



GIS Needs Assessment Report for the Health Sector in Eswatini

Final Report
November 2023

unicef 
for every child

ABBREVIATIONS

AIDS - Acquired Immune Deficiency Syndrome
ART - Antiretroviral therapy
BCG - Bacillus Calmette-Guérin
CMIS - Client Management Information System
COVAX - COVID-19 Vaccines Global Access
CRVS - Civil registration and vital statistics
CSO - Central Statistics Office
DWA - Department of Water Affairs
EA - Enumeration Area
EDCU - Epidemiology Disease and Control Unit
ENTC - Eswatini National Trust Commission
EPI - Expanded Programme on Immunization
EPR - Emergency Preparedness and Response
EWADE - Eswatini Water and Agricultural Development Enterprise
EWSC - Eswatini Water Service Corporation
GAVI - Global Alliance for Vaccines and Immunisation
GHFD - Geolocated Health Facility Data
GIS - Geographic Information System
HMIS - Health Management Information System
IA2030 - Immunisation Agenda 2030
LMICs - Low- and Middle-Income Countries
LMIS - Logistics Management Information System
MoA - Ministry of Agriculture
MOH - Ministry of Health
NDVI - Normalized Difference Vegetation Index
NERCHA - National Emergency Response Council on HIV and AIDS
NSDI - National Spatial Data Infrastructure
NTCP - National Tuberculosis Control Program
NTDs - Neglected Tropical Diseases
OGC - Open Geospatial Consortium
PCT - Podoconiosis Control and Treatment
PINs - Personal Identification Numbers

RHM - Rural Health Motivators

RHMTs - Regional Health Management Teams

SARA - Service Availability and Readiness Assessment

SDGs - Sustainable Development Goals

SDI - Spatial Data Infrastructure

SID - Strategic Information Department

STIs - Sexually transmitted infections

TB - Tuberculosis

UNESWA - University of Eswatini

UNICEF - United Nations Children's Fund

WASH - Water, sanitation and hygiene

WHO - World Health Organization

WUENIC - WHO/UNICEF Estimates of National Immunization Coverage

TABLE OF CONTENTS

Abbreviations	i
List of Figures	vi
List of Tables	vii
Acknowledgements.....	viii
Executive Summary	x
CHAPTER 1: Introduction	1
1.1 Background.....	1
1.2 Purpose of the Report.....	3
1.3 Scope and Objectives	3
1.4 Methodological approach	4
1.5 Background information on Eswatini's GIS Landscape.....	6
1.6 Opportunities for using GIS in Eswatini's Health sector	10
CHAPTER 2: Review of Data Sources in Eswatini	11
2.1 Overview of Available Data Sources	11
2.1.1 Health Facility Data	12
2.1.2 Demographic Data	13
2.1.3 Disease Surveillance Data	13
2.1.4 Environmental Data	13
2.1.5 Administrative Data	14
2.2 Types of Data.....	14
2.2.1 Spatial Data.....	16
2.2.2 Non-spatial Data	16
2.3 Data Collection Approaches	18
2.3.1 Health Facility Data	18
2.3.2 Population (Demographic) Data.....	18
2.3.3 Disease Surveillance Data	19
2.3.4 Environmental Data	19
2.3.5 Administrative Data	19
2.4 Data Quality and Reliability	20
2.4.1 Health Facility Data	20
2.4.2 Population Data	20
2.4.3 Disease Surveillance Data	20
2.4.4 Environmental Data	20
2.4.5 Administrative Data	21
2.5 Challenges and Limitations in Data Availability.....	21
2.5.1 Data Needs	21
2.5.2 Data Sharing Barriers	29

2.5.3	Data Privacy Concerns	30
2.5.4	Technical Constraints	32
CHAPTER 3:	Stakeholder Mapping	34
3.1	Identification of Key Stakeholders in GIS-Related Activities	34
3.2	Roles and Responsibilities of Each Stakeholder	35
3.2.1	Ministry of Health:	36
3.2.2	Implementing Partners:	36
3.2.3	Healthcare Facilities:	36
3.2.4	Academic and Research Institutions:	37
3.3	Collaboration and Coordination among Stakeholders	38
3.4	Opportunities for Data Sharing and Partnerships	39
3.5	Recommendations for coordination mechanism	40
CHAPTER 4:	Mapping of Existing GIS Systems and Tools	42
4.1	Overview of Existing GIS Systems in Eswatini	42
4.2	Description of GIS Software and Tools Being Used	44
4.2.1	Proprietary GIS Software:	44
4.2.2	Open-Source GIS Software:	46
4.3	Spatial Data Infrastructure and Platforms	49
4.3.1	Assessment of Data Storage:	50
4.3.2	Assessment of Data Sharing Mechanisms:	50
4.3.3	Assessment of Interoperability:	50
4.3.4	Recommendations to Improve Spatial Data Infrastructure:	51
4.4	Integration of GIS with Other Information Systems	52
4.4.1	Benefits Derived from Integration:	52
4.4.2	Recommendations to Enhance Integration:	53
4.5	Evaluation of System Capabilities, Strengths, and Limitations	54
4.5.1	Capabilities:	54
4.5.2	Strengths:	54
4.5.3	Limitations:	55
4.5.4	Areas for Improvement and Future Enhancements:	55
4.6	Summary of challenges	56
CHAPTER 5:	Rapid Assessment of Key Staff Capacity	58
5.1	Evaluation of Data Literacy and Digital Literacy Skills of Key Staff	58
5.1.1	Proficiency in GIS Software	58
5.1.2	Data Analysis Skills	60
5.1.3	Interpretation of Geospatial Data:	60
5.2	Identification of GIS Training Programs and Initiatives	61
5.3	Gaps in Capacity and Training Needs	66
5.3.1	GIS skills gaps for Reaching Zero-Dose Communities	69

5.3.2	Training priorities for Reaching Zero-Dose Communities.....	70
5.4	Recommendations for Capacity Building and Skill Development	71
5.5	Recommended research areas	75
5.5.1	Expanded Programme on Immunization (EPI):	75
5.5.2	Malaria Control:	75
5.5.3	HIV/AIDS Prevention and Treatment:.....	76
5.5.4	Tuberculosis (TB) Control:	76
5.5.5	Emergency Preparedness and Response (EPR):.....	76
5.5.6	Targeted research for reaching zero-doe communities.....	77
CHAPTER 6:	Conclusion and Recommendations	80
6.1	Summary of Findings from the GIS Landscape Analysis	80
6.2	Key Challenges and Opportunities in Eswatini's GIS Domain	80
6.2.1	Challenges	81
6.2.2	Opportunities	81
6.3	Recommendations for Improving GIS Data Availability, Stakeholder Engagement, System Infrastructure, and Staff Capacity	82
6.3.1	Key focus areas.....	82
6.3.2	Priority data investments.....	83
6.3.3	Key research topics	83
Bibliography		85
Appendices		86
Appendix 1: List of institutions and the various data types and sources used and produced.....		87
Appendix 2: List of respondents and their respective departments or organisations		92
Appendix 3: GIS Use cases for the Malaria and TB programs		95
Appendix 4: Data collection tools used in the GIS needs analysis.....		99
Section 1: Key informant questionnaire – MOH departments.....		99
Section 2: GIS professionals/users questionnaire		98
Section 3: Hardware and software checklist.....		101
Section 4: Key informant questionnaire - Institutions		104

LIST OF FIGURES

Figure 1: The user needs assessment process to be followed in the strategy development.	5
Figure 2: Stages of GIS implementation among various Ministry of Health departments/ programmes.	8
Figure 3: Spatial data needs by various Ministry of Health departments/programmes and stakeholders.	27
Figure 4: GIS adoption among the Ministry of Health departments/programmes.	42
Figure 5: Ministry of Health departments/programmes areas of GIS use.	43
Figure 6: Competency levels in the use of various GIS tools within Eswatini's health sector.	59
Figure 7: Current data skills among health sector GIS professionals.	60
Figure 8: Highest qualifications of Eswatini's health sector GIS professionals.	62
Figure 9: Current training received by various departments/programmes within the Ministry of Health.	64

LIST OF TABLES

Table 1: List of interviewed departments and their level of GIS implementation.	7
Table 2: List of GIS-related datasets listed by the stakeholders as being used on a day-to-day basis.	12
Table 3: Different types of data and their use by Eswatini's health sector GIS professionals within the health sector.	15
Table 4: List of health sector stakeholders and their potential role in GIS implementation.	34
Table 5: Examples of recommended training initiatives by health programme.	72

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EXECUTIVE SUMMARY

Pursuant to the goals of improving healthcare planning and service delivery in Eswatini, a Geographic Information System (GIS) landscape assessment was conducted for the health sector. GIS is a powerful tool that can enhance spatial planning, resource allocation, and decision-making processes in healthcare. The main objective of this assessment was to evaluate the current state of GIS implementation and utilization in the health sector. By identifying existing GIS resources, assessing their functionality, and understanding the needs of stakeholders, this assessment aims to provide recommendations for enhancing the adoption and effective use of GIS in the health sector.

The assessment covered a comprehensive review of existing GIS infrastructure, data availability, software applications, and human resources in the health sector. A combination of quantitative and qualitative research methods, including surveys, interviews, and data analysis, was employed to gather information from key stakeholders. The assessment focused on both governmental and non-governmental institutions responsible for healthcare planning and healthcare facilities. Key stakeholders, including healthcare professionals, administrators, and data managers, were interviewed to gather insights into their current use of GIS and their specific needs and challenges.

This report provides a rapid assessment of Eswatini's geospatial data and GIS capabilities within the health sector. It identifies priority areas where improved use of geographic information systems (GIS) can enhance data-driven decision making and health outcomes. The assessment answers key questions about geodata availability, GIS hardware gaps, human resource capacities, and recommendations for maximizing the impact of GIS technology.

The goal is to inform strategic investments and capacity building to fully leverage GIS to advance Eswatini's immunization program and child health initiatives. Effective use of geospatial data and analysis can play a critical role in healthcare planning, implementation and monitoring. This report provides actionable insights for stakeholders across Eswatini's health landscape.

Key Findings

- Disease surveillance and outbreak response identified as top priority area for better geodata use
- Shortage of trained GIS analysts and lack of coordination between departments hindering progress
- Use of both proprietary and open-source GIS software
- Existing geospatial datasets fragmented across various ministries and partners
- Stronger data sharing policies and governance needed to improve access
- Targeted GIS training for health workers coupled with recruitment recommended
- Centralized open data platform would enhance accessibility and transparency

- Prioritize digitizing health facility locations, catchment areas, and population demographics
- GIS Technical Working Group should comprise diverse stakeholders from MoH, CSO, Surveyor-General's Office, Ministry of ICT (Royal Science and Technology Park), Development partners, NGOs, and academia.

Where can better decisions be made using geodata?

- Disease surveillance and outbreak response
- Health infrastructure planning and accessibility analysis
- Immunization coverage and childhood health initiatives
- Community health worker routing and household profiling
- Healthcare supply chain and medicine distribution

How can UNICEF make the case for GIS support for child health?

- Highlight success of GIS projects in modeling disease risk factors for children
- Demonstrate potential to optimize immunization routes based on geospatial analysis
- Show value of household mapping to identify gaps in reaching vulnerable children
- Promote transparency and accountability through interactive child health dashboards
- Position GIS as essential tool for realizing UNICEF's mandate to reach every child

Recommended geospatial data investments:

- High resolution population demographics with child health statistics
- Digitized health facility locations with services offered /capacity data
- Transport network and infrastructure maps
- Granular data on immunization coverage and childhood disease burdens
- Geocoded community health worker assignments and household data

Priority sectors for further investigation:

- Water, sanitation and hygiene (WASH) infrastructure mapping
- Health impacts of environmental factors like air/water pollution
- Nutrition programs and food security influencing child health
- Early childhood development resources and pre-primary education access

Available geospatial datasets and collection methods:

- Fragmented across Ministry of health departments/programmes, government ministries, and external partners
- Health facility data maintained by Ministry of Health in HMIS/DHIS2
- Population demographics from national census by Central Statistics Office

GIS human resource capacity and recommendations:

- Severe shortage of GIS specialists in public health roles
- Limited knowledge of GIS applications beyond basic mapping
- Strong training and recruitment needed to build in-house expertise
- Develop partnerships with academic institutions for geospatial analytics
- Increase access to spatial data and user-friendly GIS platforms
- Change management to promote adoption of geospatial approaches
- Include GIS data and maps into routine data reporting and decision making

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Geographic Information Systems (GIS) have become an indispensable tool for analyzing and understanding spatial data across many sectors globally. In the health sector, GIS has been instrumental in disease surveillance, health access mapping, health equity analysis, and responding to disease outbreaks. This report focuses on assessing the current landscape for GIS utilization in Eswatini's health sector. It aims to develop a GIS strategy to enhance the use of spatial data and analysis to improve health outcomes, especially for remote and underserved communities.

Currently, technologies such as the use of geospatial data and analysis are being used at varying scales across low- and middle-income countries (LMICs). GIS comprises a suite of computer programs that can store, visualize, and analyse geospatial data and model spatial processes to uncover operations and situations on the ground. The use of GIS-based approaches has demonstrated the potential for improving vaccination coverage. Evidence suggests that low vaccination areas tend to cluster together, and geospatial tools can help detect these clusters and develop targeted interventions. Studies from some parts of the world have shown that use of GIS can help with micro-planning and guide optimal location of health facilities for immunization, thereby improving vaccine coverage. Apart from helping in tracking the spatial and temporal trends in immunization coverage, geospatial analyses can also provide important insights on patterns of immunization service uptake in terms of the various modalities of immunization services. For instance, geospatial analysis can be used to compare the various immunization service delivery mechanisms (fixed and outreach services and supplementary immunization activities) to help guide geographical prioritization of the various service delivery mechanisms. Similarly, variations in vaccination coverage through both routine immunization services and campaigns can be analysed to reveal patterns of coverage by each type of service delivery modality. Furthermore, geospatial analysis has the potential to provide insights into individual children's geographic patterns of immunization service delivery access over the course of their immunization journey for more granular tracking.

Eswatini faces several health challenges that GIS could help address more effectively. The inequalities, unemployment, and poverty levels higher among the rural population, unfortunately, also tends to affect health service delivery. One of such important health services is immunization, a core primary health care intervention that is critical to assuring the health of children and communities to reach universal health coverage. Eswatini has had relatively good coverage for routine immunization through the last 10 years until the COVID19 pandemic negatively impacted the coverage of most antigens, apart from BCG with BCG to measles dropout rate at 23% (January to December 2022 – HMIS data). According to the WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) 2021 data, the country has 14% zero dose children per birth cohort and 23%

un/under immunized children per birth cohort. If no measures are taken, Eswatini will take years (up to 2028) to recover back to pre-pandemic (2019) coverage levels. It is, therefore, critical that the country closely monitors the spatial and temporal trends in immunization coverage particularly the target of 90% fully immunized children coverage and equity.

Eswatini has an estimated population of 1,184,407 in 2023 according to the 2017 – 2038 Population Projections. Of this population, 42% are children below the age of 18 and 82% of children reside in rural areas. The development landscape of Eswatini is skewed, with inequalities, unemployment, and poverty levels higher among the rural population. The country has the highest HIV prevalence in the world, with 27.3% of adults infected in 2019 (UNAIDS, 2020). Tuberculosis, malaria, neglected tropical diseases, and malnutrition persist as public health concerns. Access to healthcare is inequitable, with remote rural communities lacking proximity to health facilities and workers. GIS provides spatial analysis capabilities to identify underserved areas, optimize resource allocation, target interventions, and monitor progress.

The Global Alliance for Vaccines and Immunisation (Gavi)'s 5.0 vision of leaving no one behind with immunisation by 2030 is inspired by the Sustainable Development Goals (SDGs) and aligned to Immunisation Agenda 2030 (IA2030). Equity is the organising principle of the Gavi 2021-25 (Gavi 5.0) strategy and underpins the broader “leave no one behind” ambition of the global development agenda[1]. The Immunisation Agenda (IA 2030) places priority and focus on reaching the most marginalised and vulnerable populations to ensure that all children receive all vaccines. Routine immunisation programmes, especially in low- and middle-income countries, strengthen access to and delivery of primary health care (PHC) as a pathway towards achieving Universal Health Coverage (UHC). Immunisation also contributes to global health security and achieving 14 of 17 SDGs.

GIS can help in achieving the GAVI 5.0 strategy for vaccinations by identifying the zero-dose communities and missed communities that are not receiving vaccines and developing a GIS strategy that addresses these reasons. GIS can also help in delivering immunization to zero-dose and missed communities by providing location-based data on vaccine coverage and identifying areas where there is a high prevalence of zero-dose children.

This report comes at an opportune time when GIS utilization in the health sector globally and in the region is accelerating. Neighbouring countries like South Africa, Mozambique, and Malawi are expanding GIS use for disease surveillance, health access mapping, and service delivery planning. Regional bodies like the Africa Centres for Disease Control and Prevention (Africa CDC) actively promote GIS applications for public health. As Eswatini updates its national health policies and strategies, incorporating GIS will enable an evidence-based approach leveraging spatial data.

1.2 PURPOSE OF THE REPORT

The purpose of this report is to present a comprehensive GIS landscape (or needs) assessment for the health sector in Eswatini. The report presents a landscape analysis of health information systems and data tools for identifying, reaching, and monitoring zero-dose and under-immunized children in Eswatini. Despite the efforts to improve routine immunization coverage, there are still challenges in ensuring that all children receive timely and complete immunizations. The purpose of this analysis is to provide an overview of the existing information systems and tools, identify gaps, and make recommendations to strengthen the health information system for routine immunization in Eswatini.

The report specifically aims to identify the existing GIS landscape, data sources, stakeholder engagement, system infrastructure, and staff capacity. The assessment will provide valuable insights to guide future planning and decision-making in leveraging GIS for improved health services.

1.3 SCOPE AND OBJECTIVES

The scope of this assessment includes an overview of available data sources, stakeholder mapping, mapping of existing GIS systems and tools, rapid assessment of key staff capacity, and recommendations for improvement. The objectives are to identify gaps and challenges, evaluate system capabilities, assess stakeholder engagement, and propose recommendations for enhancing GIS capacity in the health sector.

The landscape analysis attempts to answer the following questions:

- Where can better decisions be made using geodata?
- How should UNICEF Eswatini make the case for additional support to ensure no child is left behind using GIS?
- What future data investments should be prioritised?
- Which sectors or topics deserve additional investigation?
- Which geospatial data is already available and how is it being collected, maintained, or updated?
- Does Eswatini have the human resource capacity to fully utilize GIS systems and what capacity building is required?
- Which stakeholders should serve in the GIS Technical Working Group (TWG) for use of geospatial approaches for health programming?

This assessment will help Eswatini understand where GIS can be used most effectively to enhance data use for planning, implementation, and monitoring in the immunization programme. It will also inform what forms of capacity building are required to reach the desired objectives.

In addition, the analysis describes the information systems and data tools used in Eswatini's health sector with special attention on identifying, reaching, and monitoring zero-dose and under-immunized children. The findings of this analysis can be used to inform decision-making, prioritize investments, and guide the implementation of interventions to improve health services including routine immunization coverage in Eswatini.

1.4 METHODOLOGICAL APPROACH

Developing a GIS strategy for health programmes involves several steps. As per the expected outputs of the project, it is expected that the GIS Development process will follow the usual GIS Development Cycle or System Development Cycle and the workplan in Figure 1. It is not the order or precise structure of the tasks as indicated in the figure but rather that, in one way or another, that all get completed.

The landscape analysis included a rapid staff capacities and system needs assessment which was based on Tasks 1 and 2 and resulted in a report that answered the following questions:

- Where can better decisions be made using spatial data?
- How should UNICEF Eswatini make the case for additional support to ensure no child is left behind using GIS?
- What future data investments should be prioritised?
- Which sectors or topics deserve additional investigation?
- Which geospatial data is already available and how is it being collected, maintained, or updated?
- Does Eswatini's health sector have the human resource capacity to fully utilize GIS systems and what capacity building is required?
- Which stakeholders should serve in the GIS Technical Working Group (TWG) for use of geospatial approaches for health programming?

The assessment focused on the following tasks:

Task One: IT Infrastructure Assessment

- Assess current and future needs
- Include review of existing hardware/software
- Include identification of hardware, software, communications, and network requirements to support a standard GIS

Task Two: GIS Environment

- Inventory map, record, & data sources
- Inventory data being collected

Conducting a GIS user needs assessment is an important step in ensuring that the GIS meets the specific requirements of its users. By following this methodology, the study gathered valuable information on what data is needed, how it will be used, and what features are required in the GIS. This information will then be used to develop a GIS that meets the needs of its users and provides valuable insights into geographic data.

The assessment was conducted through a combination of surveys, interviews, and focus group discussions with key stakeholders in the country's immunization programme. The survey was distributed to key staff members within the relevant organizations and government departments (see Appendix 2), while interviews and focus group discussions were held with selected programme managers and officers, including GIS personnel. The user needs assessment process followed key steps as shows below:

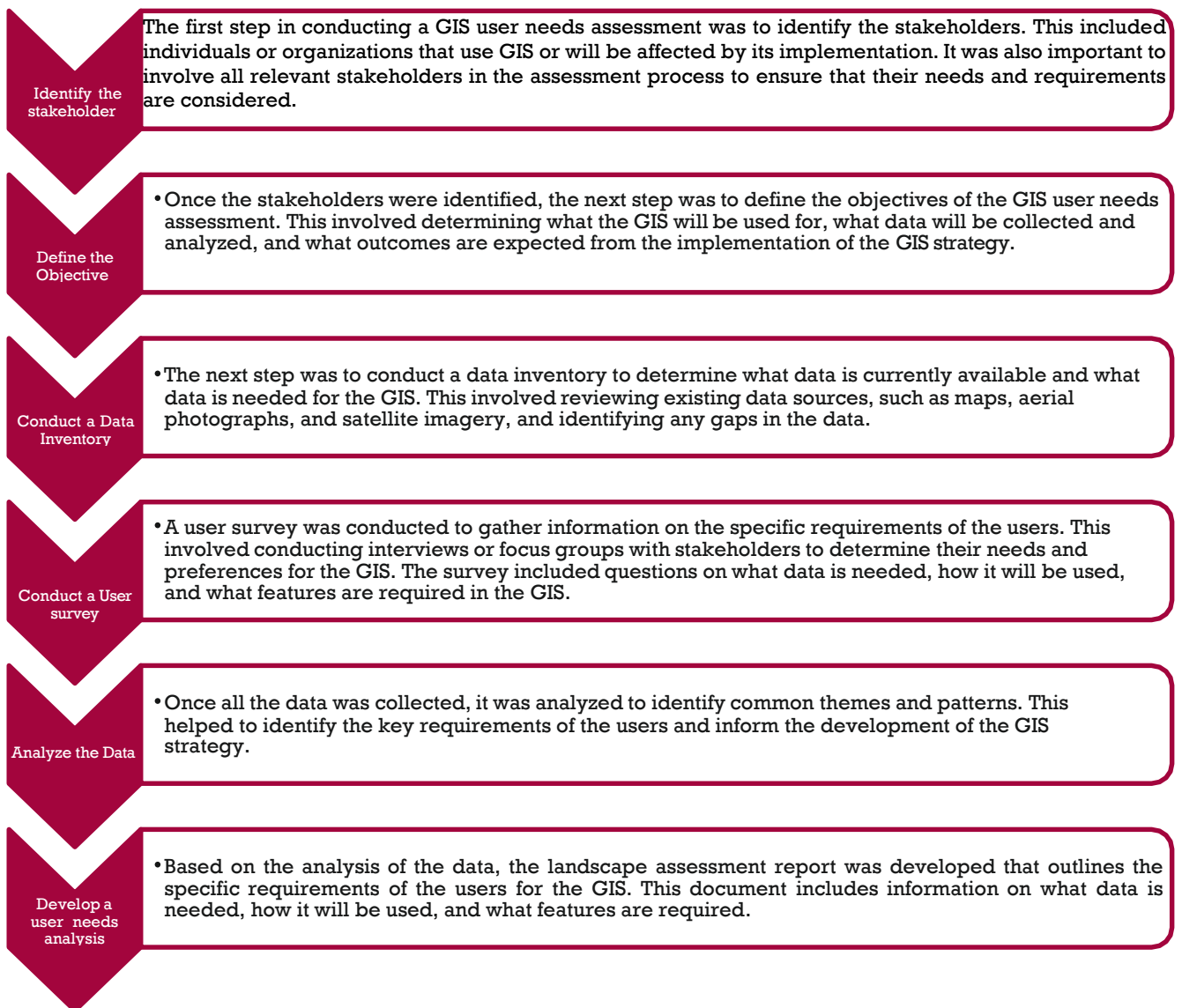


Figure 1: The user needs assessment process to be followed in the strategy development.

In the assessment process, the interviews were undertaken at three levels;

a) Key informant level – wherein a discussion was held between the consultants and individuals consisting of senior staff, mostly the department heads, heads of various units, and other staff in charge of specific programmes. This was tailored to specifically target the various departments and programs of the ministry of health, as well as fine-tuned to collect data from other organizations that collaborate with the ministry. The aim of this level of analysis was to get information on any existing GIS setups, and how their presence/absence was influencing planning and development related activities. The interviews were guided by a key informant questionnaire, which is appended to this report (Appendix 4).

b) Professional level – which consisted of individual interviews with GIS users within the visited departments/units/institutions. GIS users in the context of the survey consisted of staff hired to do GIS work, and staff who had basic or advanced knowledge on GIS regardless of whether or not they were using the systems for their day-to-day work. This level of assessment aimed at getting information on the prevailing human capacity, particularly on their competence in use of GIS, the challenges they face in delivery of their duties, as well as how GIS can enhance their efficiency. The respondent professionals were identified by the senior staff interviewed during the key informant discussion and filled in the questionnaire in the appendices.

c) Documenting of existing GIS hardware and software – which was undertaken by asking the GIS professionals the existing systems and filling in their technical information into checklists. A detailed software and hardware checklist was also used to collect data within the ministry departments. This was useful in gathering data on the computer network environment within the departments.

The landscape analysis focused on the key elements shown in Figure 1. The information was also collected using the instruments in the Appendix 4. The focus of the assessment was on the skills in computing and GIS as well as each organization's capacity (current situation, desired situation and identified gaps) in GIS. This formed the basis of a training needs analysis whereby skills gaps were identified. In this assessment, the objective was to identify to which extent GIS is currently applied in the health sector, the possible application areas, and to identify gaps in GIS utilization which needs to be addressed. This assessment also gives important input to the design of a training programme in GIS.

1.5 BACKGROUND INFORMATION ON ESWATINI'S GIS LANDSCAPE

This section provides a brief overview of the current state of GIS implementation in Eswatini, highlighting key initiatives, policies, and existing infrastructure relevant to the health sector. It provides context for understanding the current GIS landscape and its implications for the health sector. GIS play a crucial role in the health sector by providing spatial data analysis and visualization tools that aid in decision-making, resource allocation, and planning of healthcare

services. In Eswatini, GIS implementation has been steadily advancing, with key initiatives, policies, and existing infrastructure contributing to its development and relevance in the health sector.

