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Integrative Approach of Implementing Geographic Information System for Health Management: Lessons Learnt from Malawi

Patrick Albert Chikumba[1,2,*]

[1]Department of Informatics, University of Oslo, Oslo, Norway
[2]Faculty of Applied Sciences, University of Malawi – The Polytechnic, Blantyre, Malawi
*Corresponding author: pchikumba@poly.ac.mw

Abstract Literature has proposed different frameworks of implementing Geographic Information System (GIS) in developing countries, and one of them is the integrative framework in which GIS implementation activities are typically linked with activities of implementing other programs or projects. Thus, the paper discusses how the integrative framework has been applied in the GIS implementation for health management in Malawi and lessons learnt from such an application. The understanding is that GIS implementation is unique to a particular organisation, with some unique technical and organizational impacts and implications that need to carefully be addressed. This case study was conducted at the national level in Malawi's Ministry of Health between June 2015 and April 2017. In Malawi, several initiatives towards GIS implementation have been taking place since 2002, which involve the policy formulation, user training, generation of static maps, collection of spatial data (i.e. geodata) for health facilities, and deployment of DHIS2 GIS. Qualitative interpretive research methods were applied and data was collected through semi-structured interviews, document analysis and participant observation. The paper argues that it is important to consider specific problem domains and options of integration when deciding on the integrative approach of GIS implementation. The paper identifies geodata, technology and expertise as the specific problem domains, and *fully linked*, *partially linked*, and *not linked* as options for integration. The paper claims that *compatibility* of activities to be linked is one factor that can determine whether or not to apply the integrative approach. Generally, the major opportunity of the integrative approach of GIS implementation is the utilisation of time and resources such as people and finances. However, the main challenge is the lack of control on allocation and use of those resources, particularly people and their knowledge because most activities have been managed by collaborating organisations. This may bring challenges on local capacity building.

Keywords: *GIS implementation, integrative framework, DHIS2 GIS, GIS for health management*

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1. Introduction

The health sector is developing innovative ways to make use of data integration and visualization power of Geographic Information System (GIS). GIS has been applied in planning and management of health care services [1] due to, for example, its ability to manage large volumes of data quickly and readily produce spatially oriented output [2]. The combination of GIS and health applications with decision-making processes can assist in operational and management controls, and strategic planning [3]. In developing countries, GIS is applied in many health areas including health management. However, GIS is not used to address pressing needs in ways that are sustainable. This can be due to numerous challenges existing when implementing GIS, which are mostly organisational.

Literature has proposed and discussed different approaches or frameworks for successful GIS implementation in developing countries. This paper investigates the role of the integrative approach of GIS implementation in developing countries proposed by Ramasubramanian [4] in the context of health management using the case of GIS in Health Management Information System (HMIS) in Malawi. Since the proposition of the integrative framework, there is little discussion on its benefits and risks, particularly in health. In the integrative framework, the GIS implementation is embedded in the development of other policies, programs, or projects [4]. There is such practice in GIS implementation for health management in Malawi, in which most GIS initiatives are integrated with activities of other programs or projects. In Malawi, Ministry of Health decided to use GIS since 2002 as one way of improving data analysis, integration and visualisation in its HMIS.

The observation is that in developing countries, GIS is implemented in different contexts or organisations, which may individually have unique impacts and implications on the implementation process. Somers [5] points out that the GIS implementation is unique to a particular organisation or context. Therefore, specifically, the aim of this study is twofold; first, to investigate how the integrative approach of GIS implementation has been applied in the health management context and, second, discuss lessons learnt using the empirical insights from Malawi.

The rest of the paper is as follows: the second section presents the related literature, and defines three characteristics drawn from the integrative framework of GIS implementation in developing countries to be applied in this study while the third section defines the research methods. The fourth section describes some GIS initiatives to demonstrate the existence of integrative approach. The fifth section contains the analysis and discussions of the findings and lastly, the paper ends with conclusion.

