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To Share or not to Share: Deciding Factors for (not) Sharing Geospatial Data in Ugandan Health Sector Organizations

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Abstract:- This paper discusses some benefits and difficulties of sharing health information that was acquired through a geographic information system (GIS) that is beneficial and problematic. The paper presents a study that explored Ugandan health sector organizations' reasons for sharing and for not sharing geospatial data. Embedded case-study was carried in 75 health organizations to collect qualitative data in Uganda. To that end, we interviewed 32 participants from 32 health organizations that were not using GIS technology, and 57 participants from 43 health organizations that were, and compared the results. Purposive and snow ball sampling was used to come up with respondents for the study. Qualitative data was collected through use of telephoning, face-to-face interaction interviews, tape recording, review of relevant literature and secondary sources (e.g., annual reports, organizational websites). Not all organizations that were using GIS technology shared their data. The interview analyses identified key factors (i.e., availability, necessity, efficiency, collaborations, learning, and accountability factors) that encourage and (i.e., lacking resources, poor quality of data, restrictions, leadership, and inter-organizational boundaries) that hinder health organizations' choice to share or not to share geospatial data with other health organizations. Based on these factors, we provide recommendations (i.e., Establish and Harmonize a Geospatial Data Policy, Create a Coordinating Body of GIS-Using Health Professionals and Incorporate GIS Courses in the Curriculum of Universities Dealing with Health Issues) for increasing geospatial-data sharing through integrated collaborative networks across the Ugandan health sector. Our study findings indicate that there is a willingness to share geospatial data between health sector organizations or individuals in Uganda. An ICNSDI is suitable for Uganda, because many organizations share geospatial data, and even internationally, even though on a limited scale. The sharing of geospatial data is one of the biggest benefits of using GIS technology to influence geospatial data use in the health sector organizations. Our study finding shows that the knowledge, management and the documentation of geospatial data sharing are important though organizations are not sharing freely as willing as they should be.

Keywords:- *Geographical Information Systems (GIS); Spatial Data; Sharing; Heath Sector; Uganda.*

I. INTRODUCTION

In Africa, governments, organizations, UN Agencies, the donor community, and development partners strive to eradicate, prevent, and control high rates of disease spread to promote the economic and social development of communities [1]. Geospatial data and information can play a vital role in the examination and mapping of geospatial patterns of diseases [2, 3], in planning and decision-making [4], and in analyzing access to health services [5] for health sector activities to aid in the prevention and control of diseases. Hence, to plan, make decisions, implement, and achieve development in various health programs, we need geospatial data.

GIS technology is changing the way health activities are managed, and is improving the ability and capacity to share, exchange, access, collect, maintain, and use geospatial data in a digital environment. Most health activities depend on geospatial data to map where things are (e.g., in order to know the location of disease outbreaks), to map densities (e.g., populations at risk), to map change, and to map quantities [6].

Health sector organizations rely on geospatial data to know where things are, to understand how they relate to each other, and to guide them in a wide range of crucial activities: disease surveillance, evidence-based planning and decision-making, risk analysis, crisis management, health care research and management (health-facility access, utilization, and planning), community health profiling [7,6,8],fleet management, vehicle and health-commodities

tracking, coordinating and monitoring immunization programs, food (in)security and health nutrition livelihood, and health education.

Since Uganda faces challenges in all these areas, producing and sharing geospatial data to guide planning and making evidence-based decisions is extremely important. Previous work as described in the literature already explored a wide range of GIS technology use in Uganda, including rural electricity planning [9],determining the spatial distribution of underweight, overweight, and obesity among women and children [10], surveillance of sleeping sickness (remote sensing) to identify villages at high risk for sleeping sickness [11],determining spatial and temporal risk factors for the early detection of sleeping sickness patients [12],identifying areas with an elevated epidemiological risk of sleeping sickness [13],and mapping neglected sleeping sickness [14].

Thus, GIS technology has been applied in the health sector, has produced a vast amount of geospatial data, and has proved to have the potential and efficiency for contributing to health in Uganda. This raises the question which factors influence the sharing and non-sharing of geospatial data between health sector organizations. Previous work in these areas [15,16,17] received criticism for mainly focusing on the geospatial data provider's perspective [18]. Therefore, we considered influencing factors on the sharing and non-sharing of geospatial data from a user's perspective. Thus far, no studies have been conducted that were aimed at understanding the status and willingness of health sector organizations or individuals towards geospatial-data sharing in the Ugandan health sector. Therefore, we conducted our study to seek answers to these research questions:

- Which factors influence the sharing of geospatial data between health sector organizations in Uganda?
- Which factors are currently hindering the sharing of geospatial data between health sector organizations in Uganda?

The contribution of this study is to add to knowledge on the factors influencing and hindering sharing of geospatial data between the heath sector organizations. The study also aims to determine and develop geospatial data sharing strategies across the health sector and organizations handling health related activities for surveillance of health programs. The paper adds to what is already known about geospatial data sharing in other fields like urban planning and contributes knowledge of sharing to the GIS community. The knowledge will be vital in developing strategies to improve and advice to support sharing of geospatial data between health sector organizations and across other GIS organizations charged with tackling health problems to inform decision making.

II. THEORETICAL BACKGROUND

Developments in information and communication technologies have changed the way information is transmitted and disseminated, thus making communication one of the most powerful tools for modernization and development. Many frameworks and theories have been identified in the literatures that were developed to address issues concerning the sharing of geospatial data.

Previous work addressed the question which factors enable, encourage, hinder, or block the use and sharing of GIS data [19, 20, 21]. Table 1 presents an overview of the problems hindering the sharing of GIS data between Ugandan health sector organizations, according to the above-mentioned authors.

