials of a proposed GIS with respect to financial benefits (Karikari and Stillwell, 2005). The CBA could

serve as a tool to evaluate tangible benefits such as easily measurable efficiency benefits over competitive solutions and traditional work procedures not utilizing a GIS. Nevertheless, the impacts issues highlighted in table 4 provide a pedestal for evaluating also intangible and not easily measurable benefits as well. In the next section, we present the literature review on the use and impact of GIS as reported in the articles reviewed (see appendix 1) in terms of the three taxonomic designations presented in table 4. The plan defines each taxonomic designation, which considers GIS contributions and impact issues in terms efficiency, effectiveness and societal well-being. Impact issues for each taxonomic designation are based on previous researches done by Clapp et al. (1989) and Dazinger and Anderson (2002).

Clapp et al. (1989) adapt Jordan and Sutherland's (1979) program evaluation framework to develop a model, consisting of four interrelated levels of evaluation: operational efficiency, operational effectiveness, program effectiveness and contribution to well-being, in a means-end hierarchy. The first level of operational efficiency measures a system's capability in acquiring and storing data in an accessible way. This component comprises quantifiable measures such as cost. The second level in the model is operational effectiveness, which measures "... how well information needs are satisfied, and what adverse effects are created" (Clapp et al., 1989; p 42). Our interest is on operational efficiency, which economists have described as technical or productive efficiency, meaning the use of productive resources in the most technologically efficient manner or maximum possible output from a given set of inputs (Worthington and Dollery, 2000). The third level referred to as program effectiveness considers how information is employed in decision process. The fourth and ultimate level evaluates benefits to citizens with respect to individual integrity, social justice, and distribution of wealth and fulfillment of human aspirations. We observe four domains in the model of Clapp and colleagues and identify some impact issues in table 5.

According to Nedovic-Budic (1999), Clapp et al's (1989) model has facilitated a more explicit discussion among researchers studying LIS evaluation models, see Budic (1994) and Sieber (2000b). However, Clapp et al (1989) model did not consider capabilities and functions for interaction and cooperation for exchange of data and services, which have become significant in recent times. GIS, especially LIS, are largely accomplished through collaborative efforts, involving many GIS nodes (Tsou and Buttenfield, 2002), and across multiple public and private agencies involving complex systems. Nedović-Budić and Pinto (2000) discuss mechanisms and behavioral factors that can facilitate or impede GIS activities across multiple organizations.

Danziger and Andersen (2002) put forward a conceptual framework to categorize IT impacts in the public sector. They hypothesized impacts of IT at individual and collective levels. The individual impacts are on public

employee, manager, client or citizen and collective impacts shape a wider range of actors in workgroups, organizations and different levels of public service. Through an inductive logic, the authors present four spheres of influence (capabilities, interactions, orientations and value distributions) of IT in public administration and politics. The four domains comprise of 22 categories of impacts discerned in terms of information quality, efficiency and effectiveness. Danziger and Andersen analyzed IT impacts reported in 49 articles published in 15 journals from 1987-2000 and presented the effect of IT on each domain.

**Table 5.** *Summary of impact issues, based on Clapp et al. (1989)*

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I. Operational efficiency	<ul style="list-style-type: none"> <li>▪ Data acquisition capability</li> <li>▪ Data storage capability</li> <li>▪ Data accessibility</li> <li>▪ Data collection time</li> </ul>
II. Operational effectiveness	<ul style="list-style-type: none"> <li>▪ Adequacy of services relative to need</li> <li>▪ Quality</li> <li>▪ Adequate coverage (level and scale)</li> <li>▪ Specificity</li> <li>▪ Availability</li> <li>▪ Response time</li> <li>▪ Equity of service and sharing of cost</li> </ul>
III. Program effectiveness	<ul style="list-style-type: none"> <li>▪ Quicker and explicit decision making</li> <li>▪ Conflicts resolution</li> <li>▪ Facilitation of GIS activities across organizations</li> </ul>
IV. Contribution to well-being	<ul style="list-style-type: none"> <li>▪ Equal availability and accessibility of information</li> <li>▪ Participation by public in decision process</li> <li>▪ Enhancement of principles of a democratic society</li> <li>▪ Contribution to a positive feature</li> </ul>

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Danziger and Anderson’s review consolidates previous research efforts on IT impacts. The authors provided a scheme for classifying the different measures of IT success, which can serve as a framework for further empirical study. Some of Danziger and Anderson’s specific categories of IT impact such as citizen-public sector interaction, protection of legal rights and improved standard of health, safety and well-being can be considered as societal impacts. However, the conceptual domains and specific categories of IT impacts suggest that capabilities are measurable in three dimensions of information quality, efficiency and effectiveness and the three other domains (interactions, orientations and value distributions) are measured in terms

effectiveness. The research shows that 73% of IT applications in public sector are positive, 19% are negative and 8% are neither positive nor negative across the four domains. The highest proportions of positive impacts are associated with efficiency effects and lower proportion of positive impacts and negative impacts emerge across the more subjective impact of IT on people as they relate to public service. The research recorded highest percentage of negative impacts in value distribution domain.

#### **4 Literature review on impacts/benefits of geographic information systems**

##### ***4.1 Contribution to efficiency***

The definition of efficiency by Nedovic-Budic (1999) is not at variance with Stone (2002) adopted for GIS in table 4. These definitions and impact issues in table 4 guide our review of reported contributions of GIS to efficiency in the articles of this review.