2. Integrative Framework of GIS Implementation

2.1. GIS Implementation

GIS belongs to the family of information systems. However, GIS is different from other information systems because additionally it deals with spatial data (or geodata). GIS is a special case of information system in which "information is derived from the interpretation of data which are symbolic representations of features" [6]. GIS accesses spatial and non-spatial data, analyses the data, and produces output with mapping and visual display [3]. This requires people, data, hardware software, and procedures [6,7], which relate to each other. People are the most important part of GIS who overcome shortcoming of the other elements, and therefore, they need adequate knowledge and skills for proper handling of these elements. Without adequate and reliable data, GIS is not useful [8]. The data element of GIS determines types of problems to be addressed by GIS, which includes both geodata and attributes. In addition to the standard hardware components of information systems, GIS needs special peripherals for data input, output, and in some cases, storage and processing [6]. In terms of software, a special type of computer program is required and capable for storing, editing, processing, and presenting geographical data and information as maps [9]. The choice regarding technology usually depends on the types of problems to be solved, and should match with required needs and skills of its users.

"Getting GIS properly implemented is an extremely important part of the total GIS adoption process" [10]. The adoption is taken as the acceptance by users and management of the implementing organisation to use GIS in operations and decision making in health management. Since GIS implementation is unique to a particular organisation, both technical and organizational impacts and implications should carefully be addressed [4,5,11]. In this paper, GIS implementation is referred to as "an on-going process of decision-making, through which a community of participants becomes aware of, adopts, and uses GIS" [4].

The GIS implementation involves activities necessary to put GIS into practice and incorporate into existing and developing operations [12]. In GIS implementation, there is no single recognized model due to variations of implementation strategies between different thematic areas for GIS and between organisations of different sizes or purpose [10]. Generally, adoption of technology depends on the quality and extent of management involved in the process [13], which may involve the selection of strategy. The strategy is taken as a contingent plan of action designed to achieve a particular goal [14]. Different organisations have different GIS implementation approaches, ranging from the large, complex, highly coordinated enterprise-wide efforts of many local governments to the small, independent GIS implementations found in some areas of companies [15]. Thus, this paper focuses on the integrative framework of GIS implementation [4] as one approach of implementing GIS for health management in Malawi.

2.2. The Integrative Framework

Literature has revealed that studies of GIS implementation in developing countries are either on *factors*, which enable or impede implementation, or *process*, which involves key steps or decisions that are made during implementation. Hence, Ramasubramanian [4] proposes the integrative framework of GIS implementation in developing countries to accommodate both approaches. As illustrated in Figure 1, the integrative framework of GIS implementation involves five stages. In this study, the focus is on policy or programmatic goals (the first stage), funded programs or projects (the second stage) and implementing activities (the third stage).

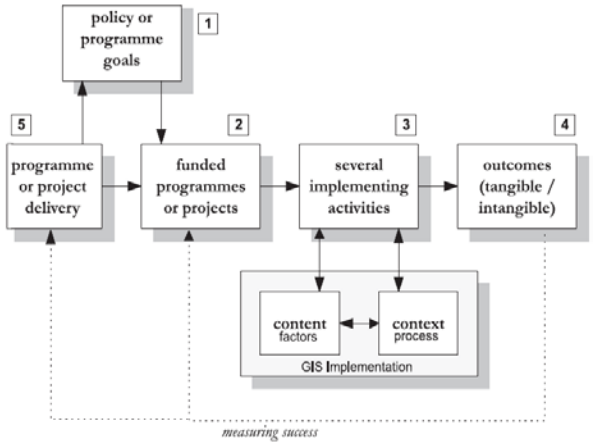

Figure 1. Integrative Framework of GIS Implementation [4]

This integrative approach "allows researchers to identify issues and decisions that may have preceded discussions about GIS implementation as well as those that are likely to impact the implementation process" [4]. The author has drawn three characteristics from the integrative framework to be used for analysis and discussion in this study. The first characteristic is that, as mentioned earlier, the integrative framework accommodates both factor and process approaches. GIS implementation

is a process in which management should make informed decisions at certain points in time. During assessment of GIS implementation in developing countries, apart from identifying factors that affect the process in a particular organisational setting, it is also important to analyse the key steps that are made in order to identify how the implementation occurs in reality [4]. For example, this helps to understand why certain decisions have been made in that particular time [16].