A. Motivators and Obstacles for Geospatial-Data Sharing

Geospatial-data sharing as a means to reduce redundancy and duplication of dataset collections needs to be handled with care, because it includes organizational and institutional issues, technical and technological issues, political issues, legal considerations (confidentiality, liability, pricing), and social and economic factors [22,16,18].In the literature, factors that influence the process of geospatial-data sharing were also identified as motivators, barriers and benefits or outcomes of data-sharing [23,24,25.26,27,28]. For example, [27, 16, 25, 26, 23, 22, 18] identifies benefits and barriers of geospatial data sharing (see Table2). The aim of these frameworks and theories was reducing duplications and redundancy, and saving organizational resources by sharing available geospatial data and technology. This can be achieved when various government and private-sector organizations build a lot of data and are willing to engage in geospatial data sharing across organizational boundaries. However, although several frameworks, models, and theories have been developed, none of the authors of these frameworks has determined the most effective geospatial sharing index factor suitable for each country or the world. Most of these frameworks do not recognize the vital organizational complexities and context, and are based on the author's individual understanding and experiences with geospatial-data sharing, which provided the basis for understanding the current sharing issues [16]. Some of these frameworks and theories have been empirically proven. For example,[29,26,22,18,16,30] tested the theory of planned behavior to explain geospatial-data sharing.

This study mainly uses [31] ideas to derive categories that positively and negatively influence geospatial-data sharing in Uganda. Understanding the influencing factors of geospatial-data sharing enabled the researchers to develop sharing strategies. May be an increase in geospatial data sharing, in turn, may accelerate initiatives to develop spatial-data infrastructures (SDIs).

III. STUDY AREA

The work described in this study was conducted in health sector organizations in the central and northern part of Uganda, located within latitudes 1°29´ South and 4° 12´ North latitude and 29°34´ East and 35°0´ longitudes. Uganda is landlocked, bordering Kenya to the east, Tanzania to the south, Rwanda to the southwest, the Democratic Republic of Congo to the west, and South Sudan to the north. The country has more than 130 administrative districts with a decentralized system of governance. Various responsibilities have been awarded to the local governments, such as planning and decision-making for health services, ranging from district to community level. However, the central government and the Ugandan Ministry of Health (MOH) have the sole role of formulating and setting policy, of supervising standards and coordinating health sector organizations and all organizations handling health-related activities in Uganda. Uganda has a population of approximately 35 million people, of whom 1,516,210 live in Kampala, 69,958 in Entebbe, 518,008 in Rakai, and 443,733 in Gulu [32].

Condition of geospatial data	Problem identification
Difficult to get integrated	Different data formats and standards, incomplete data, disjoined data, fragmented data
Data redundancy, overlapping mandates	Overlapping activities, overlapping data production, difficulties in assessing data quality
Difficult to access, lack of data sharing	No national network system, lack of sharing standards
Inadequate technology, inadequate GIS software, lack of good communication channels	Unreliable electricity to support data sharing
Lack of information about spatial data availability and about the procedure to acquire spatial data	No national data policy, lack of metadata
Lack of funding, lack of will to collect data, lack of will to keep data up to date in the future and acquire funding for this, sharing the costs among users and producers is a challenge	No defined data policy
Lack of ownership, lack of custodianship, lack of mandate for datasets	No defined data policy
Outdated/static (i.e., no clear) updating mechanism	No defined data policy
Lack of defined pricing of data	No defined data policy
Uncertainty of copyright to protect spatial data	No defined data policy
Lack of geospatial policies	No formal agreements or processes to address privacy, access, use, pricing, and liability of geospatial data
Fundamental datasets are not well-defined (i.e., user needs are not well-articulated)	No defined data policy
Limited digital core and thematic datasets, limited standards	No common policy and standards on data production, usage, and sharing

Table 1:- Problems hindering the sharing of geospatial data in health organizations
Source: Adopted from [19, 20, 21]

Benefits
Cost savings by sharing the costs of implementing spatial databases among participating organizations.
Reduced time on data collection and decision-making (i.e., spatial-data sharing reduces time spent on collecting data that has already been collected).
Increased data availability due to larger collections of archived data than would be held by one organization, thereby offering a bulky amount of geospatial data.
Multiple datasets and maps.
Improved data quality where participants use data formats and standards perceived to improve data quality.
Improved user satisfaction.
High returns on investments.
Improved decision-making by sharing information.
Enhanced organizational relationships, because cross-organizational relationships promote greater cross-organizational communication.
Cost savings due to less redundancy and duplicated efforts in collecting and maintaining data.
Barriers
Lack of both human and technical resources; incompatible old systems; lack of support from management; staff turnover.
Costs of coordinating activities of multiple organizations (e.g., networking costs).
Poor implementation of standards where organizations are not applying common data definitions, formats, standards, and models (lack of common data definitions, formats, standards, and models)
Conflicting priorities among participating organizations, causing separate organizational interests (e.g., leadership, data standards, equipment, training, and access to information).
Barriers
Data confidentiality, liability, and pricing.
Differences in GIS facilities, level of awareness, and skills in handling spatial data.
Differences in data quality.
Power disparities and differences in risk perception.
Lack of leadership and coordination mechanism.
Conflicting priorities.
Costs of data recovery, copyrights, and legal liability.
Lack of trust, unequal commitment from participating organizations.
Cultural, political, and institutional issues.

Adapted from [18, 28].

Table 2:- Benefits and barriers of geospatial-data sharing.

IV. MATERIALS AND METHODS

In this study, we focused on those parts of the interviews that addressed organizations' willingness to share geospatial data, both between GIS-using health sector organizations and across the GIS arena.

A. Research Design

This study employed a case-study design to collect information about Ugandan health sector organizations' reasons for sharing and for not sharing geospatial data. We collected qualitative data through semi-structured interviews with participants representing the Ugandan health sector. Our qualitative research method allowed an iterative and flexible study plan and real-life inquiry to generate rich narrative descriptions, clarifications, and an understanding of complex issues. This method is most useful for answering the "why" and "how" questions [33,34]. In addition, according to [33], a qualitative research method allows for transferability and provides an indirect quality assurance method of trustworthiness in assessing the outcomes, unlike quantitative methods where generalization and direct statistical tests of validity and reliability have to be applied using a predetermined step-by-step method. Similarly, a qualitative method allows the interviewer to probe deeper and ask follow-up questions during in-depth conversations and helps to uncover the why and how through exploratory exercise [35,34]. Thus, our qualitative research method is vital for understanding and getting the story behind our participants' experiences.

