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

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SUMMARY

Our objective in this paper is to review the literature on the impacts of geographic information systems (GIS) in governmental and non-governmental organizations by analyzing 53 articles published between 1998 and 2008 in five relevant 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. GIS impacts 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.

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1. INTRODUCTION

Since the growth in the use of geographic information systems (GIS) across public and private sector agencies in the 1970s (Mark et al., 1977) researchers and practitioners have struggled to examine its impacts and effects and to ensure the efficient and effective use of the technology. The aim of this paper is not to provide a framework for GIS evaluation, rather 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. 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. 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. 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.

Pervasive use of GIS indicates a high degree of expectation for bringing positive changes in pubic sector organizations broadly in terms of productivity, efficiency and effectiveness. GIS and public administration literatures agree that GIS is largely a public sector technology. For example, Sieber (2000b) observed that public agencies are leading in the implementation of GIS and Haque (2001) noted that GIS has significantly influenced the way public administrators implement public policies such as parcel or real estate management. Arguably, GIS is also linked to land information systems (LIS), which can be considered a technical component of land administration (LA)[1] in public service dealing mainly with land and real estate information (Wegener and Masser, 1996). LIS are assemblies of human, organizational, institutional and technical resources for the collection, maintenance, analysis, dissemination and use of land related information (Dale and McLaughlin, 2000). LA researchers (for example, Kaufmann, 2002; Steudler et al., 2004; Steudler and Williamson, 2002) have recommended to use performance indicators and benchmarking for the evaluation of land administration systems and LA activities like land registration. The indicators suggested by these authors include data properties (capture method, quality and accuracy); support of land market (secure, simple, at low cost) and financial input and return. However, Mitchell et al. (2008) observed that performance indicators used in LA projects in Ghana, Indonesia and Laos failed to state the magnitude of indicators such as 'reduction in land disputes' and noted that it is difficult to confirm improvements such as increase in household's income.

[1] LA refers to processes of recording and disseminating information about the ownership, value and use of land and its associated resources (UN-ECE, 1996). Steudler and Williamson (2002) define three management levels for LA: policy, management and operational control. They describe LIS as a function for managing data and information at the operational control.

Reflecting on previous research, Reeve and Petch (1999) catalogued the disappointments met by GIS users and noted that the benefits of GIS seemed to be more difficult to achieve than as presented by visionaries and purveyors of the technology. Early efforts by Antenucci et al. (1991) identified quantifiable and intangible benefits of GIS and presented a life-cycle approach to GIS cost accounting as a foundation for using a comparative cost-benefit analysis. However, this method of examining benefits does not account for the possibility of societal benefits linked with the use of GIS. Yet, "it is striking that, regardless of the criteria chosen, success had proved extremely elusive..." in 12 cases of GIS in Great Britain's local government studied by Campbell and Masser (1995; p 112) leading some scholars to note later on that the "very success of GIS is a cause of concern" (Longley et al., 2005; p32).

In the midst of these mixed outcomes 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 (Pickles, 1995). More recently, Nedović-Budić (1998) analyzed the empirical findings on the effects of GIS with the DeLone and McLean's (1992) model categories of information system (IS) success. DeLone and McLean's (1992) model comprises: system quality, information quality, information use, user satisfaction, individual impact and organizational impact. Nedović-Budić (1998) reviewed the impact of GIS technology between 1990 and 1998 in planning agencies and local governments in United States of America (USA), United Kingdom (UK) and Scandinavia. 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. Therefore, Nedović-Budić (1998) added to the DeLone and McLean (1992) model the facet of societal impact. 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".

The rest of the 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 literature on impacts of GIS. The penultimate section analyses and discusses our findings. Finally, we conclude the paper and 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.