The second characteristic is the motivation for introducing GIS. The integrative framework begins with policy or programmatic goals that provide the motivation for introducing GIS (the first stage) and they are usually translated into funded programmes or projects (the second stage). Therefore, in any assessment of GIS implementation, the contents of programs or policies being pursued, their direct and indirect effects on implementation processes, and subsequent outcomes must be taken into account [4].

The third characteristic is that GIS implementation in developing countries is typically linked with the implementation of other policies or programs. In this case, GIS implementation activities are treated as part of the several implementing activities within funded programs or projects of an organisation (the third stage).

3. Research Setting and Methodology

This section presents a brief description of the context in which the study was conducted and how data was collected and analysed.

3.1. Research Setting

This case study was conducted at the national level in Malawi's Ministry of Health between June 2015 and April 2017. The year 1999 was a remarkable year in the health sector in Malawi, as this is when the restructuring of the health information system started. In 2002, Ministry of Health introduced a comprehensive but simple and manageable HMIS in order to have a continuous routine reporting of data from health facilities. To strengthen HMIS, Ministry of Health established Central Monitoring and Evaluation Division (CMED) in the department of Planning and Policy Development for coordination, data management, advocacy and facilitation of the information use in various activities such as policy formulation, planning and program implementation at all levels.

In the same period, Ministry of Health witnessed the 'birth' of two systems, district health information software (DHIS) and GIS. DHIS is the software platform for reporting, analysis and dissemination of data for all health programs at different administrative levels. DHIS1.3 (the desktop solution) was introduced in district health offices and central hospitals to aid routine health data storage, analysis and presentation at district and national levels. Between 2009 and 2012, DHIS1.3 was upgraded to DHIS2 (the web-based solution) to enhance HMIS towards integration of various health programs.

In Malawi, the health system has five administrative levels: nation, zone, district, facility, and community. In Malawi's HMIS, data is collected and aggregated at the facility level, and then integrated and analysed at the district level. The district is identified as a focal geographic unit for integrating multiple health programs and information systems. Officers at the zonal and national levels rely heavily on district health offices in terms of data availability. The integration and analysis are done through the computerized system, DHIS2, as a central data repository.

Several initiatives towards GIS implementation have been taking place since 2002, which involve the policy formulation, user training, generation of static maps, collection of geodata for health facilities, and deployment of DHIS2 GIS.

3.2. Data Collection

In this study, qualitative interpretive research methods were applied to understand the integrative approach of GIS implementation for health management in Malawi in its social and natural settings. Semi-structured interviews, document analysis and participant observation were the data collection methods.

3.2.1. Semi-structured Interviews

Ten semi-structured interviews with seven participants at the national level were conducted at different times. In some cases, the author had to interview one participant twice or more, which provided an opportunity to confirm, verify and even build on information from previous interviews. The participants were two DHIS2 programmers who have been involved in the implementation of DHIS2; four managers of CMED who have participated in various projects that strengthen HMIS including GIS initiatives; and one member from one collaborating partner who participated in one of the geodata collections for public health facilities. All interviews were conducted at the individual participant's workplace. During interviews, the note-taking technique was used and immediately after the individual interview, notes were written up in full and sent to the respective participant through email for verification and feedback.

3.2.2. Document Analysis

Emails, minutes, reports and documents (see Table 1) that have included GIS directly or indirectly were analysed. The document analysis enabled the author to obtain the witness of past events; to identify some areas that needed further investigation; to supplement the semi-structured interviews and participant observation; and to track developments of GIS in Malawi's HMIS.