The USA's Urban Information Systems Inter-Agency Committee (USAC) efforts to develop a large-scale computing capacity at municipal level, was reported to have "computing capacity increased by 2,500 percent and the number of computer terminals increased by 550 percent in USAC project cities over the same time period" (Greenwald 2000; p 36). A case study by Kellogg (1999) shows that GIS helped community-based organizations (CBOs) to analyze the community's environmental problems by improving their knowledge of the spatial distribution of a set of environmental hazards and examples from grassroots organizations (GROs) reveal GIS as a useful tool in conveying spatial information to target audience (Sieber, 2000a).

Using cartographic and photographic data sources, Oetter et al. (2004) developed a GIS to map active channels, side channels, islands and tributaries at different points in time, and made comparisons between past and present conditions in the Willamette River flood plain in Oregon, USA. They analyzed spatial data from four dates spanning 150 years and built a model to quantify conservation and restoration potential for each flood plain. The authors recognized the advantage using a GIS in terms of flexibility of digital data. However, they noted the extensive manual effort required for conversion of spatial information from analogue to digital forms required careful manipulation and detailed attention, which implied increase in expenditure of resources. Conversely, their testimonies that it is difficult to realize the reported accomplishments without using a GIS, ability to analyze huge amount of data, and application of GIS techniques to data creation and analysis for a complex historical flood-plain environment are positive contributions to operational efficiency issues of timesaving and availability of information.

In an investigation of the capabilities of GIS as a tool to enhance participatory planning in three neighborhoods in Chicago, Al-Kodmany (2000) found that most of the available GIS data were not at a resolution suitable for neighborhood planning. The structure of available data and frequency of revision were also inadequate for neighborhood planning. It is clear from the case study that access to housing information was very difficult; however, positive efficiency contribution was reported in terms of in geo-referencing and combination of datasets regardless of their conceptual/theoretical model. From the findings of his research, Al-Kodmany (2000) argued that “present “user-friendly” GIS programs are actually not so friendly, as they require substantial skills and expertise to operate” (p 35).

A survey of utility companies on data availability shows that “only a few applications in the specific urban area studied reported data of sufficient detail and control for use in a GIS” (Ellis et al., 2003; p 15). Recently, Elwood (2008) illustrated difficulties in access to local level geospatial data by community development organizations in Humboldt Park, a neighborhood in northwest Chicago (USA). On cost, Rushton et al. (2000; p 33) remarked that “many current applications of GIS in health are extremely wasteful of resources in that their ad hoc nature requires costly GIS resources to be developed to support single project plans.”

However, we found extensive evidence of positive contribution from sharing of geographic information (GI) and geo-processing tools (services). Empirical studies in France shows that inter-municipal approach to GIS was yielding efficiency gains of access to data and updated information in the GIS Project of District Urbain d’Angers (DUA) and “the project has allowed participants to pool information and minimize costs” (Roche and Humeau, 1999; p 12). Direct financial costs are reported as typically low for participating organizations, when GIS facilities are shared (Leitner et al., 2000) and Nedović-Budić and Pinto (2000) reiterated the benefits of joint GIS activities and asserted that “clearly, coordinating and sharing databases improved operational efficiency” (p 468).

It is obvious today that the Internet has enormous impact on sharing of GI and databases. The use of Internet to access remote GI and services can have effect on efficiency in terms of data access, GI processing and dissemination (Peng, 1999). Zhong-Ren and Ming Hsiang (2003) noted that Internet GIS provides an efficient means to advertise, publish and distribute data, and using geo-processing tools. Campagna and Deplano (2004) cited the diffusion of map-based GIS such as MapQuest as an example of Web-based application. They found from a survey of public administration GI websites (PAGIwebs) in Italy that users had access to data in common CAD or GIS formats and “PAGIwebs have embedded applications developed with a client-server architecture. Spatial and thematic query and other GIS functions can be

found here. The user can browse, retrieve, and analyze data on the client side; the server supplies data or portable applications on demand” (Campagna and Deplano, 2004; p31).

To assess the advantages and disadvantages of the different modes of providing GIS to community organizations, Leitner et al. (2000) adopted measures such as responsiveness to community organizations’ needs, and financial, political and human capital costs of implementation and maintenance. They found in their survey that centralized nature of public access to GIS facilities in libraries lower costs by reducing the need for duplication. The use of Internet Map Servers (IMS) as a mode of GIS provision in another case reduces monetary and nonmonetary costs associated with utilizing the GIS. Nevertheless, Leitner et al. (2000) observed that specific needs of community organization were not considerably met with the different modes of providing GIS.

Cutter (2003) observed some GIS capabilities classifiable as contribution to efficiency in the terrorist events of 11 September 2001. The author found from published notes on the events that “... the use of GIS was extensive during the initial rescue and relief operations [...] used to develop preliminary damage assessments – at gross scales and by individual building and/or infrastructure. One of the noteworthy uses of GI Science was communication to the public on the availability of services (electricity, subway, telephone), which were visualized in the form of daily maps published in the in the New York Times and in other outlets” (Cutter, 2003; p 441). This is a positive contribution in terms of GIS capability to integrate and handle large amounts of data quickly. On the monetary aspects, Lee et al. (1999) observed that the initial costs are usually high, but the long-term benefits such as provision and access to information, and efficiency of data manipulation normally compensate the initial costs.

