GIS Situational analysis and infrastructure assessment

Prepared for

The National Statistics Office

Prepared by

Geospace International

In cooperation with

The GIS Unit

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1. Introduction

The purpose of this document is to note and discuss the findings of the situational analysis regarding the status of GIS and the GIS Unit at the Malawi National Statistics Office (NSO) as well as the findings regarding the accompanying infrastructure assessment. Specific findings will be provided as well as recommendations.

2. NSO Technical capacity and statistics quality status

It is evident that the increased demand for developmental socio-demographic statistics with regard to issues such as poverty and famine monitoring is exposing existing statistics data collection, integration, analysis and dissemination techniques, specifically in a country such as Malawi where crop vulnerability and food scarcity is a reality. Developmental issues all have distinct geographic or spatial components which must be part and parcel of the whole statistics collection and creation process for the statistics to be fully relevant and meaningful. The GIS Unit faces a real challenge with regard to educating line divisions within the organization to make use of their skills and potential. The fact that GIS and the use thereof with regard to statistical agencies in developing countries is a fairly new concept leads to inadequate understanding on how it must best be implemented and utilized.

The current GIS unit faces typical challenges of lack of funding and institutional support, insufficient data availability and maintenance as well as skill shortages and lack of government departmental cooperation and data sharing.

The GIS Unit faces the following challenges:

- Inadequate integrated and properly designed data warehouse and database
- Inadequate awareness within the organization as a whole regarding the potential and use of GIS in statistical agencies
- Lack of institutional support regarding the on going maintenance and sustainability of GIS
- Inadequate geographic base data
- Although a sufficient quota staff is in place, more skills development and training is needed for them to see the holistic process and potential of GIS
- Possible inadequate funding and operational assistance after census 2008

The census provides the NSO with the opportunity to arm the GIS Unit with the necessary hardware, software, data and skills to not only implement successful and efficient census mapping but also to act as a corporate service provider for the NSO throughout all of its activities, including inter-censal surveys and data maintenance.

There is inadequate insight amongst some of the NSO decision makers regarding the holistic potential of GIS and how it can benefit the organization in the short and long term. The unit was brought into existence four years ago as a census demarcation and mapping unit and is therefore only seen as “the guys who makes the census maps”. There is therefore a need for the senior management of the NSO to be educated in the potential and use of GIS in statistical agencies where it acts as a corporate service provider to the organization in general.

The lack of skills among some of the GIS staff can only be remedied through hands-on experience and extensive training and technical support. The data and methodology components are severely lacking, seriously limiting the functionality and potential of the GIS Unit.

A fully functional and supported GIS can provide the NSO with the following benefits:

- Greater data analysis and dissemination possibilities, in turn advocating statistics and raising the profile of the NSO
- The creation of an accurate administrative and statistical boundary spatial database
- Accurate, cost effective Census Mapping operations and with the end result being accurate EA demarcation and map creation.

- Facilitating the design and implementation of a Master Sample frame and maintaining this frame for effective survey implementation and operations
- Increasing the scope of spatial statistics analysis and census product creation, while also enabling the NSO to compare and analyse both the 1998 and 2008 census data in one spatial database.
- Further developing IT capacity within the NSO
- Fast-tracking relevant staff skills development
- Acting as a corporate service provider to the NSO
- Increasing the accuracy and effectiveness of census and survey data collection
- Saving cost and time in the long run due to decreased fieldwork activities because of better survey and census implementation methods.
- Building an accurate geo-statistical database

The **Malawi NSO** is currently on the eve of their Population and Housing Census enumeration which takes place from the **1st to the 21st of June**. They have identified a functional and operational GIS as one of the focus areas which must be addressed in order to achieve accurate spatial analysis, thematic mapping and dissemination of census results specifically and annual mandated statistics in general.

