

Effects of GIS Technology Application in Wellbeing Institutions

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Abstract:-The effects of geographical information system (GIS) technology are numerous. Aim of this study was to explore effects of GIS technology. The research utilized qualitative survey design and purposive sampling to collect qualitative data in the health sector in the study area. Interview guide constructed by the researcher helped the study data collection. Thematic coding was used to analyze qualitative study effects. The study findings indicate the following effects: Seven beneficial themes with forty-two respective sub-categories emerged and four shortcomings themes with seven sub-categories emerged: see Table III and Table IV. The growth and wide use of technology in organizations requires awareness and sensitization to encourage its implementation.

Keywords:- *Geographical Information System; Impacts; Health Sector Organizations; Uganda.*

I. INTRODUCTION

The competences, significance and effects of GIS technology are known in the literature. Some theoretical research studies have identified GIS technology applications. For instance, technology has competence in monitoring and evaluating service delivery, and in determining the distribution and magnitude of diseases (Berrang-Ford, et al., 2006). However, technology effects for health organizations still need to be assessed in both developed and developing countries (Danziger & Andersen, 2002; Mennecke, 2000; Sipe & Dale, 2003). Investigators and technology managers should highlight objective of the system is to provide an opportunity to users to have computerized techniques of resolving difficulties Landauer (as cited in Nedović-Budić, 1998).

To identify assessment measures of effects of GIS technology empirical findings was used for evaluation to

conduct a literature review Nedović-Budić (1998 and 1999). Based on that, the author discovered a diversity assessment measures resulting in unsystematic and unfounded investigation outcomes. Investigation outcomes indicate GIS technology practically have not matched, on that note, Budić as well as Budic and Godschalk, and Tulloch et al., (as cited in Nedović-Budić, 1998, 1999) examined the technology where they amalgamated evaluation to quantify the technology achievement. As highlighted by Nedović-Budić (1998 and 1999), outcomes appraised revealed effects yet, revealed effects exposed contradictory outcomes.

To note, effects of technology not only offer benefits to the public, also generate shortcomings, such highlighted as an instrument with positive organizational effects. Improving present-day disorganized assessment for GIS technology effects requires more explored effects in organizations.

Evolution of technology use needs inquiries which are important to specialists, and scholars to contribute enhanced projected effects connected with its use and adoption. Improved effects of GIS technology are important for formulating approaches for evolving technology growth which necessities inquiries.

II. LITERATURE REVIEW

A. Assessment Criteria for Effects of GIS Technology Use

Literatures identify use of information systems affects organizations in various ways. Effects exactly intended for evaluating GIS technology significance effects inside organizations include; seven types of evaluating GIS effects: system quality, information quality, information use, user satisfaction, individual effects, organizational effects, and societal effects (see Table 1). This part below deliberates on effects established by DeLone and McLean's (1992) and Nedovic-Budic's (1998, 1999) for evaluating types different effects.

| Impact categories | GIS impact assessment criteria (benefits/disadvantages) |
|------------------------|---|
| System quality | Database content, ease of use, system integration, ease of learning, convenience of access, system reliability, response time, human factors, system functionality, system flexibility, system efficiency. |
| Information quality | Relevance, usefulness, understandability, clarity, format, accuracy, appearance, sufficiency, completeness, reliability, currency, timeliness, personalization, security. |
| Information use | Application areas, nature of use (type of information used, use for intended purpose, appropriate use, purpose of use), levels of use (general vs specific), direct vs indirect use, voluntariness, motivation of use, amount and duration of use (number of inquiries, number of records accessed, frequency of access, frequency of report requests, number of reports generated, charges for system or information use, regularity of use), information used by whom? |
| User satisfaction | Overall satisfaction, information satisfaction (difference between information needed and received), enjoyment, software satisfaction, decision-making satisfaction, quality of work. |
| Individual impacts | Information understanding, learning, software/information awareness, accurate interpretation, timely problem recognition/identification (conflicts resolution), decision effectiveness (quicker and clear decision-making, decision quality, decision time, correctness of decision, confidence in decision, decision-making participation), change in decision, improved individual productivity, quality of plans, willingness to pay for information, facilitation of GIS activities across organizations, power of influence. |
| Organizational impacts | Operating-cost reductions, staff reduction, overall productivity gains, increased revenues, increased sales, return on investment, increased work volume, product quality, contribution to achieving goals, service effectiveness. |
| Societal impacts | Equity (equal availability and accessibility of information, participation by public in decision-making process, enhancement of principles of a democratic society, contribution to a positive future), citizen-public sector interaction. |

^aNote: Criteria adapted from DeLone and McLean (1992) and Nedovic-Budic (1998, 1999)

Table 1:- Assessment criteria for effects of GIS technology

B. Profits of Technology Application

Area scrutinizes effect relationship of technology profits. Describing the profits technologies to top administration of organizations before its implementation and adoption for use is an important issue (Tulloch & Epstein, 2002). To be aware-of, there classified effect (Antenucci et al., 1991; Tulloch & Epstein, 2002).