#### **4.2 Contribution to effectiveness**

The wider IS research community noted that measuring the effectiveness of IS is a difficult task (Miller and Doyle, 1987), because IS effectiveness is a multidimensional construct (Pitt et al., 1995). Thus, different effectiveness measures have been used in the past by different researchers (Seddon et al., 1999). The GIS research community discussed effectiveness in terms of satisfaction of information needs and relevance in decision-making process (Budic, 1994; Clapp et al., 1989). The effectiveness impact issues listed in table 4 guide our survey of reported effectiveness of GIS.

We identify the effort of a neighborhood (St. Clair-Superior, USA) with varied land use (residential, industrial and retail) to use GIS to tackle environmental problems such as air pollution, storage of hazardous materials and access to the lakefront as positive contribution to effectiveness. GIS

helped in solving the community's problems by improving their knowledge of the spatial distribution of a set of environmental hazards. GIS produced meaningful information, improved communication and helped in the analysis of air discharges and health concerns of the residents to support better decision-making (Kellogg, 1999). Positive contribution to effectiveness is also reported in the GIS Project of District Urbain d'Angers (DUA) in France in terms new and improved working relations between technicians, suggesting contribution to job satisfaction (Roche and Humeau, 1999). The case studies by Roche and Humeau (1999) revealed improved coordination/cooperation, as the authors concluded that "the three case studies show that a multi-partnership GIS project can increase and promote collaboration between different municipalities" (p 13).

Craglia and Signoretta (2000), in their research on geographic data-sharing experiences at local-level in UK, remarked that "... it is still going to take a long time before government agencies restructure their way of operating to become more responsive to the needs of citizens and customers" (p 787). This is an effectiveness impact issue of adequacy of service relative to need or users' satisfaction. Sieber (2000b) presents GIS implementation patterns by grassroots conservation organizations in northern California through four case studies. The cases rated GIS use almost uniformly poor, "... with isolated nature of GIS knowledge within cases" (p 23). If we link user satisfaction with successful system use (Igarria and Nachman, 1990), this is again is a negative contribution to users' satisfaction issue of effectiveness. Greenwald (2000) examines multi-jurisdictional applications of GIS in USA with the examples of Urban Information Systems Inter-Agency Committee (USAC) and Southern California Association of Governments (SCAG) Access Project (ACCESS). The study revealed total and partial failures, as USAC collapsed and ACCESS was in need of serious revision because it did not achieve its goals.

Ramasubramanian (1999) observed that efforts to develop and implement a LIS in Mauritius with the support of an international institution, yielded no progress, because some officials did not appreciate the benefit or goals of the project and did not support the project. On the positive side is PROgrama para el Manejo del Agua y del Suelo (PROMAS), a GIS project of University of Cuenca, Ecuador (Deckmyn et al., 1999). Ramasubramanian (1999) reported that PROMAS took a multi-disciplinary approach to land and water resources management, provided a structure to collect and manage information for problem solving and provided customized applications that met the requirements of end users.

Karikari et al. (2005) analyzed the application of GIS in the lands sector of Ghana, and found that nearly all cadastral and land registration systems focused on record management, rather than information exploitation. The

Lands Commission Secretariat (LCS), the leading agency in LA in Accra only used GIS for static map displays and had not used GIS for any analytical purposes. This signifies at best a mixed outcome. Researchers have suggested service quality as a measure of IS effectiveness (Kettinger and Lee, 1997; Watson et al., 1998), a comparison between what users believe should be offered and what is provided is a criterion for such measurement (Pitt et al., 1995). When the gap between users' expectations and perceptions is high as reflected in the inadequacies and inconsistencies of existing data and GIS provision in Ghana, especially "...deficiencies in the data held by some agencies with regard to format, accuracy and coverage" (Karikari et al., 2005; p 359), our judgment is that of a negative contribution.

In Papua New Guinea (PNG), a Resource Information System (PNGRIS) was established to meet the informational, resource, and personnel limits of resource management and planning agencies in the country (Montagu, 2000). But, "PNGRIS remains external to the planning process rather than achieving its intended role as an integral component of the process" (Montagu, 2000; p 191). The intended products and services were not realized, the system was inaccessible to units responsible for environmental planning and management, contributing negatively to effectiveness issues of conflict resolution, decision support and other environmental planning functions. de Vos (2007) carried out a longitudinal case study of GIS development in the Costa Rican forestry sector from 1995 to 2002. The GIS directed towards environmental monitoring with satellite technology was considerably deficient, due to poor data exchange arrangements. The reported outcomes include difficulties in managing forests, protests by environmentalists, open disputes and court cases, culminating into total disruption of relationships.

Sieber (2000a) assessed effective use of GIS through interviews and document reviews and found that GIS played a prominent role in the depiction of open space at risk, reinforced support for greenbelt and helped to scrutinize and understand decisions. In her conclusion, she remarked that the researched groups "... apply GIS to goals loftier than efficiency, such as the transformation of meaning" (p 789).