Although the GIS Unit has fairly adequate staffing, hardware and software compliments, it is really the data and methodology component of GIS where they fall seriously short, as will be illustrated later in this document. This is in part due to a slightly outdated census mapping methodology used, poor inter-departmental cooperation and lack of funding. The fact of the matter is that the GIS Unit did remarkably well to complete the demarcation as best they could within the time and with the resources they were provided. Even providing the fact that they have a lack of relevant, current and accurate spatial data, they manage to produce census EA maps which can get the job done. They made innovative use of GPS technology in making up for lack of accurate geographic base data which allowed them to create useful census maps. In any case, regarding census mapping, relative accuracy is more important than absolute accuracy.

2.1 Urgent short term implementation processes

- The establishment of an accurate **cartographic base** is essential to the creation of accurate census and survey cartography. The GIS Unit need to build a proper data warehouse and populate it with relevant and accurate spatial and attribute data.
- Obtain the relevant hardware (data server) and IT infrastructure (networking) in order to facilitate the building of a proper data warehouse. Thus, create a functional Local Area Network (LAN) at the GIS Unit office
- Complete the printing of the A4 and A3 EA maps while creating Adobe pdf files for every map
- The current staff compliment needs detailed training in thematic mapping and statistics analysis and dissemination techniques. It will be wise however for this training to take place if relevant data is available. Thus it will be best for the training to take place once the new census data is available and can be linked to the 2008 EA layer. This will enable applied practical training. Alternatively, the 1998 census layer can be used as a base for training.
- The NSO must negotiate with the Surveyor General's department to obtain the scanned 1:50000 topographic sheets or at least the hardcopy maps so that they can scan and georeference the maps themselves. A data sharing agreement must be put in place since the selling of data to each other is unacceptable.
- Educate senior managers and line divisions in the potential and use of GIS in statistical agencies.
- Obtain additional hardware (PCs) for the current staff compliment without PCs.
- After the census has taken place, there will be a lull in GIS activities. To make optimal use of this time, it will be a good idea to link the recent MICS survey data to the relevant sample EAs and create some thematic maps and statistical analysis which can be provided back to the survey department. It will be a good exercise for the GIS Unit staff since they will have to

go thought the same process regarding the census data. It will also raise the awareness of GIS in the survey department and the profile of the Unit in the NSO.

2.2 The need for GIS

If you can't measure it, you can't manage it. This is the simple truth with regard to the planning, implementation and monitoring of development and economic processes, intervention strategies and projects.
The geographic or spatial component concerning the analysis and dissemination of data is of utmost importance in order to understand causal effects and underlying trends in statistics.
Moreover, since most of the socio-demographic and some economic statistics are collected using area-based methodologies, it is logical that this data needs to be analyzed with the **spatial component** forming an integral part of the analysis.

The accurate creation of administrative and statistical area boundaries that forms the geographic frame within which data is collected, analyzed and disseminated will create an accurate base for the delivery of effective and timely statistics.

The existing GIS Unit at the NSO should be the section which delivers this essential service, but, as will be depicted later, has shortcomings with regard to its current ability to fulfill its functions effectively.

A properly implemented and integrated GIS will assist a great deal in meeting some of the challenges facing the NSO, especially concerning the following:

- The creation of an accurate geographic base to plan and implement census and survey operations from will increase the accuracy of data collection, thereby improving the accuracy of the resultant statistics, thereby increasing the demand and profile of statistics in the user community.
- The added analysis and dissemination possibilities (thematic maps, etc) will enhance decision-making. Accurate and relevant maps will go a long way to advocate the use of statistics and further increase the profile of statistics.
- Underlying spatial correlation between seemingly unrelated datasets can now be investigated due to spatial overlay and analysis techniques.
- Institutional capacity will be increased due to the added dimension GIS brings to all the core processes within the NSO. Statistical products can be expanded and the GIS Unit can act as a corporate service provider for the whole organization.
- Master sampling frames and updated survey methodology can now be created and implemented, further increasing the accuracy of surveys and census data collection as well as being able to speak directly to user-specific needs.
- The timeliness of statistics delivery will increase due to time saved on planning, sample drawing, fieldwork activities, logistics management and the like.
- Socio-demographic data especially, can now be collected more cost and time effectively with fewer resources.
- The IT infrastructure and knowledge base will be strengthened with the strengthening of the GIS infrastructure.
- A cartographic mind-set concerning data collection, analysis and dissemination will eventually filter through the whole NSO as well as other data producers and users.