2. METHODS OF SURVEY OF GIS IMPACT LITERATURE

This section provides a concise discussion on the methods and techniques used and how these were applied in this paper. The first 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. The second step included the capturing of the orientation of the journals to identify the journals that emphasized and reported on GIS use and impact issues. The third step was to examine the title of the articles of the journals identified in step 2 from which a number of articles were selected for further study.The fourth step was to review abstracts, introduction and conclusions of the articles identified in step 3 . In step five, we conducted an in depth study and content analysis of articles which had reported on GIS impact issues. The sixth step assessed each of the articles contribution and attention to the taxonomic designations of efficiency, effectiveness and societal well being. Finally 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

No.	Technique	Description	Output
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 (Caron et al., 2008; Longley et al., 2001) to identify journals that report GIS use and impact issues.	Candidate journals[2].
3	Examination of titles of articles.	Online (electronic) 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*'.	Appraisal 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 Literature review and characterization

We began with the study of the literature on information systems (IS), information technology (IT), GIS and LIS to recognize and catalog how researchers have examined and reported the impacts of IS, IT, GIS and LIS. We identify from the body of knowledge surveyed (especially from the studies of Clapp et al. (1989), Nedovic-Budic (1999) and Tulloch and Epstein (2002)) that a classification of the effects of GIS into *taxonomic designations of contribution of GIS to efficiency, effectiveness and societal well-being* can be a basis to explore impacts of GIS in the academic literature. The taxonomic designations draw on impact issues suggested by Clapp et al. (1989), and Danziger and Anderson (2002). Clapp et al. (1989) observed that the purpose of information systems (IS) in government is to serve a wide variety of users, both public and private and recognized the complexity of such systems by assuming a continuous understanding of impacts rather than simply evaluating the products of the system. The more recent specific categories of IT impacts by Danziger and Anderson (2002) provides an approach to review effects of private sector-public sector interaction and cooperation on GIS outcomes.

[2] Academic research outlets to explore for G/LIS impacts.

2.2 Capturing of orientation of journals

We study 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 our survey. We limit our selection to five journals based on our interpretation of aims, scopes, target audience and mission statements of the journals. The journals 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 in each journal during the period of review and number of articles selected for review are in table 2.

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

Journal	Period	No. of articles	No of selected articles
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

2.3 Examination of titles of articles

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.

2.4 Preliminary study of articles

After a review of the abstracts, introduction and conclusion of the 53 pre-selected articles; we limited our sample to 38 articles, which document GIS impacts in governmental and non-governmental organizations mainly from primary sources of evidence.

2.5 In-depth study and content analysis

We took a stock of research sites (locations of study area) of the articles surveyed, and classified them with the country classification of the World Economic Outlook (WEO), which divides the

world into two major groups[3]: advanced economies, and emerging and developing economies (IMF, 2008). As shown in figure 1, 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.

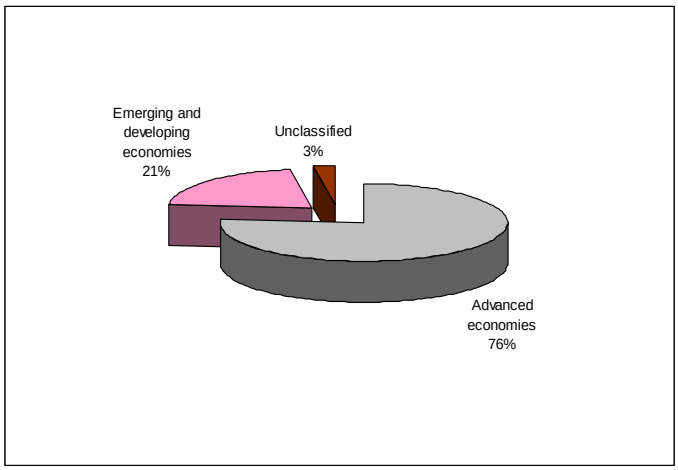

Figure 1: Research sites of articles surveyed

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 delve into the analysis of the methodologies used in each of the articles reviewed in this paper, which have used either positivist or interpretive approaches. Table 3 shows that interpretive approaches (case study and ethnography) are more frequent than the positivist approaches (experiment and surveys). The level of analysis refers to 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.