The result of the survey by Campagna and Deplano (2004) shows mixed impact of GIS on the issue of effectiveness in decision support. They found that that in most cases GI websites focused mainly on the supply of information or services (usually for general information purposes), rather than to supporting real participatory or planning processes. This study illustrated the limitations of PAGIwebs (Public Administration GI Websites) to function effectively as planning-support systems.

### ***4.3 Contribution to societal well-being***

Clapp and colleagues (1989) emphasized that any public program should be

evaluated in terms of potential benefits to citizens. We consider contribution to societal well-being with respect to the real impacts of GIS on the society (Goodchild, 2006) through the impacts issues in table 4. It is worthy of note at this moment that there is overt dearth of empirical discussions and findings on societal impacts in the articles reviewed.

Ghose (2001) observed that effective access to information creates more opportunities for both government and community empowerments and evaluated the use of GIS by the inner city neighborhood of Metcalfe Park in Milwaukee, Wisconsin for community empowerment. The societal goal of the project is noticeably “to promote empowerment of citizens traditionally excluded from the decision-making process in neighborhood planning” (Ghose, 2001; p 147). The project “... helped to redistribute socially significant measures of the analytic power of GIS from the elite user group of planners and corporations to disadvantaged sectors of the public” (p 155). Ghose reported that the project did not achieve the goal of establishing a community in-house GIS in the Metcalfe Park neighborhood, because the Metcalfe Park Residents Association (MPRA) did not have funds to employ a GIS specialist. According to Ghose, the MPRA engaged in collaboration with established organizations to solve the problem of funding. The effect, which the use of GIS may have on citizens in this neighborhood, is not obvious in its entirety; nevertheless, we consider the account rendered by Ghose as a positive contribution to well-being, through citizen-public sector interactions reported as stronger citizen participation in local governance.

In their research on modes of provision of GIS with examples from Minneapolis and St. Paul neighborhood organizations, Leitner et al. (2000) noted that legal and ethical concerns may arise within the various modes of provision of GIS. The concerns include threats to the privacy of community members, which may result from the use of GIS for neighborhood surveillance and access to sensitive community-generated data, such as health information. The article of Leitner and colleagues do not suggest a negative or positive contribution, but clearly shows that GIS can undermine the privacy of citizens in the community investigated. This bears testimony to the plethora of societal concerns raised by Rushton et al. (2000) in application of GIS to public health. They contend “... the desire to see health data in its geographic context is in conflict with protecting the confidentiality of individuals.” (Rushton et al., 2000; p 38).

#### ***4.4 Foundation and focus of GIS impact research***

Table 6 shows the frequency with which six types of frameworks of knowledge are applied in the articles surveyed. The methodology adopted in each article and other details (such as research sites) are in appendix 2. Half of the 38 articles do not make clear use of a framework of knowledge and only

8% of the articles make clear use of a theory. Theory can help accomplish three major tasks of discovery, explanation and prediction in a scientific endeavor (Liao, 1990), for example, the performance gap theory, according to Chan and Williamson (1999; p 270) “provides the theoretical base to identify scenarios of GIS diffusion according to the nature of problems being addressed”. There is insignificant use or testing of existing GIS evaluation frameworks such as Gillespie (2000); Karikari and Stillwell (2005); Nedovic-Budic (1999); Obermeyer (2005); Tulloch (1999); Tulloch and Epstein (2002). Finally, the high percentage of papers, which have no clear use of a discernible framework of theoretical knowledge mean less rigor and indicates that the most of the articles surveyed could have missed the advantages of use of theories as illustrated by Sahay and Walsham (1995) and demonstrated by Bhattacharjee (2001).

**Table 6.** *Framework of knowledge used in GIS impact research*

<b>Knowledge framework</b>	<b>Frequency</b>	<b>Percentage</b>
Theory-based: clear use of a theory.	3	8
Framework-based: use of a framework explicitly derived from a body of theoretical work.	3	8
Model-based: use of a model that is presented without reference to any deeper framework of knowledge.	10	26
Concept-based: use of a particular concept, such as ‘concept of data sharing’.	2	5
Category-based: use of a list of factors such as features to be found on GI websites	1	3
Non-framework based: no clear use of a framework of knowledge (indiscernible).	19	50
Total	38	100

The use of case study methodology by over 70% of the articles surveyed raises some methodological issues, such as making controlled observation and deductions, and allowing for replicability and generalizability (Lee, 1989). Worse still was the treatment of case study methodology. Yin (2003) argued that “any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory mode” (p 98). Only one paper (Ellis et al., 2003), which in fact used ethnographic data collection and analysis, carried out data triangulation. However, the literature and previous evaluation studies such as Serafeimidis and Smithson (2003) and Yin (2003) favor the use of the case study methodology for the evaluation of IS and public interventions.