Table 1. The Analysed Documents

No	Documents
1	Emails exchanged between CMED and stakeholders, including development partners, in September 2009 and January/February 2010
2	Minutes of GIS mapping meeting held on 15th October, 2015
3	Report on the introduction to ArcGIS for health in Malawi in November 2008
4	Report on DHIS and GIS training workshop in February 2009
5	Report on the new DHIS2 training in June 2017
6	Health Information System policy and strategy of 2003 [17]
7	Revised Health Information System policy of 2015 [18]
8	Malawi health sector strategic plan of 2011 – 2016 [19]
9	Incorporating Geographic Information into Demographic and Health Surveys [20]

3.2.3. Participant Observation

Participant observation was done during the deployment of DHIS2 GIS, which was integrated in the DHIS2 reconfiguration project. The author participated in key activities from June 2016 to January 2017 as one of DHIS2 GIS implementers. These activities include development and preprocessing of GIS data; and setting up, testing and demonstration of DHIS2 GIS at the national level and in two health districts of Blantyre and Mchinji. At the end of each day of fieldwork, the author had reviews on the field notes to have an initial understanding on daily events. The author also attended two stakeholder meetings on GIS as the passive observer.

3.3. Data Analysis

The data was analysed continuously throughout the study, that is, the data collection and analysis were carried out concurrently. In order to generate evidence from the case study, the data was analysed through four key steps: immersion in the data, coding, creating categories, and the identification of themes [21] and being guided by the characteristics drawn from the integrative framework of GIS implementation. However, these steps were not done in a linear fashion; rather the author moved back and forth through the processes in order to make sense of the whole dataset. This allowed the author to systematically integrate new data into the analysis and assess the relevance of the chosen theoretical concepts as the data analysis proceeded [21]. The data analysis was manually done.

4. Findings

In Malawi, Ministry of Health has been carrying out a number of GIS implementation activities since 2002. From the perspective of elements of GIS (i.e. procedures, data, people and technology), the activities are grouped in four main categories: policies and strategies, geodata collection, GIS user training and DHIS2 GIS deployment. Table 2 lists the activities that are used in this study to demonstrate the integrative approach of GIS implementation in health management, which are summarised below.

4.1. Motivation for Introducing GIS

Every GIS user organisation needs a plan with business rules, models, and operating practices [6,7], which can be defined in policies, strategic plans, and program documents. These policies, strategies and program documents may guide behaviours in the GIS implementation. In this study, it has been observed that the existing policies, strategies and program documents are not necessarily for the GIS implementation but for other projects or programs in which GIS initiatives are embedded.

Ministry of Health considers GIS as one of technologies for strengthening its HMIS. In 2003, the ministry formulated health information system policy and strategy [17], which intends to provide a framework for the use of information in planning, management and monitoring of health services and performance. This policy recommends the application of GIS as a powerful visual tool for planning and monitoring of health services. It emphasises on geographical variations in types and magnitude of problems, equity in distribution of health services, and service utilization. It also states the purpose of GIS, collection and update of geodata, accessibility of GIS, procurement of GIS hardware, and spatial data analysis.

It has been observed that since the introduction of this policy, there were various GIS initiatives such as the generation of static maps in 2003 and 2011, purchase of hardware in 2005 and user trainings between 2009 and 2013 (see Table 2). For the elaboration of user training see Section 4.3. Hardware components to be acquired and training participants were stated in the policy. Hence, it is argued that the health information system policy of 2003 [17] influenced the hardware components to be acquired and who should participate in the GIS trainings.

Due to significant changes in health information system in Malawi, the ministry decided to revise its health information system policy in 2015 [18]. This revised policy does not specifically include GIS as one of technologies because "… the policy is open for any relevant technologies … there are various electronic health information system projects taking place such as mobile health, GIS, and DHIS2 among others …" – one participant commented. However, it has been observed that the revised policy has some statements, which may influence the use of GIS in HMIS as a relevant technology; for example, its emphasis on the utilization, coverage and equity of services delivered. GIS can support such type of information.

There are strategic plans and program documents that directly or indirectly specify the role of GIS in health information system. For example, Malawi Health Sector Plan [19] addresses issues concerning equity including gender and geographical location. Hence, GIS can as well support such spatial dimension. ICF International produced the program document [20], which emphasises the incorporation of geographic information into demographic and health surveys. This document is a field guide to global positioning system (GPS) data collection. Hence, ICF International and Ministry of Health captured GPS data for health facilities in 2013 during the service provision assessment (SPA) survey (see Section 4.2).