Table 3: Research methodologies of articles surveyed

Methodology	Frequency	Percentage
Case study	27	71
Ethnography	2	5
Experiment	4	11
Review	1	3
Survey	3	8
Not obvious	1	3
Total	38	100

2.6 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 (±) 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,

[3] http://www.imf.org/external/pubs/ft/weo/2008/01/weodata/groups.htm#me

2002). To attain consistency, we base our judgment of +, ± and – on definitions from previous studies by Danziger and Andersen (2002) and Heeks (2002). Furthermore, the explanations provided in "*The heritage illustrated dictionary of the English Language*" edited by Morris (1969) also give broad descriptions of +, ± and – as shown in table 4.

Table 4: Definitions of positive, negative and mixed impacts of GIS

	Positive (+)	**Mixed (±)**	**Negative (–)**
(Heeks, 2002)	Success: most stakeholder groups attain their major goals and do not experience significant undesirable outcomes.	Partial failure[4]: major goals are not accomplished or significant unfavorable outcomes.	Failure: initiative never implemented or implemented but immediately abandoned.
(Danziger and Andersen, 2002)	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.
(Morris, 1969)	Measured or moving in a direction of increase, progress or forward motion.	Composed of a variety of differing, sometimes conflicting entities.	Lacking the quality of being positive.

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 ± impacts. Examples of reported outcomes classified as +, – and ± in terms of contributions to efficiency, effectiveness and societal well-being are in appendix 1. Since not all the articles reports GIS contribution for all the three taxonomic designations, an article that does not report a finding for a particular designation is assigned nil (≠) for that designation. In essence, only one of + or – or ± or ≠ can 'occur' in one taxonomic designation at a time for an article. An article that does not show one of + or – or ± is not an 'eligible candidate' for in-depth review and analysis.

2.7 Contribution of GIS to efficiency, effectiveness and societal well-being

The nature of contribution (+, ± or –) of GIS varies across the three taxonomic designations. Figure 2 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.

[4] This can also mean partial success.

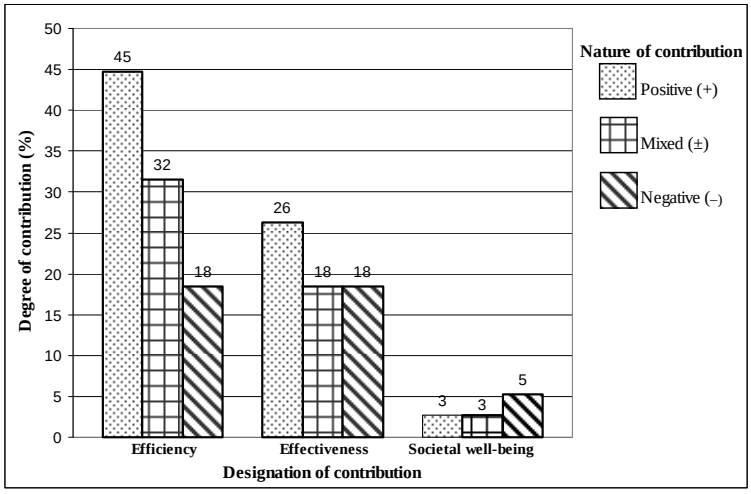

Figure 2: Nature of contribution of GIS

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

From figure 2, we see that the level of positive, mixed and negative contributions of GIS to societal well-being is very low, suggesting low attention to societal well-being by GIS impact researchers. 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 3.