## **5 Analysis of findings and discussion**

From this literature review we observe that the clearest positive impact of GIS

is its contribution to efficiency. Also, the degree of negative contribution to efficiency appears to tally with the degree of negative contribution to effectiveness. However, a negative contribution to efficiency will not lead mechanically to negative effectiveness and positive efficiency contributions will not certainly lead to positive effectiveness. Leitner et al.'s (2000) research revealed that efficiency gains do not readily lead to effectiveness. Georgiadou and Stoter (2008) recently noted that efficiency is not a value-neutral technical term, but a political claim, requiring assumptions about correct outputs and inputs reckoning. However, Nedovic-Budic (1999) considered efficiency an important organizational management objective, but not as best way to assess planning activities. She suggested that GIS evaluation measures should involve organizational goal achievement, public policy and decision-making effectiveness and societal effects. It follows that efficiency and effectiveness are multidimensional constructs, which depend on who is defining them. The discourse on GIS and society emphasizes decision support, public participation, privacy assurance, fairness and equity (Dobson, 2004). A clear perspective to assess these objectives is relevant to discover whose benefits GIS are serving. An investigation of challenges to community empowerment in participatory GIS (PGIS) applications in Ghana revealed that "those who gained most from the opportunities offered by the PGIS applications tended to be men rather than women and the better off and well connected rather than those worse off" (Kwaku Kyem, 2001; p 10).

We found from our review that the responsiveness of GIS to its intended purpose is shaped by factors, which are not rooted only in the technology. Various studies have shown that such factors include funding (de Vos, 2007); requisite training or well-qualified professionals (Karikari et al., 2005; Puri and Sahay, 2003); individuals and institutions that have interest in GIS and modes of provision of GIS (Leitner et al., 2000); user participation in GIS design (Puri and Sahay, 2003); political-economic and cultural processes (Montagu, 2000; Sikor, 2006).

The Internet is also shaping the access and use GIS. Peng and Tsou (2003) remarked that the progression of GIS technology is closely mirroring development of computer technologies. They observed that GIS "evolved from mainframe GIS to desktop GIS, to distributed GIS, which includes Internet and mobile GIS" (Peng and Tsou, 2003; p5). Access and use of GIS resources through mobile and wireless devices such as personal digital assistants (PDAs) and mobile phones is becoming widespread. The Internet has been described as the "... infrastructure that will define the 21st century ..." (Ainsworth, 2002; p A; Peng and Tsou, 2003; p 447) and indisputably, it is shaping access to GIS data, processing and dissemination. A land administration example can be found at <http://www.eulis.eu/> (European Land Information Service), which provides direct online access to official land and

property registers (GI) from participating countries. Recently, Chow (2008) adopted Google Maps Application Programming Interfaces (APIs) to develop a web prototype that disseminates GI on urban sprawl in Mundy Township of Michigan, USA. The research made known some limitations of Maps APIs, such as less spatial and analytical functionality for Internet Mapping Services. However, Chow (2008) demonstrated that the web prototype from his research is valuable in providing users with a dynamic interface for data exploration. He also proposed a framework to use Maps APIs to visualise and present GI.

Using the World Economic Outlook (WEO), which divides the world into two major groups<sup>2</sup>: advanced economies, and emerging and developing economies (IMF, 2008), our analysis of research sites (locations of study area) of the articles surveyed shows that the majority (76%) of the researches took place in the WEO advanced economies, with 19 out of the 38 articles focusing on USA and four from UK. About 21% of the articles investigated impacts in the emerging and developing economies and the research sites of the remaining 3% is not obvious. Furthermore, analysis of the 30 most popular research papers in Environment and Planning B: Planning and Design website in May 2009 reiterate that GIS research efforts are concentrated in the advanced economies. About two-fifth of the most popular papers focused on GIS use, applications or modeling. All the GIS related researches took place in the advanced economies, with only two (Liu and Zhu, 2004; Luo and Wang, 2003) focusing on issues (primary health care and urban transportation) that may have direct benefits to the society.

Among academics in general and GIS scholars in particular, there appears to be a growing interest in what can be broadly termed as the ‘social construction of technology’, which is a conception of a two-way relationship between technology and people (Harvey and Chrisman, 1998). The books of Pickles (1995), Campbell and Masser (1995) and Reeve and Petch (1999) mark a significant shift in this direction. According to Harvey and Chrisman (1998), “GIS technology, like any other technology, is more than a tool; it connects different social groups in the construction of new localized social arrangements” (p 1683).

An evaluation of interpretive research in IS by Klein and Myers (1999) shows that historical factors affect organizations implementing IS and the key finding of Myers (1994) is that IS implementation can only be understood as part of the broader social and organizational context. Law and Callon (1992) have also shown that a technological artifact is conceived and shaped within the context of a number of global and local actors. de Man and van den Toorn

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<sup>2</sup> <http://www.imf.org/external/pubs/ft/weo/2008/01/weodata/groups.htm#me>

(2002; p 51) remarked that “Social conditions will shape the application of a technology. Technology at the same time will have social impacts”.

GIS outputs such as maps could either be a privileged knowledge or bring everybody’s knowledge to a similar point (Duncan, 2006). The research of Martin (2000) suggests that an explanation to why similar GIS implementations produce different outcomes may be sought by detecting differences in the constituent actors and their interactions. Social and management theories, such as actor network theory (ANT) and stakeholders’ theory can be useful in investigating the differences in outcomes. Nevertheless, theories should be used to explain and predict the phenomenon under study with adequate attention to the motivating problems of a research (Robey and Markus, 1998). In essence, evaluation research must be rigorous and relevant to the practitioners’ audience; the support from theory has to be accompanied with a credible evidential base (Robey and Markus, 1998). While serving “socio-political needs related to legitimacy and recognition of an academic discipline” (Sahay and Walsham, 1995; p112), theories will also support the rigorousness of academic research and application of appropriate methodology can enhance the relevance of the outputs.