Our embedded case study comprised nine sub-units of analysis (i.e., a UN international agency, a not-for-profit non-government organization, a non-government organization, a government/public organization, a semi-autonomous government organization, a project-based organization, an education and research institute, a private organization, and a funding mechanism). The focus of our study was the health sector (single case) and its nine categories of health organizations (units of analysis). An embedded case-study design was most appropriate for our study, since it allowed us to concentrate on the single case and its sub-units. Nevertheless, it is important to acknowledge [34] warning to scholars who use an embedded case-study design: One of the pitfalls of using an embedded case-study design is that the study tends to "focus

on the sub-unit level and fails to return to the larger unit of analysis" (p.52). By meticulously categorizing the responses from the nine units of analysis (categories of health organizations), we ensured that the larger unit (health sector) of analysis was not neglected. The results of our study therefore provide a picture of what is happening in the health sector as a whole.

B. Sampling and Selection Criteria for Participants

We initially identified health sector organizations through internet browsing. We used a purposive sampling approach to select participants in positions of high leadership and responsibility in the organizations (e.g. managerial, academic and technical skilled GIS expertise backgrounds, and geographic locations). We used the purposive method, also known as judgment method [33], to select the most productive sample for answering our research questions from a collection of organizations who are directly or indirectly involved in health sector services. The higher leadership participants recommended potential participants for this study where a snowball approach was used. Thus, the selected participants had managerial backgrounds and expertise in GIS technology. Table 3 gives an overview of the job positions of the participants. We tried to include the broadest possible range of perspectives [36] that helped us understand and interpret the existing situation on the use of GIS technology, and design further research inquiries based on our analyzed data.

For GIS-using organizations, we limited the selection to organizations that possessed GIS technology or capabilities for at least two years. This time span should be sufficient to have enabled broad trends of changes of development of GIS technology use to have occurred. For instance, when new technology is developed in an organization, awareness and sensitization of the technology products is practically carried out to show organization top management of its benefits, and staff capacity building is carried i.e. practical on-job hands training on the use of the technology. As the aim of carrying awareness and sensitization, and staff capacity building is to promote the technology in the organization to show its effectiveness. For non-GIS using organizations, we focused on organizations within the proximity of identified GIS using organizations.

The purposive sampling approach helped us get the first five participating organizations, and an exponential non-discriminative snowball sampling approach was used to get the other 38 GIS-using organizations and 32 non-GIS using organizations, where the first participating organization was involved in identifying other organizations using GIS technology and those not using GIS technology. This snowball sampling approach helped us identify health sector organizations that were located within the proximity of the first organization, which increased participant reachability.

We identified 75 organizations to participate in our study (43 using and 32 not using GIS technology). Our selection was based on information from the Ugandan Ministry of Health (MOH), which formulates policies, establishes standards, quality assurance, mobilizes resources, capacity development, and technical support and coordinates health activities such as our study [37]. The ministry informed us that most GIS activities are outsourced due to inadequate staff expertise and to short-term and project-based funding. In those organizations, the end of a project also marks the end of GIS technology use, because GIS departments are not facilitated in these organizations.

In total, the study identified 89 participants (57 from organizations using GIS, and 32 from organizations not using GIS). In some organizations, more than one person participated in the interviews, based on the size of the organization and the number of project-based GIS-technology activities in that organization. The participating organizations were located in the Kampala, Entebbe, Gulu, and Rakai districts in Uganda. Table 4 gives an overview of the types of organizations that participated.

Our large sample size (cross-cutting the Ugandan health sector, including organizations that handled health-related activities even though these were not officially health sector organizations) was vital to understand the views, opinions, and perceptions on GIS technology, since the technology is relatively new in the Ugandan health sector. Furthermore, there are only a few health organizations in Uganda with a full-fledged GIS environment or that have fully implemented GIS technology. However, it is important to note that the required sample size for qualitative research studies is not strictly recommended like in quantitative studies [38,39]. Morse (as cited in 38) even stated that unclear guidelines on principles for sample-size selection has caused confusion in qualitative research. We opted for a large sample size, because it is wise to overestimate rather than to underestimate [39], and Morse (as cited in 38) in order to meet the qualitative principle of appropriateness of purposive sampling and of a good informant by not using a small sample (one who is articulate, reflective, and willing to share with the interviewer; [40]. Our large sample size enabled us to identify participants who were free to give information. We also chose a large sample size after some organizations were not willing to be interviewed, because GIS technology is mostly implemented and used by international organizations and funded project-based health activities. Thus, organization bureaucracy hindered our accessibility to some of the organizations. Finally, our large sample allowed us to get rich and holistic data that were sufficient for qualitative analysis. In addition to conducting semi-structured interviews, we collected data from secondary sources (e.g., annual reports, organizational websites).

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Professional background	Organizations using GIS technology	Organizations not using GIS technology	Total
Executive director	0	6	6
Monitoring & evaluation specialist	16	3	19
IT specialist/ICT manager	5	10	15
Head of department / managers	3	7	10
GIS technology staff / analysts	8	0	8
Research / project coordinator	2	5	7
Director	5	0	5
Consultant / advisor	4	0	4
Lecturer	3	1	4
Health inspector	2	0	2
Statistician	3	0	3
Medicine distribution manager / logistics coordinator	3	0	3
Other (vector control officer, geographer, senior engineer)	3	0	3
Total	**57**	**32**	**89**

Table 3:- Study Participants for the Interviews

Organization category	GIS users	GIS nonusers	Total
UN international agency (UNA)	12	8	20
Not-for-profit non-government organization (NFP)	10	10	20
Non-government organization (NGO)	6	8	14
Government/public organization (GPO)	4	2	6
Semi-autonomous government organization (SAG)	2	3	5
Project-based organization (PBO)	4	0	4
Education and research institute (ERI)	2	1	3
Private organization (PRO)	2	0	2
Funding mechanism (FM)	1	0	1
Total	**43**	**32**	**75**

Table 4:- Categorization of interviewed organizations

C. Interviews

We used an iterative data-collection approach and thematic analysis: We conducted semi-structured interviews, and subsequently identified the themes that emerged during those interviews (e.g. Sharing- Availability: availability of IT infrastructure, availability of geospatial data and skills and competences), necessity, efficiency, collaborations, learning, accountability) and not-sharing: lacking resources, poor quality of data, restrictions, no leadership, inter-organizational boundaries and so forth. The interviews allowed us to collect in-depth information through probing [41]. In addition, we conducted the interviews to get insight in the perceptions of organizations not using GIS technology and of non-technical GIS professionals. Finally, the interviews enabled us to have a face-to-face encounter with the participants. The aim was gaining an understanding of participants' perspective on what influences geospatial data sharing, of their experiences expressed in their own words, and of what hindered them to share geospatial data in the health sector.