Thus, vital evaluate to define profits produced of GIS, as (Gillespie, 2000), various studies have ascertained achieving gains of GIS technology use worldwide.

➤ System Quality

Is described essential effect evaluation criteria (see Table I), considered and used for evaluating system quality Clapp et al. (1989) (Clapp et al.1989; DeLone & McLean, 1992;Nedovic-Budic,1998,1999). Evaluation of system quality is focused on implementation of activities.

The implementation of activities executed and produced at lower cost (Tulloch & Epstein, 2002). Tottrup et al. (2009) highlight that GIS technology was used for merging different types of activities into single shape file to identify trends and gaps in service delivery. Using GIS technology enables professionals scrutinizing massive geospatial data uploaded in a database (Mullner et al., 2004). Example, it's also for comprehending and handling, for modeling, and comprehend utilization of wellbeing facilities (Tanser et al., 2006). Tanser and Le Sueur (2002) state that the result is then merged to approximate population exposure, mortality, and morbidity. This

contributes to change the way health professionals' attitude towards and use geospatial data to enable them approach health problems in a different manner.

➤ Information Quality

Information quality effect is evaluated with output identified in Table I (DeLone & McLean, 1992; Nedovic-Budic, 1998,1999). Information quality dimensions are effects that support operational effectiveness Clapp et al. (1989).

➤ Information Use

Information use effect evaluates the systems, based on measures recognized in Table I (DeLone & McLean, 1992;Nedovic-Budic, 1999). The effects support organizational purposes, errands.

➤ User Satisfaction

User satisfaction effects are evaluated by the output towards the system (DeLone & McLean, 1992;Nedovic-Budic, 1999). Effect is one of the important measures of success and effectiveness (Nedovic-Budic, 1999;Raymond, 1987), and the effect provides understanding of the users' reaction concerning the output generated by the system.

Nedovic-Budic (1999), Torzadeh and Doll (1991) highlight success of the system provides evaluation satisfaction and evaluation is important for revealing effectiveness of a system.

➤ *Individual Effects*

Individual effects is evaluated with classes recognized in Table 1. Nedovic-Budic (1999) and DeLone and McLean (1992), state effects measure significance of a system and increase decision-makers’ productivity and confidence.

A system influences and affects behavior of users using it for information production, and decisions guidance. GIS technology use in organizations supports several spatial analysis, data representations, and user satisfaction, to ease decision-making. GIS delivers summarized information faster to detect problems and make quick decisions (Mennecke & Crossland, 1996; Murphy, 1995).

➤ *Societal Effects*

In the societal context, technologies like GIS pose positive and negative effects to society. Suggested

evaluating effects using categories as identified in Table 1 benefit societal well-being.

➤ *Organizational Effects*

Organizational effects are evaluated as shown in Table 2. Effects are measurable and immeasurable (Table 2).

Budić (1994) highlight effects determine the potential of suggested GIS technology use in respect to financial gains measured using cost-benefit analysis. Cost-benefit analysis evaluates quantifiable effect measures mentioned in Table 1 which offer a basis for assessing intangible effects. To note, geospatial data technologies is known to be recognized necessity that offers specialists and communities situated in different locations a tool for development and administration of programs (Mullner et al., 2004).

| Benefit category | Tangible benefits | Intangible benefits |
|----------------------------|--|---|
| Cost reduction | Staff savings, staff time savings, direct cost savings (e.g., space, operating costs). | |
| Organizational enhancement | New forms of integration, easier interoffice coordination, new businesses, cost avoidance, productivity gains, generation of revenue/increased revenue, returns on investment in GIS technology. | |
| Improved productivity | | More words processed, more messages transmitted, improved decision-making, better information provision, more consistent access to data, improved customer service, increased citizen participation, decreased uncertainty, improved organizational image. |
| Improved support | | Improved analytical procedures, improved data and information security, decision support, expert assistance, improved modelling and planning, computer-aided support, generation of new products, introduction of data standards, more rigorous data management, enhanced visualization of graphic data, increased capabilities to integrate data and generate new understandings, keeping pace with technology, improved public image and cooperation, increased professionalism, promoting learning and development, improved ability to cope with unexpected events, and enhanced employee pride, job satisfaction, morale and motivation. |

^bNote: Adapted from Worrall (1994), Budić (1994), and Nedovic-Budic (1998, 1999).