3. Initial Findings

3.1 Institutional arrangement of the NSO

The NSO was first established in 1966. The GIS Mapping Unit however, was only established four years ago during the census planning phase and resides within the Demography and Social Statistics Division. The NSO has functional offices in all 3 regions in Malawi, but GIS capacity resides only at the Zomba Head Office.

3.2 Current status of the GIS Unit

Currently, the potential of the GIS Unit is under utilized due to a general inadequate understanding in the NSO about the potential and functionality of GIS as well as inadequate hardware, software, data, training and the funding to make the difference. The NSO is aware of this and is planning to make staff more aware of the potential of GIS regarding the functionality of line departments.
The GIS currently fulfills the function of a map creation and production unit, with minimal time and effort being spent on actual data integration, analysis and relevant thematic mapping. This lack of operational diversity is stifling the growth of the Unit and the potential functionality of the GIS.

GIS consists of 5 basic components:

- People
- Hardware
- Software
- Data
- Method

The current status of each of these components will now be discussed, with specific recommendations provided later on.

3.2.1 People

The current GIS Unit staff compliment is as follow:

4 Senior staff members:

NAME/POSITION	CORE FUNCTIONS	QUALIFICATIONS	EXPERIENCE/SKILLS
M Mwale; Statistician	GIS Unit Head	BSC Demography	Relevant GIS skills, good GIS grounding
V Mamda; Assistant Statistician	GIS Team Leader	Statistics Diploma	Relevant GIS skills, good GIS grounding
M Wachepa; Assistant Statistician	GIS Team Leader	Statistics Diploma	Relevant GIS skills, good GIS grounding
J Mkandawire; Statistical Clerk	GIS Team Leader	IT Diploma	Relevant GIS skills, good GIS grounding

21 Staff members

These staff members assist with basic GIS and cartography tasks, field mapping activities and well as map creation and printing activities. The vision is to have all the GIS Unit staff GIS literate as soon as possible.

NAME	POSITION	FORMAL GIS TRAINING	GIS EXPERIENCE
P Ntenda	Senior Cartographer	Yes	No
G Msiska	Senior Statistical Clerk	No	No
J Kapalamula	Statistical Clerk	No	No
K Manda	Assistant Statistician	No	No
O Banda	Statistical Clerk	No	No
B Mpelembe	Statistician	No	No
J Khakona	Statistical Clerk	No	No
C Buleya	Senior Statistical Clerk	No	No
E Sabuni	Statistical Clerk	No	No
F Kalonga	Statistical Clerk	No	No
G Naliya	Statistical Clerk	No	No
T Maonga	Senior Statistical Clerk	No	No
J Chipili	Statistical Clerk	No	No
T Mineyasi	Statistical Clerk	No	No

C Chilunga	Cartographic Assistant	No	No
H Saidi	Senior Statistical Clerk	No	Yes
B Modi	Statistical Clerk	No	No
G Likoloma	Cartographer	No	No
H Nkambule	Statistical Clerk	No	No
A Chavula	Statistical Clerk	No	No
J Nyirenda	Statistical Clerk	No	No

Detailed recommendations regarding training will be provided later in this document.

3.2.2 Hardware

The following matrix illustrates the current status of hardware at the unit. Detailed recommendations will be provided later in this document.

TYPE	BRAND	AGE	SPECIFICATIONS	#	OPERATIONAL
PC	Dell	4 Years	Intel CPU 2.4 Ghz, 512 MRam, 80 Gig HD	4	Yes
PC	Dell	4 Years	Pentium 4 2.4 Ghz, 512 MRam, 120 Gig	2	Yes
PC	Dell	2 Years	Pentium D CPU, 2.8 Ghz, 1 MRam, 160 Gig	3	Yes
PC	Dell Trinitrion	4 Years	Xeon CPU, 512 MRam, 120 Gig	2	Yes
Digitising Tablets	GTCO Calcomp	4 Years	Large format digitiser	2	Yes
Scanner	HP	5 Years	A4 Scanner	2	No
Printer	HP Color LaserJet 2600	1 Year	A4 Printer	4	Yes
Printer	HP Business Inkjet 2600	4 Years	A3 Printer	2	Yes
Plotter	HP Designjet 1000	4 Years	A0 Plotter	1	Yes
GPS Units	Garmin 12 XL	7 Years	Handheld – Waypoints only	20	Some
GPS Units	Garmin Etrex	4 Years	Handheld – Waypoints only	20	Some