The stages of implementation of GIS in Eswatini's health departments/programmes, based on given responses from the survey of key informants can be summarized as follows:

- **Initial Stages of Development:** This stage refers to the early phases of GIS implementation, where the technology is being explored and initial efforts are made to introduce GIS into the health departments.
- **Few Users & Applications:** At this stage, GIS is being used by a limited number of users, and its applications within the health departments are not yet extensive.
- **Extensive Use:** This stage indicates that GIS is extensively used within the health departments, implying a higher number of users and a wide range of applications.
- **Being Considered:** This stage suggests that the implementation of GIS is under consideration, indicating an interest in adopting GIS technology within the health departments.
- **Not Present and Not Being Considered:** This stage implies that GIS is neither currently in use nor being considered for implementation within the health departments.

Based on the given responses, the tabulated mentions for each stage were as follows:

Table 1: List of interviewed departments and their level of GIS implementation.

Department/Unit/Program	Stage of GIS Implementation
Epidemiology Disease and Control Unit	Initial Stages of Development
National TB Control Program	Few Users & Applications
National Malaria Programme	Extensive Use
Central Medical Store- Data Management Unit	Being Considered
SID/M&E Unit	Being Considered
Planning Unit	Being Considered
Environmental Health Department	Initial Stages of Development
Health Promotion	Not present and not being considered
Expanded Programme on Immunization	Initial Stages of Development
Rural Health Motivators Program (RHM)	Being Considered
School Health Programme	Being Considered
MoH Quality Management Programme	Being Considered
Health Management Information Systems Unit(HMIS)	Initial Stages of Development
Eswatini Health Laboratory Services (National Laboratory)	Initial Stages of Development
Eswatini National AIDS Program, Ministry of Health	Not present and not being considered
Emergency Preparedness and Response	Being Considered

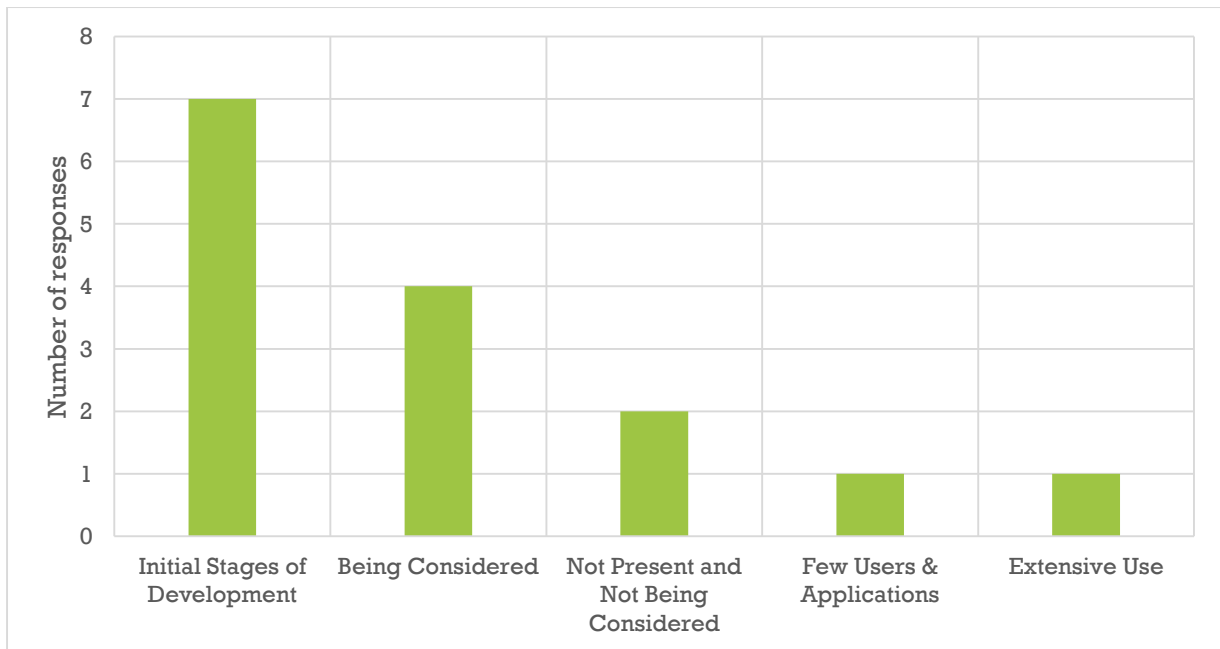


Figure 2: Stages of GIS implementation among various Ministry of Health departments/programmes.

The responses indicate a mixed stage of GIS implementation across Eswatini's health departments. While most departments are in the initial stages of development or considering the adoption of GIS, others have reached a stage of extensive use. However, there are also instances where GIS is neither present nor being considered. This suggests a varied level of progress and awareness regarding GIS implementation within the health sector in Eswatini. It highlights the need for further efforts to promote the benefits of GIS and its potential applications in improving healthcare services and decision-making.

Eswatini has recognized the importance of GIS in healthcare and has implemented several initiatives to leverage its benefits. The Ministry of Health, in collaboration with other stakeholders, has undertaken efforts to establish and strengthen GIS infrastructure within the country. These initiatives aim to improve access to spatial data, enhance data management, and support evidence-based decision-making in the health sector.

One of the key initiatives in Eswatini is the integration of GIS in disease surveillance and control programs. GIS technology enables the mapping and analysis of disease patterns, allowing public health officials to identify disease hotspots, track the spread of diseases, and plan targeted interventions. This integration has proven valuable in combating diseases such as malaria, HIV/AIDS, and tuberculosis by providing spatial insights into disease prevalence, high-risk areas, and resource allocation. Examples of use cases have been included in this report (Appendix 3).

Another important aspect of GIS implementation in Eswatini is its role in strengthening the health infrastructure. GIS is used to map healthcare facilities, including hospitals, clinics, and health

centers, along with their spatial distribution, services offered and accessibility. This information helps healthcare planners and policymakers identify gaps in service coverage and make informed decisions regarding the establishment of new facilities or the reallocation of existing resources to underserved areas.

In terms of policies, Eswatini does not have a specific policy on GIS although steps are being made towards developing a strategic framework for GIS implementation in the health sector. The Geolocated Health Facility Data initiative (GHFD) spearheaded by the WHO is one initiative which seeks to assist the Ministries of Health (MoH) to be in the position to establish, manage, update, share and use their georeferenced master list of health facilities. Elements of these lists as well other HFML-related information will be accessible as a global public good through the GHFD global database. The mission of this initiative is to strengthen the technical capacity of the Ministry of Health across levels to ensure the availability, quality accessibility and use of the HFML. Doing so increase data interoperability and reduce duplication of efforts. This initiative is also aimed at outlining guidelines, standards, and protocols for data collection, analysis, and sharing, ensuring consistency and interoperability among different health information systems. It will also emphasizes the importance of capacity building and training programs to enhance GIS skills among healthcare professionals.

Existing GIS infrastructure in Eswatini includes the limited availability of spatial data repositories, mapping tools, and dedicated GIS units within the Ministry of Health's Strategic Information Department and some of the disease control programmes (e.g. malaria). These resources support, to a limited extent, the collection, storage, and analysis of geospatial data related to health, enabling evidence-based decision-making and efficient resource allocation.

The current state of GIS implementation in Eswatini's health sector has significant implications. By harnessing spatial data and analysis capabilities, decision-makers can identify health disparities, target interventions to vulnerable populations, optimize resource allocation, and improve overall health service delivery. GIS enables the integration of various health datasets, such as disease prevalence, healthcare facilities, population demographics, and environmental factors, providing a comprehensive understanding of health-related challenges and their spatial distribution.

However, challenges remain in fully realizing the potential of GIS in the health sector. These include the need for sustained investment in GIS infrastructure, capacity building to enhance technical skills, data quality assurance, and the establishment of data-sharing mechanisms among different stakeholders.

In conclusion, GIS implementation in Eswatini's health sector has made significant strides, driven by key initiatives, policies, and existing infrastructure. By harnessing the power of spatial data analysis, Eswatini can better understand health challenges, improve resource allocation, and make informed decisions to enhance the delivery of healthcare services across the country. Continued

investment and collaboration among stakeholders are essential to further strengthen GIS implementation and maximize its potential in improving health outcomes in Eswatini.

1.6 OPPORTUNITIES FOR USING GIS IN ESWATINI'S HEALTH SECTOR

Geodata can significantly enhance decision-making processes in various sectors. In the context of Eswatini, the following areas can benefit from better utilization of geospatial data:

Health Sector: Geospatial data can support decision-making in health planning, resource allocation, and service delivery. It can help identify underserved areas, optimize healthcare facility locations, and improve disease surveillance and outbreak response through spatial mapping and analysis. Focus should be placed on strategic departments such as the Strategic Information Department (SID), Expanded Programme on Immunization (EPI), School Health Programme, Epidemiology Programme, and Emergency Preparedness and Response (EPR).

Environmental Health Planning: Geospatial data can assist in environmental health planning, including identifying areas with poor sanitation, water contamination, and environmental hazards. It can support efforts by the Environmental Health Services department to address these issues effectively.

Disease Control Programs: Geospatial data can aid in the control and prevention of diseases such as malaria, AIDS, and tuberculosis. It can help identify high-risk areas, track disease prevalence, and target interventions for improved program effectiveness. Collaboration with the National Malaria Control Program, National AIDS Program, and National TB Control Program is essential.

CHAPTER 2: REVIEW OF DATA SOURCES IN ESWATINI

2.1 OVERVIEW OF AVAILABLE DATA SOURCES

This section provides an overview of the data sources available for GIS applications in the health sector. It includes information on spatial, non-spatial, and administrative data sources, such as health facility data, population data, disease surveillance data, and environmental data.

The success of GIS in the health sector relies heavily on the availability of reliable and accurate data. In Eswatini, there are various sources of data that can be used for GIS applications, including spatial, non-spatial, and administrative data. The primary sources of data in Eswatini include the Central Statistics Office (CSO), Surveyor Generals Office, Ministry of Health (MOH), and various GIS stakeholders. These sources provide comprehensive demographic, health, and environmental data. The CSO releases annual statistical reports, surveys, and census data, which provide valuable insights into the population's health status. The MOH, on the other hand, provides data related to health services, disease prevalence, and health infrastructure. UNICEF and other UN departments provide data related to child health, education, and social protection. Other GIS stakeholders, such as NGOs and research institutions, also provide essential health-related data, while the Surveyor Generals Office is the primary source of data such as the administrative boundaries of Eswatini, etc.

These datasets are used for various purposes, including mapping outbreaks and signals related to public health threats, analyzing and mapping demographic information, tracking infectious disease cases, identifying healthcare hotspots, conducting service delivery mapping, mapping administrative divisions, analyzing environmental factors, and mapping educational institutions.

Overall, the findings from the survey demonstrate the wide range of datasets utilized by GIS professionals in Eswatini's health sector. These datasets play a vital role in informing decision-making, planning, and analysis processes, enabling effective healthcare delivery and response to public health challenges.

Table 2: List of GIS-related datasets listed by the stakeholders as being used on a day-to-day basis¹.

Category	Datasets
Administrative Boundaries	Chiefdoms, Tinkhundla, Regional Boundaries
Health Facilities	Patient Hotspots, Facilities
Demographic Data	Census, Population
Disease Data	Infectious Disease Case Data, Malaria
Service Delivery Mapping	Country Shapefile, Community Shapefile, Public Health Emergencies
Infrastructure and Transportation	Transport, Energy
Environmental Data	Ecology, Land Cover, Geomorphology, Hydrology, Weather Data, NDVI (Normalized Difference Vegetation Index)
Education	Schools, Education
Miscellaneous	Coordinates (Plotting service points), Household Enrollment, Points of Interest

These data sources provide valuable insights and support decision-making in the health sector. Below is a breakdown and brief discussions of the different types of data sources available for GIS applications in the health sector:

2.1.1 HEALTH FACILITY DATA

In Eswatini, a health facility is in the Essential Health Care Package (EHCP) defined as any healthcare facility that provides essential health services and interventions that serve the greater burden of disease within a community. Health facility data is one of the main sources of data for GIS applications in the health sector. This includes information on the location, types, and services provided by health facilities. These data are collected through routine reporting and can be accessed through the Health Management Information System (HMIS) or other data systems such as DHIS2. Health facility data is essential for mapping health services, identifying gaps in service coverage, and planning targeted interventions. However, the lists do not comprehensively include all the private facilities. This data is used in the Service Availability and Readiness Assessment (SARA), the last one of which was conducted in 2017. This assessment makes use of the facilities list,

¹ More details are provided in Appendix 1.

which stipulates facilities by type and service offered, to assess the coverage of health services in the country.

However, these lists are outdated and may need to be updated (both in terms of location information and attribute) in consideration of additional health facilities that were established during the COVID-19 pandemic. The Health Management Information System (HMIS) unit within the Strategic Information Department (SID) under the MoH has the curation mandate over the health facility lists and the lead for the development of the health facility master list (HFML) and/or health facility registry (HFR).

2.1.2 DEMOGRAPHIC DATA

Population data is critical for understanding the distribution of health needs and resources within a specific area. This data includes demographic characteristics such as age, gender, and household size. In Eswatini, population data is collected through the national census, which is conducted every ten years, as well as through demographic and health surveys. GIS-readable datasets are currently available for the 1997, 2007 and 2017 censuses conducted by the CSO. In Eswatini, the lowest censal unit is the enumeration area which is the smallest geographical unit where the census is conducted. Population data is often used to create population density maps, identify vulnerable populations, and assess health service utilization.

2.1.3 DISEASE SURVEILLANCE DATA

Disease surveillance data is collected through various systems, including the National AIDS Programme, Epidemiology Disease and Control Unit (EDCU), the National Malaria Control Program (NMCP) and the National Tuberculosis Control Program (NTCP). Additionally, data is also collected through surveys such as Multiple Indicator Cluster Survey (MICS), Global School-based Student Health Survey (GSHS), STEPwise approach to surveillance (STEPS) and the HIV Incidence Measurement Survey (EHIMS). The data collected provide information on the prevalence and incidence of diseases, as well as treatment outcomes. Disease surveillance data is crucial and used for mapping disease burden and hotspots, detecting outbreaks, and monitoring the effectiveness of interventions. Examples of use cases are provided in this report (Appendix 3).

2.1.4 ENVIRONMENTAL DATA

Environmental data, such as climate, air quality, and water quality, can also be integrated into GIS applications in the health sector. This data can provide insights into the environmental factors that contribute to disease transmission and morbidity. For example, mapping areas with high levels of air pollution can help identify populations at risk of respiratory diseases. In Eswatini, some environmental data is collected by various government agencies and research institutions such as the Eswatini Environment Authority (EEA), Eswatini National Trust Commission (ENTC), Eswatini Water Service Corporation (EWSC), Department of Water Affairs (DWA), Ministry of Agriculture

(MoA), Eswatini Water and Agricultural Development Enterprise (EWADE) and the Universities. Other datasets are open-source datasets collected by various international organizations and institutions particularly data obtained from remote sensing platforms such as satellite-derived data. However, there is a need for better integration and sharing of this data with health-related agencies in order for this data to be used. Currently, there is very limited to no use of such data within the health sector in Eswatini.

2.1.5 ADMINISTRATIVE DATA

Administrative data refers to data collected and managed by government agencies and other organizations for administrative purposes. This includes data on births, deaths, and other vital events, as well as data on health services utilization, health insurance, and health workforce. This data can be useful for mapping health indicators and identifying areas with specific health needs. The CMIS, for example, utilizes data from Ministry of Home Affairs who are the custodians of the Personal Identification Numbers (PINs) and other personal identification information. However, there are challenges in accessing and using administrative data for GIS applications, such as data quality and compatibility issues stemming from the use of different software. In addition, there is the lack of Chiefdom boundaries data in Eswatini. This is a crucial limitation considering that Chiefdoms are the key administrative (and possibly planning) units in the country.

In conclusion, there are various sources of data available for GIS applications in the health sector in Eswatini. These data sources provide valuable information for understanding the health landscape and planning interventions. However, there are still some challenges that need to be addressed to fully leverage the potential of GIS in the health sector, such as data quality, interoperability, and accessibility.

2.2 TYPES OF DATA

This subsection explores the different types of data used in GIS applications, including spatial data (geographical features, maps), non-spatial data (attribute data), and administrative data (health records, population statistics). It discusses the relevance of each data type for health sector GIS applications.

GIS applications in the health sector utilize various types of data to provide insights and support decision-making. The findings from a survey of health sector GIS professionals in Eswatini reveal interesting insights into the GIS activities and data types utilized within the sector. The survey collected information on five specific GIS activities: data analysis, map development, GIS analysis/classification, visuals (demography), and querying. The data types considered were vector data (predominantly ESRI shapefiles), raster data, Keyhole Markup Language (KML) files, maps, and tabular data.

Data analysis emerged as a prominent GIS activity, with 7 professionals indicating its use. This suggests that health sector GIS professionals in Eswatini are actively engaged in analyzing data using GIS techniques. However, no mentions were made specifically regarding the use of raster data, KML, maps, or tabular data for data analysis.

Table 3: Different types of data and their use by Eswatini's health sector GIS professionals within the health sector.

GIS Activity	Vector	Raster	KML	Maps	Tabular
Data analysis	7	0	0	0	8
Map development	16	0	0	0	0
GIS Analysis/Classification	10	2	0	0	2
Visualization	8	0	1	0	4
Querying	2	0	0	0	4

Map development, which involves designing and producing maps, was the most frequently mentioned activity, with 16 professionals indicating its importance. This finding indicates that there is a strong emphasis on creating maps within the health sector in Eswatini. However, no specific mentions were made regarding the use of raster data, KML, maps, or tabular data for map development.

GIS analysis/classification was reported by 10 professionals, suggesting that spatial analysis and classification techniques are being employed in the health sector. Two professionals mentioned the use of raster data and two mentioned the use of tabular data in this context. This indicates that GIS professionals in Eswatini are utilizing both vector and raster data, as well as tabular data, for GIS analysis/classification tasks.

Visualization, the representation of data through use of common graphics, such as charts, plots, infographics, and even animations, was another relevant GIS activity, with 8 professionals mentioning its use. One professional specifically mentioned the use of KML, while four professionals mentioned the use of tabular data for creating visuals related to demography. This finding implies that health sector GIS professionals in Eswatini are leveraging both spatial and non-spatial data to visualize geographic information.

Lastly, querying was mentioned by two professionals. While no specific data types were associated with querying, four professionals mentioned the use of tabular data. This suggests that querying tasks in the health sector primarily involve working with tabular data or databases.

Overall, the survey findings highlight the prevalence of map development and the importance of data analysis among the health sector GIS professionals in Eswatini. Additionally, the use of both

vector and raster data, along with tabular data, is evident in GIS analysis/classification and visualization activities. The findings provide valuable insights into the current practices and data types employed by health sector GIS professionals in Eswatini, which can inform future research and decision-making processes in the field. Nevertheless, the

The data used in the activities mentioned above can be broadly categorized into three types: spatial data, non-spatial data, and administrative data. Below is a closer look at each type and its relevance for health sector GIS applications.

2.2.1 SPATIAL DATA

Spatial data refers to information that is associated with a specific location or area on the earth's surface². This data includes geographical features such as roads, rivers, and buildings, as well as maps and satellite imagery. In health sector GIS applications, spatial data is used to visualize and analyze health data in a geographical context. For example, plotting health facility locations on a map can help identify areas with poor access to health services. Spatial data is also used to create disease maps, which can help identify disease hotspots and inform targeted interventions.

2.2.2 NON-SPATIAL DATA

Non-spatial data, also known as attribute data, refers to information that is not tied to a specific location. This data includes demographic characteristics, socio-economic status, and health indicators. In health sector GIS applications, non-spatial data is often linked to spatial data through a common identifier, such as a unique facility or individual code. This allows for the creation of thematic maps, which can help identify patterns and trends in health outcomes. Non-spatial data is also used for statistical analysis and modeling, which can provide insights into the factors influencing health outcomes.

The list of non-map information commonly used in Eswatini's various health departments that includes a reference to a geographic location was mentioned by various programmes/departments. These included the following (although notably, most are spatial in nature):

Central Statistics Office Enumeration Areas (Major and Minor Areas): These are geographic divisions used by the Central Statistics Office to organize and collect data for statistical purposes.

LMIS Health Facility Coordinates: LMIS refers to the Logistics Management Information System. Health facility coordinates provide the geographic locations of health facilities, enabling effective management and distribution of medical supplies and resources.

² TechTarget (20230). <https://www.techtarget.com/searchdatamanagement/definition/spatial-data#:~:text=Spatial%20data%20is%20any%20type,in%20a%20geographic%20coordinate%20system>.

Deworming Coverages by Inkhundla - for NTD and School Health Programs: This information refers to the coverage of deworming programs in various geographic areas called Tinkhundla, which are administrative divisions in Eswatini. It is relevant for Neglected Tropical Disease (NTD) control and School Health Programs.

Community Application for a New Health Facility: This refers to a geographic location where there is a community's request or application for the establishment of a new health facility.

Acute Flaccid Paralysis (AFP) Case Locations: AFP case locations indicate the geographic distribution of reported cases of acute flaccid paralysis, which is important for disease surveillance and response.

Distribution of Households, Community-Based Health Organizations, Outreach Sites, etc.: This information pertains to the geographic distribution of households, community-based health organizations, outreach sites, community health volunteers, Tinkhundla centers, chiefdoms, neighbourhood care points, Gogo centers, schools, churches, water sources, industrial areas, and shopping centers. It helps in understanding the spatial distribution and accessibility of health-related resources and services.

Location of Schools, Locations of Health Facilities, Communities, Catchment Area, Population, Children with Certain Diseases: These are various geographic references related to the location and characteristics of schools, health facilities, communities, catchment areas, population distribution, and children with specific diseases. This information aids in planning and delivering targeted healthcare interventions.

COVID-19 and Immunization Cases: This refers to the geographic locations of reported cases of COVID-19 and immunization activities, enabling monitoring, response, and resource allocation.

Laboratory Equipment Placement: This information indicates the geographic placement of laboratory equipment, assisting in the efficient distribution and utilization of diagnostic resources.

HIV New Infections, TB New Cases, STIs Hot Spots: These references involve the geographic distribution of new HIV infections, tuberculosis (TB) cases, and hot spots for sexually transmitted infections (STIs). It assists in targeting prevention and control efforts in specific areas.

Health Hazards, Accident Locations: This information comprises geographic references to health hazards and accident locations. It helps in identifying areas prone to health risks and improving emergency response.

It's important to highlight that these were specified as non-spatial data perhaps due to the predominant use of tabular data in many government departments and institutions as a result of limited GIS skills. Nevertheless, this information, along with their associated geographic locations, allows for spatial analysis, resource allocation, and targeted interventions within Eswatini's health

departments. By understanding the geographic context of these data points, decision-makers can make informed choices and strategize effectively for improved health outcomes.

2.3 DATA COLLECTION APPROACHES

Here, we examine the methods and frequency of data collection approaches used by the various stakeholders for the identified data sources. It covers data collection techniques, data management protocols, and data update frequency. Understanding data collection processes is essential for ensuring data accuracy and timeliness.

The methods and frequency of data collection for GIS applications in the health sector vary depending on the type of data source. Below is a closer look at the data collection processes for the identified data sources.

2.3.1 HEALTH FACILITY DATA

Health facility data is collected through routine reporting from health facilities. This data is often entered into the Health Management Information System (HMIS), Client Management Information System (CMIS) or the District Health Information System (DHIS2). The data is usually collected on a monthly or quarterly basis and is then verified and validated by the Ministry of Health. The CMIS provides real time collection and reporting of health facility data. Health facility data is also periodically audited to ensure data accuracy and completeness. Currently, the Strategic Information Department is in a process of developing a comprehensive Health Facility Master List (HFML) as part of the Global Health Facility Database (GHFD) initiative. A desk review and engagements with the MoH, HMIS Unit and M&E TWG indicated that MoH has several health facility lists with both public and private facilities. However, these lists are not publicly accessible (Moyo and Lema, 2023³). The Health Management Information System (HMIS) within the Strategic Information Department (SID) is currently the primary source of the master facility list in Eswatini. Newly established facilities or facilities that are closing business are reported and captured in the HMIS. All other existing systems within the health sector and supporting partners source the master facility list from the HMIS. Therefore, a list of facilities exists on the Client Management Information System (CMIS) and DHIS2 that is in use in the country. However, as earlier indicated, these lists do not comprehensively include all the private facilities and outdated. There is, therefore, a need for the creation of a master list which will be systematically updated.

2.3.2 POPULATION (DEMOGRAPHIC) DATA

Population data is collected through national censuses, which are conducted by the CSO every ten years. There are also intercensal surveys that are conducted mid-way between the major censuses. In addition, demographic and health surveys are conducted periodically to collect data on

³ GHFD Country Situation Analysis Report, Eswatini, March 2023

population characteristics, health indicators, and health behaviors. These surveys are usually conducted every five years and provide valuable information for GIS applications in the health sector.

2.3.3 DISEASE SURVEILLANCE DATA

The Epidemiology Disease and Control Unit (EDCU) is responsible for collecting and reporting surveillance data and mostly notifiable diseases in Eswatini. Disease surveillance data is also collected through various systems, such as the National Malaria Control Programme (NMCP) and the National Tuberculosis Control Programme (NTCP). These systems collect data on the prevalence and incidence of diseases, as well as treatment outcomes. Disease surveillance data is usually collected on a monthly or quarterly basis as well as on as-per-need /ad-hoc basis. Additionally, data that is also collected through surveys such as Multiple Indicator Cluster Survey (MICS), Global School-based Student Health Survey (GSHS), STEPwise approach to surveillance (STEPS) and the HIV Incidence Measurement Survey (EHIMS) is infrequent. However, such data is regularly verified and validated by the respective MoH programme.

2.3.4 ENVIRONMENTAL DATA

Environmental data is collected by various government agencies and research institutions. This data is collected using different methods, such as remote sensing, field surveys, and laboratory analysis. The frequency of data collection varies depending on the type of data, with some data being collected in near real-time and others being collected periodically, such as climate data by the Eswatini Meteorological Services.

2.3.5 ADMINISTRATIVE DATA

Administrative data is collected and managed by government agencies and other organizations for administrative purposes. The Surveyor-General's Office (SGO) has the overall oversight on administrative and cadastral data. Other data is usually collected on a continuous basis, such as health records being updated whenever a patient visits a health facility. However, there may be delays in data entry and updates, leading to data lag and potential inaccuracies.

In conclusion, data collection for GIS applications in the health sector involves a combination of routine reporting, periodic surveys, and continuous data collection. It is essential to have proper data management protocols in place to ensure data accuracy and completeness. Regular data updates are also crucial to provide timely and relevant information for GIS analysis and decision-making in the health sector.

2.4 DATA QUALITY AND RELIABILITY

This section evaluates the quality and reliability of the available data sources. It discusses data integrity, accuracy, completeness, and consistency. The assessment helps identify potential data quality issues that may impact the effectiveness of GIS applications in the health sector.

The quality and reliability of data sources are crucial for GIS applications in the health sector. Poor data quality can lead to inaccurate and unreliable maps and analyses, which can have serious implications for decision-making. Let's assess the quality and reliability of the identified data sources:

2.4.1 HEALTH FACILITY DATA

The HMIS unit is yet to assess the existing HFML in terms of its quality, completeness, validity, uniqueness, timeliness, accuracy, and consistency (Moyo and Lema, 2023). The available HFLs are not publicly accessible to be able to assess their quality. As the HFLs are being consolidated into a single HFML through the HMIS unit, the mechanism, including documented protocols, for updating and maintaining the HFML is yet to be established/implemented.