These examples above demonstrate that the decisions made on various GIS initiatives in HMIS has been influenced by the existing policies, strategies, and program documents, which is in line with the understanding of Ramasubramanian [4] that policies and program documents motivate the introduction of GIS.

4.2. Geodata Collection

This study focused on two major projects of capturing GPS data for health facilities across the country. As stated earlier, in 2013, while carrying out the national service provision assessment survey, Ministry of Health in collaboration with ICF International captured GPS data for public health facilities (from central hospitals down to health posts) and some private health facilities in cities. The service provision assessment survey took at large-scale a detailed look at the status (especially availability and quality of services) of health facilities in Malawi and it was conducted within eight months [22]. This GPS data collection was one of activities in the service provision

assessment survey, and health officers, such as medical assistants and nurses from health centres, were trained on how to record GPS data.

Then in 2015 and 2016, UNICEF Malawi captured GPS data for public health facilities including village and outreach clinics with the aim of generating the evidence for future planning exercises, for example, using the GPS data to conduct gap analysis for revealing the population living in deprivation. This exercise took almost two years and was not integrated with any other project or program. The team composed of UNICEF (as funder, coordinator and quality controller), Ministry of Health providing the health technical capacity, and GIS officers from the department of Lands.

4.3. GIS User Training

All GIS trainings, as listed in Table 2, involved mainly HMIS officers from district health offices and central hospitals and M&E officers from zonal health offices. Since GIS application was not yet introduced, ArcGIS and ArcView were used in the trainings except the training in 2017 that included DHIS2 GIS. In 2009, the user training was on DHIS2 (for three days) and GIS (for two days) in which most trainees complained on the lack of hands-on sessions because two days was not enough for GIS beginners. Since that training was for building capacity in GIS particularly in GPS data capturing, processing and analysis, the participants needed enough time to learn various concepts both theoretically and practically. "In that time, GIS was a new phenomenon to us and we needed adequate time to acquire what was necessary" – one participant emphasised. It has been observed that the following trainings in 2010 and 2013 were conducted only on GIS and for 5 days each. Then, during the deployment of DHIS2 GIS, some participants suggested to integrate the GIS training with that of DHIS2. This was experienced in the user training in 2017 as the part of the DHIS2 GIS rollout.

4.4. DHIS2 GIS Deployment

GIS in DHIS2 (referred to as DHIS2 GIS) is one of the tools used to disseminate and present data as maps. This GIS module is bundled in DHIS2, which allows the integration of health data collected in DHIS2 with geodata stored in the same database [23]. Hence, the setup of DHIS2 GIS is generally a matter of populating coordinates of the organisation units, for example, health facilities and districts, into the database. Immediately, the coordinates are populated, maps will be available in the GIS module of DHIS2. However, the coordinates need to be acquired and preprocessed before being uploaded into DHIS2 GIS.

As illustrated in Figure 2, the deployment of DHIS2 GIS was done as part of the DHIS2 'reconfiguration' project to rebuild the DHIS2 towards the integrated national HMIS by restructuring the DHIS2 database for easy integration with other health information systems. This was done from March 2016 to May 2017. The GIS setup was done by the same team, which was reconfiguring DHIS2 with the facilitation of the author. One day training was conducted to equip the team with basic knowledge of DHIS2 GIS setup and use, since it was the first time for the team to carry out such exercise and members had inadequate GIS knowledge.

Table 2. GIS Implementing Activities in Malawi's HMIS

2003	2005	2009 & 2010	2011	2013	2015	2016	2017
HIS Policy- Ministry of Health Mapping health facility and district catchment areas and generating corresponding static maps	Purchasing GPS for health districts and a plotter for the national level	Training- Ministry of Health	Updating static maps of 2003	Training - Ministry of Health Strategic Plan- Ministry of Health Program document- ICF International Mapping health facilities– ICF International & Ministry of Health	Revised HIS Policy– Ministry of Health Mapping village & outreach clinics (Phase 1)– UNICEF	Mapping village & outreach clinics (Phase 2)– UNICEF Deploying DHIS2 GIS - Ministry of Health	Roll out of DHIS2 GIS– Ministry of Health Training- Ministry of Health