This review indicates a dearth of theoretically and empirically grounded research on the contributions of GIS to societal well-being, with relatively few studies from emerging and developing economies.

We argued that without theories and without taking the research efforts closer to real world situations; GIS researchers are inadequately equipped to decide how GIS benefits public administrations and citizens. GIS impact research therefore needs theories, which enable us to pass judgment between the outcomes of GIS implementation and their intended goals, and state with acceptable confidence positive and negative outcomes. The use of theories can also help GIS researchers to give reasons for positive and negative outcomes.

In conclusion, there is insignificant use of social and economic theories to analyze organizations and impacts of GIS on important aspects of a society’s interests (see table 4). The concentration of the research efforts in the so-called advanced economies could be a reflection of the countries where the journals are published, but the journals surveyed are international and not regionally biased. Therefore, the result of our analysis can signify less attention to GIS impact research in emerging and developing economies.

## **6 Future research suggestions and conclusion**

In this paper, we build on works of IS, IT, GIS, LIS and public administration scholars to propose an approach to classify GIS impacts in terms of the contribution of the technology to efficiency, effectiveness and societal well-being. To realize our substantive goal, we review and analyze GIS impacts in

five academic journals using three taxonomic designations based on similarities of impact issues. Our review largely agrees with Tulloch's (1999) observation that efficiency and effectiveness benefits have been the object of attention in GIS impact research and confirms Sheppard et al. (1999) remark of limited research attention to societal context influencing GIS implementation and societal effects of GIS. Overall, there is no serious departure from the findings of Nedović-Budić. This review reveals that the mixed outcomes observed in 1998 for advanced economies (USA, the Scandinavia and UK) persist, and findings from emerging and developing countries (Costa Rica, Ecuador, Ghana, Mauritius, Moldova, Papua New Guinea and Vietnam) are also mixed, with clearest positive impacts only in the area of efficiency.

The first research implication of our findings is the need for rigorous empirical research; by this we mean apposite use of research philosophies and theories. As Georgiadou et al. (2005) pointed out, IS "implementation analysis is best guided by an interpretive philosophy where the different social meanings constructed by various stakeholder groups are emphasized, as contrasted to a positivist approach where assumptions are made about objectivity of data and the generation of statistical generalizations" (p 1126). GIS as an IS type (Walsham and Sahay, 1999) can benefit from the interpretive approaches, because these emphasize human agency (Georgiadou, 2005). The fact that the same institution, or the same human action, can have different meanings for different human actors and even for researchers (Lee, 1991) explains why similar GIS projects produce different outcomes. Human and other contextual factors that shape the impacts of GIS can be better understood by applying theories to understand how a system is configured and introduced for a particular application. From our literature review, we observe that this is a fundamental issue in determining the nature of contribution of GIS to efficiency, effectiveness and societal well-being.

Our second inference and suggestion is the need to connect to existing GIS evaluation methods and frameworks. The current situation can hinder the theoretical development of an academic field, as frameworks already developed are rarely tested or applied in different settings. We concur with Sahay and Walsham (1995) remarks that "an important element in the progress of any academic discipline is a periodic stock taking of the status of the research" (p 111) and give an analysis of status of the GIS impact research regarding basis or framework of knowledge and methodologies. From the body of knowledge reviewed we find that a classification of the effects of GIS into taxonomic designations in terms of contribution of GIS to efficiency, effectiveness and societal well-being can be a basis to explore the impacts of GIS in the academic literature.

Thirdly, there is a need to fill the gap in geographic focus, through an international and multidisciplinary research on society-wide impact issues in emerging and developing economies. We suggest longitudinal interpretive approaches (such as case studies and ethnographies), involving single-case, multiple-case and comparison of cases. A step further is to use theories to inform research design and data collection, outline correct operational measures for the concepts being studied, triangulation of data sources and specifying the extent to which research findings can be generalized.

Finally, the nature and degree of contribution of GIS in all the taxonomic designations, especially to societal well-being, raises some concerns on the nature of the relationship between 'the technology' and 'the process' which it is intended to serve) and there has been little rigorous analysis of GIS impacts. This update on the impacts of GIS points to the need for more research built on a credible evidential base and on the effects of GIS in dealing with society-wide issues in developing countries.

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### Appendix 1. Reviewed articles by journal