Nevertheless, the health facility data is considered to be of good quality and fair reliability, as it is collected through routine reporting and is regularly verified and validated by the Ministry of Health. However, there may be some issues with data completeness, as not all health facilities may report their data on time or accurately and some do not report at all. Additionally, there may be discrepancies in data collection methods and definitions, which can impact data consistency.

2.4.2 POPULATION DATA

Population data is also considered to be of good quality and reliability, as it is collected through national censuses and demographic and health surveys using standardized methods. However, there may be some issues with data completeness, as not all individuals may be captured in these surveys. Be that as it may Eswatini collects very high-quality demographic data and at very high resolution (fine scale enumeration areas).

2.4.3 DISEASE SURVEILLANCE DATA

Disease surveillance data is generally considered to be of good quality and reliability, as it is collected through established systems including the HMIS and CMIS, and is regularly verified and validated by the Ministry of Health. However, there may be some issues with data completeness, as not all cases may be reported or recorded accurately. There may also be discrepancies in data collection methods and definitions, which can impact data consistency.

2.4.4 ENVIRONMENTAL DATA

Environmental data is often of good quality and reliability, as it is collected using standardized methods and is subject to regular quality control checks. However, there may be some issues with data completeness, as not all areas, environmental parameters or pollutants may be monitored. There may also be discrepancies in data collection methods and definitions, which can impact data consistency.

2.4.5 ADMINISTRATIVE DATA

Administrative data may have some issues with data quality and reliability. There may be discrepancies in data collection methods and definitions, leading to data inconsistencies. Additionally, there may be delays in data entry and updates, leading to data lag and potential inaccuracies. Moreover, data on births, deaths and cause of death, although collected frequently, is relatively poor. However, efforts are being made to improve the quality and reliability of administrative data through data governance, decentralization and standardization initiatives. The country's civil registration and vital statistics (CRVS) system is still largely locally paper-based locally, but there is increasing electronic processing. Another key gap is the lack of authorised chiefdom boundaries which is a key administrative unit for the Kingdom of Eswatini. This affects the quality of Tinkhundla boundaries which are based on the Chiefdoms.

In conclusion, while the identified data sources are generally of good quality and reliability, there may be some issues with data completeness, consistency, and accuracy. It is crucial to regularly assess and address these data quality issues to ensure the effectiveness of GIS applications in the health sector.

2.5 CHALLENGES AND LIMITATIONS IN DATA AVAILABILITY

This subsection outlines the challenges and limitations related to data availability in the health sector. It explores issues such as data gaps, data sharing barriers, data privacy concerns, and technical constraints. Understanding these challenges is crucial for addressing data-related obstacles in GIS implementation.

The success of GIS in the health sector relies heavily on the availability of reliable and accurate data. However, there are various challenges and limitations that hinder the availability and use of data in Eswatini. These challenges include data gaps, data sharing barriers, data privacy concerns, and technical constraints. Let's take a closer look at each of these challenges:

2.5.1 DATA NEEDS

One of the main challenges in data availability for GIS applications in the health sector is data needs. This refers to missing or incomplete data, which can limit the ability to accurately map and analyze health indicators. Data needs can occur due to various reasons, such as limited resources for data collection, lack of standardized data collection methods, or data being collected for different purposes and thus omitting certain key parameters for spatial analysis. Data needs and gaps can

also be more prevalent in certain areas or populations, leading to unequal representation and potential biases in GIS analysis.

Below is a list of basic spatial datasets that are required by Eswatini's Health Sector in order to enhance their mandates. This list highlights those basic datasets that must be easily accessible and availed to each of the health sector programmes/units/departments.

Strategic Information Department (SID):

- Administrative boundaries (including Chiefdom boundaries)
- Health facility locations by type and service provision and their catchment areas
- Demographic data, including population density, age distribution, and gender breakdown
- Disease surveillance data, including reported cases, outbreaks, and trends
- Health service utilization data, such as outpatient visits and hospital admissions
- Health workforce distribution and availability

Expanded Programme on Immunization (EPI):

- Administrative boundaries (including Chiefdom boundaries)
- Clearly demarcated facility catchment areas
- Immunization coverage rates and drop-out rates
- Vaccine supply chain data, including storage facilities and transportation routes
- Population data for identifying areas with low immunization coverage
- Socioeconomic data for understanding barriers to immunization

School Health Programme:

- Administrative boundaries (including Chiefdom boundaries)
- Location of schools and educational institutions
- Health services provided in schools, such as health screenings and immunization programs
- Student enrollment data and demographic characteristics
- Environmental data related to school health, such as sanitation facilities and water sources

Health Promotion Department:

- Administrative boundaries (including Chiefdom boundaries)
- Clearly demarcated facility catchment areas
- Socioeconomic data to identify vulnerable populations and target health promotion campaigns
- Geographic data on health facilities, community centers, and public spaces for organizing health promotion activities
- Data on health behavior and risk factors, including smoking rates, physical activity levels, and nutritional habits

- Accessibility data to assess the reach of health promotion initiatives in different areas

National Malaria Control:

- Administrative boundaries (including Chiefdom boundaries)
- Geospatial data on malaria cases, including incidence rates and hotspots
- Environmental data related to malaria transmission, such as mosquito breeding sites and climate factors
- Data on vector control activities, such as insecticide-treated bed net distribution and indoor residual spraying
- Population data for targeting interventions in high-risk areas

Epidemiology Programme:

- Administrative boundaries (including Chiefdom boundaries)
- Disease surveillance data, including notifiable diseases and emerging infectious diseases
- Spatial data on disease clusters and outbreaks
- Data on risk factors and determinants of diseases
- Environmental data related to disease transmission, such as water quality and air pollution levels

Emergency Preparedness and Response (EPR):

- Administrative boundaries (including Chiefdom boundaries)
- Mapping of health facilities with emergency response capabilities
- Infrastructure data, including roads, airports, and communication networks
- Population density data for estimating potential impact areas during emergencies
- Data on vulnerable populations and their locations for targeted emergency response planning
- Data on traffic volumes and accident hotspots for strategic positioning of response teams

Environmental Health Services:

- Administrative boundaries (including Chiefdom boundaries)
- Data on environmental hazards, such as air pollution, water contamination, and waste management
- Geographic data on environmental health inspections and compliance
- Health facility data related to environmental health services, such as hospital waste management and sanitation facilities
- Socioeconomic data to identify communities at higher risk of environmental health issues
- Sanitation data such as water access coverage, households with basic sanitation services

Planning Department:

- Administrative boundaries (including Chiefdom boundaries)
- Health infrastructure data, including locations of hospitals, clinics, and health centers
- Demographic data for population projections and health service planning
- Land use and zoning data for assessing healthcare accessibility in urban and rural areas
- Socioeconomic data for understanding health disparities and planning targeted interventions

National AIDS Program:

- Administrative boundaries (including Chiefdom boundaries)
- HIV prevalence data at subnational levels
- Data on HIV testing and counseling services, including testing sites and coverage rates
- Antiretroviral therapy (ART) coverage and adherence data
- Socioeconomic and demographic data for identifying populations at higher risk of HIV infection

National TB Control Program:

- Tuberculosis (TB) case data, including incidence rates and treatment outcomes
- Geographic data on TB treatment centers and laboratories
- Data on drug-resistant TB cases and treatment regimens
- Socioeconomic data for identifying vulnerable populations and barriers to TB diagnosis and treatment

Quality Assurance Services:

- Administrative boundaries (including Chiefdom boundaries)
- Data on healthcare quality indicators, such as patient satisfaction and service delivery standards
- Health facility accreditation data and compliance records
- Adverse events and patient safety data
- Geographic data on health facility performance and quality gaps

Based on the responses from the survey conducted as part of this study, the key data needs are ranked in order of popularity and summarized as follows:

Population per sublocation (Total: 16): This data type appears the most frequently in the responses. It indicates the need for data on the population size for each sublocation. Understanding the population distribution at a granular level helps in planning healthcare services and resource allocation effectively.

Health facilities (Total: 16): This data type also has 16 occurrences, indicating a high demand for data related to health facilities. It includes information on the locations, capacities, and services

provided by healthcare facilities. Accurate and up-to-date data on health facilities is crucial for ensuring access to quality healthcare and effective healthcare service delivery.

Age-sex distribution (Total: 15): This data type ranks third with 15 occurrences. It represents the need for data on the distribution of population by age and sex. This information is essential for understanding the healthcare needs of different demographic groups and developing targeted interventions.

Settlement patterns (Total: 15): Settlement patterns also have 15 occurrences, highlighting the importance of data on the distribution and types of human settlements. Understanding settlement patterns helps in assessing population density, access to services, and planning healthcare interventions based on geographic distribution.

Road network data (Total: 14): Road network data is requested 14 times. This data type focuses on detailed information about the road infrastructure, including conditions, connectivity, and accessibility. Accurate road network data is vital for planning transportation logistics and improving healthcare access, particularly in remote or underserved areas.

Major towns & urban centers (Total: 14): This data type also has 14 occurrences, indicating the need for data on major towns and urban centers. It includes information on the population size, infrastructure, and healthcare services available in these areas. Such data helps in prioritizing resource allocation and planning healthcare interventions effectively.

Vaccine coverage (Total: 12): Vaccine coverage data is requested 12 times. It pertains to the proportion of the population that has received specific vaccines. This information is crucial for assessing the effectiveness of immunization programs and identifying areas that require targeted interventions.

Public areas (Total: 12): Public areas data also has 12 occurrences, highlighting the need for information on parks, recreational spaces, and gathering places. Such data is relevant for health promotion activities, disease prevention, and planning social interventions for community well-being.

Gender (Total: 11): Gender-related data is requested 11 times. It includes information on gender-specific health issues, access to healthcare services, and gender disparities in health outcomes. Understanding gender-specific health needs is important for developing inclusive and equitable healthcare interventions.

Sanitation facilities (Total: 11): Sanitation facilities data also has 11 occurrences. It pertains to the availability and distribution of sanitation facilities, such as toilets, waste management systems, and hygiene practices. This data is crucial for promoting public health and preventing the spread of diseases.

Water distribution (Total: 11): Water distribution data is requested 11 times. It focuses on the distribution of water resources and access to clean and safe drinking water. Understanding water availability and identifying areas with insufficient access is important for planning water-related interventions and improving health outcomes.

Location of markets (Total: 9): The need for data on the location of markets appears 9 times. This data is relevant for understanding food availability, proximity to healthcare services, and planning interventions related to nutrition and food security.

Distribution of transport networks (Total: 9): This data type also has 9 occurrences. It pertains to the distribution of transport networks, including roads, highways, and transportation infrastructure. Accurate data on transport networks is vital for planning healthcare service delivery, emergency response systems, and ensuring timely access to healthcare facilities.

Street addresses (Total: 8): The need for street address data appears 8 times. Street addresses enable precise location identification for healthcare services, emergency response, and efficient resource allocation.

Land use distribution (Total: 7): Land use distribution data appears 7 times. It focuses on the types of land uses in different areas, such as residential, commercial, agricultural, or industrial. Understanding land use distribution is important for assessing environmental health impacts and planning infrastructure based on specific land uses.

Zoning data (Total: 7): Zoning data is also requested 7 times. It involves land-use regulations and designations within specific geographic areas. Zoning data helps in understanding land-use patterns, environmental factors, and planning healthcare services accordingly.

Topography (Total: 5): Topography data is requested 5 times. It includes information on the physical features and elevation of the land surface. Topographic data aids in understanding terrain characteristics, identifying flood-prone areas, and planning infrastructure development in relation to health services.

Land cover (Total: 4): Land cover data is requested 4 times. It refers to the physical coverage of the Earth's surface by various types of vegetation, water bodies, or artificial surfaces. Land cover data is valuable for environmental health assessments, land management, and understanding the relationship between land cover and health outcomes.

None (Total: 1): There are two occurrences where "None" is indicated, suggesting that there are specific data needs that have not been identified or requested in the given list.

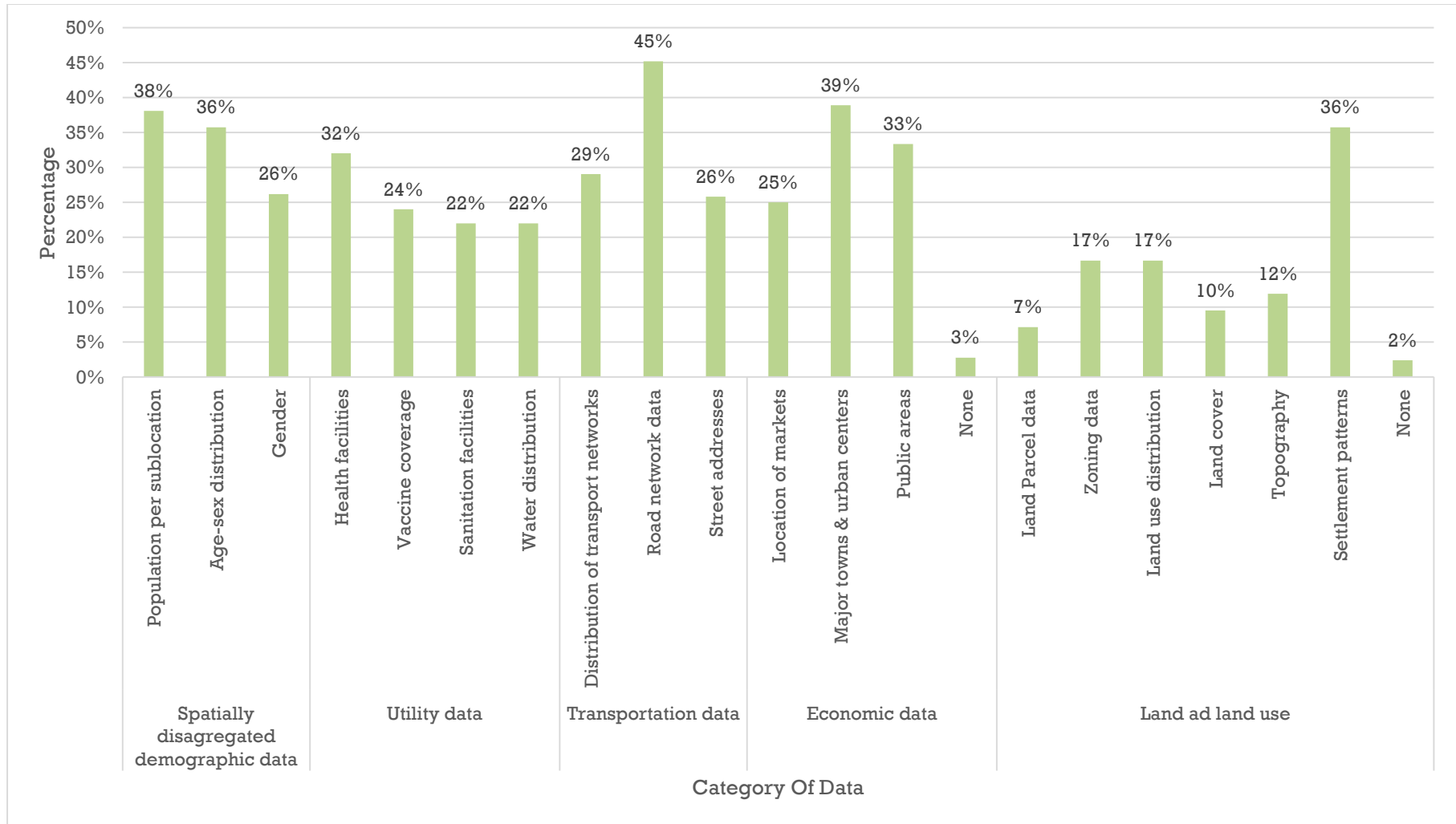


Figure 3: Spatial data needs by various Ministry of Health departments/programmes and stakeholders.

2.5.1.1 SPECIAL ATTENTION TO REACHING ZERO-DOSE COMMUNITIES:

Key data needs for Eswatini's Health Sector to fully utilize GIS in reaching zero-dose communities include the following:

Immunization Coverage Data: Accurate and up-to-date data on immunization coverage rates at subnational levels is crucial. This includes data on fully immunized children, partially immunized children, and zero-dose children. The data should be geographically tagged to identify areas with low coverage and zero-dose communities.

Demographic Data: Detailed demographic data is needed to identify the characteristics of zero-dose communities. This includes population density, age distribution, gender breakdown, and socioeconomic factors. It helps in understanding the population at risk and their geographic distribution.

Geospatial Data for Targeting Interventions: Geographic data, such as administrative boundaries, settlement locations, and population distribution maps, is essential for targeting interventions. It helps identify areas with zero-dose communities and plan outreach activities accordingly.

Health Facility Data: Data on the location, capacity, and services provided by health facilities is important for identifying gaps in immunization coverage. It helps determine the proximity of health facilities to zero-dose communities and assess their capacity to deliver immunization services.

Accessibility Data: Data on transportation networks, road conditions, travel time, and distance to health facilities is crucial for assessing the accessibility of immunization services. It helps identify areas with limited access to healthcare and zero-dose communities due to transportation barriers.

Socioeconomic Data: Socioeconomic data, including poverty rates, literacy levels, household income, and education levels, provides insights into the social determinants of health and helps identify communities at higher risk of being zero-dose. It helps in designing targeted interventions and addressing barriers related to social and economic factors.

Community-Level Data: Data on community characteristics, such as community leaders, community health workers, and local organizations, is valuable for community engagement and mobilization efforts. It helps in establishing partnerships, conducting outreach activities, and addressing community-specific challenges.

Mapping of Zero-Dose Communities: Creating a comprehensive map of zero-dose communities is essential for visualizing their spatial distribution and identifying priority areas. This map can be used as a planning tool to allocate resources and prioritize interventions.

Data on Barriers and Challenges: Data on barriers and challenges specific to zero-dose communities, such as cultural beliefs, vaccine hesitancy, migration patterns, and language barriers,

provides insights into the underlying factors contributing to low immunization coverage. It helps in developing targeted strategies to overcome these challenges.

Monitoring and Evaluation Data: Robust monitoring and evaluation data, including data on immunization campaign coverage, follow-up visits, and vaccine supply chain management, is crucial for tracking progress in reaching zero-dose communities. It helps in assessing the effectiveness of interventions and making data-driven adjustments to strategies.

By collecting and analyzing these key datasets using GIS, the health sector in Eswatini can better understand the spatial distribution of zero-dose communities, identify the underlying factors contributing to low immunization coverage, and develop targeted interventions to reach and immunize these communities effectively.

Collecting and analyzing these key datasets will facilitate comprehensive spatial analysis and support evidence-based decision-making in various health programs in Eswatini. It will enable targeted interventions, resource allocation, and monitoring of health outcomes to reach zero-dose communities and improve overall health service delivery.

2.5.2 DATA SHARING BARRIERS

Data sharing is crucial for GIS applications in the health sector, as it allows for the integration of different data sources and the creation of comprehensive and accurate maps. However, there are often barriers to data sharing, such as data ownership and control, data confidentiality concerns, and technical barriers. For example, different government agencies and health sector stakeholders may have their own data systems and may be hesitant to share data due to privacy concerns or lack of interoperability between systems. The key barriers are briefly discussed as follows:

Institutional Barriers: One of the main barriers to GIS data sharing in the health sector is the lack of institutional coordination and collaboration. Different departments and organizations may have their own datasets and systems, leading to data silos and a lack of standardized sharing protocols.

Limited Awareness and Understanding: A significant barrier is the limited awareness and understanding of the benefits and processes of GIS data sharing among key stakeholders. This includes decision-makers, health professionals, and technical staff who may not fully grasp the potential of GIS and the importance of sharing data for informed decision-making.

Data Ownership and Control: Concerns regarding data ownership and control can hinder GIS data sharing. Different entities may perceive data as their proprietary asset, leading to reluctance in sharing it with others. Lack of clear guidelines on data ownership and sharing rights further exacerbates this barrier.

Data Privacy and Security: Protecting sensitive health information is crucial for maintaining privacy and confidentiality. Concerns about data privacy and security can act as barriers to sharing

GIS data, especially when it involves personally identifiable information. Ensuring compliance with data protection regulations and establishing robust security measures are essential to overcome this barrier.

Technical Challenges: Technical barriers can impede GIS data sharing. These include the use of incompatible data formats, differing data models, and challenges in data integration and interoperability between different GIS platforms and systems. Limited technical infrastructure and resources further contribute to these challenges.

Legal and Policy Constraints: The absence of clear legal and policy frameworks for GIS data sharing can hinder data sharing efforts. Lack of specific regulations, data sharing agreements, and guidelines on data licensing and intellectual property rights can create uncertainties and barriers to sharing GIS data.

Capacity Constraints: Limited capacity and expertise in GIS data management and sharing can act as barriers. The lack of trained personnel with knowledge of GIS technologies and data sharing practices can hinder effective implementation and maintenance of data sharing initiatives.

Resource Limitations: Insufficient funding, inadequate technical resources, and limited access to necessary hardware and software can pose significant barriers to GIS data sharing. Lack of financial resources and investment in building and maintaining GIS infrastructure can hinder data sharing efforts.

Cultural and Organizational Factors: Organizational cultures and practices can influence data sharing attitudes. Resistance to sharing data due to concerns about competition, mistrust, or lack of incentives can be barriers that need to be addressed at the organizational level.

Overcoming these barriers requires a multi-faceted approach involving stakeholder engagement, capacity building, policy development, and technical improvements. It involves establishing collaborative platforms, raising awareness about the benefits of GIS data sharing, developing clear legal and policy frameworks, investing in technical infrastructure, and fostering a culture of collaboration and trust among stakeholders.

2.5.3 DATA PRIVACY CONCERNS

In the era of big data, data privacy has become a significant concern. This is especially true in the health sector, where sensitive personal health information is collected and used for GIS applications. Data privacy concerns can hinder the sharing and use of health data, as individuals and organizations may be hesitant to share data due to potential privacy breaches. This can limit the availability of data for GIS applications and impact the accuracy and effectiveness of analyses. The key GIS-related data privacy concerns in Eswatini's health sector are briefly discussed as follows:

Personally Identifiable Information (PII): GIS data in the health sector often contains personally identifiable information, such as names, addresses, and medical records of individuals. The primary concern is the potential unauthorized access or disclosure of this sensitive information, which can lead to privacy breaches, identity theft, or discrimination.

Data Anonymization and De-identification: Proper anonymization and de-identification techniques are necessary to protect privacy when sharing GIS data. The challenge lies in ensuring that data is effectively anonymized to prevent re-identification while still maintaining its utility for analysis and decision-making.

Data Sharing and Consent: Sharing GIS data in the health sector may involve sharing data across different organizations or with external partners. Ensuring that appropriate consent has been obtained from individuals whose data is being shared is important to respect privacy rights and comply with relevant data protection regulations.

Data Minimization: The principle of data minimization states that only the minimum necessary data should be collected and retained. In the context of GIS data, there is a need to ensure that only relevant and essential data is collected and used to minimize privacy risks associated with excessive data collection and storage.

Data Security: GIS data needs to be protected from unauthorized access, alteration, or destruction. Robust security measures, such as encryption, access controls, and secure storage, should be implemented to safeguard GIS data and prevent data breaches that could compromise individuals' privacy.

Geospatial Tracking: GIS data often includes geolocation information, such as GPS coordinates or addresses. The privacy concern arises when this information is used for tracking individuals' movements or for profiling purposes. Safeguards should be in place to prevent unauthorized tracking or misuse of geospatial data.

Data Retention and Disposal: Proper data retention and disposal practices are crucial to protect privacy. GIS data should be retained only for as long as necessary and securely disposed of when it is no longer needed, to minimize the risk of unauthorized access or use of outdated data.

Third-Party Data Sharing: Sharing GIS data with third-party entities, such as research institutions or private organizations, introduces additional privacy risks. Contracts and agreements should be in place to ensure that the data is used only for authorized purposes, and appropriate safeguards are implemented to protect privacy during data sharing.

Cross-Border Data Transfer: When GIS data is transferred across borders, particularly to countries with different data protection regulations, privacy concerns may arise. Adequate measures, such as data transfer agreements or standard contractual clauses, should be implemented to ensure that privacy standards are maintained during cross-border data transfers.

Addressing these GIS data privacy concerns requires implementing a comprehensive privacy framework that includes policies, procedures, and technical safeguards. This framework should align with relevant data protection regulations, incorporate privacy by design principles, and involve ongoing monitoring and assessment to ensure compliance and protect individuals' privacy rights.

2.5.4 TECHNICAL CONSTRAINTS

Technical constraints, such as limited resources and technical expertise, can also hinder data availability for GIS applications in the health sector. For example, data may be collected but not properly stored or managed, making it difficult to access and use for GIS analysis. Technical constraints can also limit the ability to integrate and analyze different types of data, such as spatial and non-spatial data, which can lead to incomplete or inaccurate maps. The key technical constraints are summarized below.

Outdated Infrastructure: A significant constraint is the presence of outdated technical infrastructure, including hardware, software, and network capabilities. Older systems may not have the processing power or storage capacity required to effectively handle and analyze GIS data, leading to performance limitations and inefficiencies.

Lack of Interoperability: Incompatible data formats, differing data models, and a lack of interoperability between different GIS platforms and systems pose technical constraints. This hinders the seamless integration and sharing of GIS data between different departments, organizations, and systems within the health sector.

Limited Data Integration: Integrating GIS data from various sources is essential for comprehensive analysis and decision-making. However, technical constraints, such as data incompatibility, varying spatial resolutions, inconsistent attribute definitions and lack of common fields (Primary keys) between GIS datasets, make it challenging to effectively integrate and harmonize disparate GIS datasets.

Insufficient Data Storage and Management: GIS data, especially in the health sector, can be voluminous and require adequate storage capacity. Limited data storage infrastructure can restrict the amount of data that can be stored and accessed, impeding comprehensive and long-term analysis.

Data Processing and Analysis: Processing and analyzing large GIS datasets require significant computational resources. Limited processing power and lack of advanced analytical tools can hinder the capacity to perform complex spatial analysis, modeling, and visualization, limiting the insights that can be derived from GIS data.

Limited Access to Spatial Data Infrastructure (SDI): The absence of a well-established and accessible Spatial Data Infrastructure (SDI) can be a technical constraint. SDI provides frameworks,

standards, and tools for managing and sharing geospatial data. Its absence can impede efficient data sharing and collaboration across the health sector.

Data Accuracy and Quality Control: Ensuring the accuracy and quality of GIS data is crucial for reliable analysis and decision-making. Technical constraints, such as limited data validation and quality control processes, can result in inaccuracies, inconsistencies, and incomplete datasets, compromising the reliability of GIS-based applications.

Limited Technical Expertise: The availability of skilled personnel with expertise in GIS technologies and data management is essential. However, a shortage of trained professionals can restrict the adoption, implementation, and maintenance of GIS systems, limiting the technical capabilities within the health sector.

Connectivity and Internet Access: Reliable connectivity and internet access are essential for efficient sharing and access to GIS data. However, technical constraints such as limited internet infrastructure and connectivity gaps in remote areas can hinder real-time data exchange and access, particularly in rural healthcare facilities.