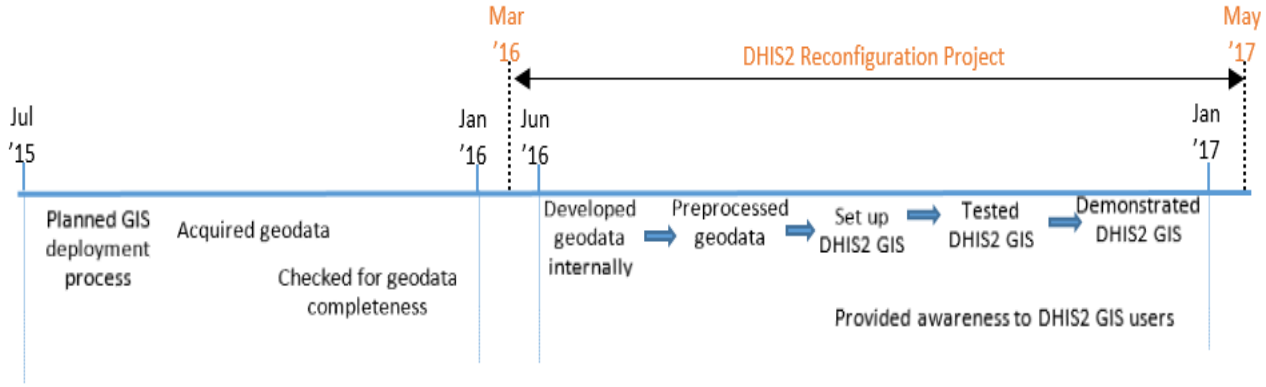

Figure 2. DHIS2 Reconfiguration Project and DHIS2 GIS Deployment

5. Analysis and Discussions

As an ongoing process, the GIS implementation involves decisions that are made on what resources to use and how and when to carry out activities based on various factors. As listed in Table 2, various activities have been carried out in the GIS implementation as part of the program to strengthen HMIS in Malawi, and this started as early as 1999. In this context, GIS is embedded in HMIS. With reference to the model in Figure 1, it can be said that several implementing activities in strengthening HMIS have been carried out, which include GIS implementation activities. However, the findings indicate that there have been some projects within the HMIS strengthening program in which GIS implementation activities were embedded. These projects were specifically related to geodata, technology, and knowledge building.

From this perspective, the paper has identified three domains in which the integrative approach of GIS implementation can be perceived – geodata, technology, and expertise. These domains overlap and are interdependent. Each domain may have unique problems, which may be addressed through the integrative approach. It has been observed that there are some projects or programs that are specifically related to geodata (e.g. GPS data collection), technology (e.g. DHIS2 GIS deployment) or knowledge building (e.g. user training).

In the geodata domain, the key activity that may require the integrative approach is the geodata collection, particularly for health facilities. For example, in 2013, the GPS data collection was embedded in the service provision assessment survey [22]. This survey was a funded project going through all stages as in Figure 1 and one of the implementing activities was the physical visits to health facilities whose coordinates were recorded.

In the technology domain, GIS involves hardware and software. Each category can have its own unique problems to be addressed in the GIS implementation and the integrative approach can also be applied. For instance, DHIS2 GIS was deployed as part of the DHIS2 reconfiguration project (see Figure 2). In some cases, GIS hardware can be acquired through certain projects; for example, in 2013, ICF International donated GPS to the ministry as the part of the SPA survey.

Since GIS is of limited value without people who manage and use it to solve real world problems [8], Ministry of Health has put effort to enhance skills and knowledge of HMIS officers who are custodians of data and technologies at the district level through various trainings as shown in Table 2. Some trainings on GIS were linked with those of DHIS2.

As stated earlier, geodata, hardware, software and expertise are the fundamental elements of GIS [6, 7], which are related. To address a problem in one domain, it is needed to address a particular problem in another domain. For instance, to acquire required geodata, the implementing organisation needs necessary technology and expertise as it happened in the GPS data collection in 2013 in which ICF International bought the GPS and trained the health personnel. Similarly, to successfully deploy DHIS2 GIS, the ministry needed to acquire geodata and train DHIS2 team and HMIS officers.