Table 2:- Tangible and intangible organizational benefits of GIS technology use

C. *Shortcomings of Technology Use*

Despite numerous effect benefits associated with GIS technology, there are also shortcomings (Mennecke, 2000; Nedovic-Budic, 1998). GIS technology use for activities creates shortcomings that necessity serious consideration. Numerous literature studies acknowledged wide GIS technology use shortcomings (such as violating clients’ privacy and confidentiality, creating unemployment, misinterpretation of results), in disbelief of a saying that new technologies only come along with positive effects to

users and the community at large. Beneath the identified comprehensive shortcoming effects, there exist thematic effects on applying technology on sector discipline. Sipe and Dale (2003) highlight that literature regarding GIS technology use doesn’t put much concern on shortcoming effects related with its use, but only states about GIS competences and paybacks. The authors’ further note that investigative inquiries don’t represent the actual field situations, but moderate difficulties connected, to some extent escalates the existing community difficulties. The

community shortcoming effects comprise staff job loss (Matthews, Moudon, & Daniel, 2009; Mullner et al., 2004; Nedovic-Budic, 1998) and patient violation privacy, and confidentiality (Matthews et al., 2009; Mullner et al., 2004). The community shortcoming effects related to technology use affects its adoption, and implementation for activities.

Regarding shortcoming effects, hardware and software, on that note, Sipe and Dale (2003), and Tanser and Le Sueur (2002) state that GIS technology software and hardware are these days affordable and cheap. Whereby analogue datasets have to be changed to computerized format, that will need daily scrutiny for up-to-datedness, completeness, consistency, legitimacy, and quality, which needs resources both financial and human expertise (Mullner et al.2004).

With reference to organizational effect, to keep in line with GIS technology use, organizations should have available various computerized shape-files, skilled staff expertise to collect and capture, and to maintain datasets in order to have a continuous functioning system is important (Sipe & Dale, 2003; Tanser & Le Sueur, 2002).

User-satisfaction effect, envisioned among the shortcoming effects of technology use are purpose, liberation empowerment (Nedovic-Budic, 1999).

Shortcomings concerning societal effects raise ascertaining and merging geographical data which has to be done with skills not to violate patients privacy and confidentiality (Matthews et al., 2009;Mullner et al., 2004; VanWey et al., 2005).

Concerning individual effect, some of the shortcoming effects attached to GIS is misunderstanding outcomes, through lack of training (Mullner et al., 2004; Nedovic-Budic, 1998; Sipe & Dale, 2003).

III. MATERIALS AND METHODS

The type of research used a case-study explanatory research. The study respondent was GIS-users and non-GIS users. The study respondent was 57 GIS-users and 32 non-GIS users from health sector in Uganda. An interview guide was prepared and was used in order to evaluate effects of GIS technology use. Interview questions were developed by researchers to fit the research questions best. The qualitative survey was conducted among respondents located in Uganda which was taken around 2013. Information was gathered from Ugandan health sector organizations' about benefits and shortcomings related with GIS technology. Qualitative method used for data collection through semi-structured interviews was enviable to answer the why and how of this study questions (Marshall, 1996; Yin, 2009). Data analysis method applied content analysis, as it is flexible (Miles & Huberman, 1994; p.10). The qualitative data was transcribed; codes developed which led to formation of categories.

IV. RESULTS

A. *Effects of GIS Technology Use in Health institutions*

Effect provided a collection perceived benefits that were according to GIS. The identified effects were from GIS and societal effects. Effects identified are ascertained, (see Appendix 1: Table III).

➤ *Benefits Concerning System Quality*

Is flexible handling several shape-files and controls merged spatial diverse formants to have tangible choices.

Has the capability to handle heavy shape-files and its versatility to scrutinize, competence. Heavy shape-files rates GIS as acknowledged regarding with the system as one-stop center with access, sharing, and communication.