We started our data collection with the Ugandan MOH (the coordinating organization of health and health-related activities in Uganda) and then extended our collection to proximate health organizations. The aim was getting familiarized with accessibility of health information, seeking permission to access necessary documents, and conducting interviews. Access to some of the health organizations using GIS technology was a problem, due to unwillingness to cooperate, especially as far as confidentiality and security of health data (especially individual data) are concerned. In addition, financial audits and financial year reports affected our data collection, since most of the GIS activities were project based and funded, and most organizations had deadlines for submitting financial reports and proposals for further funding. Nevertheless, we managed to conduct interviews and gather sufficient information to answer our study questions.

We conducted semi-structured interviews (audiotaped face-to-face and wrote down notes during telephonic), to assess each health organization's purpose of sharing or not sharing geospatial data. Since we set out to get uniform information to ensure comparability of our data, we used an interview schedule with categorized themes and issues. We requested participants to feel free to give detailed answers.

D. Data Analysis

We transcribed the qualitative data from the interviews and subsequently transferred these to Microsoft Excel to enable easy coding and the creation of key categories. Our analysis process involved segmenting the information and developing coding categories. We identified major themes and clustered them, after which we categorized the data into emerging themes and presented a narrative report using ideas from a developed framework by [42]. This process enabled us to get an in-depth description of the results. Thus, we used a qualitative content analysis, because it is "flexible" [42; p.10] and guides in providing ways of "discerning, examining, comparing and contrasting, and interpreting meaningful patterns or themes" [43; P.31].

Compared to quantitative analysis, qualitative analysis is guided by fewer universal rules and standardized procedures (e.g., data reduction, data display, conclusion drawing, and verification). We analyzed all qualitative data manually by reading through the transcripts and by highlighting responses to each question in order to build themes. We adopted the procedure for analysis from [42] data matrix display.

We analyzed the qualitative interview data by using a summary sheet (data reduction and display), to explore the perceptions of health decision-makers about the sharing or not sharing geospatial data in the health organizations to eliminate data redundancy and wastage of limited resources. A summary sheet is a single sheet with some focusing or summarizing questions about a particular field contact [42]. The summary sheet presents the questions and a summary of the responses of each interviewee. We coded all interviews manually. As stated in section 4.3, all participants were asked to answer predetermined questions. We analyzed their answers in a matrix format to identify common categories, similarities in their responses, and direct quotes.

We categorized the sections of analysis in this study according to the framework identified in the literature. In order to get insight in the current situation of sharing or not sharing geospatial data, we asked participants to mention any factors which have influenced or hindered sharing of geospatial data between the health sector organizations. We used the existing literature to categorize the mentioned factors into technical and non-technical factors [31].

V. RESULTS

A. Sharing of Geospatial Information

Not all organizations that were using GIS technology shared their data. Our study findings (see Table 5) show that 44% of the interviewed participants shared data with other health sector organizations in most cases to a greater extent, while 14% participants shared data greatly, 12% of interviewed participants only shared data limitedly with specific groups they had partnership with, 19% of the participants shared data in minimal manner with health sector organizations they had similar activities with memorandum of understanding. Another group of 11% of participants did not share data with other health sector organizations, but only shared data internally within their organizations, the districts they were working with, and areas where they were implementing health programs.

Our study findings indicate that there is a willingness to share geospatial data between health sector organizations or individuals in Uganda. A broad range of data-sharing possibilities emerged. Two participants said:

We do share to a large extent. That is, we are strengthening the capacity of government by building the geodatabases at MDR-TB facilities. After collecting coordinates, we were able to populate these geodatabases established in those health facilities, for example in KCCA, Mulago, Kitgum, and Mbarara. These are our intervention sites that we are supporting, but for sustainability issues, we were able to invite health workers from these different MDR-TB treatment centers, such as Arua, Mbale, and other regional referral hospitals for GIS training and we expect continuity of sharing this information.

- Participant belonging to a not-for-profit non-government organization

As one of our mandate we share back with our implementing partners to a greater extent who in one way the other are responsibly implementing an activity in the health sector due to the fact that they are serving under the PEPFAR-USAID umbrella. For example in some previous projects, we had around 5 African and European partnering countries, so it was a key that data should be exchanged and shared amongst the partners, were we standardized the reporting and defined data format.

- Participant belonging to a project-based organization

Other participants who reported sharing data to a minimal extent said:

To a smaller extent, because not every organizations is using GIS and not all organizations appreciate its importance, and that is why we find there are overlaps in organizations activities. For example there are many different organizations providing HCT and TB services being provided in just one district creating overlaps.

- Participant belonging to a non-government organization.

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Extent of GIS use for sharing geospatial data and information	GIS-users (57 Participants)	
	Frequency	Percent
Greater57 GIS-using participants	25	44
Great	8	14
Small/limited	7	12
Smaller/ minimal	11	19
Don't share	6	11
Total	**57**	

Table 5:- Overview of the extent of geospatial data sharing

Not so much in other words to a smaller extent, unlike places like UBOS were they have a GIS unit and are always doing GIS activities, here it's like a by the way. Also am not purely GIS person and the organization is lucky that I did my own training in GIS and bought my own ArcGIS software. The organization has never gone out looking for somebody who did GIS, its' not a daily routine activity, we can take a long time without doing GIS work, which comes once in a while.
–Participant belonging to a UN international agency.