Another observation is that the link between the GIS implementation activities and those of other programs and projects can be in three different ways. GIS implementation activities can fully be linked, or partially linked, or not be linked at all, with implementing activities of other programs or projects (see Figure 3). For instance, the GPS data collection in 2013 was fully embedded in the survey; that is, its all activities, such as preparations, training, GPS data capturing, were done as part of the survey. The DHIS2 GIS deployment was partially embedded in the DHIS2 reconfiguration project in the sense that some activities of the GIS deployment were not part of the DHIS2 reconfiguration as shown in Figure 2. An example of *not linked* option is the geodata collection by UNICEF and some GIS user trainings in 2010 and 2013.

Thus, the paper suggests that it is important to consider the identified domains and options for integration when deciding on the integrative approach of GIS implementation. Compatibility of activities to be linked can determine whether or not to link GIS implementation activities with those of other programs or projects. In this context, *compatibility* is perceived as a condition in which two or more activities from different programs or projects are being executed together without critical problems or conflicts. This can be achieved if there are commonalities between activities to be linked. Coley Consulting [24] points out that a project can be considered to have five key characteristics that have to be managed – scope, resource, time, quality, and risk. From this perspective, this case study has identified *shared scope*, *shared time* and *shared resources* as such commonalities. This study perceives the scope as what to be covered in a project; the resource as what can be used to meet the scope; and the time as when to undertake different tasks [24]. If at least one of these is not achieved, there exists either a *partially linked* or *not linked* option. For example, see Table 3.

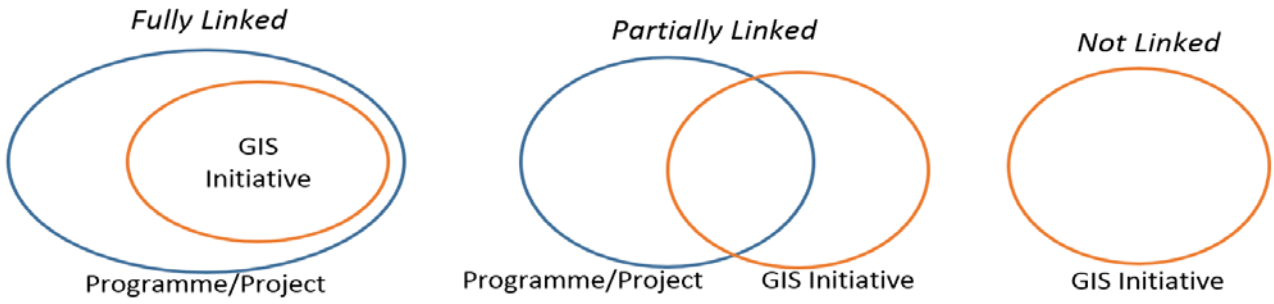

Figure 3. Three Options for Integration

Table 3. The compatibility of GIS initiatives and implementing activities of other programs or projects

GIS initiative	Option of integration	Shared scope	Shared time	Shared resource
GPS data collection in 2013	Fully Linked	Service provision assessment (SPA) survey of public health facilities including recording GPS data for those facilities	Training on SPA included that of GPS and GPS data was recorded during the physical visits to health facilities	Same budget and same health personnel recorded both the status of health facilities and GPS data
User training in 2009	Partially Linked	User training on DHIS2 and GIS	Within the same 5 days of the training	Same budget, same participants (HMIS and M&E officers), but different facilitators and separate platforms (DHIS2 and ArcGIS)
User training in 2017	Fully Linked	User training on DHIS2 and GIS	Within the same 5 days of the training	Same budget, same participants (HMIS and M&E officers), same facilitators, same platform (DHIS2 GIS)
DHIS2 GIS deployment	Partially Linked	Reconfiguration of DHIS2 including set up of GIS	With the same time except planning and geodata acquisition which were done before the DHIS2 reconfiguration;	Same platform (DHIS2), same people reconfigured DHIS2 and set up GIS

In the *fully linked* option, all three commonalities should be achieved and there is no critical conflicts between activities. Taking examples of the GPS data collection in 2013 and user training in 2017, the activities were within the same scope and time and shared the same resources. While in the *partially linked* option, such as in user training in 2009 and DHIS2 GIS deployment, the concerns were on resources (different platforms - DHIS2 and ArcGIS) and time respectively.