➤ *Information Quality*

Concerning observed up-to-datedness, as numerous institutions share data, GIS acknowledged offer precise evidence based information. Additionally, GIS technology is acknowledged to offer easy understandability unlike written literature, tables, and charts, it provides a depicting real condition of society.

➤ *Information Use*

Information use is vital effect cherished and to be comprehended by wide populace and reaches through web-based interfaces and health education and communication.

Effects that benefit populace are ease policy process and advocacy which improves decision-making.

➤ *Individual effects*

Recognized effects include decision effectiveness. GIS technology improves to envisage/see and analyze problems easily to make faster decisions.

➤ *User Satisfaction*

Effects associate bulky shape-files to diverse outcomes of reality happening on the ground. Technology merges shapefiles and visualizes information into a map for easy viewing. Thus, helps link data from different sources.

➤ *Organizational Effects*

Organizational effects link to capability of improved support for organizational programs. Effects capability is offer needed help to facilitate quick response for decision making. Similarly, effects facilitate to determine extent of disease spread. On that note, responsible institutions then plan quick response control to prevent disease spread.

Identified effects also ascertain organizations improve accountability and transparency in their implemented programs using the technology.

➤ *Societal Effects*

Societal effects include GIS bridges gap between planners and decision makers, and whole communities which improves sharing of information.

B. Shortcomings of GIS Use in Health Sector Organizations

Although technology has profit effects, using it also causes shortcoming effects as shown in Appendix 2: Table IV. Shortcomings categorized as themes were borrowed from evaluation measure of technology effects of DeLone and McLean's (1992) and Nedovic-Budic's (1999). Literature notes researchers can borrow, and transfer theoretical ideas used in other disciplines to apply to suit their inquiry studies (Nedovic-Budic, 1999; Webster & Watson, 2002). Evaluating shortcoming effects of GIS technology use is vital to provide reaction to developers and users of the technology.

Identified are four broad shortcoming effects of GIS and seven sub-category effects. The effects were recognized to be connected shortcoming effects connected with adoption of GIS technology use for activities.

Participants state need for time and specialized skilled expertise to use GIS technology, if someone is to use GIS in their programs.

GIS technology use requires availability and stable power supply to enable it be applied for analysis, storage of geospatial data in servers, share and transmit data across networks. Unstable power affects technology implementation and adoption in areas of poor power supply.

To be aware of, GIS application has both profits and shortcomings. Implying institutions should take notice and appreciate GIS as its.

V. CONCLUSION AND DISCUSSION

Research purpose to ascertain effects of GIS comprise shortcomings effects. The study demonstrates users and intending users of GIS technology for health and health-related activities should bear in mind that its use results into effects as ascertained in the frameworks of Clapp et al. (1989). These frameworks were not precisely envisioned for evaluating GIS effects in the health organizations. Mentioned shortcomings of this paper, views and outcomes show that frameworks applied for ascertaining benefits and shortcomings of GIS technology use show related diverse shortcomings (see Appendix 1: Table III and Appendix 2: Table IV, respectively).

Findings indicate GIS users ascertain effect regarding GIS use (see Appendix 1: Table III).