Addressing these technical constraints requires investment in technical infrastructure, including hardware, software, and network capabilities, to support efficient GIS data management, analysis, and sharing. Additionally, capacity building initiatives to enhance technical skills among health sector personnel and the establishment of a robust Spatial Data Infrastructure (SDI) can help overcome these constraints and enable effective utilization of GIS in the health sector.

In conclusion, there are various challenges and limitations related to data availability in the health sector in Eswatini. These challenges need to be addressed to ensure the availability of reliable and accurate data for GIS applications and to fully leverage the potential of GIS in the health sector. This may require collaboration and coordination among different stakeholders, as well as investments in data infrastructure and capacity building.

CHAPTER 3: STAKEHOLDER MAPPING

3.1 IDENTIFICATION OF KEY STAKEHOLDERS IN GIS-RELATED ACTIVITIES

This section identifies key stakeholders involved in GIS-related activities in the health sector. It includes stakeholders from government agencies, civil society organizations (CSOs), international organizations (e.g., UNICEF, WHO), and other relevant entities.

Here is a table showing the type of organization, name of the organization, and their role in the implementation of GIS in Eswatini's health sector:

Table 4: List of health sector stakeholders and their potential role in GIS implementation.

Type of Organization	Organization Name	Role in Implementation of GIS
International Organizations	UNICEF	Supporting the implementation of GIS in health sector
	WHO	Providing technical expertise in GIS implementation
	UNFPA	Assisting with GIS data collection and analysis
Government Agencies	Surveyor General's Office	Providing geospatial data and mapping services
	Central Statistics Office	Collecting and managing statistical GIS data
Academia	University of Eswatini	Conducting research and training on GIS technologies
	Southern African Nazarene University	Collaborating on GIS projects and research
	Baylor College of Medicine Children's Foundation Eswatini	Supporting GIS applications for healthcare
Ministry of Health Departments	Strategic information department (SID)	Managing health-related GIS data and analysis
	Expanded Programme on Immunization (EPI)	Mapping immunization coverage and vaccine distribution
	School health programme	GIS-based planning and monitoring of school health
	Health Promotion department	Using GIS for health promotion campaigns
	National malaria control	GIS-based surveillance and control of malaria
	Epidemiology programme	GIS mapping and analysis of disease outbreaks
	Emergency preparedness and response (EPR)	GIS support for emergency response planning
	Environmental health services	Mapping and monitoring environmental health issues
	Planning Department	Spatial planning for health facilities and services
	National AIDS program	GIS-based monitoring and control of HIV/AIDS
National TB Control program	GIS mapping and analysis of tuberculosis cases	

Type of Organization	Organization Name	Role in Implementation of GIS
	Quality Assurance Services	GIS support for ensuring healthcare quality
Ministry of Health Implementing Partners	FHI360	Supporting GIS implementation in health programs
	CHAI	GIS-based planning and monitoring in healthcare
	ICAP	GIS for HIV/AIDS program monitoring and evaluation
	DATA FOR IMPLEMENTATION (DATA.FI)	GIS data collection and analysis for health projects
	NERCHA	GIS support for HIV/AIDS coordination and planning
	PACT	GIS-based program implementation and monitoring
	EGPAF	GIS for pediatric HIV/AIDS program interventions
	URC	GIS data analysis and support for health programs
	CABRINI MINISTRIES	GIS for healthcare service delivery
	Young Heroes	GIS data collection and analysis for HIV/AIDS programs
	JHPIEGO	GIS support for maternal and child health programs
	World Vision	GIS-based planning and monitoring in health projects
	CANGO	GIS for community-based health programs
	Save The Children	GIS support for child health and protection projects
	BAYLOR CLINICS	GIS for healthcare service delivery
Bantwana Initiative	GIS-based planning and monitoring for child welfare	

Please note that this table is not exhaustive and there may be other organizations involved in the implementation of GIS in Eswatini's health sector.

3.2 ROLES AND RESPONSIBILITIES OF EACH STAKEHOLDER

This subsection outlines the roles and responsibilities of each identified stakeholder in GIS implementation. It highlights their contributions to data collection, data sharing, capacity building, and policy development. Understanding stakeholder roles helps foster collaboration and coordination. Effective implementation and utilization of Geographic Information System (GIS) in the health sector of Eswatini requires collaboration and coordination among various stakeholders. Each stakeholder has distinct roles and responsibilities that contribute to data collection, data sharing, capacity building, and policy development. Understanding these roles fosters collaboration and ensures a cohesive approach to GIS implementation. The following section outlines the roles and responsibilities of each identified stakeholder in GIS implementation in Eswatini's health sector.

3.2.1 MINISTRY OF HEALTH:

Role: The Ministry of Health plays a pivotal role in leading and coordinating GIS implementation efforts in the health sector.

Responsibilities:

- Develop a national GIS strategy for the health sector in collaboration with other stakeholders.
- Allocate resources for acquiring GIS software, hardware, and data integration tools.
- Establish and operationalize a dedicated team of GIS experts (Steering Committee) within the Ministry to support GIS implementation and capacity building.
- Facilitate data collection efforts, ensuring the availability of accurate and up-to-date health-related spatial data.
- Foster collaboration with regional health departments and healthcare facilities for data sharing and utilization.
- Develop policies and guidelines for data sharing and privacy in compliance with applicable regulations.

3.2.2 IMPLEMENTING PARTNERS:

Role: These are responsible for overseeing healthcare planning and service delivery at the national to local level.

Responsibilities:

- Provide support and guidance to healthcare facilities for GIS implementation.
- Coordinate data collection efforts within their areas of operation, including geocoding health facility locations and capturing relevant spatial data.
- Ensure the quality and accuracy of regional health data for GIS analysis and decision-making processes.
- Facilitate data sharing among healthcare facilities and stakeholders within the areas of operation.
- Collaborate with the Ministry of Health to align institutional GIS initiatives with the national GIS strategy.
- Contribute to policy development to support GIS implementation and utilization.

3.2.3 HEALTHCARE FACILITIES:

Role: Healthcare facilities, including hospitals, clinics, and health centers, are key stakeholders in GIS implementation.

Responsibilities:

- Collect and maintain accurate geospatial data related to health facility locations, services, and infrastructure.
- Share health-related data with relevant stakeholders, including the Ministry of Health and regional health departments.
- Collaborate with the Ministry of Health and regional health departments in data collection efforts, ensuring the availability of comprehensive and up-to-date spatial data.
- Utilize GIS tools and analysis to support healthcare planning, resource allocation, and service delivery.
- Participate in capacity building programs to enhance GIS skills among healthcare professionals and administrators.
- Provide feedback and insights on the effectiveness of GIS implementation and suggest improvements.

3.2.4 ACADEMIC AND RESEARCH INSTITUTIONS:

Role: Academic and research institutions contribute to GIS implementation by providing expertise, research, and training.

Responsibilities:

- Conduct research on GIS applications in the health sector, including spatial analysis of health-related data.
- Provide training programs and capacity building initiatives to enhance GIS skills among healthcare professionals and administrators.
- Collaborate with the Ministry of Health and regional health departments to support data collection and analysis efforts.
- Contribute to policy development through evidence-based research and recommendations.
- Share research findings and best practices in GIS implementation in the health sector.

International Organizations and Donors:

Role: International organizations and donors provide financial and technical support for GIS implementation.

Responsibilities:

- Provide funding for acquiring GIS software, hardware, and data integration tools.
- Offer technical expertise and guidance on best practices in GIS implementation.
- Support capacity building initiatives, including training programs and workshops.
- Facilitate knowledge exchange and collaboration between Eswatini and other countries/regions implementing GIS in the health sector.

- Contribute to policy development by sharing international standards and guidelines for GIS implementation.

By understanding the roles and responsibilities of each stakeholder involved in GIS implementation in Eswatini's health sector, collaboration and coordination can be fostered. This ensures that data collection, data sharing, capacity building, and policy development efforts are streamlined, leading to effective GIS utilization and improved healthcare planning and service delivery in Eswatini.

3.3 COLLABORATION AND COORDINATION AMONG STAKEHOLDERS

This section explores the existing collaboration and coordination mechanisms among the identified stakeholders. It assesses the effectiveness of current partnerships, identifies gaps, and proposes strategies to enhance collaboration in leveraging GIS for the health sector.

There are several existing collaboration and coordination mechanisms among stakeholders in the health sector in Eswatini. These mechanisms aim to facilitate data sharing, promote collaboration, and improve decision-making through the use of GIS. Let's assess the effectiveness of current partnerships, identify gaps, and propose strategies to enhance collaboration in leveraging GIS for the health sector:

Existing Collaboration Mechanisms

The Ministry of Health (MOH) has signed several partnerships with stakeholders, such as the Health Data Collaboratives and UN agencies, to promote collaboration and data sharing. These partnerships have led to the development of GIS tools and the use of GIS in decision-making. The MOH also collaborates with Regional Health Management Teams (RHMTs) and Civil Society Organizations (CSOs) to collect and report data for GIS activities.

Effectiveness of Current Partnerships

Overall, current partnerships have been effective in promoting collaboration and data sharing in the health sector. However, there are some challenges that hinder the effectiveness of these partnerships. For instance, the lack of a comprehensive data sharing policy and the limited participation of private sector organizations and academic institutions in data sharing and collaboration.

Identified Gaps

One of the main gaps in existing collaboration mechanisms is the limited involvement of private sector organizations and academic institutions in data sharing and collaboration for GIS activities. These stakeholders have valuable data and technical expertise that can contribute to the improvement of GIS in the health sector. Another gap is the lack of a comprehensive data sharing policy that can provide a clear framework for data sharing and collaboration among stakeholders.

Strategies to Enhance Collaboration

To enhance collaboration and data sharing among stakeholders in the health sector, the following strategies are proposed:

- Develop and implement a National GIS Data Sharing Policy that outlines standards, guidelines, and procedures for data sharing.
- Encourage the participation of private sector organizations and academic institutions in data sharing and collaboration for GIS activities.
- Foster a culture of collaboration and knowledge-sharing among stakeholders through regular meetings, workshops, and conferences.
- Strengthen the implementation of existing partnerships, such as the Health Data Collaboratives, by involving more stakeholders and expanding the scope of data sharing beyond health facilities.

In conclusion, while there are existing collaboration mechanisms among stakeholders in the health sector in Eswatini, there are still gaps that need to be addressed to enhance collaboration and leverage GIS for the health sector. By implementing the proposed strategies, collaboration can be improved, leading to better data quality and decision-making in the health sector.

3.4 OPPORTUNITIES FOR DATA SHARING AND PARTNERSHIPS

Here, we identify opportunities for data sharing and partnerships among stakeholders. It examines existing frameworks, platforms, and initiatives that promote data sharing and collaboration. Recommendations are provided to strengthen data sharing mechanisms and partnerships.

There are several opportunities for GIS data sharing and partnerships among stakeholders in the health sector in Eswatini, which can lead to improved data quality, increased collaboration, and better decision-making. Let's examine some existing frameworks, platforms, and initiatives that promote data sharing and collaboration:

National Spatial Data Infrastructure (NSDI)

The NSDI is a framework that aims to facilitate the sharing and integration of geospatial data across sectors and organizations. It provides standards, guidelines, and tools for data sharing and promotes collaboration among stakeholders. However, the NSDI is not yet fully implemented in Eswatini, and efforts are needed to strengthen its implementation and promote data sharing among stakeholders.

Health Data Collaboratives

The Health Data Collaboratives, led by the World Health Organization, is a global initiative that promotes the sharing of health data to support decision-making and research. In Eswatini, the Ministry of Health (MOH) has signed a memorandum of understanding with the Health Data

Collaboratives to share health data and collaborate on data analysis and capacity building. This partnership can be strengthened by involving other stakeholders and expanding the scope of data sharing beyond health facilities.

Open Data Platforms

Several open data platforms, such as the Africa Open Data Platform, provide a centralized repository for sharing data and promoting collaboration. These platforms can be leveraged to share GIS data among stakeholders in the health sector and promote transparency and accountability.

Based on these opportunities, the following recommendations are provided to strengthen data sharing mechanisms and partnerships:

Develop a National GIS Data Sharing Policy

A comprehensive policy that outlines the standards, guidelines, and procedures for sharing GIS data should be developed and implemented. This will provide a clear framework for data sharing and promote collaboration among stakeholders.

Strengthen the Implementation of the NSDI

Efforts should be made to fully implement the NSDI in Eswatini and promote its use among stakeholders. This will facilitate data sharing and integration and support decision-making.

Encourage Participation in Health Data Collaboratives

Other stakeholders, such as Civil Society Organizations (CSOs) and academic institutions, should be encouraged to participate in the Health Data Collaboratives and share their data for analysis and research. This will promote collaboration and innovation in the use of GIS for health.

Utilize Open Data Platforms

Open data platforms should be utilized to share GIS data among stakeholders in the health sector. This will increase data accessibility and transparency and support data-driven decision-making.

In conclusion, there are several opportunities for GIS data sharing and partnerships among stakeholders in the health sector in Eswatini. By implementing the recommended actions, data sharing can be strengthened, leading to improved decision-making and health outcomes.

3.5 RECOMMENDATIONS FOR COORDINATION MECHANISM

The current GIS Technical Working Group (TWG) is a key coordinating mechanism for GIS implementation within the Ministry of Health. However, to make it effective, the TWG should consist of relevant stakeholders from various departments and organizations involved in health programming and geospatial data utilization. The following stakeholders should be considered:

Ministry of Health Representatives: Representatives from key departments within the Ministry of Health, such as the Strategic Information Department (SID), Expanded Programme on Immunization (EPI), Epidemiology Programme, and Emergency Preparedness and Response (EPR), should be included to ensure alignment with health priorities.

UNICEF Eswatini: UNICEF Eswatini should have representation in the TWG, as they are driving the GIS needs assessment and can provide technical expertise and guidance.

WHO Eswatini: a WHO representative Eswatini makes sure that local technical teams receive knowledge and expertise from around the world. Local teams from WHO that have experience with geospatial technologies may be able to provide valuable insights into how GIS is implemented in Eswatini.

Surveyor-General's Office: Involving representatives from the national mapping agency ensures access to foundational geospatial data and expertise in spatial data management.

Academic Institutions: Representatives from academic institutions with expertise in GIS and public health can contribute valuable insights, research collaboration, and capacity-building support.

Development Partners: Engaging development partners, such as international organizations and NGOs working in the health sector, can foster collaboration, resource mobilization, and knowledge sharing.

Civil Society Organizations: Involving civil society organizations focused on health and child welfare can bring community perspectives, facilitate community engagement, and ensure that the needs of vulnerable populations are adequately addressed.

The composition of the GIS TWG should be inclusive, representative, and reflect the multidisciplinary nature of geospatial approaches for health programming.

CHAPTER 4: MAPPING OF EXISTING GIS SYSTEMS AND TOOLS

4.1 OVERVIEW OF EXISTING GIS SYSTEMS IN ESWATINI

This section provides an overview of the existing GIS systems implemented in Eswatini's health sector. It includes an inventory of the systems and their applications, highlighting key functionalities and areas of utilization.

The survey conducted during this study revealed that half of the Ministry of Health's Departments/programmes use GIS. Of these, a majority only started using GIS within the past 5 years.

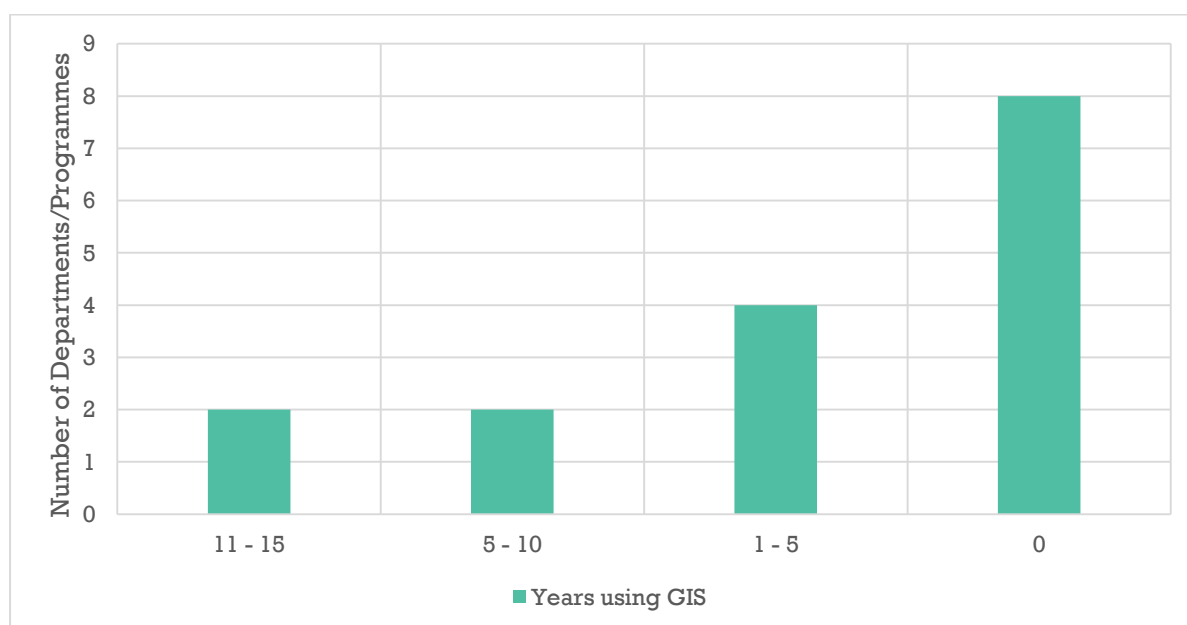


Figure 4: GIS adoption among the Ministry of Health departments/programmes.

Currently, the key uses of GIS within the sector are focused on planning, disease monitoring and determining access to health services.

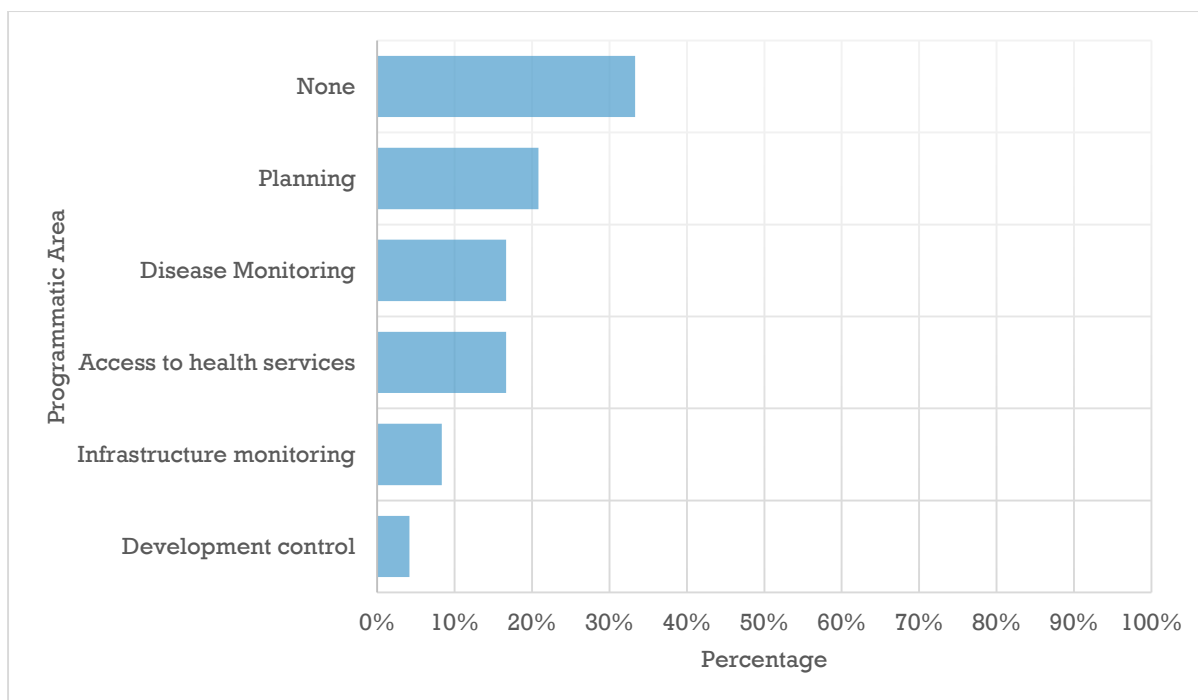


Figure 5: Ministry of Health departments/programmes areas of GIS use.

Notably, most of the day-to-day GIS-related activities undertaken by GIS professionals in Eswatini's health sector can be summarized as follows, along with the number of mentions:

- Data collection and cleaning: 13 mentions
- Data Analysis: 12 mentions
- Data maintenance and editing: 12 mentions
- Data modeling: 9 mentions
- Map Development: 10 mentions
- GIS System management: 7 mentions
- Projects Coordination: 1 mention

These activities highlight the core tasks performed by GIS professionals in the health sector. Data collection and cleaning, along with data analysis and maintenance, are frequently mentioned, indicating the importance of handling and preparing data for further analysis and visualization. Data modeling is mentioned in several instances, suggesting the utilization of spatial modeling techniques. Map development is also a prominent activity, indicating the creation and design of maps for various purposes. GIS system management is mentioned, highlighting the responsibility of managing and maintaining GIS systems. Projects coordination is mentioned less frequently, suggesting the involvement of GIS professionals in coordinating GIS-related activities within projects.

Overall, the activities mentioned reflect the diverse range of tasks undertaken by GIS professionals in Eswatini's health sector, encompassing data management, analysis, modeling, and map development, as well as system management and project coordination.

4.2 DESCRIPTION OF GIS SOFTWARE AND TOOLS BEING USED

This section describes the GIS software and tools currently in use in the health sector. It covers both proprietary and open-source software, discussing their features, capabilities, and limitations. Understanding the software landscape helps inform decision-making regarding system upgrades or adoptions.

The effective utilization of GIS in Eswatini's health sector relies on appropriate software and tools that meet the specific needs and requirements of healthcare planning and service delivery. In this section, we provide an overview of the GIS software and tools currently in use, covering both proprietary and open-source options. We discuss their features, capabilities, and limitations, aiming to inform decision-making regarding system upgrades or adoptions. The following software tools were highlighted as being used in the health sector.

4.2.1 PROPRIETARY GIS SOFTWARE:

ArcGIS ESRI Suite:

Key Features: Comprehensive GIS software suite with advanced tools for data management, analysis, and visualization. Offers powerful geoprocessing capabilities and spatial analysis tools. Provides options for desktop, web, and enterprise deployments.

Capabilities: ArcGIS can be used in Eswatini's health sector for spatial analysis of health data, such as disease mapping, hotspot identification, and resource allocation. It can facilitate the integration of health data with other socioeconomic and environmental data for comprehensive analysis and decision-making.

Limitations: Cost can be a limitation, especially for full enterprise deployments. Training and expertise may be required to utilize the software effectively. Continuous licensing and updates may be necessary for access to the latest features.

Database Management (SQL, Access, etc.):

Key Features: SQL and database management systems like Microsoft Access provide structured storage and management of geospatial data. SQL allows for querying and manipulation of spatial data within a database. Access offers a user-friendly interface for database management.

Capabilities: Database management systems can be utilized in Eswatini's health sector for storing and managing health-related geospatial data. They enable efficient data retrieval, validation, and indexing, supporting data integration and analysis.

Limitations: Database management systems focus on data management and querying rather than advanced spatial analysis. Additional GIS software may be required for in-depth spatial analysis. Access is limited to desktop environments and may have scalability limitations for large datasets.

Business Intelligence Tools (Power BI and Tableau):

Key Features: Business intelligence tools like Power BI and Tableau enable data visualization, reporting, and analysis from various sources, including geospatial data. They offer interactive dashboards, reports, and mapping capabilities.

Capabilities: Power BI and Tableau can be used in Eswatini's health sector for visualizing and analyzing health data, including geospatial data. They can help in creating interactive dashboards and reports to monitor health indicators, resource allocation, and health service utilization.

Limitations: GIS functionalities may not be as extensive as dedicated GIS software, these platforms are mainly for spatial data visualisation than creation and geoprocessing. Advanced geospatial analysis may require additional configuration or plugins. Eswatini's health sector may need to invest in training and expertise to fully utilize the tools.

STATA:

Key Features: Comprehensive statistical analysis, import/handling of spatial data, basic spatial analysis, integration with other statistical software.

Capabilities: Performs advanced statistical analysis, handles spatial data, basic spatial analysis functions, extensive data manipulation.

Limitations: Basic spatial analysis capabilities compared to specialized GIS software, limited geospatial data visualization options.

SurveyCTO:

Key Features: Customized mobile data collection forms, GPS integration, data management/synchronization, integration with external GIS software.

Capabilities: Creates tailored survey forms, captures geospatial data, manages and syncs data, integrates with GIS software.

Limitations: Limited spatial analysis capabilities, relies on external GIS software for advanced analysis and mapping.

4.2.2 OPEN-SOURCE GIS SOFTWARE:

QGIS:

Key Features: Open-source desktop GIS software with a user-friendly interface. Supports a wide range of data formats and offers comprehensive GIS functionalities. Provides a large plugin repository for extending functionality.

Capabilities: QGIS can be utilized in Eswatini's health sector for spatial data management, analysis, and visualization. It can assist in mapping health facilities, disease prevalence, and health indicators. QGIS's flexibility and extensibility allow for customization and integration with other health systems.

Limitations: Limited technical support compared to commercial software. Documentation and training materials may be less extensive. Eswatini's health sector may require additional resources for technical support and plugin development.

DHIS 2:

Key Features: Open-source software platform for health data management and analysis. Allows for data collection, analysis, visualization, and reporting at various levels of a health system. Supports geospatial data management and mapping capabilities.

Capabilities: DHIS 2 can be used in Eswatini's health sector for managing and analyzing health-related data within a spatial context. It enables the integration of geospatial data with other health information, facilitating mapping and visualization of health indicators, disease prevalence, and health facility locations. DHIS 2's reporting and visualization features can support decision-making and monitoring of health outcomes.

Limitations: DHIS 2's GIS functionalities may not be as extensive as dedicated GIS software. Customization and implementation may require technical expertise. Additional resources may be needed for technical support and customization based on Eswatini's specific health data requirements.

Google Earth:

Key Features: Web-based GIS tool providing a virtual globe and map-based visualization. Offers satellite imagery, aerial photography, and 3D buildings. Allows for the creation and sharing of custom maps and placemarks.

Capabilities: Google Earth can be used in Eswatini's health sector for visualizing health-related data in a spatial context. It can help in understanding geographical factors impacting health outcomes, such as accessibility to healthcare facilities or environmental factors. Google Earth's user-friendly interface and accessibility make it suitable for non-technical users.

Limitations: Google Earth's analysis capabilities are limited compared to dedicated GIS software. It may not provide advanced spatial analysis tools required for complex health data analysis. Online functionality relies on stable internet connectivity.

GeoDa Software:

Key Features: Open-source software for geospatial data analysis and exploratory spatial data analysis (ESDA). Provides tools for spatial autocorrelation analysis, clustering, spatial regression, and visualization of spatial data patterns.

Capabilities: GeoDa can be utilized in Eswatini's health sector for analyzing spatial patterns and relationships in health data. It can assist in identifying spatial clusters of diseases, assessing spatial autocorrelation, and exploring the determinants of health outcomes.