Others did not see sharing as a fundamental part of their responsibilities, and provided reasons for not engaging in it. One participant said:

Our usage of GIS technology for the exchange of geospatial data with other health sector organizations is very minimal, because we don't have the capacity to update it, not much data and information in our database to offer other organizations.
- Participant belonging to a government/public organization.

Other participants who do not share data at all, said: "The challenge at the moment in sharing data and information is the behavior and attitude of some people personalizing data and fearing competition, organizational policies, security reasons; confidentiality of specific data types e.g. HIV/AIDS status of individuals". One participant belonging to a government/public organization said: "Because some studies data are confidentially dealing with individual patients we don't share data with anyone but exchange and share internally".

Organizations that share information currently do so through emails, annual reports, websites, seminars, office visits, workshops, and conferences where particular information is shared based on the theme of the meeting. Some organizations have annual health-sector reports, annual sector meetings with stakeholders, and review meetings as avenues of information sharing. In general, there are various means of sharing information, for example through technical working groups (e.g., inter-ministerial working groups, geo-information working groups, and environmental information networks) and institutional mechanisms/formal meetings with stakeholders in various forms (e.g., senior and top management, a committee, all ministerial reviews in the health sector, annual national health assembly) in which information is shared with the districts and all other ministries who are concerned with health.

B. Why People Share: Factors That Influence Data Sharing

We identified six categories that explain why geospatial data are shared with others: avail-ability, necessity, efficiency, collaborations, learning, and accountability (see Table 6). To have effective sharing and collaboration between health sector organizations in Uganda, organizations should focus their attention on these sharing indices.

Availability refers to the presence of crucial parts in order to be able to execute GIS functions (e.g., the IT infrastructure which facilitates geospatial data sharing). The presence of the geospatial data itself is a factor, because lacking these data makes sharing impossible. The skills and competences to use and share geospatial data are also essential. One of the participants said: "The existence of IT infrastructure such as internet, computers, skilled manpower, software, GIS environment or space, et cetera, which makes it easy to exchange and share information". Another participant said: "The biggest motivation for sharing data is that data exist in one organization, but not in another, which is a very common scenario".

Necessity refers to the type of data one needs to have in order to be able to function at all. Geospatial data sharing is inevitable in some cases, for example to fulfill the agreements in contract work or to perform one's core business. One participant said: "Interest and usage for which you might need the data, because if you don't have its use, even when you are provided with information, it will be of no value to you". Another participant mentioned: "One of the biggest factors is the need to improve service delivery, and access to required geospatial data from other organizations has been our biggest motivator for collaboration and for exchanging and sharing data and information".

Efficiency refers to the awareness that better performance through standardization or waste avoidance are key motivators for sharing geospatial data. Standardization of data types and reports, the reduction of redundancy, and the speed with which routine reports were compiled were reasons to share data. A participant said: "The ease for dissemination when people quickly understand maps better than written literature or other

formats of presenting information. So much can be presented within a map and it gives a good impression as opposed to tables". Finally, 42 organizations out of the 43 organizations were aware of the sunk costs that come with GIS data collection. To finally arrive at the situation that these data become available costs huge efforts and significant amounts of money. Therefore, one can use data that are already available to reduce costs. A participant mentioned: "One of the factors is that resources aren't enough. Ideally, all sectors can collect the data they want, but in cases where resources aren't enough, they have to share the available data from other sectors".

Collaborations refers to the networking and agreements or memorandum of under-standing with other organizations that lead to geospatial data sharing. Such collaborations facilitate the use and sharing of geospatial data, either enforced by regulatory institutions, or through outreaching boundary spanners. Two participants said:

Some organizations have a memorandum of understanding to exchange their information to avoid bureaucracies in organizations where someone can take months without accessing information a person wants from an organization. For example, when organizations are doing similar activities, they tend to exchange and share experiences and knowledge, and learn from each other's mistakes.
–Participant belonging to a private organization

Institutional or formal mechanism to share where we have working groups. So if there are institutional mechanisms, it's easy to share when someone attends that working group or GIS meeting and inquires for data within the group, such as layer of health facilities. So when we share or exchange the data, we avoid a lot of duplications of limited resources. We are operating within our mandate as the central statistical coordinating agency and we operate within the statistics act that states that data are free.
–Participant belonging to a semi-autonomous government organization.

Learning refers to an increasing professionalism that leads to better use and exploration of new possibilities. Professionalization is highly important to promote complex health issues and fight devastating diseases. While organizations are handling various aspects, they are willing to share and learn from others. This goes in hand with the availability of formal and informal network and sharing platforms, that are basically based on who knows whom, that facilitate information sharing and collaboration. In addition, participants mentioned the relationships in the activities of various organizations, such as working towards a common interest, doing similar activities or interventions, or the same operational zones and coordinating bodies for information sharing. These initiatives provide opportunities for information sharing and increased collaboration across the sector and to the general public with an interest in health issues. So learning and professionalizing increases geospatial data sharing. In some cases, specific tasks were allocated to certain groups to become more professional and specialized. Such a division of labor increased service delivery. Furthermore, the awareness of interconnectedness and mutual dependability led to increased geospatial data sharing. One participant said:

We stand to benefit if we share, for example if I want some data tomorrow which someone else has, I will be able to access it, you don't have to go to the field also and do the same.
–Participant belonging to a UN international agency.

Accountability is, last but not least, important for GIS technology use as it forces organizations to provide evidence of efficiency, efficacy, and added value. Thereby, collaboration and sharing becomes crucial. One has to show donors how their money was spent, and this also creates positive reputations. To be held accountable also means to open up for sharing. A participant said:

Accountability purposes to account to the donors, the public, beneficiaries, and government, which shows a kind of transparency. For example, the MOH has always encouraged the sharing of data between health sector organizations, and it has encouraged through showing an example by sharing data with others to inspire accountability and transparency.
–Participant belonging to a non-government organization

C. Why People Do Not Share: Problems That Hinder Data Sharing

We identified five categories that explain why geospatial data are not shared in collaboration with other users: lacking resources, poor quality of data, restrictions, leadership, and interorganizational boundaries (see Table 7).