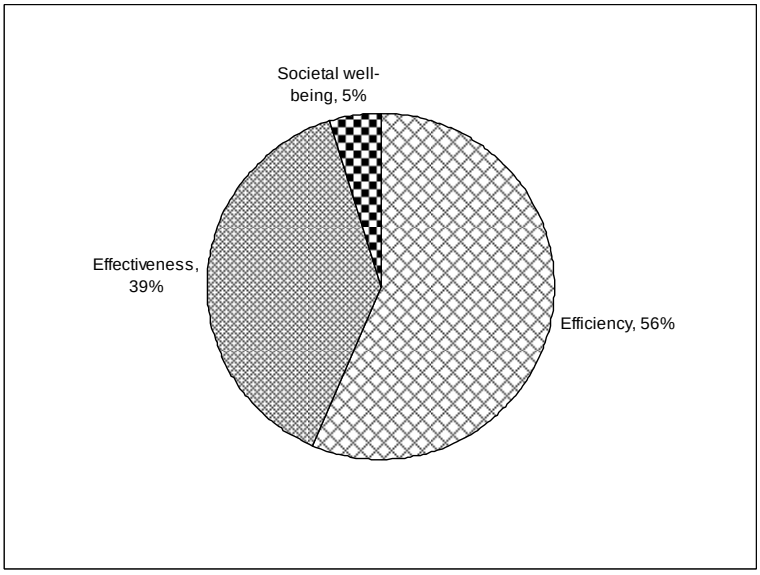

Figure 3: Level of attention to GIS impact research

2.9 Limitations

Our methodology, of course has some limitations. 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 publication in developing countries and non-English publications. However, most of the findings in the articles reviewed are based on evidence gathered from information collected from real-life experiences or observations (Kumar, 2005), suggesting a positive impression on conclusions drawn in this paper. The methodology as shown in table 1 is repeatable, each step was taken in an unbiased manner. We hope that the iterative refinement of the methodology and its application in this research will make the methodology useful for further survey of G/LIS impact and a pedestal for developing frameworks for assessing G/LIS impacts. In appendix 2, we provide the list of articles reviewed in the five journals.

3. CLASSIFICATION OF THE GIS IMPACT LITERATURE

In the literature, we found prominent the use of efficiency, effectiveness, user satisfaction and service quality measures. Models, such as design-actuality gaps (Heeks, 2002), were suggested to explain IS failure and success. The literature shows how benefits occur and the stage at which the benefits occur, for example Kudyba and Diwan (2002) suggest that investment in IT enhances productivity over time. Tulloch (1999) presents a conceptual model to show how benefits build up at various stages in the development of multipurpose land information systems (MPLIS). We also learn from the literature how some academics assessed the validity of existing IS models (Rai et al., 2002) and reviewed the methods and criteria of evaluating GIS/LIS (Nedovic-Budic, 1999).

Table 5: A classification of GIS impact literature based on similarities of impact issues

Taxonomic designation	Definition	Impact issue
Contribution to efficiency	the degree to which GIS operates with minimum waste, duplication, and expenditure of resources (Stone, 2002).	1. Availability and accessibility to products and services 2. Cost (monetary and nonmonetary costs associated with utilizing a service or buying a product) 3. Coverage and completeness 4. Data acquisition capability 5. Data storage capability 6. Time-saving
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.	1. Adequacy of service relative to need 2. Improved planning, coordination and cooperation 3. Improved products and services 4. Job satisfaction 5. Potentials for conflict resolution 6. Support for quicker, more explicit articulation of decisions (improved decision support) 7. User satisfaction
Contribution to societal well-being	reported 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)	1. Citizen-public sector interactions (participation) 2. Economic benefits 3. Enhancement of principles of a democratic society, for example, freedom from constraints such as corruption 4. Improved standard of health and safety 5. Long term contribution to positive future 6. Protection of legal rights, such as privacy (surveillance and confidentiality) 7. 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

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

To advance the knowledge about the impacts of GIS we lay out a plan, which will be used later for the literature review. Table 5 above explains the definitions of 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 also listed based on previous research done by Clapp et al. (1989) and Dazinger and Anderson (2002).