No data server is currently available, but the staff does make regular backups on CD and individual PCs. The IT infrastructure is not sufficient. There is for example no networking infrastructure at the unit. The computers are not networked and only 4 PCs have internet and e-mail connectivity. The wireless connection is very slow in some areas. It is therefore insufficient to make use of helpful web based applications such as Google Earth or even consider web based dissemination. 6 UPS Units are in operation to keep seemingly regular power cuts' affect to a minimum.

3.2.3 Software

The following matrix will illustrate the current software status at the GIS Unit. Recommendations will be provided later in the document.

TYPE	BRAND	AGE	LICENSED	# LICENSES/ PACKAGES
ArcGis 8	ESRI	5 Years	Yes	5
ArcView 3.3	ESRI	7 Years	Yes	1
ArcInfo	ESRI	5 Years	Yes	1
Microsoft Office	Microsoft	1 Year	Yes	9

3.2.4 Office space and furniture

Office space and furniture is inadequate, with 25 persons sharing one office of approximately 72 square meters. Considering the amount of maps the GIS unit will have to create and handle as well as large equipment such as printers and plotters currently in the office, office space is insufficient. This means current working conditions are uncomfortable and unproductive. Larger office space is therefore necessary, especially if all staff within the unit will receive PCs.

3.2.5 Data

The following data is available at the NSO:

TYPE	SPATIAL/ STATISTICAL	FORMAT	SOURCE	CURRENCY	ACCURACY /SCALE
Roads	Spatial	Shapefiles	National Roads Agency	2007	1:50000
Rivers	Spatial	Shapefiles	DANIDA	2007	1:50000
Administrative Boundaries	Spatial	Shapefiles	DANIDA	2006	From 1998 EA boundaries
GPS Collected Point data (landmarks, schools, villages, hospitals)	Spatial	Shapefiles	NSO	2007	Normal handheld accuracy
Hardcopy Maps	Spatial	Analogue	Various	1998	1:2500, 1:25000, 1:50000
1998 Digital EA Boundaries	Spatial	Shapefiles	DANIDA	1998	n/a
2008 Digital EA Boundaries	Spatial	Shapefiles	NSO	2008	n/a

The following data is not available:

- Any remote sensing or imagery data
- Any scanned and georeferenced 1:50000 topographic map sheets
- Any hardcopy 1:50000 map sheets
- Any digital cadastral or town plan maps
- Any place name polygon data

It is clear that although the GIS Unit at the NSO has adequate resources regarding hardware, software and staff, data is one component they are severely lacking in. A long term sustainable future looks bleak when taking account their data deficiencies. Moreover, since they are combining datasets of differing accuracies and scale into one workspace the boundaries do not match.

One of the GIS Units most immediate concerns after the enumeration would be to accurately redigitise all the relevant administrative and EA boundaries so that it fits the underlying backdrop. This is the most compelling reason why the NSO needs to obtain the scanned and georeferenced 1:50000 topographic map sheets so it can be used as backdrop. Satellite imagery will be a better option but it will be costly.

Detailed recommendations will follow later in the document.

3.2.6 Method

Method entails that once the people, hardware, software and data is in place, the following must be implemented or should exist for the GIS to achieve its full potential and provide relevant deliverables:

- In order to analyze data efficiently, clear guidelines must be created regarding the methods and type of analysis to be done on the data
- Clear parameters must be set regarding what type of outputs will be required by the NSO line units as well as external users
- Knowledge within the NSO and the GIS Unit regarding the application of GIS to achieve the above and to assist line units in achieving their own goals must exist
- The GIS Unit itself must have a clear understanding of data integration, analysis and dissemination techniques for statistical data across various domains such as demography and surveys.
- In the short term, method will imply the specific data creation, collection and warehousing strategy to be implemented by the GIS Unit.