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| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|-------------------|-------------------------|---|---|
| System quality | Data storage capability | Enables to store bulky information and saves space and simplifies, provides better data and information storage and improved record keeping with details instead of having a lot of paper maps (50,3) | “GIS enables us to store bulky information and integrates information from different sources into a single shape file”. |
| | Easy visualization | Enables to visualize/see the information on the map in a short time and be able to make | “GIS aids in quick view of features where somebody can easily view and conceptualize things at a glance like how is the country divided when presented in |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|-------------------|--|---|---|
| | | quick decisions (42,13) | a map format, i.e. with GIS we can easily visualize and analyse to come to quick decisions”. |
| | Usefulness of the system features and functions: Data integration capability | Combines different types of datasets, information from different sources to become one layer/shape file compared to other information systems (30,3) | “Another advantage is its’ spatial analysis which enables you to combine different datasets from different sources to come up with one layer of interest” |
| | Database content capability | Provides data management database for storage, access, capture data, manipulate, analyse, reproducing, processing, updating, exchange and sharing of available information which it can easily be backed up in any form (25,9) | “GIS is a useful tool to break the monotony of presenting data in a format of tables, graphs and charts that has been common. It displays our results in a visual form quick to understand”. |
| | Database content capability | Web-based GIS enables easy presentation, access, sharing, exchange of information, improves reporting of the activities and number of reports generated which eliminates the traditional method of flow information, and the information is instantly available across the globe (17,8) | “Web-based-GIS enables easy reporting, publishing, accessing, sharing and exchange, analyzing of information to know who is doing what where, monitoring and evaluation of our interventions. GIS is actively being used in our organization all the time, every day, for example if you can just look through DevTrac, you would find everyone who is going to the field is filling in a report in DevTrac”. |
| | Convenience of access/data accessibility | Improves documentation and provides a faster platform to ease access of data and information both internally and externally as changes are reflected automatically (14,2) | “GIS improves accessibility of data and information both at the district, in the country by all stakeholders”. |
| | Monitoring and data validation | Good tool for monitoring and managing of epidemic disease outbreaks and other epidemiological trends in spatial, time and space (9,0) | “It would also improve on our understanding of disease outbreaks because we would be able to locate exactly which village or particular cell within our catchment area is having the outbreak”. |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|---------------------|---|---|--|
| | Data analysis | Good system for mapping, analysing data, guides in evidence based planning and fast decision-making (9,0) | “GIS increases/improves on the understanding of some information for some people. For those people who couldn’t understand the tables can at least understand the visual aspect of a map. In our organization, the demand for map products has increased because people see exactly where they want go, which services are being provided per district and which areas are still lagging behind as far as service delivery of health services are concerned” |
| | Data accuracy | Provides more accurate information, data or results for planning and decision-making (7,2) | “GIS gives real time and accurate information and it helps in decision-making because you are able to see what you are doing and analyse” |
| | Data currency | Provides up-to-date, real time evidence information and better credible data or results as the system is shared by several organizations (9,4) | “GPS also gives us real time reports about vehicle movements, for example even if I am at the head office I can know that at particular time a vehicle was parked at Mbarara”. |
| | Data availability | Improves availability of more data and information needed for planning of what organizations have been doing (8,1) | “GIS use increases availability of data and information needed for planning e.g. more specific information about the location of diseases and be able to respond faster to disease spread with more detailed data”. |
| | Usefulness of the system features and functions: system flexibility and user-friendly | A flexible tool, provides interactive and user-friendly interface that analyses and responds to many information requests (6,6) | “GIS is user friendly, because after the training I was able to do analysis things on my own e.g. it’s not like STRATA or SPSS software we do online”. |
| Information quality | Easy understandability and readability format | Provides a summarized, clear pictorial visual display of information, results, products in map format which are eye catching, easy to understand and interpret by GIS non-professionals (32,18) | “Advantage of using GIS is that the human mind doesn’t forget what it has seen but it will always forget what it has read easily e.g. when you look at the burden map of HIV/AIDS and the spread its indicating that in the north western and the around the lakes/water bodies region HIV/AIDS burden is too high, it keeps visualizing in your mind why is HIV/AIDS burden still high in those regions, it gives you |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|-------------------|---|---|---|
| | | | a summary of an interesting report compared at you reading a big report to understand what it says about HIV/AIDS”. |
| | Timeliness and saves time | Avails real time data, information and responses (17,12) | “GIS helps to capture real time data e.g. when you go to the field, you collect data and you produce updated maps depicting reality on the ground”. |
| | Accuracy and evidence-based information | Gives accurate information and informed evidence-based results in map format and reports which can be relied upon for future implementations of services and guides to make quick decisions (27,20) | “GIS provides us with evidence-based information to guide decision-making for example for us we are considered to be a social marketing organization, we work through outlets, health facilities, we distribute commodities and also we provide services. So we want to know how wide is our coverage, we find where to scale up if it needs to open up more outlets, we identify gaps and if we are to expand beyond those areas, so that we don’t open up where we are already flooded up”. |
| Information use | Nature of use: use for intended purpose: Planning | Provides better planning for equitable distribution use of limited resources and making activity/intervention priorities (9,0) | “It would help us in planning then it could save us some money as well because sometimes human resource which is more expensive than GIS devices/gargets in the long run would be reduced and would probably reduce in our human resource and just employ few individuals/people to do much of the work that is being done manually and it would be better”. |