It is important to keep in mind that developing a taxonomy or nomenclature is an intricate task and overlaps often occur, for example, data quality, which Danziger and Andersen consider an information quality measure, can also be a measure of effectiveness. This is because high-quality data has been described as data fit for use by data consumers, meaning usefulness and usability from the consumers' point of view (Strong et al., 1997). This relates to use and user satisfaction, which DeLone and McLean (1992; 2003) consider as measures of effectiveness success. Ascertaining societal benefits represents a greater challenge. In the social sciences, terms such as well-being and good health are standards of 'good life' (Veenhoven, 2000). The measures of societal impact in GIS literature embrace empowerment at individual and community levels (Corbett and Keller, 2005), equity (Tulloch, 1999; Tulloch and Epstein, 2002) and economic benefits (Feder and Nishio, 1998).

Clapp et al. (1989) adapt Jordan and Sutherland (1979) program evaluation framework to develop a model, which consists 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 6.

Table 6: Summary of impact issues, from Clapp et al. (1989)

I.	Operational efficiency	▪ Data acquisition capability ▪ Data storage capability ▪ Data accessibility
II.	Operational effectiveness	▪ Adequacy of services relative to need ▪ Quality ▪ Adequate coverage (level and scale) ▪ Specificity ▪ Availability ▪ Response time ▪ Equity of service and sharing of cost
III.	Program effectiveness	▪ Quicker and explicit decision making ▪ Conflicts resolution
IV.	Contribution to well-being	▪ Equal availability and accessibility of information ▪ Participation by public in decision process ▪ Enhancement of principles of a democratic society ▪ Contribution to a positive feature

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 became 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.

Tulloch and Epstein (2002) build on a theoretical model MPLIS by Tulloch (1999) to categorize GIS/LIS benefits into efficiency, effectiveness and equity. Efficiency benefits emerge when GIS/LIS supports mapping and data management more rapidly at reduced costs. Effectiveness benefits evolve from complex applications of GIS/LIS, which are not possible in analogue format. Equity or empowerment is the contribution of MPLIS to the nature and degree of participation by citizens and organizations in decisions about land and resources. Yet, this requires a clearer understanding of term empowerment and the conditions that influence individual or community empowerment (Corbett and Keller, 2005).

The description of when the benefit is likely to occur and indication of how to observe and measure the benefits render Tulloch and Epstein's model usable for evaluation of GIS/LIS. The model suggests that the benefits will not occur at one point in time; rather it develops in stages over a period. The adoption of this model as an evaluation framework will require an extensive definition of impact issues to measure, especially for the community-oriented equity benefits, which Clapp et al (1989) referred to as societal benefits.

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. 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.

Danziger and Anderson's review consolidates previous research efforts on IT impacts. The authors provide 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 update of the original DeLone and McLean IS Success Model of 1992 (DeLone and McLean, 2003) did not depart from the process and causal considerations of the original model, but incorporated three new dimensions of *service quality, intention to use and net benefits*. Post 1992 IS evaluation researches, for example Pitt et al (1995) support service quality as a measure of IS success. New IS impact measures, such as *group, inter-organizational and industry, consumer and societal impacts* emerge with original individual and organizational impacts dimensions in a new category called *net benefits*. The *intention to use* (attitude) dimension was introduced because of "… the difficulties in interpreting the multidimensional aspects of "use" …" (DeLone and McLean, 2003; p 23).

From this paper, we learn how the authors improved the original model with academic contributions of other IS researchers and advance our understanding of dimensions of IS success measures, such as use, intention to use and user satisfaction. According to DeLone and McLean (1992; 2003) system quality and information quality can be considered as a 'lens for looking at efficiency impacts', service quality, use and user satisfaction as a 'lens for looking at effectiveness' and net benefits as a 'lens for looking at societal impacts'. Net benefits can be defined in terms of how a section of the society or group benefits from IS success. Nevertheless, specific metrics are required to adopt the updated model to evaluate societal impacts of GIS.

4. LITERATURE REVIEW ON IMPACTS/BENEFITS OF GEOGRAPHIC INFORMATION SYSTEMS

We present below the literature review on the use and impact of GIS as reported in the articles surveyed (for a detailed list see appendix 3) in terms of GIS contributions to efficiency, effectiveness and societal well-being.