<b>Environment and Planning B: Planning and Design</b>
<ol style="list-style-type: none"> <li>1. Campagna, M. and G. Deplano (2004). Evaluating Geographic Information Provision within Public Administration Websites. <i>Environment and Planning B: Planning and Design</i>, 31:21-37</li> <li>2. Carver, S., A. Evans, R. Kingston and I. Turton (2001). Public Participation, GIS, and Cyberdemocracy: Evaluating On-Line Spatial Decision Support Systems. <i>Environment and Planning B: Planning and Design</i>, 28:907-921</li> <li>3. Ceccato, V.A. and F. Snickars (2000). Adapting GIS Technology to the Needs of Local Planning. <i>Environment and Planning B: Planning and Design</i>, 27:923-937</li> <li>4. Craglia, M. and P. Signoretta (2002). From Global to Local: the Development of Local Geographic Information Strategies in the United Kingdom. <i>Environment and Planning B: Planning and Design</i>, 27:777-788</li> <li>5. de Vos, H.J.D. (2007). Organisational Culture: Institutionalisation of GIS for Forest Monitoring in Costa Rica. <i>Environment and Planning B: Planning and Design</i> 2007, 34:355-368</li> <li>6. Lee, J., L. Tian, L.J. Erickson and T.D. Kulikowski (1998). Analyzing Growth-Management Policies with Geographical Information Systems. <i>Environment and Planning B: Planning and Design</i>, 25:865-879</li> <li>7. Montagu, S. (2000). GIS and Natural Resource Planning in Papua New Guinea: A Contextual Analysis. <i>Environment and Planning B: Planning and Design</i> 27:183-196</li> <li>8. Nedovic-Budic, Z. and J.K. Pinto (2000). Information Sharing in an Interorganizational GIS Environment. <i>Environment and Planning B: Planning and Design</i>, 27:455-457</li> </ol>
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<ol style="list-style-type: none"> <li>1. Elwood, S. (2008). Grassroots Groups as Stakeholders in Spatial Data Infrastructures: Challenges and Opportunities for Local Data Development and Sharing. <i>International Journal of Geographical Information Science</i>, 22:71-90</li> <li>2. Harvey, F. and D. Tulloch (2006). Local-Government Data Sharing: Evaluating the Foundations of Spatial Data Infrastructures. <i>International Journal of Geographical Information Science</i>, 20:743-768</li> <li>3. Hendriks, P.H.J. (2000). An Organizational Learning Perspective on GIS. <i>International Journal of Geographical Information Science</i>, 14:373-396</li> <li>4. Karikari, I., J. Stillwell and S. Carver (2005). The Application of GIS in the Lands Sector of a Developing Country: Challenges Facing Land Administrators</li> </ol>

in Ghana. *International Journal of Geographical Information Science*, 19:343-362

5. Martin, E.W. (2000). Actor-Networks and Implementation: Examples from Conservation GIS in Ecuador. *International Journal of Geographical Information Science*, 14:715-738
6. Sieber, R.E. (2000a). Conforming (to) the Opposition: The Social Construction of Geographical Information Systems in Social Movements. *International Journal of Geographical Information Science*, 14:775-793

#### **Land Use Policy**

1. Cashin, S.M. and G. McGrath (2006). Establishing a Modern Cadastral System within a Transition Country: Consequences for the Republic of Moldova. *Land Use Policy*, 23:629-642
2. Feder, G. and A. Nishio (1998). The Benefits of Land Registration and Titling: Economic and Social Perspectives. *Land Use Policy*, 15:25-43
3. Lee, J.T., M.J. Elton and S. Thompson (1999). The Role of GIS in Landscape Assessment: Using Land-Use-Based Criteria for an Area of the Chiltern Hills Area of Outstanding Natural Beauty. *Land Use Policy*, 16:23-32
4. Sikor, T. (2006). Politics of Rural Land Registration in Post-Socialist Societies: Contested Titling in Villages of Northwest Vietnam. *Land Use Policy*, 23:617-628

#### **Transactions in GIS**

1. Beckler, A.A., B.W. French and L.D. Chandler (2005). Using GIS in Areawide Pest Management: A Case Study in South Dakota. *Transactions in GIS*, 9:109-127
2. Cutter, S. L. (2003). GI Science, Disasters, and Emergency Management. *Transactions in GIS*, 7:439-446
3. Field, K. and L. Beale (2004). Using GIS to Model Incidence, Prevalence and Spread of Non-legal Drug Use. *Transactions in GIS*, 8:423-439
4. Ghose, R. (2001). Use of Information Technology for Community Empowerment: Transforming Geographic Information Systems into Community Information Systems. *Transactions in GIS*, 5:141-163
5. Oetter, D.R., L.R. Ashkenas, S.V. Gregory and P.J. Minear (2004). GIS Methodology for Characterizing Historical Conditions of the Willamette River Flood Plain, Oregon. *Transactions in GIS*, 8:367-383
6. Proctor, S.P., S. Gopal, A. Imai, J. Wolfe, D. Ozonoff and R.F. White (2005). Spatial Analysis of 1991 Gulf War Troop Locations in Relationship with Postwar Health Symptom Reports Using GIS Techniques. *Transactions in GIS*, 9:381-396
7. Ramasubramanian, L. (1999). GIS Implementation in Developing Countries: Learning from Organisational Theory and Reflective Practice. *Transactions in GIS*, 3:359-380