Lacking resources comes in different forms, but the overall characteristic is the absence of crucial parts, such as a health GIS infrastructure, proper network connections, and GIS expertise. These are needed to be able to execute GIS functions. For instance, participants mentioned the lack of a proper network connection to access each other's data.

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Factor	Category	Why it enables geospatial data sharing (N=43 GIS-using participant organizations)
Availability	The presence of crucial parts, to be able to execute GIS functions	
	Availability of IT infrastructure	The use of internet, computers (26)
	Availability of geospatial data	Data available in one organization, but absent in another (23) Free and easily accessible geospatial data (7) Availability of demand or need and increase in use for geospatial data (7)
	Skills and competences	Availability of GIS skills, knowledge, and capabilities to operate the technology (4) Leadership in top management having knowledge of IT (3) Organization/individual behavioral attitude, willingness and motivation to share to identify needs (12)
Necessity	Geospatial data are the type of data one needs to have access to, in order to be able to function at all	
	Essential data types	Need for specific/special type of dataset (3) Relevance of the data to the health field (cannot do without) (5)
	Contracts	Geospatial data are needed to fulfill obligations for contractor activities (e.g., consultancy) (2)
Efficiency	Better performance through standardization or waste avoidance	
	Standardization	Improve data quality, standardize reporting, define data formats (6)
	Reduce redundancy	Reduce duplication of efforts in collecting and maintaining the same geospatial dataset (redundancy of datasets) (8)
	Quick routine reports	Demand for data for writing routine reports and designing programs (7) Reduce time spent in data collection and decision-making (4)
	Reduce costs	Collecting geospatial data is too expensive, so better use the already available data properly (12) Lack of enough resources to collect the data an organization needs to run its activities (6)
Collaborations	Networking and agreements with other organizations lead to geospatial data sharing	
	Participating in networks	The nature of programs organizations are engaged in: Working towards common goals (having common interests), in similar operational zones, or doing similar activities or interventions (18) Collaborative projects: Working towards a common interest and an increase in the availability of data (5) Encourage collaboration, knowledge learning, capacity building, and GIS technology use for sharing (4) Having a memorandum of understanding between organizations. (12). Existence of informal body networks (16)
	Harmonizing, nationally and internationally	Harmonize planning and interventions with the national strategic plan of the government, especially with the MOH (4) Generate collaborations with other countries and within the country (10) Existence of sharing platforms/forums, institutional/formal mechanisms, and a coordinating body, such as a working group (19)
	Following agreements	Agree to work with compatible systems (2)
Learning	Increasing professionalism leads to better use and exploration of new possibilities	
	Sharing	Organizational learning: Sharing knowledge about the benefits of data sharing, sharing experiences, and learning from each other's successes and mistakes (28) Expand networking to broaden areas of research, and to share knowledge and experiences (24)
	Professionalization	Need for evidence-based information for decision-making, proper planning, and disease forecasting (11)
	Division of labor	Identify gaps in the health system's service delivery (identify where services are concentrated, where these are sparse, and

		where these are non-existent in order to adequately apply resources) (6) Improve service delivery, avoid duplication of services, wastage of resources and reduce time of accessing geospatial data (31)
Accountability	Providing evidence of efficiency, efficacy and added value	
	Show donors how the money is spent	A need to show accountability and transparency to donors, the public, beneficiaries, and the government (41) Political influence: organization and government requirement, mandate, policy to share non-confidential health information with other organizations or anyone interested (41) Donor requirement: funded by the same donor (16)
	Educate people by sharing insights	Widen and ease dissemination, since people understand maps better than written literature or other representation formats (2) Equitable distribution of resources (5) Establish the internal capacity and be able to share what has been achieved (1) For advocacy purpose (for GIS use for health activities) and resource mobilization to get more support from donors (8)
	Reputation and image	Good leadership to maintain the image of an organization (3) Gain self-confidence (4) Make GIS products visible, as maps are used as a communication means (4) Positive acknowledgement and encouragement from data users (6)

Table 6:- Factors That Influence Geospatial Data Sharing

Without a suitable network, one cannot share, and some existing networks are not capable of transferring the high amount of geospatial data. This constraint causes real challenges and decreases the success of spatial-data sharing. In addition, a lack of a suitable infrastructure department for capturing data (e.g., a central depository or a common platform). For example, there are too few GIS-specialist posts in the government employment structures. Also, a lack of expertise is problematic. As one of the participants said:

There is lack of GIS expertise, the fact that many organizations don't have people who can use GIS. You find that they have the software and even purchased the GPS equipment, but don't have anybody to use them. I have come across a number of health sector organizations with that challenge and yet, the equipment is as good as useless after one year, because there are new advances, so maybe one of the hindrances to sharing data can be related to that. For instance, if I have my data and another organization wants to use the data, they want the data plus my services, because they don't have people to do GIS work and yet, my services may go at a cost and that becomes a hindrance to sharing.
- Participant belonging to a not-for-profit non-government organization

Poor quality of data discourages the sharing of geospatial data. A lack of confidence about the quality of geospatial data produced by other organizations fuels the reluctance to use other's data sources. At the same time, spreading data that turn out to be unreliable could cause legal issues that organizations want to prevent. If data are incomplete, for example, bad decisions could be made on the basis of those data. And who is accountable for the consequences of such decisions?

Organizational *restrictions* come in different forms: Policies and norms are a key determining factor. While it has largely been seen that most of the organizations that share data are doing so because it fits their policies and mandate, it is clear that some organizations that are not sharing have non-disclosure clauses in their policies. This may be the case when there is a fear of competition from other organizations, and a fear of losing autonomy over information control and organizational power. For instance, private sector organizations behave like retailers and wholesalers who are each other's competitors, and NGOs are afraid to share their data and information, because they use it to get funding. Therefore, these organizations prefer being the only ones who acquire the benefits of their geospatial data. Lack of cooperation and lack of trust have also been mentioned as key factors influencing organizational decisions on whether or not to share data. Furthermore, data confidentiality, sensitivity of specific data types, security issues, political interference, and a lack or unavailability of lower-level, digital, geospatial health data emerged as key factors that hinder geospatial data sharing. Confidentiality and sensitivity of the data, for example, is concerned with the integrity of the organization and dealing with individual patients' geospatial data (e.g., in the case of HIV or TB patients). This is a big challenge that needs to be handled carefully in order not to breach the privacy of the clients.