4.1 Contribution to efficiency

Efficiency is typically a ratio of outputs to inputs, which can be expressed as cost savings, cost avoidance, or productivity gains (Nedovic-Budic, 1999). Efficiency impact issues considered in the literature surveyed are in table 5.

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 adverse, 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 have 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 lowers 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 effectiveness impact issues listed in table 5 guides 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 conclude 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 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 (Igbaria 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 land administration 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

Generally, technology is documented in the academic literature a set of tools, machines, materials that has transformed or holds the potential for transforming society in positive directions and has capabilities to solve human problems (Berman and Tettey, 2001; Prakash and De, 2007). We attempt to investigate these assertions with respect to GIS technology by looking at some of the impacts issues of societal well-being in table 5. 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 that 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).

From the 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, negative efficiency contribution will not mechanically lead to negative effectiveness and positive efficiency contribution will not certainly lead to positive effectiveness. Even though, efficiency gains may be construed from different perspectives - see Kopp (1981) and Stone (2002) - efficiency gains do not readily lead to effectiveness, as reflected in Leitner et al.'s (2000) research.

4.4 Foundation and focus of GIS impact research

Table 7 shows the frequency with which the 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 3. 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 Bhattacherjee (2001).

Table 7: Framework of knowledge used in GIS impact research

Knowledge framework	Frequency	Percentage
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) argues 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.

We found from our survey 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).

5. ANALYSIS OF FINDINGS AND DISCUSSION

Among academics in general and GIS scholars in particular, there appears to be a growing interest in what can be broadly termed as social construction of technology, which is a conception of a two-way relationship between technology and people (Harvey and Chrisman, 1998). The book of Pickles (1995) and the publications of 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 (2002; p 51) remark that "Social conditions will shape the application of a technology. Technology at the same time will have social impacts".

For these reasons, a social constructivist approach to GIS impact research can forestall treating GIS technology as a neutral "black box", by providing a basis to explain how the technology arose from social, economic and technical relations that are already in place. Furthermore, the approach can help researchers to investigate why the adoption of a technology distributes or redistributes opportunities and constraints equally or unequally, fairly or unfairly (Bijker and Law, 1992; Mitev, 2000).

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, "if theory is found to explain and predict the phenomenon under study, but the motivating problems remain unsolved, the research has not succeeded" (Robey and Markus, 1998; p10). In essence, evaluation research must be rigorous and relevant to the practitioners' audience, the support from useful logic and 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 an academic research and the use of appropriate methodology can enhance the relevance of the outputs.

GIS outputs such as maps could either be a privileged knowledge or bring everybody's knowledge to a similar point (Duncan, 2006). 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).

Finally, this literature 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. 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. 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 (Montgau, 2000).

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) points 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 interpretive approaches (ethnographies, case studies) in a longitudinal manner, involving single-case, multiple-case and comparison of cases. A step further is to use theories to

inform research design and data collection, outline of correct operational measure for the concepts being studied, triangulation of data sources and specifying the extent to which research findings can be generalized.

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. Recent empirical findings by Esnard (2007) show a mismatch between the actual use and potential use of GIS for community and land redevelopment initiatives in the USA. 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. Finally, there has been little rigorous analysis of GIS impacts to ascertain how citizens derive true benefits from the technology. This update on the impacts of GIS points to the need for more research built on a credible evidential base on the effect of use of GIS in dealing with society-wide issues in developing countries.