**Urban and Regional Information Systems Association (URISA)**

1. Al-Kodmany, K. (2000). Extending Geographic Information Systems to Meet Neighborhood Planning Needs: The Case of Three Chicago Communities. *Urban and Regional Information Systems Association (URISA)*, 12:19-37
2. Caron, C. and Y. Bédard (2002). Lessons Learned from Case Studies on the Implementation of Geospatial Information Technologies. *Urban and Regional Information Systems Association (URISA)*, 14:17-36
3. Chan, T.O. and I.P. Williamson (1999). A Model of the Decision Process for GIS Adoption and Diffusion in a Government Environment. *Urban and Regional Information Systems Association (URISA)*, 11:7-16
4. Ellis, C.D., C. Quiroga, S.Y. Shin, and R.J. Pina (2003). GIS and Human-Centered Systems Design: Using Ethnographic Data Collection and Analysis Methods to Design a Utility Permitting Support System. *Urban and Regional Information Systems Association (URISA)*, 15:5-22
5. Esnard, A.M. (2007). Institutional and Organizational Barriers to Effective Use of GIS by Community-Based Organizations. *Urban and Regional Information Systems Association (URISA)*, 19:13-21
6. Greenwald, M.J. (2000). Beyond City Limits: The Multi-Jurisdictional Applications of GIS. *Urban and Regional Information Systems Association (URISA)*, 20:31-43
7. Harvey, F. (2001). Constructing GIS: Actor Networks of Collaboration. *Urban and Regional Information Systems Association (URISA) Journal*, 13:29-37
8. Keating, G.N., P.M. Rich and M.S. Witkowski (2003). Challenges for Enterprise GIS. *Urban and Regional Information Systems Association (URISA)*, 15:23-36
9. Kellogg, W.A. (1999). From The Field: Observations on Using GIS to Develop a Neighborhood Environmental Information System For Community-Based Organizations. *Urban and Regional Information Systems Association (URISA)*, 11:15-32
10. Leitner, H., S. Elwood, E. Sheppard, S. McMaster and R. McMaster (2000). Modes of GIS Provision and their Appropriateness for Neighborhood Organizations: Examples from Minneapolis and St. Paul, Minnesota. *Urban and Regional Information Systems Association (URISA)*, 12:45-58
11. Roche, S. and J.B. Humeau (1999). GIS Development and Planning Collaboration: A Few Examples from France. *Urban and Regional Information Systems Association (URISA)*, 11:5-14
12. Rushton, G., G. Elmes and R. McMaster (2000). Considerations for Improving Geographic Information System Research in Public Health. *Urban and Regional Information Systems Association (URISA)*, 12:31-49
13. Sieber, R. E. (2000b). GIS Implementation in the Grassroots. *Urban and Regional Information Systems Association (URISA)*, 12:15-29

**Appendix 2. Country of interest of each research, basis, methodology and level of analysis**

	<b>Author(s)</b>	<b>Year</b>	<b>Basis</b>	<b>Methodology</b>	<b>Level of analysis</b>	<b>Country</b>
<b>Environment and Planning B: Planning and Design</b>						
1	Lee et al.	1998	Indiscernible	Case study	County	USA
2	Montagu	2000	Indiscernible	Case study	National	PNG
3	Nedovic-Budic & Pinto	2000	Framework	Case study	National	USA
4	Ceccato and Snickars	2000	Indiscernible	Case study	National	Sweden
5	Carver et al.	2001	Indiscernible	Case study	Local/ regional	UK
6	Campagna and Deplano	2004	Category	Survey	National	Italy
7	de Vos	2007	Theory	Case study	Projects	Costa Rica
<b>International Journal of Geographical Information Science(IJGIS)</b>						
8	Hendriks	2000	Model	Case study	Private sector	Not stated
9	Martin	2000	Theory	Case study	NGO	Ecuador
10	Keating et al.	2003	Model	Not obvious	NGO	USA
11	Karikari et al.	2005	Indiscernible	Case study	NGO	Ghana
12	Harvey and Tulloch	2006	Concept	Ethnography	Local govt	USA
13	Elwood	2008	Indiscernible	Case study	NGO	USA
<b>Land Use Policy</b>						
14	Feder and Nishio	1998	Model	Case study	Multi national	Dev. countries
15	Lee et al.	1999	Indiscernible	Experiment	County	UK
16	Cashin and McGrath	2006	Concept	Case study	National	Moldova
17	Sikor	2006	Indiscernible	Case study	Project	Vietnam
<b>Transactions in GIS</b>						
18	Ramasubramanian	1999	Framework	Case study	Academia	Dev. countries
19	Ghose	2001	Indiscernible	Case study	NGO	USA
20	Cutter	2003	Model	Case study	WTC	USA
21	Field and Beale	2004	Model	Experiment	National	UK
22	Oetter et al.	2004	Indiscernible	Experiment	Flood plain	USA
23	Beckler et al.	2005	Indiscernible	Experiment	Township	USA
24	Proctor et al.	2005	Indiscernible	Case study	Military	USA

<b>Urban and Regional Information Systems Association (URISA)</b>						
25	Roche and Humeau	1999	Indiscernible	Case study	Municipality	France
26	Chan and Williamson	1999	Model	Case study	Nation/state	Australia
27	Kellogg	1999	Indiscernible	Case study	NGO	USA
28	Craglia and Signoretta	2000	Model	Case study	Local	UK
29	Greenwald	2000	Indiscernible	Case study	Counties	USA
30	Sieber	2000b	Model	Case study	NGO	USA
31	Leitner et al.	2000	Model	Case study	NGO	USA
32	Rushton et al.	2000	Indiscernible	Review	Academia	USA
33	Al-Kodmany	2000	Indiscernible	Case study	NGO	USA
34	Sieber	2000a	Indiscernible	Case study	NGO	USA
35	Harvey	2001	Theory	Survey	NGO	Switzerland
36	Caron and Bédard	2002	Model	Case study	Municipality	Canada
37	Ellis et al.	2003	Indiscernible	Ethnography	State	USA
38	Esnard A-M	2007	Framework	Survey	States	USA