Limitations: GeoDa's focus is primarily on statistical analysis rather than comprehensive GIS functionalities. Limited data management and editing capabilities may require additional software for data preparation. Training and expertise may be required to utilize the software effectively.

Open Data Kit (ODK):

Key Features: Open-source data collection toolset designed for mobile devices. It consists of several components, including ODK Collect for data collection, ODK Aggregate for data management, and ODK Briefcase for offline data transfer. It supports various data types, including geospatial data.

Capabilities: ODK allows users to create customized digital forms for data collection in the field. It supports offline data collection, GPS data capture, and multimedia attachments. ODK Aggregate enables data storage and management on a server or cloud platform. ODK Briefcase facilitates data transfer between devices and the server.

Limitations: ODK is primarily focused on data collection and management rather than advanced GIS analysis. It requires technical setup and configuration for server deployment. Customization and programming skills may be needed for complex form development.

OpenStreetMap (OSM):

Key Features: Collaboratively-built and freely available map data created by a community of contributors. OSM provides an open and editable map of the world, including geographic features, roads, buildings, and points of interest.

Capabilities: OSM allows users to access, edit, and contribute to a global spatial dataset. It can be used for creating custom maps, geocoding, routing, and spatial analysis. OSM data can be downloaded and used offline. It offers a range of mapping tools, such as the iD Editor and JOSM, for data contributions and editing.

Limitations: OSM data quality can vary by region and is dependent on community contributions. It may not have the same level of detail or coverage as commercial map providers. OSM lacks some proprietary datasets and may have less reliable data for specific regions or niche applications.

DIVA-GIS:

Key Features: Import/export of spatial data formats, georeferencing, basic spatial analysis, thematic mapping, integration with R.

Capabilities: Handles various spatial data formats, performs basic spatial analysis functions, allows for data visualization.

Limitations: Limited advanced spatial analysis capabilities, less intuitive user interface, limited documentation and support.

EpiInfo:

Key Features: Data collection/management/analysis for epidemiological studies, basic GIS functionalities, thematic mapping.

Capabilities: Collects and analyzes epidemiological data, performs basic GIS tasks, generates thematic maps.

Limitations: Not specifically designed for complex GIS tasks, limited advanced spatial analysis capabilities.

Google Maps:

Key Features: Interactive web mapping, satellite imagery, street view, geocoding, routing, APIs for integration.

Capabilities: Offers mapping and navigation functionalities, supports geocoding and routing, provides custom mapping options.

Limitations: Limited advanced GIS analysis capabilities, terms of use and licensing restrictions may apply.

KOBO Collect:

Key Features: Mobile data collection, GPS integration, data management/synchronization, integration with external GIS software.

Capabilities: Customizes mobile survey forms, captures geospatial data, manages and syncs data, integrates with GIS software.

Limitations: Limited spatial analysis capabilities, relies on external GIS software for advanced analysis and mapping.

May require technical expertise for integration with external GIS software.

It is important to note that the choice of GIS software should align with the specific needs, technical capacity, and budgetary considerations of the health sector in Eswatini. Organizations should carefully evaluate the features, capabilities, and limitations of each software option to make informed decisions regarding system upgrades or adoptions. Considerations may include data compatibility, ease of use, scalability, support options, and the availability of training resources within the country.

Furthermore, it is worth exploring potential collaborations with software providers, academic institutions, and international organizations to access discounted or subsidized licenses, training, and technical support. Open-source software options can also provide cost-effective alternatives with a vibrant user community that offers support and a wide range of plugins or extensions.

By understanding the landscape of GIS software and tools in use in Eswatini's health sector, stakeholders can make informed decisions to optimize GIS implementation and maximize its potential for improving healthcare planning, resource allocation, and service delivery.

4.3 SPATIAL DATA INFRASTRUCTURE AND PLATFORMS

The spatial data infrastructure (SDI) and platforms play a critical role in supporting the implementation of Geographic Information System (GIS) applications in the health sector in Eswatini. This section examines the current state of the SDI and platforms, focusing on data storage, data sharing mechanisms, and interoperability. An assessment of these aspects is provided, followed by recommendations to improve the spatial data infrastructure in Eswatini's health sector. It is important to note that the survey revealed that only one department revealed that they have a dedicated computer for GIS applications which might be due to the fact most departments do not have a dedicated GIS unit hence there is currently a task shifting in the departments that are utilising GIS. This further cements the fact that GIS is still at its infancy in the sector. Based on the responses regarding the GIS software needs for Eswatini's health sector, the following components/technologies are mentioned:

GIS Software (ArcGIS, QGIS, etc.): This is mentioned in multiple responses, indicating a need for GIS software to effectively implement activities in the health sector.

Upgrade/Advanced GIS Software: Some professionals express a need for upgrading their existing GIS software or acquiring more advanced GIS software to enhance their capabilities.

GIS Data: The availability of GIS data is identified as a requirement for effective implementation of GIS activities within the health sector.

Database Management System: Several professionals highlight the need for a database management system, indicating the importance of organizing and managing spatial and non-spatial data efficiently.

Data Analysis Software: There is a mention of the need for specific software tools to perform data analysis tasks related to GIS activities in the health sector.

These findings suggest that there is a demand for robust GIS software, including upgrades or advanced versions, to support the implementation of activities in Eswatini's health sector. Additionally, the availability and management of GIS data, along with database management systems and data analysis software, are identified as essential components for effective GIS implementation. By addressing these software needs, the health sector in Eswatini can enhance its GIS capabilities and optimize the use of geospatial data for decision-making and resource allocation.

4.3.1 ASSESSMENT OF DATA STORAGE:

The data storage infrastructure for GIS applications in the health sector in Eswatini faces several challenges. Currently, data storage is fragmented, with different health programs and departments maintaining separate databases. This fragmentation hinders efficient data management and hampers the ability to integrate and analyze data from multiple sources. Additionally, there is a lack of standardized data models and formats, making it difficult to achieve interoperability and data exchange between different systems.

4.3.2 ASSESSMENT OF DATA SHARING MECHANISMS:

Data sharing mechanisms in Eswatini's health sector are limited, leading to siloed data and missed opportunities for collaboration and informed decision-making. The existing data sharing practices primarily rely on manual processes, such as ad-hoc data extraction and sharing through email or physical media. This approach is time-consuming, prone to errors, and restricts real-time access to updated information. Lack of standardized protocols and platforms for data sharing further exacerbates the problem.

4.3.3 ASSESSMENT OF INTEROPERABILITY:

Interoperability, the ability of different systems to exchange and use data, is crucial for effective GIS applications in the health sector. However, in Eswatini, interoperability challenges persist. The absence of common data standards, metadata schemas, and data integration frameworks makes it difficult to combine and analyze data from various sources. Moreover, limited interoperability

hinders the integration of GIS with other health information systems, such as electronic health records and disease surveillance systems.

4.3.4 RECOMMENDATIONS TO IMPROVE SPATIAL DATA INFRASTRUCTURE:

Establish a Centralized Spatial Data Repository: Develop a centralized repository for health-related spatial data, ensuring data storage is consolidated, standardized, and accessible to authorized stakeholders. This repository should adhere to international geospatial data standards and support multi-user access and data sharing. Similar to all health related statistics for the ministry which is currently collected and disseminated by the SID department, the GIS data can all be deposited in the SID/HMIS unit and shared with all eligible stakeholders. This will ensure that certain key attributes are properly collected on both the spatial and attribute data at all the levels of data collection to facilitate ease of spatial analysis and sharing of the data with other stakeholders.

Implement Data Governance Framework: Establish a comprehensive data governance framework to define data ownership, data quality standards, data sharing protocols, and data access controls. This framework should address privacy and security concerns while promoting data sharing and collaboration among different health programs and departments.

Adopt Open Standards and Interoperability: Encourage the use of open geospatial standards, such as those defined by the Open Geospatial Consortium (OGC), to ensure interoperability between different GIS applications and systems. Implement standardized metadata schemas, data models, and data exchange protocols to facilitate seamless data integration and sharing.

Develop Web-based GIS Platforms: Invest in the development of web-based GIS platforms that provide user-friendly interfaces, allowing stakeholders to access and visualize spatial data through web browsers. These platforms should support data querying, analysis, and reporting functionalities while ensuring data security and privacy.

Capacity Building and Training: Provide training and capacity building programs to enhance the GIS skills of health professionals and data managers. This includes training on data collection, data management, spatial analysis, and the use of GIS platforms. Capacity building initiatives should be tailored to specific user groups and promote the understanding of spatial data in decision-making processes.

Collaboration and Partnerships: Foster collaboration and partnerships between the Ministry of Health, academia, research institutions, and development partners to leverage expertise, resources, and best practices in spatial data infrastructure development. Engage stakeholders in the design and implementation of the SDI to ensure its relevance and sustainability.

Improving the spatial data infrastructure and platforms supporting GIS applications in Eswatini's health sector is crucial for effective decision-making, planning, and monitoring of health programs. By addressing data storage, data sharing mechanisms, and interoperability challenges, Eswatini

can establish a robust SDI that enables seamless integration, analysis, and visualization of spatial data. The recommended actions outlined above will contribute to enhancing the spatial data infrastructure and fostering the use of GIS in the health sector, ultimately improving health outcomes in Eswatini.

4.4 INTEGRATION OF GIS WITH OTHER INFORMATION SYSTEMS

The integration of Geographic Information System (GIS) with other information systems in Eswatini's health sector holds significant potential for improving decision-making, planning, and response to health-related challenges. This section explores the current state of integration, data exchange protocols, and benefits derived from the integration of GIS with other information systems, such as health management information systems (HMIS) and other management systems. Recommendations are provided to enhance the integration and maximize its impact.

Extent of Integration:

In Eswatini's health sector, the integration of GIS with other information systems is still limited. While efforts have been made to develop independent GIS applications, the integration of spatial data with HMIS and other management systems is not yet fully realized. Currently, there is limited interoperability between GIS and these systems, and data exchange protocols are not standardized or widely implemented.

Data Exchange Protocols:

The lack of standardized data exchange protocols poses a significant challenge to the integration of GIS with other information systems. Incompatibilities in data formats, data models, metadata standards, and communication protocols hinder the seamless exchange of information between different systems. As a result, data sharing and integration between GIS, HMIS, and other management systems are often manual, time-consuming, and error-prone.

4.4.1 BENEFITS DERIVED FROM INTEGRATION:

Despite the limited integration, there are potential benefits that can be derived from the integration of GIS with other information systems in Eswatini's health sector. These include:

Enhanced Decision-Making: Integration of GIS with HMIS and other management systems can provide spatial context to health data, enabling better decision-making. Spatial analysis and visualization of data can help identify patterns, trends, and hotspots, facilitating targeted interventions and resource allocation.

Improved Planning and Resource Allocation: Integrating GIS with HMIS and management systems allows for better planning and resource allocation. Spatial data analysis can assist in identifying underserved areas, population densities, and vulnerable populations, guiding the allocation of healthcare resources, infrastructure development, and emergency response planning.

Efficient Disaster Management: GIS integration with disaster management systems enables real-time mapping and monitoring of disasters, such as disease outbreaks or natural calamities. Spatial analysis can support the identification of affected areas, resource mobilization, and evacuation planning, enhancing the effectiveness of disaster response and recovery efforts.

Enhanced Epidemiological Surveillance: Integration of GIS with HMIS can strengthen epidemiological surveillance by incorporating spatial data into disease reporting and monitoring. Mapping disease cases, tracking disease spread, and identifying high-risk areas can aid in early detection, contact tracing, and targeted interventions to control disease outbreaks.

4.4.2 RECOMMENDATIONS TO ENHANCE INTEGRATION:

Standardize Data Exchange Protocols: Develop and implement standardized data exchange protocols, including data formats, metadata standards, and communication protocols, to ensure seamless interoperability between GIS, HMIS, and management systems. Adherence to international geospatial and health data standards, such as those defined by the Open Geospatial Consortium (OGC) and World Health Organization (WHO), should be promoted.

Establish Data Governance Mechanisms: Establish data governance mechanisms to define data ownership, data sharing policies, and data access controls. This will facilitate the secure and controlled exchange of spatial data between different systems while addressing privacy and security concerns.

Invest in Technical Infrastructure: Allocate resources for the development and enhancement of technical infrastructure, including hardware, software, and network capabilities, to facilitate the integration of GIS with other information systems. Ensure that systems have the capacity to handle large volumes of spatial data, support real-time data exchange, and enable efficient data processing and analysis.

Promote Collaboration and Capacity Building: Foster collaboration between stakeholders involved in GIS, HMIS, and management systems. Conduct capacity building activities to enhance the technical skills of professionals working with these systems, promoting cross-disciplinary knowledge exchange and fostering a culture of collaboration and integration.

Pilot Integration Projects: Initiate pilot projects to demonstrate the value and benefits of integrating GIS with HMIS and management systems. These projects can serve as showcases to raise awareness, secure buy-in from stakeholders, and provide practical insights for scaling up integration efforts.

Enhancing the integration of GIS with other information systems, such as HMIS and management systems, is crucial for leveraging the full potential of spatial data in Eswatini's health sector. Standardized data exchange protocols, collaborative efforts, and investment in technical infrastructure are key to achieving seamless interoperability. By promoting integration, Eswatini

can derive numerous benefits, including improved decision-making, enhanced planning, efficient disaster management, and strengthened epidemiological surveillance. The recommended actions outlined above will contribute to maximizing the impact of integration and fostering a more integrated and data-driven approach to health management in Eswatini.

4.5 EVALUATION OF SYSTEM CAPABILITIES, STRENGTHS, AND LIMITATIONS

This section evaluates the capabilities, strengths, and limitations of the existing Geographic Information System (GIS) systems and tools in Eswatini's health sector. The assessment takes into account factors such as performance, scalability, user-friendliness, and technical support. The evaluation aims to identify areas for improvement and inform future system enhancements to ensure the effective utilization of GIS in the health sector.

4.5.1 CAPABILITIES:

The GIS systems and tools, although very limited, in Eswatini's health sector demonstrate several capabilities that contribute to their usefulness in decision-making and planning processes. These include:

Spatial Data Analysis: The GIS systems and tools, especially the ESRI Suite and QGIS, allow for spatial data analysis, enabling the identification of patterns, trends, and relationships in health-related data. This capability supports evidence-based decision-making and resource allocation.

Mapping and Visualization: The systems and tools provide mapping and visualization capabilities, allowing users to create informative maps and visual representations of health data. This facilitates effective communication of spatial information to stakeholders.

Integration with Data Sources: The GIS systems and tools can integrate with various data sources, including health management information systems, demographic data, and environmental data. This capability enables the integration of spatial data with other relevant information, enriching the analysis and decision-making processes.

4.5.2 STRENGTHS:

The existing GIS systems and tools in Eswatini's health sector exhibit several strengths that contribute to their effectiveness. These strengths include:

Local Relevance: Some of the systems and tools have been customized to address specific health challenges and priorities in Eswatini. This localization enhances their applicability and relevance to the local context.

Data Accessibility: The GIS systems and tools provide access to spatial data and information, allowing users to retrieve and analyze data relevant to their needs. This accessibility facilitates evidence-based decision-making and planning.

Collaborative Features: Some GIS systems and tools offer collaborative features, enabling multiple users to work together on spatial analysis, data sharing, and decision-making processes. This promotes teamwork and knowledge exchange among health professionals and stakeholders.

4.5.3 LIMITATIONS:

Despite their capabilities and strengths, the existing GIS systems and tools in Eswatini's health sector have certain limitations that need to be addressed:

Performance and Scalability: Some GIS systems and tools may experience performance issues when dealing with large datasets or complex analyses. Scalability can be a concern, especially if the systems are unable to handle increasing data volumes or user demands.

User-Friendliness: The usability and user-friendliness of some GIS systems and tools may vary. Some systems require technical expertise to operate effectively, limiting their accessibility and usability for non-technical users.

Technical Support: The availability of technical support for GIS systems and tools may vary. Inadequate technical support can hinder the effective utilization of these systems, particularly for troubleshooting issues or implementing system enhancements.

4.5.4 AREAS FOR IMPROVEMENT AND FUTURE ENHANCEMENTS:

Based on the evaluation, several areas for improvement and future enhancements can be identified:

Performance Optimization: Enhance the performance and scalability of GIS systems and tools to handle large datasets and complex analyses. This can involve optimizing data storage and retrieval processes, improving computational efficiency, and adopting scalable infrastructure solutions.

User-Friendly Interfaces: Focus on improving the user-friendliness of GIS systems and tools to make them accessible to a wider range of users. This may involve developing intuitive interfaces, providing comprehensive user documentation and training, and incorporating user feedback into system design and updates.

Technical Support and Training: Strengthen technical support services for GIS systems and tools, ensuring timely assistance for users and addressing technical issues. Additionally, invest in capacity building and training programs to enhance the GIS skills of health professionals, enabling them to effectively utilize the systems and tools.

Enhanced Integration Capabilities: Foster improved integration capabilities of GIS systems and tools, allowing seamless integration with other health information systems, such as health management information systems and electronic health records. This integration will facilitate comprehensive data analysis and decision-making processes.

Standardization and Interoperability: Promote the adoption of standardized data formats, metadata schemas, and communication protocols to enhance interoperability between GIS systems and tools. This will enable data sharing, integration, and collaboration across different platforms and systems.

The evaluation of the existing GIS systems and tools in Eswatini's health sector highlights their capabilities, strengths, and limitations. To enhance their effectiveness, it is essential to address areas for improvement, such as performance optimization, user-friendliness, technical support, and integration capabilities. By implementing future enhancements based on these recommendations, Eswatini can maximize the potential of GIS in the health sector, supporting informed decision-making, planning, and response to health challenges.

4.6 SUMMARY OF CHALLENGES

The challenges in the use of GIS in Eswatini's health sector, derived from a survey questionnaire, can be summarized as follows:

- **Knowledge/Skills:** There is a need for improved knowledge and skills in performing geospatial analysis within the health sector.
- **Licensing and incomplete datasets:** Challenges related to licensing and the availability of incomplete datasets hinder the effective use of GIS in the health sector.
- **Execution of GIS data estimates on maps:** Difficulties are encountered in executing GIS data estimates on maps, which may impact the accuracy and reliability of the results.
- **Insufficient capacity:** The survey identified insufficient capacity in terms of resources, infrastructure, and expertise to fully utilize GIS in the health sector.
- **On-site GIS support:** The absence of on-site GIS support poses challenges in terms of troubleshooting and technical assistance.
- **Lack of dedicated machine and upgraded GIS software:** The absence of a dedicated machine for GIS work and outdated GIS software hinder the implementation of GIS activities. Additionally, professionals expressed a need for comprehensive training.
- **Availability of updated GIS data/shapefiles:** The availability of updated GIS data and shapefiles is a challenge, potentially limiting the accuracy and timeliness of geospatial analyses.
- **Poor network:** Issues with the network infrastructure can affect the performance and accessibility of GIS applications and data.
- **Maintenance license payment:** Difficulties in paying for maintenance licenses may impact the continuity and support of GIS software.
- **Limited availability of well-maintained and accessible datasets:** The limited availability of well-maintained and easily accessible datasets hampers the ease of conducting GIS work in the country.

- **Limited support for GIS capacity-building:** There is a lack of support for GIS capacity-building opportunities, hindering the development of skills and expertise in the use of GIS within the health sector.
- **Staff shortage:** The survey indicates a shortage of staff with GIS knowledge and skills in the health sector.

These challenges in Eswatini's health sector highlight the need for addressing knowledge gaps, improving access to complete and updated datasets, enhancing technical infrastructure, providing training opportunities, and ensuring adequate support and resources for GIS implementation. By addressing these challenges, the health sector can leverage GIS effectively for improved planning, decision-making, and resource allocation.

CHAPTER 5: RAPID ASSESSMENT OF KEY STAFF CAPACITY

5.1 EVALUATION OF DATA LITERACY AND DIGITAL LITERACY SKILLS OF KEY STAFF

This section evaluates the data literacy and digital literacy skills of key staff involved in GIS activities. The findings provide insights into the current level of competence in these areas and identify areas where improvement or training may be required.

The survey was designed to gather self-assessment data from the staff regarding their skills and knowledge related to GIS software, data analysis, and interpretation. The survey also included open-ended questions where participants could provide additional comments or feedback.

5.1.1 PROFICIENCY IN GIS SOFTWARE

The survey results indicated a low level of proficiency in using GIS software among the health sector staff. Many participants rated their skills as basic or below average. Common challenges reported included difficulty in navigating the software interface, limited knowledge of advanced tools and functionalities, and struggles with managing and manipulating geospatial data effectively.

The findings indicate a general low level of proficiency in the use of the various GIS tools currently being used by the various departments within the Ministry of Health. Overall, the findings highlight the varying levels of proficiency in using different software tools. Some tools, like data collection tools and database management systems, are commonly used with different proficiency levels. However, tools such as DHIS2 and GeoDa appear to have a higher concentration of users at the novice level, indicating they might be less prevalent. The distribution of proficiency levels for other tools, such as Google Earth, Power BI, QGIS, Tableau, and ArcGIS, is relatively more balanced.

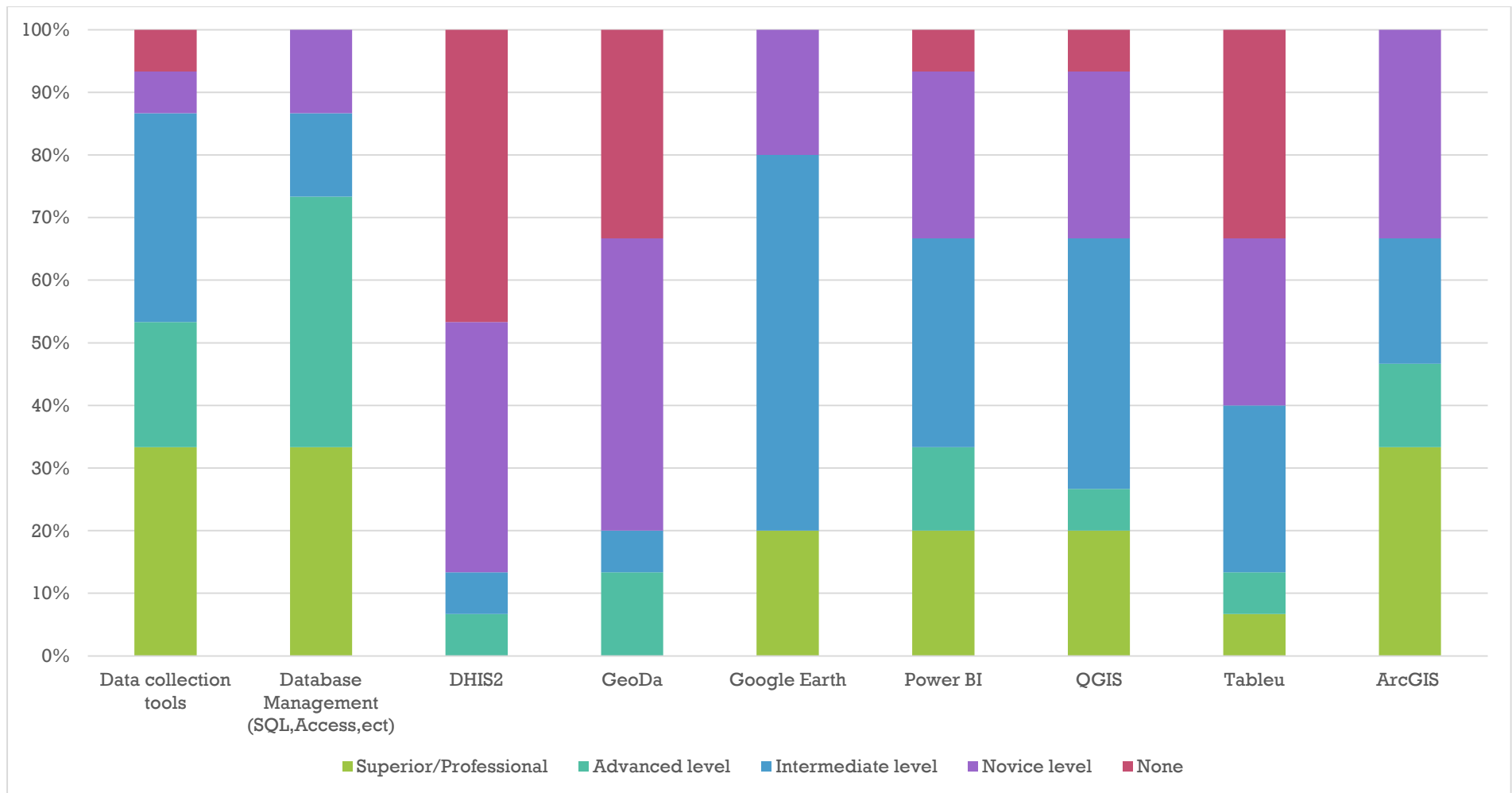


Figure 6: Competency levels in the use of various GIS tools within Eswatini's health sector.

5.1.2 DATA ANALYSIS SKILLS

The data analysis skills of the staff were found to be lacking in proficiency according to the survey results. A significant portion of the participants rated their skills as low or needing improvement. From the analysis, it was evident that most of the sector users are limited to the ability to produce basic thematic maps and some spatial analysis. Challenges reported included limited knowledge of data manipulation techniques, inadequate understanding of statistical methods and advanced machine learning techniques, and difficulties in drawing meaningful conclusions from geospatial data.

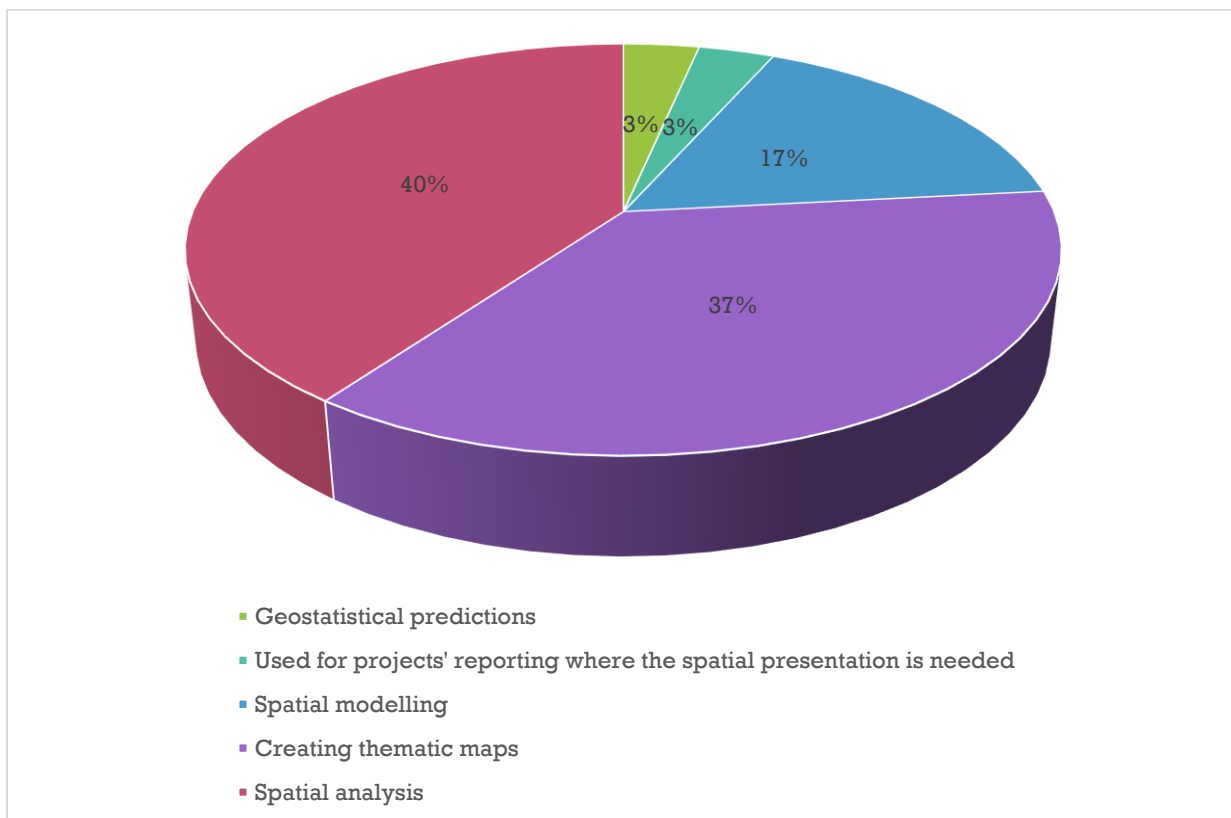


Figure 7: Current data skills among health sector GIS professionals.