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Appendix 1: Examples of positive, mixed and negative impacts

	Nature of contribution		
Designation of contribution	**Positive**	**Mixed**	**Negative**
Efficiency	"The project has allowed participants to pool information and minimize costs." (Roche and Humeau, 1999; p 12)	"The GIS projects were strong in collecting most existing information, but several problems arose concerning data definitions." (de Vos; p 361)	"Another major problem lies in the area of data processing and analysis. The LCS, like most other agencies in Ghana, has not utilized the GIS equipment available for any analytical purposes, except for map displays." (Karikari et al., 2005; p348)
Effectiveness	"PROMAS develops customised applications that meet the requirements of end-users …". (Ramasubramanian, 1999; P 376)	"A few participants have used ACCESS in specific planning functions […] but none have fully integrated the system into their planning process." (Greenwald, 2000; p 39)	"Our study shows that the projects assessed mostly followed a "garbage-can" process and that solutions are concrete GIT applications with little or no relation to organizational corporate strategies." (Caron and Bédard, 2002) p 32
Societal well-being	"It 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." (Ghose, 2001, p 155)	"Often, 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)	"The use of GIS by community organizations also raises […] threats to the privacy of community members that may result from the use of GIS for neighborhood surveillance …" (Leitner et al., 2000; p 56.

Appendix 2: Reviewed articles by journals

Environment and Planning B: Planning and Design	

1. Campagna, M. and Deplano, G. (2004) Evaluating geographic information provision within public administration websites, *Environment and Planning B: Planning and Design,* **31,** 21-37.
2. Carver, S., Evans, A., Kingston, R. and Turton, I. (2001) Public participation, GIS, and cyberdemocracy: evaluating on-line spatial decision support systems, *Environment and Planning B: Planning and Design,* **28,** 907-921.
3. Ceccato, V. A. and Snickars, F. (2000) Adapting GIS technology to the needs of local planning, *Environment and Planning B: Planning and Design,* **27,** 923-937.
4. Craglia, M. and Signoretta, P. (2002) From global to local: the development of local geographic information strategies in the United Kingdom, *Environment and Planning B: Planning and Design,* **27,** 777-788.
5. de Vos, H. J. d. (2007) Organisational culture: institutionalisation of GIS for forest monitoring in Costa Rica, *Environment and Planning B: Planning and Design 2007,* **34,** 355-368.
6. Lee, J., Tian, L., Erickson, L. J. and Kulikowski, T. D. (1998) Analyzing growth-management policies with geographical information systems, *Environment and Planning B: Planning and Design,* **25,** 865 - 879.
7. Montagu, S. (2000) GIS and natural resource planning in Papua New Guinea: a contextual analysis, *Environment and Planning B: Planning and Design* **27,** 183-196.
8. Nedovic-Budic, Z. and Pinto, J. K. (2000) Information sharing in an interorganizational GIS environment, *Environment and Planning B: Planning and Design,* **27,** 455-457.

International Journal of Geographical Information Science	

1. Elwood, S. (2008) Grassroots groups as stakeholders in spatial data infrastructures: challenges and opportunities for local data development and sharing, *International Journal of Geographical Information Science,* **22,** 71 - 90.
2. Harvey, F. and Tulloch, D. (2006) Local-government data sharing: Evaluating the foundations of spatial data infrastructures, *International Journal of Geographical Information Science,* **20,** 743-768.
3. Hendriks, P. H. J. (2000) An organizational learning perspective on GIS, *International Journal of Geographical Information Science,* **14,** 373 - 396.
4. Karikari, I., Stillwell, J. and Carver, S. (2005) The application of GIS in the lands sector of a developing country: Challenges facing land administrators 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 McGrath, G. (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 Nishio, A. (1998) The benefits of land registration and titling: Economic and social perspectives, *Land Use Policy,* **15,** 25-43.
3. Lee, J. T., Elton, M. J. and Thompson, S. (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., French, B. W. and Chandler, L. D. (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 Beale, L. (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., Ashkenas, L. R., Gregory, S. V. and Minear, P. J. (2004) GIS Methodology for Characterizing Historical Conditions of the Willamette River Flood Plain, Oregon, *Transactions in GIS,* **8,** 367-383.
6. Proctor, S. P., Gopal, S., Imai, A., Wolfe, J., Ozonoff, D. and White, R. F. (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 Bédard, Y. (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 Williamson, I. P. (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., Quiroga, C., Shin, S.-Y. and Pina, R. J. (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., Rich, P. M. and Witkowski, M. S. (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., Elwood, S., Sheppard, E., McMaster, S. and McMaster, R. (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 Humeau, J.-B. (1999) GIS Development and Planning Collaboration: a Few Examples from France, *Urban and Regional Information Systems Association (URISA),* **11,** 5-14.
12. Rushton, G., Elmes, G. and McMaster, R. (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 3: Country of interest of each research, basis, methodology and level of analysis