| | Nature of use: Research work and reference | Helps to determine study areas for research work and GIS information can be used for reference purposes (9,1) | “Using GIS would make decision-making and work to be done in much faster way which would provide us easier and organized atmosphere at the our organization when we know we have information that we can quickly retrieve, access with ease and in the long run it becomes cheaper if we have our information together e.g. in case if we need to write out a paper like a manuscript for a peer review journal it gets better for us do that”. |
| | Decision-making | Guides in making activity/intervention priorities in decision-making (7,1) | “GIS guides in making activity priorities. So if we are to do an outreach GIS helps us to know where to prioritize and where we can put more efforts than other places”. |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|--------------------------------|---|---|--|
| | Nature of use: coordination and end of evaluation | Helps in annual outcome coordination and end of evaluation formats (6,0) | “Helps management in coordination and evaluation of partners and respective activities they are providing and providing updated information e.g. on a monthly basis who is working where, number of people receiving ARVs, number of people treated on daily basis.”. |
| | Policy decision and advocacy purposes | Eases the process of policy decision and advocacy purposes (6,0) | “The advantage with GIS information helped us to come up with easy understandable reports where the visualization of the map really makes someone to appreciate the results and one of the reports called The Human Resource Audit Report which was produced for 2012 was instrumental in the MOH, as they used this report to advocate for more staffing within the health sector to the parliament”. |
| User impact(user satisfaction) | Simplification of work: data collection, documentation, management, implementations and presentations | Work made easier, more efficient and effectiveness (13,14) | “The kinds of benefits are simplification of work and also getting more accurate results and reports”. |
| | Decision effectiveness: improved decision analysis | Contributes to better evidenced-based, correctness of decision, effective and improve decision-making (5,1) | |
| Individual impact | Decision effectiveness: shortens time to make decisions | Saves a lot of time in data collection, analysis, enables faster evidenced decision-making and planning of health activities or any interventions that you may want to undertake(6,7) | |
| | Better decision-making and planning | Improves and makes better effective timely and effective decision-making and planning of services easier based on informed evidence (20,13) | “GIS can be used for better planning and to guide decision-making for especially social services since you know you are going to put the service in an appropriate place where there is absorption capacity instead of developing a service in a place where there is no one going to utilize a particular service”. |
| Organizational impact | Operating cost reductions: cost saving | Reduction in operational costs (14,10) | “The benefits of using GIS will be reducing the costs of operations, having timely information to be able to generate reports”. |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|-------------------|--|---|--|
| | Cost effective | Efficient utilization of resources both financial and human based on evidence (15,0) | “Enables organizations to achieve its goals and objectives which increases service effectiveness” |
| | Improves job performance | Improves on efficiency and effectiveness of organization operations and job performance thus allows comparison of different parishes to know their performance (12,1) | |
| | Effective governance, transparency and accountability | Improves and promotes effectiveness reporting information, governance, transparency and accountability to donors and tracking to know service providers in different parts of the country (26,16) | “Since we deal with issues of accountability and governance, GIS could help and benefit us by producing maps showing who is doing what, where, so its best tool for informing government the accountability for CSOs”. |
| | Gaps identification and challenges in service delivery | Pictorially, helps identify gaps and challenges in service delivery(health infrastructure) (31,10) | “GIS helps identify gaps in service delivery, which areas are over served, underserved or not served at all”. |
| | Sharing, collaboration, exchange and partnerships | Improves easy sharing, collaboration and exchange of information and formation of partnerships between organizations using it (13,4) | “GIS technology creates data sharing, collaboration and partnership between organizations using it. For instance to develop a map on the extent of the spread of a disease outbreak in our organization, we need to develop partnership with UBOS who produces population data and administrative boundary layers for the whole country to enable us determine the extent, which districts are affected and what number of the population is affected” |
| | Evidence-based in-depth analysis | Enables easy, quick and convenient to carry in-depth analysis (10,1) | |
| | Data communication, presentation, reporting, and dissemination | Improves internal and external communication, presentation, reporting, advocacy | “Provides a modern way of reporting performance, achievements and failures. The level of success vary from place to place and helps you to see why |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|-------------------|---|---|---|
| | | and dissemination of evidence-based information to the communities (10,1) | you are not doing well and when results are shown on the maps people can contribute a lot to answer why they are not doing well which an ordinary report cant portray”. |
| | Eases monitoring and evaluation, and client follow-ups | Provides ease tracking, monitoring and evaluation of programs and service delivery (15,10) | “For all the projects, GIS helps us to locate and identify the study participants; helps us to identify and monitor geographical “For all the projects, GIS helps us to locate and identify the study participants; helps us to identify and monitor geographical |
| | Reductions in data duplication: cost saving | Reduces on the cost and eliminates the duplication of efforts involved in data collection across the organization (8,0) | |
| | Product quality: reduces manual work and data collection time | Reduces bulky paper work of data to send and store and data collection time that is currently operated in Uganda(8,4) | “Provides an advantage for organization to minimise the costs by reducing staff numbers handling geographical work. The information that someone can generate if we talked about staff reduction, for instance at organizational level when you compare the costs of obtaining the two different types of outputs that is using GIS and without using GIS, so it minimises the costs by reducing staff handling geographical work”. |
| | Staff reductions | Reduces the number of organization staff/ human resource (6,4) | |
| | Programme/activity coordination and networking | Provides evidenced-based proper programming, implementation, coordination, networking and can facilitates rational decision-making (12,15) | “GIS can also help to track progress in achieving the targets; it can also support evidence based programming and can facilitates rational decision-making. GIS was considered important for our activities to help establish coverage and coordination of our services” |
| Societal impact | Equity: equal resource allocation to the right communities | Provides proper and equitable allocation of resources and services/interventions to the needy areas and rightful beneficiaries as we can track those areas that aren't served and those which are well served or facilitated (14,3) | “GIS can help improve allocation of resources because if you are using GIS you can be able to identify where the gaps are in resource allocation so you can allocate efficiently” |