5.1.3 INTERPRETATION OF GEOSPATIAL DATA:

The survey results revealed a low level of proficiency in the interpretation of geospatial data among the staff. Many participants rated their skills as basic or needing improvement. Challenges reported included difficulties in recognizing patterns and trends, limited understanding of spatial relationships, and struggles in providing meaningful interpretations and conclusions based on the geospatial data.

The survey results indicate a low level of proficiency in using GIS software, data analysis, and interpretation among the key staff involved in GIS activities. The staff reported challenges in

navigating GIS software interfaces, manipulating and cleaning data, applying statistical methods, and drawing meaningful conclusions from geospatial data.

These findings highlight the need for targeted training and development programs to enhance the data literacy and digital literacy skills of the staff. It is crucial to provide comprehensive training on GIS software, including basic and advanced functionalities, as well as data analysis techniques and interpretation methods. Additionally, hands-on exercises, workshops, and practical projects can be implemented to improve the staff's skills and confidence in applying GIS tools and techniques.

By addressing the identified areas of low proficiency, the organization can empower its staff to effectively utilize GIS software, conduct data analysis, and interpret geospatial data. This will contribute to enhancing the success of GIS activities and enable the staff to make more informed decisions based on reliable geospatial information.

5.2 IDENTIFICATION OF GIS TRAINING PROGRAMS AND INITIATIVES

The study also identified existing GIS training programs and initiatives available for health sector staff. Two thirds of the GIS professionals surveyed indicated that they have undertaken some GIS training. Notably, a majority (53%) of the members of the GIS cadre surveyed only possess certificates and diplomas. It includes both internal and external training opportunities, such as workshops, online courses, and certification programs. Recommendations are provided to address training gaps and enhance staff capacity.

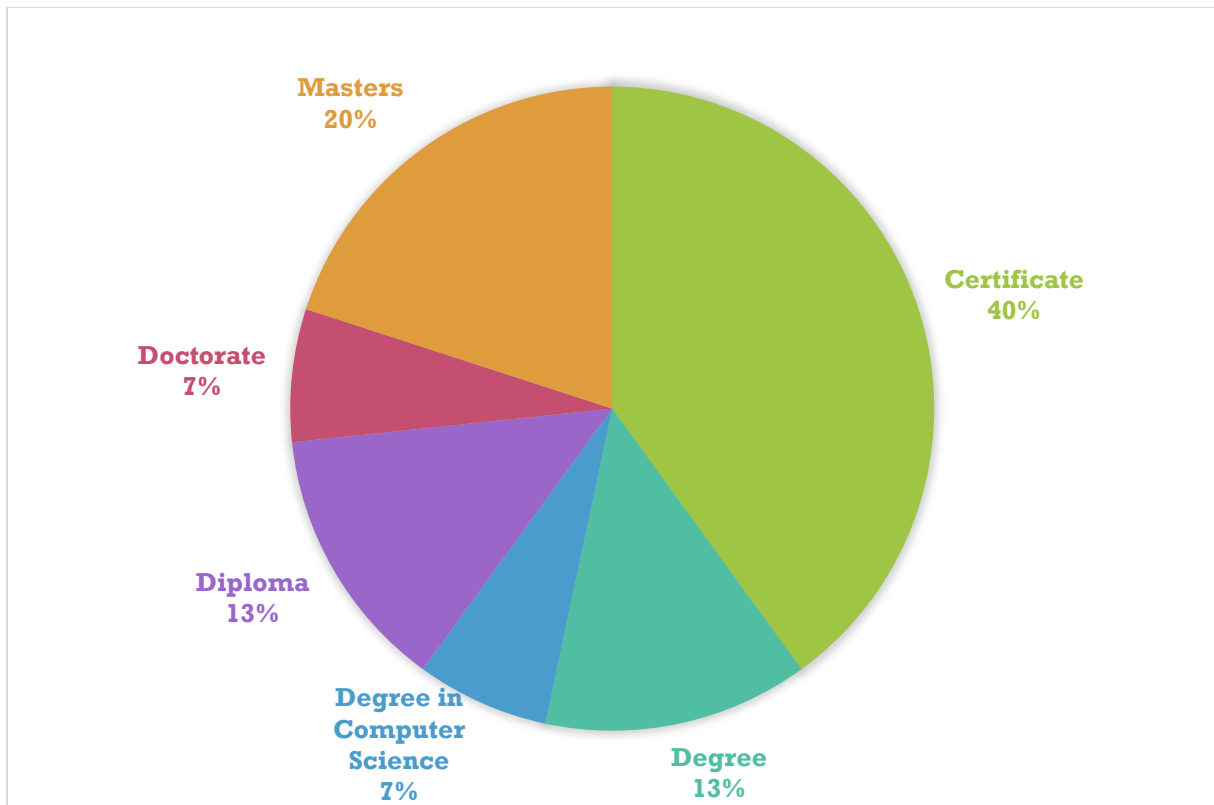


Figure 8: Highest qualifications of Eswatini's health sector GIS professionals⁴.

The results of GIS-related training needs, as identified by health sector GIS professionals in Eswatini, can be summarized as follows:

GIS Training: Six respondents reported not having received any GIS training, while eight respondents considered GIS training to be highly relevant, and one respondent found it to be relevant.

Database and System Management: Six respondents reported not having received any training in database and system management. Five respondents considered it to be highly relevant, while one respondent did not find it relevant.

Data Analysis (Advanced Excel and Power BI): Six respondents reported not having received any training in data analysis using advanced Excel and Power BI. Seven respondents found it to be highly relevant, and two respondents found it relevant.

⁴ This chart includes all GIS users in all the stakeholders consulted, including MoH, the implementing partners, other government departments (CSO, SGO) and the international organisations such as WHO, UNICEF, etc. This must not, therefore, be interpreted as showing a certain capacity within the MoH where only 3 departments are using GIS.

Data collection and data management: Six respondents reported not having received any training in data collection and data management. One respondent found it relevant, while eight respondents considered it to be highly relevant.

Global health care systems: Six respondents reported not having received any training in global health care systems. Six respondents found it to be highly relevant, one respondent did not find it relevant, and two respondents found it relevant.

Public health: Six respondents reported not having received any training in public health. Six respondents considered it to be highly relevant, one respondent did not find it relevant, and two respondents found it relevant.

Water and sanitation: Six respondents reported not having received any training in water and sanitation. Three respondents found it to be highly relevant, one respondent did not find it relevant, and five respondents found it relevant.

These results indicate a consistent need for training across various GIS-related skills within the health sector in Eswatini. GIS training, data analysis, data collection and management, and knowledge in specific areas such as global health care systems, public health, and water and sanitation are all identified as relevant or highly relevant by the respondents. The findings highlight the importance of providing comprehensive training programs to enhance GIS skills and knowledge in the health sector, enabling better data management, analysis, and decision-making processes.

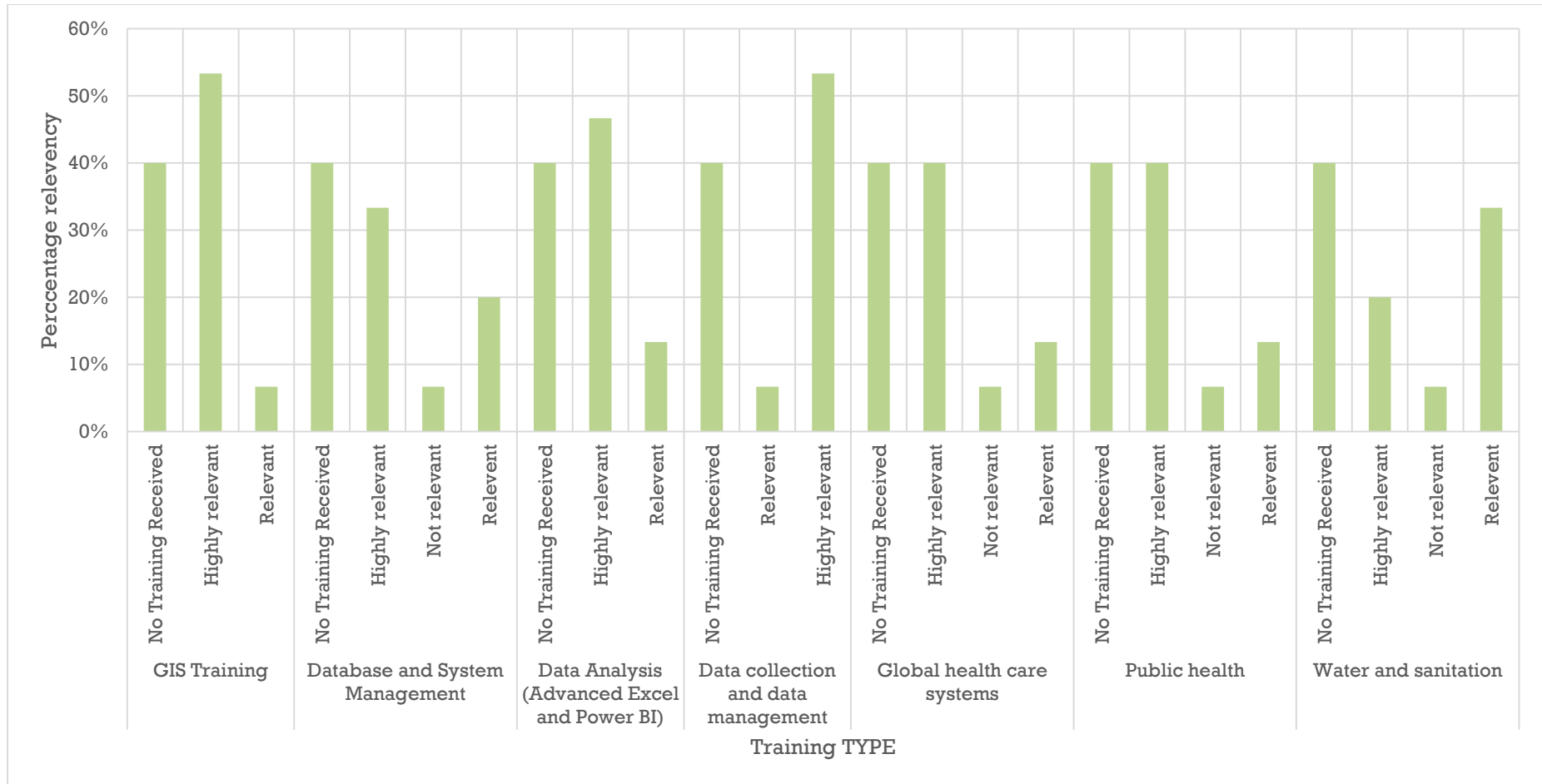


Figure 9: Current training received by various departments/programmes within the Ministry of Health.

The following training programs were identified for meeting current and future training needs within the health sector.

Internal Training Programs:

Ministry of Health (MOH) Training Programs: The MOH occasionally but rarely conducts GIS training programs for its staff. These programs cover various aspects of GIS applications in public health, including data collection, mapping, spatial analysis, and decision-making.

National Emergency Response Council on HIV and AIDS (NERCHA): NERCHA, in collaboration with the MOH, offers GIS training programs focused on HIV and AIDS prevention, treatment, and care. These trainings equip health sector staff with GIS skills to analyze and map HIV prevalence, identify high-risk areas, and plan targeted interventions.

Other implementing partners such as ICAP also provide occasional training for their staff on GIS. These, together with the training offered by the Ministry of Health, are mainly basic training offering without much advanced spatial data analytics.

External Training Opportunities:

ESRI Training: ESRI, a leading GIS software provider, offers a range of training programs and courses. The ESRI Virtual Campus provides online courses covering various GIS topics, including data management, spatial analysis, and mapping. These courses are self-paced and can be accessed remotely. Such training is also available locally through companies such as Datamatics Eswatini and ESRI South Africa as well as the University of Eswatini.

Coursera: Coursera, an online learning platform, offers a wide range of GIS courses from reputable institutions and universities. Health sector staff can access courses such as "Introduction to GIS" and "Spatial Data Science and Applications" to enhance their GIS skills. Coursera courses provide certificates upon completion.

Geospatial Training Services: Geospatial Training Services offers instructor-led online courses specifically focused on GIS for health applications. These courses cover topics such as health facility mapping, disease surveillance, and spatial epidemiology.

University of Eswatini (UNESWA): UNESWA offers undergraduate and postgraduate courses in GIS and related subjects. Recently, UNESWA introduced a 4-year undergraduate course in Geographic Information Science (GISc) which is targeted at various sectors in Eswatini. Such programmes offer an opportunity for the health sector to train their staff in some of the training needs identified in this document (see section below).

5.3 GAPS IN CAPACITY AND TRAINING NEEDS

This subsection highlights the gaps and training needs identified during the rapid assessment. It examines areas where staff require further training or skill development to effectively utilize GIS in the health sector. The identified gaps inform recommendations for capacity building. Based on the rapid assessment, the following gaps and training needs were identified among Eswatini's health sector staff:

Fundamental GIS Concepts and Skills: Many health sector staff members lack a solid foundation in GIS concepts and skills. There is a need for training programs that provide a comprehensive understanding of GIS fundamentals, including spatial data, coordinate systems, data formats, and basic mapping principles.

Data Collection and Management: Health sector staff require training in efficient data collection methods and data management practices. This includes skills in data cleaning, data validation, database management, and integration of different data sources into GIS platforms.

Spatial Analysis and Visualization Techniques: Staff members need training in advanced spatial analysis techniques to analyze health-related data effectively. This includes skills in artificial intelligence applications, hotspot analysis, spatial interpolation, proximity analysis, and spatial overlay operations. Training should focus on applying these techniques to priority public health challenges and decision-making.

Health Sector-specific Applications: There is a need to provide training on GIS applications specific to the health sector. This includes mapping health facilities, disease surveillance, resource allocation, spatial epidemiology, and identifying high-risk areas for targeted interventions. Staff members should be trained on how to utilize GIS tools and techniques to address public health challenges effectively.

Spatial Epidemiology: Training in spatial epidemiology will enable staff to understand the relationship between health outcomes and geographic factors. Topics to cover may include disease mapping techniques, spatial clustering analysis, spatial autocorrelation, and spatial regression modeling. This training will empower staff to conduct spatially informed epidemiological studies and support evidence-based interventions.

Interdisciplinary Collaboration: Training programs should emphasize the importance of interdisciplinary collaboration between GIS professionals and healthcare practitioners. Staff should be trained on effective communication, collaboration, and the integration of GIS into the broader health planning and decision-making processes. This training will promote cross-sectoral collaboration and ensure that GIS is effectively utilized to address health challenges.

GIS Software Proficiency: Health sector staff require training in specific GIS software applications, such as ESRI ArcGIS or QGIS, to effectively utilize GIS tools and functionalities. Training should

cover basic to advanced software operations, including data manipulation, geoprocessing, map production, and spatial analysis using GIS software.

Interpretation of Spatial Data: Staff members need training in interpreting and analyzing spatial data and maps. This includes understanding key spatial patterns, interpreting thematic maps, identifying spatial relationships, and effectively communicating spatial information to stakeholders.

Integration of GIS with Health Information Systems: Training is required to enhance staff capacity in integrating GIS with existing health information systems. This includes understanding interoperability, data sharing protocols, and utilizing GIS outputs to enhance data-driven decision-making in the health sector.

Below is an elaboration on the gaps and training needs focusing on areas where staff requires further training or skill development to effectively utilize GIS in various departments of the Ministry of Health. Special attention is given to reaching zero-dose communities in Eswatini.

Strategic Information Department (SID):

Gaps: The SID requires training in GIS data collection methodologies, spatial analysis techniques, and data visualization to effectively analyze and present health-related information.

Training Needs: Training on GIS data collection tools, spatial analysis software, and data visualization techniques would enhance the department's capacity to generate spatially informed strategic information.

Expanded Programme on Immunization (EPI):

Gaps: The EPI has limited expertise in GIS for planning and monitoring immunization coverage, identifying underserved areas, and targeting interventions.

Training Needs: Training on GIS applications for immunization planning, spatial analysis of coverage data, hotspot identification, and mapping of zero-dose communities would enable the EPI to optimize their immunization programs.

School Health Programme:

Gaps: The School Health Programme lacks GIS knowledge and skills required for mapping and monitoring health conditions in schools, identifying health risks, and planning interventions.

Training Needs: GIS training focusing on school health data mapping, spatial analysis of health risks, and spatial planning for health services in schools would enhance the capacity of the School Health Programme.

Health Promotion Department:

Gaps: The Health Promotion Department requires GIS training to effectively target health promotion campaigns, identify priority areas for health education, and evaluate the impact of interventions.

Training Needs: GIS training on spatial analysis for health promotion, mapping of health-related behaviors, and spatial targeting of health education campaigns would support the department in their efforts.

National Malaria Control:

Gaps: Although the National Malaria Control Program has been using GIS for two decades, it still requires additional GIS skills for malaria surveillance, mapping of malaria cases, vector control planning, and monitoring the effectiveness of interventions.

Training Needs: GIS training focusing on malaria surveillance techniques, spatial analysis of malaria data, hotspot identification, and mapping of vector breeding sites would strengthen the capacity of the program.

Epidemiology Programme:

Gaps: The Epidemiology Programme may benefit from GIS training to enhance disease surveillance, spatial analysis of disease patterns, outbreak mapping, and identifying high-risk areas.

Training Needs: Training on GIS for epidemiological surveillance, spatial analysis of disease data, mapping disease outbreaks, and hotspot identification would empower the Epidemiology Programme to better understand disease dynamics.

Emergency Preparedness and Response (EPR):

Gaps: The EPR department requires GIS skills for emergency planning, spatial analysis of risks, real-time mapping of emergency incidents, and resource allocation.

Training Needs: GIS training focusing on emergency planning, spatial analysis of risk factors, real-time incident mapping, and resource allocation would enhance the department's ability to respond effectively to health emergencies.

Environmental Health Services:

Gaps: The Environmental Health Services department lacks GIS knowledge and skills required for mapping environmental health risks, spatial analysis of health hazards, and planning interventions.

Training Needs: GIS training on environmental health mapping, spatial analysis of health hazards, and spatial planning for environmental health interventions would enable the department to better address environmental health challenges.

Planning Department:

Gaps: The Planning Department requires GIS skills for spatial planning of health infrastructure, resource allocation, and analyzing the impact of health interventions.

Training Needs: Training on GIS for health infrastructure planning, spatial analysis of resource allocation, and impact assessment of health interventions would support evidence-based planning within the department.

National AIDS Program:

Gaps: The National AIDS Program requires GIS training to analyze HIV/AIDS prevalence, identify high-risk areas, target prevention and treatment interventions, and assess the impact of programs.

Training Needs: GIS training focusing on spatial analysis of HIV/AIDS data, hotspot identification, mapping of service coverage, and impact assessment would enhance the program's ability to address HIV/AIDS effectively.

National TB Control Program:

Gaps: The National TB Control Program needs GIS skills for mapping TB cases, identifying high-burden areas, planning interventions, and monitoring treatment outcomes.

Training Needs: Training on GIS for TB case mapping, spatial analysis of TB prevalence, hotspot identification, and monitoring treatment outcomes would strengthen the program's capacity to combat tuberculosis.

Quality Assurance Services:

Gaps: The Quality Assurance Services department requires GIS knowledge and skills to assess the accessibility and quality of healthcare services, identify gaps, and monitor service delivery.

Training Needs: GIS training on spatial analysis for healthcare service assessment, mapping of service coverage and quality indicators, and monitoring service delivery would enable the department to ensure quality healthcare provision.

5.3.1 GIS SKILLS GAPS FOR REACHING ZERO-DOSE COMMUNITIES

This section elaborates on the gaps and training needs identified during the rapid Geographic Information System (GIS) needs assessment for the health sector in Eswatini, with a specific focus on reaching zero-dose communities. It examines areas where staff requires further training or skill development to effectively utilize GIS in identifying and targeting these communities for immunization efforts.

Limited Spatial Analysis Skills: The assessment revealed a gap in the spatial analysis skills required to identify and map zero-dose communities accurately. Staff lack proficiency in using GIS tools and techniques to analyze immunization coverage data, identify underserved areas, and prioritize interventions.

Inadequate Data Collection Strategies: The assessment identified a need for improved data collection strategies to capture information on zero-dose communities. Staff lack knowledge of spatial data collection methodologies, hindering the accurate identification and mapping of these communities.

Insufficient Targeting of Interventions: The assessment highlighted the need for better targeting of interventions to reach zero-dose communities. Staff require training in utilizing GIS to identify high-risk areas, determine the demographic characteristics of zero-dose communities, and design targeted interventions accordingly.

5.3.2 TRAINING PRIORITIES FOR REACHING ZERO-DOSE COMMUNITIES

GIS Data Collection Methods: Staff should receive training on effective GIS data collection methods, including the use of mobile data collection tools, geospatial surveys, and the integration of data from different sources. This training would enhance the accuracy and completeness of data collected on zero-dose communities.

Spatial Analysis Techniques: Training in spatial analysis techniques is crucial for staff to identify and map zero-dose communities accurately. This training should include methods for analyzing immunization coverage data, identifying spatial patterns and disparities, and generating hotspot maps to prioritize interventions.

Data Visualization and Communication: Staff should be trained in data visualization techniques to effectively communicate information regarding zero-dose communities to stakeholders. This includes creating informative maps, charts, and graphs that facilitate a better understanding of the spatial distribution of immunization gaps.

Targeted Intervention Planning: Training should focus on utilizing GIS for targeted intervention planning to reach zero-dose communities. Staff should learn how to integrate demographic, socioeconomic, and health data to identify communities at higher risk of being zero-dose, enabling the design of tailored strategies for immunization outreach.

Collaboration and Knowledge Sharing: Training should emphasize collaboration and knowledge sharing among staff working on reaching zero-dose communities. This includes sharing best practices, case studies, and lessons learned to enhance the effectiveness of GIS-based approaches in immunization programs.

Monitoring and Evaluation: Staff should receive training on using GIS for monitoring and evaluating interventions aimed at reaching zero-dose communities. This includes tracking progress, assessing the impact of interventions, and making data-driven adjustments to improve immunization coverage.

The rapid GIS needs assessment in Eswatini's health sector identified several gaps and training needs concerning reaching zero-dose communities. The training requirements include GIS data collection methods, spatial analysis techniques, data visualization, targeted intervention planning, collaboration, and monitoring and evaluation. By addressing these gaps and providing the necessary training, staff in Eswatini's health sector can enhance their to effectively utilize GIS for planning, monitoring, and targeting health interventions, leading to improved health outcomes and service delivery. This also include identifying, mapping, and targeting zero-dose communities. This, in turn, will contribute to improved service delivery and health outcomes in Eswatini.

5.4 RECOMMENDATIONS FOR CAPACITY BUILDING AND SKILL DEVELOPMENT

Based on the assessment of staff capacity and training needs in the use of Geographic Information Systems (GIS) in Eswatini's health sector, this section provides detailed recommendations for capacity building and skill development initiatives. These recommendations aim to enhance GIS competencies among health sector staff, including suggestions for training programs, mentorship, and knowledge exchange.

Training Programs:

- Develop comprehensive GIS training programs tailored to the specific needs of each department within the Ministry of Health. These programs should cover both foundational and advanced GIS concepts and techniques.
- Include practical, hands-on exercises and case studies that allow staff to apply GIS skills to real-world health sector scenarios. This will enhance their understanding and proficiency in GIS applications.
- Provide training on GIS data collection methods, spatial analysis techniques, data visualization, and targeted intervention planning to address the identified gaps and training needs.
- Collaborate with local and international GIS experts or training institutions to deliver specialized GIS training programs for health sector staff.

Mentorship and Coaching:

- Establish a mentorship program where experienced GIS professionals provide guidance and support to health sector staff. This mentorship can help staff apply GIS skills in their day-to-day work and address specific challenges they encounter.

- Encourage regular interaction between mentors and mentees through one-on-one meetings, workshops, or online platforms to foster knowledge sharing and skill development.
- Pair staff members with mentors who have expertise in their respective departments or areas of interest, ensuring relevant and targeted support.

Knowledge Exchange and Collaboration:

- Facilitate regular knowledge exchange sessions, seminars, or workshops where health sector staff can share their GIS experiences, best practices, and lessons learned.
- Encourage cross-departmental collaboration and learning by organizing joint training sessions or projects that involve staff from different departments. This will promote a multidisciplinary approach to GIS utilization in the health sector.
- Foster partnerships with academic institutions, research organizations, and other relevant stakeholders to leverage their expertise in GIS and promote knowledge exchange.

Online Resources and Learning Platforms:

- Develop an online repository of GIS resources, including tutorials, manuals, video lectures, and case studies. These resources should be easily accessible to health sector staff and serve as self-paced learning materials.
- Explore the use of online learning platforms or Massive Open Online Courses (MOOCs) focused on GIS for health applications. These platforms can provide staff with flexible and interactive learning opportunities.

The table below shows examples of training initiatives that can be conducted for the key health programmes.

Table 5: Examples of recommended training initiatives by health programme.