Problematic *leadership* is a key factor as well. Without a call for evidence about the efficiency, efficacy, or added value of the organization's functioning, the opportunities of geospatial data sharing are not used. There were indicators of weak cultures for sharing, reasons to expect a lack of

integrity in organizations, no vision, and downright fear for engaging in geospatial data sharing.

Inter-organizational boundaries exist as well, and are reasons for not sharing geospatial data. Out of the 43 GIS-using participant organizations, 28 of the participants mentioned fear of competition from other organizations, lack of awareness and knowledge about sharing benefits and importance, and lack of data-sharing guidelines and thus fear of data abuse or use for political gain as problems that hinder geospatial data sharing (see Table 7).

VI. DISCUSSION

We aimed to identify the factors that influence and the problems that hinder geospatial data sharing in Ugandan health sector organizations. The summary of factors that enable (see Table 6) and hinder (see Table 7) geospatial data sharing provides a context for understanding the actual dynamics from a user perspective. Based on this context, we provide three recommendations below, for improving geospatial data sharing and collaboration through integrated collaborative networks. The integrated collaborative networks should aim to strengthen the capacity of health information systems to provide high-quality, timely data and information useful for solving health problems at different levels [44]. In addition, integrated collaborative networks should support innovation in the monitoring and evaluation of health intervention programs.

- *Recommendation 1: Establish and Harmonize a Geospatial Data Policy through Government*

The improvement of collaboration and geospatial data sharing begins with government, because organizations that use geospatial data do not have control over private companies. The Ugandan government should enact a rule that makes geospatial data sharing free among government institutions. Such a rule does exist, but it is inactive and weak. The literature and participant responses indicate that a geospatial data policy is lacking in Uganda. Moreover, a protection law against data abuse is lacking. This lack of policies and laws hinders geospatial data sharing for most organizations. This has led health organizations to practice technical know-who, to reduce misuse and abuse. Thus, participants proposed to enact a harmonized information policy in the country. Such a policy would cater for desired mechanisms, such as geospatial data accessibility, geospatial data sharing, collaboration, pricing for commercial organizations (e.g., the private sector), data custodianship, data ownership, type of network systems to be used that are capable of transferring bulky geospatial data (spatial-data infrastructures), data standards and formats, the use of a uniform software licensing agreements accessed through the Web, client privacy, copyright law for the protection of data production and data dissemination, security, and confidentiality and sensitivity of specific data types. Establishing a geospatial data policy (i.e., rules, legislations, and mechanisms) will encourage collaboration and geospatial data sharing within the health sector and the GIS technology arena.

Establishing and harmonizing a geospatial data policy also means *making the software available and providing key licenses that can be shared on a network*. For example, the open-source quantum GIS, DHIS2, or environment software for classification in schools, which allows someone to still use their license if they do not have their key, but if they are connected on the school's network. Comparable to such a school network or to an organization's network that allows printing, one could access a uniform GIS-software license on a network.

- *Recommendation 2: Create a Coordinating Body of GIS-Using Health Professionals for the Collaboration and Coordination of Activities*

To open avenues for free geospatial data sharing, the GIS technocrats should set up a technical coordinating body of GIS technology uses. For example, health architects have a coordinating body, but GIS professionals do not have a GIS body. The GIS community, with the guidance of government as the arm of the law, should develop a GIS-user group for the improvement and management of GIS applications at the national level. The creation of a GIS-using health professional body was one of the strategies identified in our study to improve inter-organizational collaboration and geospatial data sharing between health sector organizations. The issue raised was that this body's responsibility would market GIS health activities, create collaboration among users of GIS technology, come up with data standards and formats, and coordinate GIS activities. On the other hand, such a coordinating body of GIS-using health professionals should be formed including a wide spectrum of organizations of both users and producers of GIS technology. This would create awareness and sensitization about sharing benefits by practical demonstrations through workshops and trainings using successful examples of collaboration and spatial-data sharing. In addition, such a coordinating body would facilitate the availability of core geospatial datasets, increase access to up-to-date, digital, lower-level health data, aim at eliminating bureaucracies of data accessibility, and increase collaboration and geospatial data sharing between organizations by coordinating all GIS-using health organizations. As part of this effort, the coordinating body could utilize public spending through improved coordination among the organizations in their GIS-related investments, and introduce GIS concepts, methods, and processes to these organizations.

Creating a coordinating body of GIS-using health professionals also means establishing an integrated collaborative networked spatial-data infrastructure (ICNSDI) for collaboration and geospatial data sharing. An SDI emerged as a critical area for enhancing knowledge and geospatial data sharing, usage, and access. The platform would ensure quality of data, routine sharing, create collaborations, improve networking and coordination, reduce or even eliminate duplication or redundancy of datasets, reduce costs of data collection and maintenance of several datasets, and regulate GIS technology use. It would probably also regulate data use to ensure that an organization's data are not abused or misused for personal

gains. An integrated collaborative networked SDI was proposed to be implemented in partnership with the ministry of ICT, to reduce restricted access rights to (existing) geospatial datasets. For instance, developing a concrete integrated collaborative networked SDI (ICNSDI) is where the whole core of sharing geospatial data starts from employing GIS professionals in organizations which would influence the sharing through formulating technical working groups (e.g., geo-information management working groups) where people should showcase to bring all people on board, coordinating activities, collaborations, marketing GIS activities by advocating for geospatial data use and creating awareness and sensitization about the benefits of sharing. Geospatial data sharing and spatial information management are identified as vital components of an SDI [22].

- *Recommendation 3: Incorporate GIS Courses in the Curriculum of Universities Dealing with Health Issues*

In the long term, GIS courses should be incorporated in health curricula of universities. Training at this level would ensure an increase in health workers who are knowledgeable about GIS and therefore, implementation should not be a challenge. This would address the most frequently mentioned challenge in most health sector organizations, namely a lack of GIS expertise.