| Impact categories | Code | Code description of benefits of GIS use(outcome) (frequency: GIS-users, Non-GIS-users) | Sample quote |
|-------------------|---|---|---|
| | citizen-public sector interaction | Enables to share information with the public and the stakeholders (9,0) | “Creates collaboration between services providers and users”. |
| | Community engagement | Participation of communities in planning and decision-making(7,0) | “GIS helps us identify events of priority at health facility and community level which makes us allocate resources and interventions equitably to the needy areas” |
| | Data access to and availability | Increased access to and availability of data generated through different health GIS-user organizations (7,0) | |
| | Reduces unemployment and creates employment | Reduces unemployment for office-based staff and creates employment to untrained personnel and the community at large if GIS is adapted(7,0) | “The GIS technology like the GPS machine for data collection is a user friendly technology for mapping disaster risk prone areas and someone can easily learn how to use it just like the way people use their phones”. |

Table 3:- Appendix 1:The benefits of GIS use or assessing impacts of GIS use in the health sector

| Category factor | Sub-category | Code | Code description | No. of responses | Sample quote |
|-----------------|--------------|------------------------------------|--|------------------|--|
| System quality | Technical | Expertise | Requires expertise and continuous training | 26 | “Another disadvantage is someone must be having expertise and knowledgeable about GIS use to make sense out of the data or do advanced analysis (forecasting disease outbreak, risk analysis modelling) for someone to move faster to analysis issues”. |
| | | Data quality | Inaccuracy of data and misinterpretation leads to wrong decision-making | 12 | “Inaccurate data and misinterpretation of the GIS information can lead to wrong decision making or decisions misallocations of features to different places if someone doesn't have skills” |
| | | IT technology - GIS infrastructure | Tagged on internet and technology (Requires good GIS infrastructure) connection) | 4 | “Requires GIS environment like IT equipment, good quality printers to use that software, a computer with big capacities to show the maps and satellite images to store the images and for analysis”. |
| | | | | 4 | “Web based GIS heavily relies on internet and power to enable to use web-mapping applicability, access, share, and exchange data and information. So someone without internet cannot access information or when there is power break down people can't exchange, access or share information and a person gets stuck with the work you are doing”. |