Department	Recommended Training Initiatives
Strategic Information Department (SID)	1. GIS data collection methodologies 2. Spatial analysis techniques 3. Data visualization and reporting
Expanded Programme on Immunization (EPI)	1. GIS for immunization planning and monitoring 2. Spatial analysis of coverage data 3. Hotspot identification and mapping of zero-dose communities
School Health Programme	1. GIS for health mapping in schools 2. Spatial analysis of health risks in schools

	3. Planning interventions for school health services
Health Promotion Department	<ol style="list-style-type: none"> 1. GIS for targeted health promotion campaigns 2. Spatial analysis of health-related behaviors 3. Mapping health education coverage in priority areas
National Malaria Control	<ol style="list-style-type: none"> 1. GIS for malaria surveillance and mapping 2. Spatial analysis of malaria cases and vector control planning 3. Monitoring the effectiveness of malaria interventions
Epidemiology Programme	<ol style="list-style-type: none"> 1. GIS for disease surveillance and outbreak mapping 2. Spatial analysis of disease patterns 3. Hotspot identification and targeting high-risk areas for intervention
Emergency Preparedness and Response (EPR)	<ol style="list-style-type: none"> 1. GIS for emergency planning and resource allocation 2. Real-time incident mapping and spatial analysis of risks 3. Monitoring and evaluation of emergency response interventions
Environmental Health Services	<ol style="list-style-type: none"> 1. GIS for mapping environmental health risks 2. Spatial analysis of health hazards 3. Planning interventions for environmental health services
Planning Department	<ol style="list-style-type: none"> 1. GIS for spatial planning of health infrastructure 2. Spatial analysis of resource allocation and impact assessment 3. Monitoring and evaluation of health interventions based on spatial data
National AIDS Program	<ol style="list-style-type: none"> 1. GIS for HIV/AIDS prevalence mapping 2. Spatial analysis of high-risk areas 3. Targeted planning and evaluation of prevention and treatment interventions
National TB Control Program	<ol style="list-style-type: none"> 1. GIS for mapping TB cases and high-burden areas 2. Spatial analysis of TB transmission patterns 3. Targeted planning of prevention and treatment interventions

NB: The above table provides an example of recommended training initiatives for each department. The actual initiatives should be tailored based on the specific needs and priorities identified within each department.

The following additional recommendations are made to address the identified gaps and enhance staff capacity in GIS within Eswatini's health sector:

Offer Blended Training Approaches: Combine traditional workshops with online courses to provide a blended learning approach. This approach allows flexibility for staff members to learn at their own pace, access training materials remotely, and participate in interactive workshops to reinforce their skills.

Provide Hands-on Practical Training: Emphasize hands-on practical training sessions where staff members can apply GIS skills to real-world health sector scenarios. This approach will enhance their understanding of GIS applications and build confidence in utilizing GIS tools and techniques.

Collaborate with GIS Experts and Institutions: Collaborate with GIS experts, universities, and research institutions to provide specialized training modules and guest lectures. These collaborations can bring in-depth expertise and diverse perspectives to the training programs.

Utilize Online Training Platforms: Leverage online training platforms, such as ESRI Virtual Campus and other reputable online learning platforms, to provide flexible and self-paced training opportunities. Online courses can supplement in-person training sessions and enable staff members to access training materials at their convenience.

Establish a GIS User Group: Create a GIS user group within the health sector to foster knowledge sharing, collaboration, and continuous learning. The user group can organize regular meetings, workshops, and knowledge exchange sessions to support ongoing skill development and address emerging GIS challenges.

Promote Mentorship and Peer Learning: Encourage experienced GIS practitioners within the health sector to mentor and support colleagues in developing GIS skills. Establish peer learning networks where staff members can share experiences, seek guidance, and learn from each other's practical applications of GIS in the health sector.

Promote Continuous Learning: Encourage health sector staff to engage in continuous learning by providing incentives, such as educational scholarships, study leave, and access to online learning platforms. Foster a culture of lifelong learning and professional development within the health sector.

Monitor and Evaluate Training Outcomes: Regularly monitor and evaluate the outcomes of the GIS training programs to assess their effectiveness in enhancing staff capacity. Collect feedback from participants and track the application of GIS skills in real-world health sector projects to measure the impact of the training.

Establish a GIS Certification Program: Develop a GIS certification program specifically tailored to the needs of the health sector in Eswatini. This program should provide standardized training and assessment, leading to recognized certifications that validate the GIS skills of health sector staff.

To enhance GIS competencies among health sector staff in Eswatini, it is recommended to implement comprehensive training programs, mentorship initiatives, and knowledge exchange platforms. These recommendations aim to address the identified gaps and training needs, ensuring that staff can effectively utilize GIS in reaching zero-dose communities. By investing in capacity building and skill development, Eswatini's health sector can leverage GIS to improve immunization coverage and ultimately contribute to better health outcomes for the population.

5.5 RECOMMENDED RESEARCH AREAS

In order to maximize the benefits of GIS in Eswatini's health sector, it is important to identify priority research areas that can inform evidence-based decision-making and improve health outcomes. This section provides detailed recommendations for priority research areas, focusing on key health programs, where GIS can be effectively utilized to address critical challenges and gaps.

5.5.1 EXPANDED PROGRAMME ON IMMUNIZATION (EPI):

- **Spatial analysis of immunization coverage:** Conduct research to analyze the spatial patterns of immunization coverage across different regions and identify areas with low coverage. This can help target interventions and resources to improve immunization rates in underserved communities.
- **Accessibility and proximity analysis:** Investigate the accessibility of immunization services by analyzing travel time and distance to immunization facilities. This research can identify underserved areas and inform the establishment of new immunization sites or mobile clinics to improve accessibility.
- **Hotspot analysis of vaccine-preventable diseases:** Use GIS to identify hotspots or clusters of vaccine-preventable diseases, such as measles or pertussis. This research can help understand the spatial dynamics of disease transmission and guide targeted vaccination campaigns.

5.5.2 MALARIA CONTROL:

- **Spatial analysis of malaria incidence and risk factors:** Conduct research to map and analyze the spatial distribution of malaria cases and identify environmental or socio-economic risk factors associated with high transmission areas. This can inform targeted interventions, such as vector control measures or distribution of bed nets, in areas with the highest burden of malaria.
- **Modeling the impact of climate change on malaria transmission:** Use GIS and climate data to model the potential impact of climate change on malaria transmission patterns. This

research can help anticipate changes in disease prevalence and guide adaptation strategies for effective malaria control.

- **Accessibility of healthcare facilities for malaria treatment:** Assess the accessibility and proximity of healthcare facilities equipped to diagnose and treat malaria. This research can identify areas with limited access to treatment and inform the placement of new facilities or mobile clinics to ensure timely care.

5.5.3 HIV/AIDS PREVENTION AND TREATMENT:

- **Spatial analysis of HIV prevalence and high-risk areas:** Conduct research to map HIV prevalence rates and identify high-risk areas or populations using GIS. This can help target prevention and treatment interventions, such as HIV testing campaigns or the distribution of antiretroviral therapy, to areas with the greatest need.
- **Geospatial analysis of HIV care and treatment cascade:** Investigate the spatial patterns of the HIV care and treatment cascade, including HIV testing, linkage to care, retention in care, and viral suppression rates. This research can identify gaps and barriers along the cascade and guide strategies for improving outcomes at each stage.
- **Accessibility of HIV-related services:** Assess the accessibility of HIV-related services, including testing centers, clinics, and support services, by analyzing travel time and distance. This research can identify areas with limited access to services and inform the placement of new facilities or mobile clinics to improve accessibility.

5.5.4 TUBERCULOSIS (TB) CONTROL:

- **Spatial analysis of TB incidence and treatment outcomes:** Conduct research to map TB incidence rates and treatment outcomes using GIS. This can help identify areas with high TB burden and poor treatment outcomes, guiding targeted interventions to improve detection, treatment adherence, and cure rates.
- **Geospatial analysis of TB transmission patterns:** Investigate the spatial patterns of TB transmission by analyzing contact tracing data and spatial proximity of TB cases. This research can inform strategies for targeted screening, active case finding, and infection control measures to interrupt transmission chains.
- **Accessibility of TB diagnostic and treatment facilities:** Assess the accessibility and proximity of healthcare facilities equipped to diagnose and treat TB. This research can identify areas with limited access to services and inform the placement of new facilities or mobile clinics to ensure early diagnosis and effective treatment.

5.5.5 EMERGENCY PREPAREDNESS AND RESPONSE (EPR):

- **Hazard mapping and vulnerability assessment:** Use GIS to map hazards, such as floods, droughts, or disease outbreaks, and assess the vulnerability of populations and health

facilities. This research can inform emergency preparedness plans and resource allocation strategies to mitigate the impact of disasters.

- **Real-time incident mapping and situational awareness:** Develop research to leverage GIS for real-time incident mapping, tracking the spread of diseases or monitoring the impact of emergencies. This research can enhance situational awareness, facilitate timely response, and support resource mobilization for effective emergency management.
- **Accessibility of emergency healthcare services:** Assess the accessibility and proximity of emergency healthcare services, including hospitals and trauma centers, using GIS. This research can identify areas with limited access to emergency care and inform the placement of new facilities or the optimization of existing ones to ensure timely and life-saving interventions.

The recommended priority research areas for the use of GIS in Eswatini's health sector, focusing on key health programs, provide valuable opportunities to improve evidence-based decision-making and enhance health outcomes. By conducting research in these areas, leveraging GIS technology, and analyzing spatial patterns and relationships, policymakers and health professionals can effectively target interventions, allocate resources, and improve accessibility to healthcare services. These research areas contribute to strengthening immunization programs, malaria control efforts, HIV/AIDS prevention and treatment strategies, tuberculosis control measures, and emergency preparedness and response in Eswatini's health sector. The findings from these research endeavors have the potential to inform evidence-based policies and interventions that can lead to improved health outcomes and better overall health system performance in the country.

5.5.6 TARGETED RESEARCH FOR REACHING ZERO-DOSE COMMUNITIES.

Reaching zero-dose communities, where children have not received any routine immunizations, is a critical challenge in Eswatini's healthcare system. GIS technology offers a valuable toolset for identifying and addressing barriers to immunization coverage. This section suggests key research areas that can leverage GIS to improve immunization outreach efforts and target zero-dose communities in Eswatini.

5.5.6.1 SPATIAL ANALYSIS OF IMMUNIZATION COVERAGE:

- Conduct a comprehensive spatial analysis to assess immunization coverage rates across different regions of Eswatini.
- Utilize GIS to map immunization coverage at the sub-national level, considering factors such as administrative boundaries, population density, and health facility locations.
- Identify spatial patterns and disparities in immunization coverage, particularly in rural and remote areas.

This research can provide insights into areas with low coverage and zero-dose communities, guiding targeted interventions and resource allocation.

5.5.6.2 ACCESSIBILITY AND DISTANCE ANALYSIS:

- Perform an accessibility analysis using GIS to understand the spatial distribution of health facilities providing immunization services in relation to communities.
- Analyze travel time, transportation infrastructure, and road networks to assess the proximity of zero-dose communities to immunization services.
- Identify areas where long travel distances act as barriers to immunization uptake.

This research can guide the establishment of mobile clinics or outreach programs to improve accessibility and reduce geographic disparities in immunization coverage.

5.5.6.3 DEMOGRAPHIC AND SOCIOECONOMIC FACTORS:

- Explore the influence of demographic and socioeconomic factors on immunization coverage in Eswatini.
- Utilize GIS to map population characteristics, such as population density, income levels, education status, and household composition, in relation to immunization rates.
- Identify vulnerable groups or marginalized communities that may have higher concentrations of zero-dose children.

This research can provide insights into the social determinants of immunization coverage and guide targeted interventions and tailored communication strategies.

5.5.6.4 CULTURAL AND BEHAVIORAL FACTORS:

- Investigate the cultural and behavioral factors influencing immunization acceptance and utilization in Eswatini.
- Utilize GIS to understand spatial variations in cultural practices, beliefs, and community norms that impact immunization decisions.
- Identify areas with low acceptance rates due to cultural or religious reasons.

This research can guide the development of culturally sensitive communication campaigns and community engagement strategies, fostering trust and addressing misconceptions surrounding immunization.

5.5.6.5 COLD CHAIN INFRASTRUCTURE AND SUPPLY CHAINS:

- Assess the effectiveness of the immunization cold chain infrastructure and supply chains in Eswatini using GIS.
- Analyze the spatial distribution of vaccine storage facilities, transportation routes, and logistical challenges.
- Identify areas where the cold chain is compromised, leading to suboptimal vaccine delivery and potential zero-dose communities.

This research can inform improvements in cold chain management, supply chain optimization, and the identification of areas requiring infrastructure investments to ensure the timely and reliable delivery of vaccines.

5.5.6.6 GIS-BASED IMMUNIZATION OUTREACH PLANNING:

- Develop GIS-based models for optimizing immunization outreach planning in Eswatini. Consider factors such as population density, travel time, health facility locations, and community engagement data.
- Utilize GIS tools to identify optimal locations for mobile clinics or temporary immunization centers, taking into account the specific geographic and demographic characteristics of different regions.

This research can enhance the efficiency and effectiveness of immunization outreach activities, ensuring that zero-dose communities are reached more effectively.

Leveraging GIS for research in reaching zero-dose communities in Eswatini holds great potential for strengthening immunization programs. By utilizing spatial analysis, accessibility assessments, demographic insights, cultural understanding, and supply chain optimization, GIS can inform evidence-based strategies for improving immunization coverage and reaching underserved populations. These key research areas, tailored to Eswatini's context, can guide future studies and interventions, contributing to the goal of achieving higher immunization rates and ensuring that no child in Eswatini remains unvaccinated.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY OF FINDINGS FROM THE GIS LANDSCAPE ANALYSIS

This section summarizes the key findings from the GIS landscape analysis conducted in this report. It highlights the main insights regarding data sources, stakeholder engagement, system infrastructure, and staff capacity in the health sector.

An assessment of the geospatial data already available in Eswatini is crucial for optimizing its utilization. The following data sources were considered:

Surveyor-General's Office: The national mapping agency provides foundational geospatial data, including administrative boundaries, transportation networks, and topographic information. Collaboration with the national mapping agency can ensure access to accurate and up-to-date base maps.

Health Information Systems: Existing health information systems, such as electronic medical records and disease surveillance systems, may already capture geospatial data. Integrating and analyzing this data can provide valuable insights into health trends and service utilization patterns.

Remote Sensing and Satellite Imagery: Remote sensing data, including satellite imagery and aerial photographs (digital orthophotos), can provide information on land cover, vegetation, and environmental changes. Partnerships with the Surveyor-General's Office and other international remote sensing institutions can facilitate access to such data for analysis and monitoring purposes.

Mobile Data Collection: Mobile data collection tools, such as smartphones and tablets, can capture geospatial data during surveys and field visits. Eswatini can leverage these tools to collect data on immunization coverage, service availability, and other relevant indicators.

Data maintenance and updates should be a priority to ensure the accuracy and timeliness of geospatial information. Establishing data sharing agreements, data governance frameworks, and mechanisms for regular data updates will contribute to maintaining the quality of geospatial data.

In conclusion, improving the utilization of GIS in Eswatini has the potential to enhance decision-making processes, address health inequalities, and ensure that no child is left behind. UNICEF Eswatini can make a strong case for additional funding to support the roll out of GIS within Eswatini's health sector.

6.2 KEY CHALLENGES AND OPPORTUNITIES IN ESWATINI'S GIS DOMAIN

This section highlights the key challenges and opportunities in Eswatini's GIS domain, specifically related to the health sector. It also discusses the obstacles faced in utilizing GIS effectively and explores the potential benefits and opportunities that can be harnessed.

6.2.1 CHALLENGES

Key challenges in Eswatini's GIS Domain in the Health Sector include the following:

Data Availability and Quality: One of the key challenges in Eswatini's GIS domain is the availability and quality of geospatial data, especially in the health sector. Data gaps or inconsistencies can hinder effective decision-making and analysis. Ensuring the collection, maintenance, and updating of accurate and up-to-date geospatial data is crucial.

Technical Infrastructure: Limited technical infrastructure, including hardware, software, and connectivity, can impede the effective implementation of GIS in the health sector. Insufficient access to computers, reliable internet connectivity, and GIS software can hamper data processing, analysis, and dissemination.

Capacity and Skills: The availability of skilled GIS professionals and staff with expertise in geospatial analysis within the health sector may be limited. Building the capacity of personnel to utilize GIS tools and techniques is essential for effective implementation and utilization.

Data Integration and Interoperability: Integrating and harmonizing different datasets from various sources can be challenging due to differences in data formats, standards, and interoperability. Ensuring seamless data integration across multiple health information systems and other relevant databases is crucial for comprehensive spatial analysis.

Sustainability and Institutionalization: Ensuring the long-term sustainability of GIS initiatives within the health sector can be challenging. Lack of dedicated funding, weak institutional frameworks, and limited interdepartmental collaboration may hinder the integration of GIS into routine health planning and decision-making processes.

6.2.2 OPPORTUNITIES

Key opportunities in Eswatini's GIS Domain in the Health Sector include the following:

Enhanced Decision-Making: GIS provides an opportunity to improve decision-making by integrating spatial data with health indicators. It enables evidence-based planning, resource allocation, and targeted interventions to address health disparities and reach underserved communities effectively.

Improved Disease Surveillance and Response: GIS can enhance disease surveillance systems by visualizing disease patterns, identifying high-risk areas, and facilitating early detection and response to outbreaks. It enables real-time monitoring, data-driven interventions, and improved coordination among health stakeholders.

Targeted Interventions: GIS can support targeted interventions in immunization programs, school health initiatives, and disease control efforts. It enables the identification of zero-dose communities,

mapping of health facilities, and optimizing service delivery to reach vulnerable populations effectively.

Health Equity Analysis: GIS can help identify health inequities and disparities across different geographic areas and population groups. It enables the analysis of social determinants of health, such as access to clean water, sanitation facilities, and healthcare services, supporting efforts to reduce inequities and improve health outcomes.

Resource Optimization: GIS can assist in optimizing the allocation of resources, such as healthcare facilities, medical supplies, and health workforce. It enables spatial modeling, accessibility analysis, and scenario planning to ensure efficient resource distribution and utilization.

Collaboration and Partnerships: GIS provides opportunities for collaboration and partnerships among different stakeholders, including government agencies, development partners, academic institutions, and civil society organizations. Collaborative efforts can leverage expertise, resources, and data sharing to enhance the effectiveness of GIS implementation in the health sector.

Harnessing these opportunities requires addressing the challenges mentioned earlier. Building technical capacity and skills, improving data availability and quality, strengthening institutional frameworks, and ensuring sustainable funding are critical for maximizing the potential benefits of GIS in Eswatini's health sector.

6.3 RECOMMENDATIONS FOR IMPROVING GIS DATA AVAILABILITY, STAKEHOLDER ENGAGEMENT, SYSTEM INFRASTRUCTURE, AND STAFF CAPACITY

This subsection provides comprehensive recommendations for improving GIS data availability, stakeholder engagement, system infrastructure, and staff capacity in the health sector. The recommendations are based on the findings and analysis conducted throughout the report.

6.3.1 KEY FOCUS AREAS

To make a compelling case for additional support in utilizing GIS to ensure no child is left behind, UNICEF Eswatini should consider the following strategies:

Highlighting Equity: UNICEF should emphasize the importance of geospatial data in identifying marginalized and underserved communities, including zero-dose communities, where children are more likely to be left behind. GIS can enable targeted interventions to reach these communities and address their specific needs.

Demonstrating Impact: UNICEF should showcase successful examples where GIS has been used to improve child-focused interventions and demonstrate the positive impact on the well-being of children. This includes highlighting cases where geospatial data has been used to optimize resource allocation, improve service delivery, and reduce inequities in access to essential services.

Aligning with National Priorities: UNICEF should align the use of GIS with Eswatini's national development priorities, such as the Strategic Information Department's goals, the Expanded Programme on Immunization's targets, and the School Health Programme's objectives. Emphasizing the potential role of GIS in achieving these priorities will strengthen the case for additional support.

Engaging Stakeholders: UNICEF should engage key stakeholders, including the Ministry of Health departments (such as the Planning Department, Health Promotion Department, and Quality Assurance Services), to build consensus and support for utilizing GIS. Collaboration with these departments can help demonstrate the relevance and benefits of GIS in their specific areas of focus.

6.3.2 PRIORITY DATA INVESTMENTS

To prioritize future data investments, the following areas should be considered:

Immunization Data: Investments should be made to improve the collection, management, and analysis of immunization data, including coverage rates, dropout rates, and geographic disparities. Collection of such attribute data at primary level (facility level systems) such as CMIS should consider the need to link this data to spatial datasets for immunization coverage visualisation purposes. This will support targeted interventions and ensure that zero-dose communities are reached.

Education Data: Geospatial data related to education, such as school locations, enrollment rates, and access to educational resources, should be prioritized. This will enable evidence-based decision making to address educational disparities and ensure that no child is left behind.

Population Data: Investments in up-to-date and detailed population data, including demographic characteristics and socio-economic indicators, will provide a robust foundation for planning and targeting interventions to reach vulnerable children.

Social Determinants of Health: Collecting and integrating data on social determinants of health, such as poverty rates, access to clean water, and sanitation facilities, will enable a comprehensive understanding of the factors contributing to child well-being and guide interventions accordingly.

6.3.3 KEY RESEARCH TOPICS

Additional investigation should focus on the following sectors or topics:

Zero-Dose Communities: Special attention should be given to reaching zero-dose communities in Eswatini. Investigating the reasons behind non-vaccination and identifying the geographical locations of these communities will inform targeted strategies for reaching and immunizing every child.

Health Inequalities: Investigating health inequalities among different population groups, including rural vs. urban areas and different socio-economic strata, will provide insights into the

underlying factors contributing to disparities in health outcomes. This analysis can help design interventions that address these inequalities effectively.

Disease Surveillance and Outbreak Response: Further investigation into the use of geospatial data for disease surveillance and outbreak response can enhance early warning systems, enable rapid response, and support effective control measures. This includes exploring the integration of real-time data sources, such as mobile health applications and remote sensing, for timely and accurate decision-making.

Environmental Health Hazards: Investigating the spatial distribution of environmental health hazards, such as air pollution, water contamination, and vector-borne diseases, can guide targeted interventions and help prioritize areas for environmental health interventions.

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APPENDICES

APPENDIX 1: LIST OF INSTITUTIONS AND THE VARIOUS DATA TYPES AND SOURCES USED AND PRODUCED.

Dataset name:	Data Type	Scale of data coverage	Main sources of data	Is data shared with other organizations?	Organization
Administrative Boundaries	Polygon	Continental	NGOs	Yes	World Health Organization
Census	Polygon	National	Other governmental institutions	Yes	World Health Organization
Ecology	Polygon	National	Other governmental institutions	Yes	World Health Organization
Education	Point	National	Other governmental institutions	Yes	World Health Organization
Energy	Line	National	NGOs	Yes	World Health Organization
Geomorphology	Line	National	Other governmental institutions	Yes	World Health Organization
Health	Point	Continental	NGOs	No	World Health Organization
Health Facility	Point	National	Other governmental institutions	Yes	World Health Organization
Hydrology	Line	National	Open source platforms	Yes	World Health Organization
Land Cover	Polygon	National	Open source platforms	Yes	World Health Organization
Malaria	Point	National	Other governmental institutions	No	World Health Organization
Points of Interest	Point	National	Other governmental institutions	Yes	World Health Organization

Population	Tabular	National	Open source platforms	Yes	World Health Organization
Transport	Line	National	Open source platforms	Yes	World Health Organization
Region	Polygon	Regional	Primary data collection from field visits	Yes	World Vision
Tinkhundla	Polygon	Inkhundla	Primary data collection from field visits	Yes	World Vision
Chiefdoms	Polygon	Chiefdom	Primary data collection from field visits	Yes	World Vision
Tigodzi	Polygon	Sigodzi/Ward	Primary data collection from field visits	Yes	World Vision
Households	Point	Chiefdom	Primary data collection from field visits	Yes	World Vision
Health Facility	Point	National	Other governmental institutions	Yes	World Vision
Schools	Point	National	Other governmental institutions	Yes	World Vision
Churches	Point	National	NGOs	Yes	World Vision
Water plants	Line	Inkhundla	Primary data collection from field visits	Yes	World Vision
NCPs	Point	Chiefdom	Primary data collection from field visits	Yes	World Vision
Health Emergencies	Line	Regional	Generated within organization	Yes	Emergency Preparedness and Response

Notifiable Condition IDNS	Tabular	Regional	Generated within organization	Yes	Emergency Preparedness and Response
Country Boundaries	Line	National	Open source platforms	Yes	Georgetown Global Health Eswatini
Tinkhundla Boundaries	Line	Inkhundla	Open source platforms	Yes	Georgetown Global Health Eswatini
Facility List	Point	National	Primary data collection from field visits	Yes	Georgetown Global Health Eswatini
Enumeration Number(EA)	Polygon	National	Generated within organization	No	Central Statistical Office (CSO)
HOUSEHOLDS	Point	National	Generated within organization	No	Central Statistical Office (CSO)
Regional Boundaries	Polygon	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Tinkhundla	Polygon	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Roads	Line	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Rivers	Line	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Health Facilities	Point	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Schools	Point	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Ecological Zones	Polygon	National	Generated within organization	Yes	Central Statistical Office (CSO)

Municipalities boundaries	Polygon	National	Other governmental institutions	Yes	Central Statistical Office (CSO)
Tinkhundla boundaries	Polygon	National	Generated within organization	Yes	Surveyor General's Department
Regional Boundaries	Polygon	National	Generated within organization	Yes	Surveyor General's Department
International boundary	Polygon	National	Generated within organization	Yes	Surveyor General's Department
Cadastre	Polygon	National	Generated within organization	Yes	Surveyor General's Department
50k topo-cadastral sheets	Line	National	Generated within organization	Yes	Surveyor General's Department
2.5k topo-cadastral sheets	Line	Urban areas	Generated within organization	Yes	Surveyor General's Department
10m contour lines	Line	National	Generated within organization	Yes	Surveyor General's Department
2m contour lines	Line	Urban areas	Generated within organization	Yes	Surveyor General's Department
DEM (40m resolution)	Point	National	Generated within organization	Yes	Surveyor General's Department
Imiphakatsi points	Point	National	Generated within organization	Yes	Surveyor General's Department

Schools	Point	National	Other governmental institutions	Yes	Surveyor General's Department
Health facilities	Point	National	Other governmental institutions	Yes	Surveyor General's Department
Tinkhundla centres	Point	National	Other governmental institutions	Yes	Surveyor General's Department
National Boundary	Polygon	National	Other governmental institutions	Yes	NERCHA
Regional Bounday	Polygon	Regional	Other governmental institutions	Yes	NERCHA
Tinkhundla Bounday	Polygon	Inkhundla	Other governmental institutions	Yes	NERCHA

APPENDIX 2: LIST OF RESPONDENTS AND THEIR RESPECTIVE DEPARTMENTS OR ORGANISATIONS

NO:	RESPONDENT NAME	POSITION	ORGANISATION/DEPARTMENT	SURVEY RESPONSE
MOH DEPARTMENTS/PROGRAMMES				
1	Senzokuhle Musukhona	Data Architect	Strategic information department (EDCU)	Completed
2	Zanela Simelane	HMIS Manager	Strategic information department (HMIS)	Completed
3	Thabo Motsa	M&E Officer	Strategic information department M&E Unit	Completed
4	Themba Dlamini	Programme Manager	National TB Control program	Completed
5	Sibonakaliso Vilakati	IT Manager	National Malaria Programme	Completed
6	Mavis Vilane	Senior M&E Analyst	Central Medical Store- Data Management Unit	Completed
7	John Myeni	Program Manager	Rural Health Motivators (RHM)	Completed
8	Calvin S. Dlamini	Health promotion officer	Health Promotion	Completed
9	Mxolisi Masuku	Higher Technical Officer	Emergency Preparedness and Response	Completed
10	Bongani Sigudla	Senior Environmental Health officer	Environmental Health Department	Completed
11	Tholokwakhe Simelane	Surveillance officer	Expanded Programme on Immunization (EPI)	Completed
12	Dr Malvern Masango	National TB/HIV Technical Advisor	National AIDS program	Completed
13	Mangaliso Langa	LIS Manager	National Laboratory	Completed
14	Midrand Xaba	Program Manager	School health programme	Completed