	Author(s)	Year	Basis	Methodology	Level of analysis	Country
	Environment and Planning B: Planning and Design					
1	Lee et al.	1998	Indiscernible	Case study	County	USA
2	Montagu	2000	Indiscernible	Case study	National	PNG
3	Nedovic-Budic and 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
	International Journal of Geographical Information Science(IJGIS)					
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
	Land Use Policy					
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
	Transactions in GIS					
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
	Urban and Regional Information Systems Association (URISA)					
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	2007	Framework	Survey	States	USA

Appendix 4: Articles dropped after preliminary study

Environment and Planning B: Planning and Design	
9. Liu S, Zhu X, 2004, "Accessibility Analyst: an integrated GIS tool for accessibility analysis in urban transportation planning" *Environment and Planning B: Planning and Design*, **31** 105-124.	
10. Ramos R A R, Silva A N R d, 2007, "A spatial analysis approach for the definition of metropolitan regions? the case of Portugal" *Environment and Planning B: Planning and Design* **34** 171-185	
11. Wang X, White-Hull C, Dyer S, Yang Y, 2000, "GIS-ROUT: a river model for watershed planning" *Environment and Planning B: Planning and Design* **27** 231-246	
12. Yu S M, Han S S, Chai C H, 2007, "Modeling the value of view in high-rise apartments: a 3D GIS approach" *Environment and Planning B: Planning and Design*, 34 139-153	
International Journal of Geographical Information Science	
7. Lee S, Choi J, 2004, "Landslide susceptibility mapping using GIS and the weight-of-evidence model" *International Journal of Geographical Information Science*, **18** 789 – 814	
8. Lindemann J D, Baker W L, 2002, "Using GIS to analyse a severe forest blowdown in the Southern Rocky Mountains" *International Journal of Geographical Information Science*, **16** 377 – 399	
9. Robinson T P, Harris R S, Hopkins J S, Williams B G, 2002, "An example of decision support for trypanosomiasis control using a geographical information system in eastern Zambia" *International Journal of Geographical Information Science* **16** 345 – 360	
Land Use Policy	
5. Barnes G, 2003, "Lessons learned: an evaluation of land administration initiatives in Latin America over the past two decades" *Land Use Policy* **20** 367-374	
6. Bennett R, Wallace J, Williamson I, 2008, "Organising land information for sustainable land	
7. Geneletti D, 2004, "A GIS-based decision support system to identify nature conservation priorities in an alpine valley" *Land Use Policy* **21** 149-160	
8. Mitchell D, Clarke M, Baxter J, 2008, "Evaluating land administration projects in developing countries" *Land Use Policy* **25** 464-473	
9. Rajabifard A, Williamson I, Steudler D, Binns A, King M, 2007, "Assessing the worldwide comparison	
10. Steudler D, Rajabifard A, Williamson I P, 2004, "Evaluation of land administration systems" *Land Use Policy* **21** 371-380	
11. Thapa R B, Murayama Y, 2008, "Land evaluation for peri-urban agriculture using analytical hierarchical process and geographic information system techniques: A case study of Hanoi" *Land Use Policy* **25** 225-239	
Transactions in GIS	
8. Deckmyn J, Feyen J, Cisneros F, De B, vre B, 1999, "PROMAS: Building GIS Capacity through Research and Extension Projects" *Transactions in GIS* **3** 376-376	
Urban and Regional Information Systems Association (URISA)	
Nil	