| Category factor | Sub-category | Code | Code description | No. of responses | Sample quote |
|-----------------------|---------------|-----------------------|--|------------------|---|
| | | Data standards | Requires standards for producing, capturing data | 1 | “Without standards for producing, capturing and creation of administrative boundaries, health facilities makes the exercise of updating spatial data difficult. For example in Uganda new political districts, sub counties, parishes and villages are being created every now and then which makes updating administrative boundaries loose meaning, before you digitize the new district boundary another district has been split from that one. Then health facilities are just build anyhow I think just for consumption but need”. |
| | GIS Equipment | Software and hardware | Expensive renewing of the software | 16 | “Needs a specific software, the cost of the GIS software is high and expensive renewing GIS accessories like the software, GPS every year which may not be accessible by many organizations” |
| Organizational impact | Institutional | Resources | Expensive to establish, buy and maintain GIS infrastructure | 32 | “GIS is expensive to establish, buy and maintain the software license plus its accessories such as GPS devices, GIS professionals, servers and its’ not easy nor known where to access it from. It creates lack of appreciation from top management as people see it has no advantage and not willing to commit so much scares resources” |
| | | | Data collection is resource intensive | | 9 |
| | | | Expensive training personnel and rated a wastage of resources by policy makers | 9 | “GIS training is very expensive where someone who wants to train in GIS has to go out of the country. Where employers are not willing to spend money because they see it as wastage of resources and health sector organizations in Uganda have limited budgets.” |
| | | | | | “Competing for resources with other sectors for instance buying a GIS map printer is seen as a wastage of resources”. |
| | | No disadvantages | No disadvantages | 13 | “I don’t see any disadvantage may be money because the GPS gargets are costly to acquire. It’s not necessarily disadvantage may be a challenge that is the gargets are expensive”. |
| | | Data availability | Requires existing data and shape files | 5 | “GIS requires the existence of the previous data for someone to really bring the trend of disease out, so without data someone cannot use GIS ” |
| | | | Requires up-dated data and shape files | 2 | “Without an updated base layers, the results can be potentially misleading especially when you are using the old layers”. |
| | | | Requires metadata GIS cannot stand alone | 1 | “GIS cannot stand alone, it still needs to go with some literature to accompany it however much as it doesn’t give a bigger |

| Category factor | Sub-category | Code | Code description | No. of responses | Sample quote |
|--------------------------------|--------------|---------------------------------------|--|------------------|--|
| | | | | | story but you need to accompany it with some writer up i.e. metadata describing the type of feature, date of production, area of location, projection used” |
| User impact(user satisfaction) | Attitude | Biasness | GIS professionals become obsessed with GIS environment | 1 | “GIS professionals become obsessed with GIS environment and tend to have biased mind of other tools”. |
| | | High risk of becoming blind | Working longer hours creates high risk of becoming blind | 1 | “People using GIS for longer hours have high risk of becoming blind compared to those who work few hours” e.g. in developing countries people work for few hours compared to African countries who work the whole day. GIS has a disadvantage with the person who is interacting with the computer interface is harmful because someone cannot work like the way a person can work like other manual methods of map production. GIS use needs someone to work or sit for a few minutes and go away |
| Societal impact | Legal | Security, privacy and confidentiality | No privacy and confidentiality | 5 | “Using GIS has no privacy and confidentiality of individual data (client, field workers, drivers) which could be abused by people who have bad intentions and with a small area, maps could stigmatize people in the case of HIV” |
| | Social | Time demanding | Time consuming and requires continuous practice | 19 | “GIS is time consuming so if you have other tasks or activities to handle besides using GIS then they may not get a fair share of your time. Needs continuous practice for someone to be able to operate it”. |
| | | staff reduction and Unemployment fear | Creates staff reduction and Unemployment fear | 7 | “GIS reduces the number of staff in organizations, work and does not need many people to produce a map thus GIS makes people jobless if the technology is implemented”. |
| | | User friendliness | Not user friendly | 4 | “GIS as a tool is not user-friendly to those without technical knowledge to operate, since it requires specialized training and a lot of practice, I think the developers of the software should make it user friendly for users”. |
| | | Conflicts | Creates conflicts | 2 | “Can create conflicts because it would bring the unknown to light which kind of causes troubles”. |
| | Economic | Data consumption | Data collected based on consumption not demand | 1 | “Spatial data is not collected based on demand but its’ based on consumption. For instance we have been having some issues with UBOS and we the data users were proposing for them to estimate demand various data and then collect on data for demand because in Uganda we have looked more on data consumption but we have not look at the demand for data. For example, looking the health sector perspective, were we are saying we need many health facilities and when |

| Category factor | Sub-category | Code | Code description | No. of responses | Sample quote |
|-----------------|--------------|------|------------------|------------------|--|
| | | | | | <p>someone moves around the whole country, you find that at least every sub-county has health facility but without infrastructure in general like number of health facilities needed, number of population that can access the nearest health facility their households, number of health workers houses, health workers which should be correlated with type of disease outbreaks that occur in specific areas. So if we already have the existing health facilities, houses for health workers, how many do we need to add on, then how much materials do we need. All in all we are not planning properly, we are planning in upside manner but not by projecting</p> |

Table 4:- Appendix 2: The shortcomings of GIS use or assessing impacts of GIS use in the health sector