On one hand, one major opportunity of the integrative approach of GIS implementation is the utilisation of time and resources such as people and finances. It has been observed that when GIS implementation activities are carried out together with those of other programs or projects, there is sharing of resources (see Table 3), which is in line with the understanding of Ramasubramanian [4]. This can result in reducing costs and time. For example, in 2013, due to the shared time and resources it was possible to record GPS data for 977 public health facilities within eight months [22]. This is taken as an achievement because data collection in GIS is the most time-consuming and expensive, yet important, task [8]. Even during the reconfiguration of DHIS2, the set up of GIS was done within one week because GIS is inbuilt in DHIS2; that is, the deployment of DHIS2 takes care of its GIS module. The other time for DHIS2 GIS deployment was for geodata preparations, user awareness, testing and demonstrations of the system.

On the other hand, the focus or priority on activities, allocation and use of required resources can be a challenge. It is important to make right decisions in order to avoid ignoring important issues as far as the GIS implementation is concerned. For the successful execution of activities, resources need to be evaluated, manipulated, and deployed appropriately within the context of the implementing organisation [25]. GIS implementation requires well-trained and skilled personnel to manage its activities. However, it has been observed that in the geodata collection in 2013, people involved were the health personnel with little knowledge of GIS; they were just trained in GPS use during the service provision assessment training. Some studies have shown that declining prices and improving accuracy of GPS have made even people, who have little skills and knowledge of GIS, being able to collect geodata by themselves.

Although Ministry of Health has invested in HMIS officers at the district level in GIS knowledge through training, the officers were not involved in the geodata collection and DHIS2 GIS deployment. Since HMIS officers are expected to provide all necessary GIS support to users in their respective district health offices, they need a conducive environment to practice what they have learnt so that they can continuously improve their knowledge and skills through learning-by-doing [26]. Success in the operational management of GIS requires customer support, effective operations, and data management among others [8]. Therefore, HMIS officers need the development of skills and knowledge for easy management of GIS in their districts.

It has been observed that the reason for not involving HMIS officers in most GIS implementation activities is threefold. First, the nature of work may influence the decision, for example, "… in the service provision assessment survey, the core work was to assess health facilities and not necessarily recording GPS data … we felt that HMIS officers had no much work to do … medical assistants and nurses managed to collect GPS data after being trained …" – one participant emphasised. Second, collaborating organisations have funded and facilitated most of these GIS initiatives due to lack of capacity in Ministry of Health, which resulted in the ministry having little control on the allocation and use of resources such as HMIS officers. The funder and facilitator made most decisions. Third, GIS practical experience is also a factor to determine 'who should do what' in GIS implementation activities. By the time of collecting geodata and deploying DHIS2 GIS, although HMIS officers were trained in GIS, they had no adequate experiences to do the work. Thus, the implementing agency decided to look for GIS expertise elsewhere.

6. Conclusion

The paper discusses how the integrative framework has been applied in the GIS implementation for health management in Malawi and lessons learnt from such application. It emphasises that in the GIS implementation, there are three main domains – geodata, technology, and expertise, having some problems, which may be addressed through the integrative approach. Another observation is that, where the integration is possible, GIS initiatives could be either fully or partially linked with implementing activities of other programs or projects. This is possible

because of the compatibility between activities from different programs to be integrated in terms of shared scope, time, and resources.

The major opportunity of the integrative approach is the sharing of resources such as time, cost, and people. However, the main challenge is the lack of control on allocation and use of those resources, particularly people and their knowledge, because most implementing activities of programs or projects with which GIS initiatives are linked are funded and managed by collaborating organisations. This may negatively influence the local capacity building.

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