15	Thabang Masangane	Quality Management Officer (Lead)	Quality	Completed
16	Sifiso Mavuso	Acting Principal Planning Officer	Planning Unit	Completed
MOH SUPPORT PARTNERS				
17	Makhosane Matsebula	Senior Strategic Information Advisor	FHI360/M&E	Completed
18	Nolwazi Dlamini	System developer	CABRINI MINISTRIES	Completed
19	Qhubekani Mpala	Country Programs Manager	Clinton Health Access Initiative (CHAI)	Completed
20	Simanga Msibi	IT/Digital Health Officer	Georgetown Global Health Eswatini	Completed
21	Themba Matsebula	Strategic Information Manager	Young Heroes	Completed
22	Bhekinkhosi Magagula	Director, Strategic Information	ICAP	Completed
23	Mzwandile Vilakati		DATA FOR IMPLEMENTATION (DATA.FI)	No Response
24	Mlungisi Dlamini		EGPAF	No Response
25	Dr Yohannes Ghebreyesus	Country Director	URC	Completed
26	Dr Bongani Masango	HIV PREVENTION COORDINATOR	JHPIEGO	Completed
27	Mayibongwe Dlamini	Informatics Coordinator	World Vision	Completed
28	Sandile Dlamini	M&E Manager	BAYLOR CLINICS	Completed
29	Thulani Earnshaw		Bantwana Initiative	No Response

OTHER KEY STAKEHOLDERS				
30	Tengetile Tsabedze	Health Specialist	World Bank	Completed
31	Rachel Masuku	Programme Analyst	UNFPA/Population and Development	Completed
32	Nelson Isidoro	Monitoring and Evaluation Specialist	UNICEF	Completed
33	Patrick Mkhonta	Assistant Surveyor General	Ministry of Natural Resources and Energy/Surveyor General	Completed
34	Nelsiwe Dlamini	Statistician	Ministry of Education	Completed
35	Sibusiso Mamba	Monitoring and Evaluation Officer	NERCHA/M&E	Completed
36	Dr Nick Dlamini	Senior Researcher/Lecturer	University of Eswatini/Geography, Environmental Science and Planning	Completed
37	Makhosi Dlamini	National Project Coordinator	WHO/Universal Health Coverage	Completed
38	Dancia Phiri	Senior Projects Management Officer	RSTP/Innovation and Technology Management	Completed
39	Simelane Sabelo	Senior Statistician	Central Statistics Office	Completed

APPENDIX 3: GIS USE CASES FOR THE MALARIA AND TB PROGRAMS

NATIONAL MALARIA CONTROL PROGRAMME					
Use Case	Description	MoH Programme	Key Outcomes	Critical Success Factors	Key Challenges
Mapping malaria incidence	GIS is used for mapping malaria cases using surveillance officers who visit all places with reported malaria cases	Malaria programme	Mapping of malaria cases Generating stratification maps Generating risk maps and foci maps	Stratification was developed to rank risk into 4 categories as per WHO recommendation	Difficulty in demarcating Foci boundaries Getting high-resolution weather data and population data for risk prediction. Human mobility tracking remains a challenge
Spatial analysis and visualization of malaria cases	GIS is used for creating malaria risk maps	Malaria programme	Visualization of cases by Region, Inkhundla and locality and time Surveillance catchment areas	Cases can be identified at the lowest level which is household and intervention can then be directed there	Well defined locality list boundaries are required
Malaria case management	GIS is used in management of malaria cases	Malaria programme	Commodity planning and monitoring	Distribution of commodities to affected facilities based on case burden and risk	Accurate facility catchment area boundaries data

			Health facility catchment areas		
Vector management	GIS is used in vector management	Malaria programme	Long-lasting Nets distribution Indoor Residual spraying Mapping of breeding sites	Needs can be tracked to see which areas have nets and which areas are short of nets	Monitoring vegetation index and land uses can be challenging without the relevant remote sensing data
Health Facility Mapping	GIS is used to map health facilities that provide malaria commodities.	Malaria programme	Improved access to malaria services Optimized facility locations Enhanced healthcare planning	Accurate geospatial data Collaboration with local stakeholders User-friendly mapping interfaces	Data accuracy and maintenance Infrastructure and resource constraints Addressing disparities in access

NATIONAL TB CONTROL PROGRAMME

Use Case	Description	MoH Programme	Key Outcomes	Critical Success Factors	Key Challenges
Mapping health facilities providing TB treatment	GIS is used to map health facilities that provide TB treatment.	TB programme	<p>Improved access to TB services</p> <p>Optimized facility locations</p> <p>Enhanced healthcare planning</p>	<p>Accurate geospatial data</p> <p>Collaboration with local stakeholders</p> <p>User-friendly mapping interfaces</p>	<p>Data accuracy and maintenance</p> <p>Infrastructure and resource constraints</p> <p>Addressing disparities in access</p>
Mapping of reported TB cases (locality of patient homestead)	Spatial analysis and mapping of individual TB cases, the address of each case at time of entry into the study was geocoded by assigning a latitude and longitude for the patient homestead using the adherence officers.	TB programme	Visual representation of the TB cases by type of TB (drug resistant or drug susceptible)	Contact tracing based on the index case	<p>Data accuracy and maintenance</p> <p>Infrastructure and resource constraints</p>
Spatial analysis and visualization of TB cases (clinically defined and mapped TB cases)	Using GIS to locate and track a particular type of TB infections and monitor its spread within the country	TB programme	Monitoring the trends of a certain type of TB infection in relation to the other types of infections	Predict the disease spread after linking it to other types of TB infections	<p>Movement of patients resulting in data inaccuracies</p> <p>Difficulties in TB diagnoses</p>

<p>TB Surveillance /Spatially targeted interventions (TB hot spots maps)</p>	<p>GIS is used for creating heat maps for recently identified TB cases with an overlay of Tinkhundla boundaries</p>	<p>TB programme</p>	<p>Timely identification of TB outbreaks Staging the mobile clinic at the epicenter of the TB outbreak</p>	<p>Quick referrals and linkages to care Alert the community about the TB outbreak while at the community providing the outreach services</p>	<p>Systems working in silos (no integration between facility/community data at national level and mapped data)</p>
<p>Producing road networks for optimizing laboratory services</p>	<p>GIS is used for creating route maps for shortest path to health facilities for delivery of specimens</p>	<p>TB programme</p>	<p>Collaborations with support partners for quickest routes to facility for</p>	<p>Lower turnaround time for results Optimised resource allocation</p>	<p>Incompleteness of road network data</p>

APPENDIX 4: DATA COLLECTION TOOLS USED IN THE GIS NEEDS ANALYSIS

SECTION 1: KEY INFORMANT QUESTIONNAIRE – MOH DEPARTMENTS

This section of the questionnaire is focusing mainly on the different MOH departments/units/programs.

UNICEF Eswatini Country Office, in support of the Ministry of Health (MOH), in conducting a GIS needs assessment on the status of GIS use at both the National and organizational Levels. This is being done by profiling the existing policy, GIS infrastructure (hardware, software and data) and human resources to utilize emerging GIS technologies for the immunization programme and develop a strategy to govern and strengthen the GIS utilization in Eswatini. The information provided in this interview guide will form the framework for intervention on issues related to adoption of GIS technologies for enhanced utilization in reaching zero-dose communities in Eswatini.

Department/Unit/Program.....

Position in department

BASIC DEPARTMENT PROFILE

Primary responsibilities of department?

How many people are employed in your department?

GIS AVAILABILITY & USE

1. Does your department currently use GIS for some of its work? a) Yes b) No
(if no, skip to question 7)
2. When did your department start using GIS? (day/month/year)
3. Which GIS related activities does the department undertake?
 - a) Create data using applications
 - b) analyse data
 - c) maintain and edit data
 - d) presenting data in various formats
 - e) Modelling situations
 - f) Others
4. On which programmatic areas does the department use GIS?
 - a) Planning
 - b) Development control
 - c) Disease Monitoring
 - d) Access to health services
 - e) Infrastructure monitoring
 - f) Other.....

5. Do you have a section dedicated to GIS activities? a)Yes b) No . If No, skip to question 7

6. How is GIS currently staffed in your department?

No. of full time staff	No. of part time staff	No. of interns/ students	No. of contractors/ service provider	No. of IT staff

7. Whether your department uses or does not use GIS, what stage of implementation is GIS in your department?

- a) Not present and not being considered
- b) Being Considered
- c) Initial Stages of Development
- d) Few Users & Applications
- e) Extensive Use
- f) Few Users
- g) Extensive Use
- h) Many users

8. Do you have a vision, strategy and action plan regarding the management and use of geospatial technologies to support the department/program? Please tick what applies.

- The vision, strategy and action plan have been defined, they are being captured in official documents
- The vision, strategy and action plan have been defined, but not yet captured in official documents
- The Ministry/department is in the process of defining its vision, needs, strategy and plan
- No vision, strategy or action plan have been defined yet
- Other, Specify.....

9. Have you determined geospatial data and technologies related specifications, standards and protocols in your department/unit? Please check what applies.

- Specifications, standards and protocols have been determined, are in an official document (guideline) and are aligned with the National Spatial Data Infrastructure (NSDI).
- Specifications, standards and protocols have been determined, are in an official document (guideline) but they are not aligned with the NSDI.
- Specifications, standards and protocols are in the process of being determined
- No vision, strategy or action plan have been defined yet

Please indicate any additional information you think relevant about this topic

Impacts of GIS in Operations

- 10. Do you think that GIS could positively contribute to the work of your department? a) Yes b) No
- 11. If you were to get a GIS, which are the two most important components you would want provided (circle the two most important)
 - a) Hardware (computers, GPS devices etc)
 - b) Software
 - c) Capacity development for staff
 - d) GIS data
 - e) Others
- 12. If you were to create a GIS department, on which activities would your department utilize GIS technologies?

GIS DATA AVAILABILITY, SHARING & DATA NEEDS

13. Please list any maps commonly used by your department and indicate if they are in digital or hardcopy format

Description (land use maps, parcel data, topo maps)	Hardcopy	Digital non-referenced	Digital GIS format

14. Please indicate any non-map information commonly used in your department that includes a reference to a geographic location (e.g. development approvals by location with physical location description)

Description of information (e.g., list of approved developments by location)	Digital	Hardcopy

- 15. Does your department share any of this data with other organizations? a) Yes b) No c) Unknown (if no go to question 18)
- 16. If yes, does your department/division charge for this data? a) Yes b) Sometimes c) No d) unknown
- 17. Are there restrictions to usage of the shared data? a) Yes b) Sometimes c) No d) unknown
- 18. Does your department receive GIS data from other organizations? a) Yes b) No

-) Unknown (if no go to question 22)
19. If yes, is your department/division charged for this data? a) Yes b) Sometimes c) No
d) unknown
20. Are there restrictions to usage of the received data? a) Yes b) Sometimes c) No
d) unknown
21. How frequently does your department exchange GIS data?
a) Hourly
b) Daily
c) Weekly
d) Annually
e) As needed/periodically
f) Never
22. Does your department have a web site? a) Yes b) No
23. Does your department provide any forms of maps on the website? a) Yes b) No
24. Does your department/division use aerial photography in its GIS? a) Yes b) No
(if no go to question 27)
25. If yes, what resolution of aerial photography do you use? (define all resolutions that
apply)
26. Where does your department/organization get the imagery from?
a) Purchase from
b) Google Earth
c) Donations by organization
d) Free Landsat imagery
e) Other

GIS DATA NEEDS

27. In addition to the various maps you have in your department, which kinds of spatial data do you need to ease your operations (pick/identify the 5 most urgent data needs)

Spatially disaggregated Demographic data	Population per sublocation	Gender	Age-sex distribution			
Utility data	Water distribution	Sanitation facilities	Health facilities	Vaccine coverage		
Transportation data	Distribution of transport networks	Street addresses				
Economic Data	Location of markets	Major towns & urban centres				
Land & land use	Land Parcel data	Zoning data	Land use distribution	Land cover	Topography	Settlement patterns

Other						
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CONTRACTING EXTERNAL ENTITIES TO UNDERTAKE GIS WORK

- 28. Has your department/program ever contracted out any GIS work to outside entities (including companies & individual contractors to undertake specific tasks)?
 - a) Yes
 - b) No
- 29. If yes, please indicate the contractual year.....dicFor which aspects did/do you engage contractors?
 - a) generating basic layers
 - b) Acquiring imagery
 - c) Interpreting imagery
 - d) editing/manipulating data
 - e) creating maps for reports
 - f) Undertaking spatial analysis and writing reports on related interpretations
 - g) Others
- 30. Which was the nature of the contracted entities
 - a) Public Entities (e.g. Universities)
 - b) Private companies
 - c) Individuals
 - d) All
- 31. Kindly list all the public entities and private companies that your department has ever contracted to undertake GIS work

.....

.....
- 32. Kindly list the specific expertise that contracted individuals had/have (e.g. spatial planning, image extraction & analysis etc)
- 33. In your view, how would you rate the cost incurred from such contracting, if any
 - a) Very high
 - b) High
 - c) Fair
 - d) Cheap
 - e) Very cheap

BUDGET ALLOCATIONS FOR GIS ACTIVITIES

- 34. Over the past 5 years, did the department/organization allocate any resources that were used for the development of GIS aspects?
 - a) Yes
 - b) No

35. Over the past year, how much money from the departmental/organizational budget was dedicated to GIS related activities (including for hiring personnel, hardware, software, GIS services outsourcing)

Activity	Cost Range (Emalangenzi)				
	Less 50,000	50,000 - 100,000	100,000 - 500,000	500,000 - 1,000,000	Above 1,000,000
Hiring personnel					
Hardware purchase and maintenance					
Software purchase and maintenance					
Outsourcing GIS services					
Other, Specify..... ...					

36. What proportion of this budget was spent on various components over the last year (%)

37. Of this budget, what proportion was used to pay for outsourced services (including hiring of external entities to perform duties, purchasing data etc)

Hardware	software	Human resource development	Data acquisition

HUMAN RESOURCE DEVELOPMENT

- 38. Within the last 5 years, has your department/ program organized or facilitated any GIS training for its staff?
a) Yes b) No
- 39. Has any member of the GIS team/department attended any training with support from the government? a)Yes b) No
- 40. Has the department/organization partnered with any GIS organization for any activity?
a) Yes b) No
- 41. If yes, which organization and what was the aim of the partnership.....

42. Would your department/program be willing to support an inter- organizational GIS training in any of the following ways? Tick all applicable
- a) Hosting training
 - b) Facilitating staff to attend
 - c) Exhibiting in event
 - d) Making presentations
 - e) Volunteering trainers
 - f) Financial sponsorship
 - g) Other
43. Is there interest within your department/unit to build or enhance GIS capacity in its employees in the future? a)Yes b) No

Future GIS Desires

44. Whether you are using or not using GIS currently, which GIS technologies and activities would you be interested to adopt in the future?
- a) Mobile technology
 - b) Web technology
 - c) Big data
 - d) Automated data collection and inventory
 - e) Advanced training for staff
 - f) Other

CHALLENGES IN IMPLEMENTATION OF GIS

45. What have been your major challenges to using GIS technologies in your department
46. What have been your major challenges in your department when creating a GIS lab in your department?

SECTION 2: GIS PROFESSIONALS/USERS QUESTIONNAIRE

This section of the questionnaire is focusing on GIS users in the Government Ministries, including the MOH, CSO, etc. and or other organisations such as the health partners (NGOs).

Name of ministry/ organization Department/Unit.....

Job Title Academic Qualifications

1. Kindly describe the activities you undertake on a day to day basis
.....
2. How long have you been a GIS professional?
3. Have you always worked in this department? a) Yes b) No
4. If no, where did you transfer from?
5. Which GIS softwares are you competent in (list softwares and level of competence – professional, basic, etc.)

Software Name	Can use with difficulty	Basic competence – can use to view data	Confident– can use to edit and present data	Competent – can use to create, edit, present data	Professional – can use to create, edit, present data and to do modelling

6. Which GIS Software and GPS devices are being accessible in your department? List all the softwares and data collection devices in the table below

Software/GPS	Version/Model/Type	Total Number of licenses/gadgets	Comments

7. Which datasets do you use on a day to day basis (frequently)

Dataset (eg land parcels, roads, etc)	Main use

8. Which open GIS data platforms are you familiar with (e.g. opendata.co.ke, google earth, Landsat imagery, openstreetmap, boundaries maps etc.).....

9. Which of these platforms have you used in the past and for what purpose

Name of open data platform	Main use

10. What datasets would you like to have (rank them per importance)

Dataset (e.g. land parcels, roads, etc.)	1 - important	2 – Very important	3 – Extremely Important

11. Have you undertaken on-the-job training courses (seminars, online courses etc)? a) Yes
b) No

12. If Yes, kindly list courses you have taken, what they entailed and their relevance to your work

Name course	Summary & relevance to your work

13. Have you worked with other departments on GIS related assignments? a) Yes b) No

14. If yes, describe the collaborating departments and the nature of assignments

Department	Purpose of collaboration

15. Have you worked with external contractors on GIS related projects for the organization?
a) Yes b) No

16. If yes, describe the consultant types and names, the assignments you worked on, and impacts on your department operation

Name of contractor (for companies and public entities, include name; for individual consultant indicate individual)	Assignment undertaken e.g. data generation for CIDP	Impacts for your department & lessons learnt e.g. capacity building for staff

17. What GIS technologies are you missing in order to be able to effectively implement your activities?
.....

18. What are the major challenges you face in performing your duties
.....

19. How is GIS currently being used in your department/unit/program? Please select what applies

Creating thematic maps

Spatial analysis

Spatial modelling

Other, Specify.....

20. **What are the opportunities for enhancing GIS usability in your department?**
21. **Any extra comments on GIS related issues?**

SECTION 3: HARDWARE AND SOFTWARE CHECKLIST

This section of the questionnaire is focusing on the different MOH departments/units/programs

1. How is your department/unit/organisation networked?
 - a) Not Networked,
 - b) Local Area Network,
 - c) Wide Area Network,
 - d) Wireless,
 - e) Others

2. How is your department/unit/organisation connected to the Internet?
 - a) Not connected
 - b) Broadband cable
 - c) Wireless network
 - d) Dial-up connection
 - e) Other

Your organization may or may not have an established GIS department/office. However, does your organization/department have any of the following supplies or hardware? (if yes, how many)

	How Many pieces	Models, YOM (for all items other than GIS computers)	Are the hardware supplies currently working/in use? (1 Yes 2 No)	If not in use, why? (1 No Power connection 2 Broken down 3 they have not yet been set up 4 inherited from a previous office/ administration in non-working condition)
Dedicated GIS computers (including recent purchases)				
GPS units				
Normal Printer (indicate paper max paper size it can print)				
Replacement ink for printer				
Server Computer				
Plotter (for large maps)				
Plotter replacement ink				

Rolls of paper for plotter				
Mobile mapper				
Other equipment (include GIS compatible equipment – incorporating compatible surveying hardware)				

3. Kindly provide the following technical information on the dedicated GIS computers

Computer No.	Computer properties (RAM, storage space,)	Year Purchased	Connected to network? Which kind of network (LAN, wireless)	Additional processing hardware (e.g. media card)

SECTION 4: KEY INFORMANT QUESTIONNAIRE - INSTITUTIONS

This section of the questionnaire is focusing on the key relevant Government Ministries and or other organisations such as the health partners (NGOs), excluding the MOH

UNICEF Eswatini Country Office, in support of the Ministry of Health (MOH), in conducting a GIS needs assessment on the status of GIS use at both the National and organizational Levels. This is being done by profiling the existing policy, GIS infrastructure (hardware, software and data) and human resources to utilize emerging GIS technologies for the immunization programme and develop a strategy to govern and strengthen the GIS utilization in Eswatini. The information provided in this interview guide will form the framework for intervention on issues related to adoption of GIS technologies for enhanced utilization in reaching zero-dose communities in Eswatini.

Name of Institution/Agency

Type of Institution/Agency (Government, Parastatal, Private, NGO)

Organization operational scope: (National collective, national disaggregated into sub-regions, urban areas only, Tinkhundla)

Main activities undertaken by institution

DATA

1. Which are the main GIS related activities the organization is involved with?
 - a) Collecting data from various sources
 - b) interpreting data (non imagery) for various purposes
 - c) generating data
 - d) Maintaining and manipulating data
 - e) Sourcing satellite imagery/aerial photos
 - f) Interpreting imagery
 - g) Modelling scenarios
 - h) Presenting data as maps for various uses
 - i) Compiling reports on data based findings/outcomes
 - j) Research & policy development
 - k) Education & training
 - l) Other (Specify)
2. Which forms of data/datasets does the institution have/use? (Kindly Refer to CODES FOR QUESTION 2 appended for general dataset types)

Kind of data/datasets	Format 1. Digital Referenced map format, 2. Digital Non-referenced map format 3. Hardcopy map format 4. Digital non map format	Scope of data coverage/ disaggregation 1. Global, 2. Regional/ continental, 3. National, 4. Regional, 5. Inkhundla, 6. Chiefdom, 7. Sigodzi/Ward, 8. Urban areas (kindly specify if data covers only small parts of Eswatini)	Main sources of data 1. Generated within organization, 2. open source platforms, 3. other governmental institutions, 4. NGOs, 5. primary data collection from field visits, 6. satellite imagery interpretation	Is data shared with other organizations? 1. Yes 2. No

3. **If data is shared with other institutions, which are the major institutions?**

- a) Government agency
- b) Private companies
- c) Learning institutions
- d) NGOs
- e) Donor agencies
- f) Other ...

4. **What are the terms of data sharing:**

4a. Are there charges associated with data? 1. Yes

2. No

4b. If yes, what are the guidelines for data pricing? (e.g. Emalangeni. X for layer y)

.....

4c. Are there restrictions to shared data use (e.g. re-sharing)? 1. Yes

2. No

4d. If yes, what are the key restrictions?

5. **In your opinion, how would you describe the cost of data acquisition in Eswatini**

- a) very expensive,
- a) Expensive
- b) Fair
- c) Cheap,
- d) Very cheap).

6. Can you give some examples of specific costs associated with data acquisition? e.g. the average cost of acquiring one square meter of imagery, cost of processing/generating GIS layers etc?

.....

7. **Is your institution using open data platforms to undertake any of its work? 1. Yes 2. No**

7a. if yes, which Open Data Platforms do you use?

7b. what are the major uses of open data.....

ORGANIZATIONAL SETUP AND HUMAN CAPACITY

8. How is your organization structured for efficient delivery of services? (In the space provided below, kindly describe/ sketch the structure of the organization, particularly defining the main departments, their functional roles and the number of staff employed in each department. Please provide an organizational structure/flowchart if available)
9. For the technical staff working on GIS related activities, kindly fill the table below indicating the numbers and general competencies (kindly also include the composition of the ICT department)

Department (Include technical departments/ sections working on GIS work. Kindly also include the ICT department if in existence)	No. of staff (permanent , part time, consultants)	No. of staff with PhDs	No. of staff with MSc/ MAs	No. of staff with degree s	No. of staff with Dips.	No. of staff with with Certs	Which are the most common training backgrounds of staff in department (1. Geospatial/ geomatics/ Geography 2. GIS based trainings, 3. Surveying, 4. Urban planning, 5. ICT, 6. Environmental studies, 7. Engineering). If possible/known, indicate in brackets number of staff in each training or indicate share of staff with various trainings

HARDWARE AND SOFTWARE

10. Does the institution have guidelines on hardware, software and networking to be used?
1. Yes 2. No (indicate if guidelines exist for only one component and ask to get a copy)
11. Whether guidelines exist or not, the organization might have a range of hardware ranging from basic to advanced performance. With regards to computers and other key hardware, kindly describe the properties which the institution uses to rank hardware (as basic, optimal/moderate & high performance). E.g. basic computers have RAM of less than 1GB, storage of less than 500GB, and processor less than 2GHz)

Properties of basic systems (e.g. 500GB, 4GB RAM, Corei3)	Properties of moderate systems (e.g. 1TB, 16GB RAM, Corei7)	Properties of high performance systems (e.g. 1PB, 162GB RAM, 200 cores)

12. Which forms of hardware does the institution have to enable it to undertake its work (only for technical departments including ICT)

	Total No. of items available in technical depts.	No. of basic	No. of optimal	No. of high
Desktop computers				
Laptops				
Plotters				
Servers				
Handheld GPS units				
Mobile Mappers				
Scanners				
Drones				
Aero plane/ Helicopter				
other				

13. What are the most commonly used GIS softwares in your institution, what is their nature of license and why do you prefer to use them?

Software (Name & versions)	License type (open source vs paid; networked vs standalone)	Reasons for preferring identified software

14. Is the institution networked? 1. Yes 2. No

What type of networking is used in the institution?

- a. Local Area Network,
- b. Wide Area Network
- c. Wireless
- d. Others

PARTNERSHIPS

16. Has institution partnered with any other organizations for delivery of its work

1.
Yes 2 No

17. If yes, which are the key partners for the organization?

Partner (tick which apply)	Examples of key partners	Major aspects partnerships are based on (research, data acquisition, data sharing/ dissemination)
Governmental agency		
Parastatals dealing with GIS related work		
Learning Institutions		
Private companies		
Inkhundla		
Professional organizations (both global & local,		

WORK IN GOVERNMENT

18. Is your institution undertaking any GIS support work to other government departments/? 1. Yes 2 No

19. If yes, which Tinkhundla is the institution working in and what are the activities being undertaken? Does institution have Tinkhundla based offices? 1. Yes 2 No

20. If yes, how are institution activities interlinked to those of the Tinkhundla? Health related work

21. Does the institution undertake any health integration related activities? 1. Yes

2
No

If yes, which activities?

.....

CONTRIBUTION OF AGENCY/INSTITUTION TO GIS POLICY AND FRAMEWORK
DEVELOPMENT

22. Is the institution contributing in any way to the development of geospatial policies or other operational framework in Eswatini
1. Yes 2 No
23. If yes, what are the areas of interventions/ what is the institution doing towards this goal?

CHALLENGES & RECOMMENDATIONS

24. What are the GIS related challenges your institution faces in terms of:
- 24a. Hardware
- 24b. Software.....
- 24c. Human resource
- 24d. Data
- 24e. Managing partnerships.....
- ...
- 24f. Software licensing.....
25. Based on your experience, what is the advice you can give to an institution that is starting up a GIS lab in terms of:
- 25a. Staffing (basic background of staff to hire (train other professional vs hire GIS trained personnel, number of staff per workload)
- 25b. Hardware (types of hardware (computers, plotters, scanners etc), few high performance computers versus many low processing power computers, recommended processing power etc)
- 25c. Software (e.g. do you recommend use of open source licensed software)
- 25d. Data (e.g. would you recommend use of available data platforms or generation of data or
formation of partnerships with data generation etc)
.....
- 25e. Managing partnerships (e.g. is it of benefit to collaborate and have partnership with other GIS users and organisations)
.....
- 25f. Software licensing (e.g. how best can organisations maintain their GIS licenses to avoid having expired proprietary licenses or would you suggest the use of open source across the organisation)



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