The underlying theme is to *increase advocacy, and create sensitization and awareness about GIS technology use and the benefits of sharing.* Health organizations should be willing to share whatever geospatial data are available. Government should take the lead in the advocacy, sensitization, and awareness processes to improve organizational attitudes and possible individual unwillingness to share geospatial data with others. Government involvement will reduce commercialization of geospatial data and fear of competition from other organizations, increase data demand, and reduce misuse and abuse of data from specific individuals for political gains.

VII. CONCLUSION

An ICNSDI is suitable for Uganda, because many organizations share geospatial data, and even internationally, even though on a limited scale. The sharing of geospatial data is one of the biggest benefits of using GIS technology to influence geospatial data use in the health sector organizations. Our study finding is showing that the knowledge and management and the documentation of geospatial data sharing are important and organizations are exercising sharing, but they are not sharing freely and as willing as they should be.

The results from the study described in this chapter indicate that there is a significant potential for collaboration and geospatial data sharing within the Ugandan health sector and organizations tasked with handling health-related activities. This will require the government to initiate the creation of a collaborative sharing platform (an SDI) which encompasses all components of data sharing that a country needs.

Even though some health sector organizations do collaborate and share geospatial data to a great extent, not much of the total available institutional geospatial data are shared with other organizations. Organizations have to ask which type and level of data they need but arrangements are made to deliver only national up-to parish level geospatial data to them even though they had asked village level data. In addition, the collaboration and sharing of geospatial data is only confined to GIS-using organizations with donor supporting organizations but not all health sector organizations. Ugandan health sector organizations share their data in informal networks or via technical know-who with specific organizations they work with on the same or related activities. Thus, if an organization does not know any staff from a different organization, a person cannot access that organization's geospatial data. Furthermore, this study has shown both positive and negative sides of geospatial data sharing between Ugandan health sector organizations. Looking at the negative side, the redundancy of platforms for geospatial data sharing has caused people to lose morale for sharing. On the positive side, the formation of a platform facilitates collaboration and geospatial data sharing. This should be continuously maintained to encourage continuous collaboration and geospatial data sharing between organizations.

The use of GIS technology for collaboration and geospatial data sharing in Ugandan health sector organizations has been facilitated by the availability of an IT infrastructure (which simplifies online sharing and networking to share knowledge) and by the existence of special online GIS user groups (which helps management and improves GIS technology use, because the groups provide an opportunity to facilitate data availability and sharing among the organizations that are involved in these groups).

Geospatial data sharing is known to be problematic, but provides vital information for targeting control measures of health diseases. Therefore, the development of an ICNSDI should be encouraged. An ICNSDI that encompasses policies for sharing, access, ownership, and custodianship will deter misuse. Moreover, collaboration in the production and interpretation of geospatial data should be encouraged within the GIS arena, because this will reduce redundancy of data collections and wastage of limited resources.

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Factor	Category	Why it hinders geospatial data sharing (N=43 GIS-using participant organizations)
Lacking resources	The absence of crucial parts in order be able to execute GIS functions	
	Lack of IT infrastructure	Slow Internet, no computers (8) Limited skills to operate the GIS technology (8) Lack of awareness, appreciation and knowledge about GIS technology and its benefits (14) Poor IT network systems (20) Lack of a suitable infrastructure department for capturing data (central depository one-stop center/a common platform) (13) GIS has not been fully integrated to the existing health-management information system (5) Lack of resources to develop web-based database system (5)
	Lack of geospatial data	Lack or unavailability of geospatial data to share (32) Lack of knowledge of existing available datasets and from where to get data (11) Lack of demand for geospatial data (10) Lack of accessibility to geospatial data (6) Lack of capacity (continuous funding) to keep continuous update of data (4)
	Lack of skills and competences	No professional body to guide data standards and sharing(9)
Poor quality of data	GIS technology use is discouraged, because the quality of the data is low	
	Essential data types are not reliable or available	Lack of resources/budget allocation for geospatial data collection and dissemination (42) Incomplete, outdated data and scattered in paper form (11) Lack of custodian of geospatial health data(7) Lack of lower-level, digital, geospatial health data(5) Poor documentation (8)
Restrictions	Protection policies lead to not sharing geospatial data	
	Participating in networks	Donor demands, influence, or restrictions (4) Some organizations attach costs to their data (commercialization) (17)
	Competition nationally and internationally	No spatial-data policy (legislation, clear guidelines, mechanism, and protection law of personal information) (15)
	Following agreements	Organizational restrictive policies and norms (24) Lack of client privacy (2) Lack of data ownership (4)
No leadership	No call for evidence of efficiency, efficacy, or added value	
	Weak culture of sharing	Lack of advocacy (5) Poor leadership and performance of GIS-using organizations (2) Bureaucracy in organizations (8) Lack of willingness to share data (having organizational and behavioral attitudes and poor organizational culture) (18)
	Lack of integrity in the organization	Conspicuous dealing with individual patients' geospatial data (6)
	No vision	Lack of awareness and knowledge about sharing benefits and importance (28) Lack of copyright law (protection law) regarding data production and dissemination (7) Lack of defined rules/law, regulations abiding organizations, procedures and infrastructure for data (10)
	Fear	Security issues and fearing data can be abused or used for political gain (36) Fear of competition from other organizations (28) Fear of misuse and abuse of data that will destroy the image of the organization (4) Lack of defined sharing procedures, regulations, rules, and infrastructure (10) Confidentiality and sensitivity of specific data types (38) Lack of cooperation and lack of trust between GIS-using organizations (9)

Inter-organizational boundaries		Lack of knowledge about GIS-using health organizations (7) Different data formats (3) Different organization objectives and priorities to achieve (19) Limited relationship between GIS-using organizations (3) Personal behavioral attitude, nature of the people and behavior across organizations or individuals (17) Lack of standards for collecting, producing data (17) Lack of meta data (4) Stalk with old traditional methods of sharing data and solving a problems (3)

Table 7:- Why not share: Problems that hinder geospatial data sharing