Currently, very little exists in the line of the above mentioned methodological prerequisites, which constrains the use and value that GIS should have for the NSO severely. Moreover, there is the danger that the GIS Unit will not receive the institutional or financial support from the NSO that it needs to fulfill its core functions after the census is done and dusted.

Think of the whole concept in terms of a motor vehicle:

- The hardware is the body, wheels, seats, interior and chassis of the vehicle.
- The software is the engine of the vehicle. Without an engine, the vehicle goes nowhere.
- Data is the fuel that makes the engine run. Bad data (bad fuel) will mean that the engine will never run to its full potential and it will not last long. Inadequate data will mean that the car will only go so far. Data also has to be maintained and augmented regularly.
- The people or staff is they who drive the vehicle. Without someone knowing how to drive the vehicle properly, it will not be driven in a sustainable manner and the rules of the road will not be observed. The use of the vehicle will therefore be limited.
- The method is the knowledge that the staff must have regarding how to drive the vehicle, what the rules of the road are, how to fix the vehicle if it is broken down and which fuel will work best with the engine.
- This vehicle has to be maintained regularly in order for it to run in a sustainable manner. As noted, this GIS Unit is currently not receiving adequate maintenance and institutional support from the NSO and therefore the operational capability and usefulness of the Unit is severely impaired.

GIS is therefore created through interacting and interdependent components. Without all of these components being effective, the system's use and functionality is limited.

This is currently the case at the GIS Unit.

3.3 The role of the GIS Unit in population census activities

Before we continue, it is necessary to outline the role of the GIS Unit in population census activities. Although the planning and census mapping phase are basically complete, it will provide insight nto what is required during the subsequent phases. A functional and properly implemented GIS Unit will play a major part in all the facets of the Census. Any Census can be divided into 5 main phases. The role of the GIS Unit in each of these phases will be discussed. The phases are:

- The Planning phase
- The Census Mapping revision phase
- The Enumeration phase
- The Data Processing phase
- The Analysis and Dissemination phase

3.3.1 The Planning phase

This is the most important phase, since the basic methodology, operations and logistics for the Census is determined. These three factors determine the amount of money and resources needed to implement the Census. Care should be taken to include the different roles to be played by the GIS

Unit in the budgetary planning so that enough resources will be available for it to fulfill its role. Currently, neither financial or institutional resources are sufficient for the GIS Unit to fulfill even its core functions.

The role of the GIS Unit during the planning phase will be the following:

- To provide accurate information with regard to the existing census cartography, specifically concerning:
  - The state of the cartography (currency, maintenance, accuracy)
  - Problems identified, such as EA coding structure, EA size structure, EA parameters, administrative boundary problems
  - New raster and vector data needed to implement the revision
- To provide suggestions for addressing these issues as well as possible methodologies, including proposed imagery coverage and costing to augment base data where necessary
- To provide suggestions on questionnaire content which would enhance spatial analysis possibilities
- To provide suggestions with regard to database design and development

The GIS Unit will therefore form an integral part of the planning team. The resources needed will be dealt with according to its role during each of the phases.

3.3.2 The Census Mapping phase

The GIS Unit will play a leading role during this phase since it will be its responsibility**.** A weak and inaccurate cartographic base, especially where the revision and demarcation of EA boundaries are concerned, leads to ineffective and inaccurate field data collection (enumeration) as well as poor analysis and dissemination. It is therefore the foundation of all census operations.

The role of the GIS Unit during this phase can be summarized as follow:

- Implement an operational and functional GIS
- Acquire and integrate the necessary spatial and attribute primary and secondary data.
- Implement the appropriate census mapping methodology according to settlement type.
- Create an accurate and current census cartography layer including administrative, EA and supervisor area boundaries.
- Provide the necessary fieldwork support and maps
- Create and print the final enumeration and supervisor area maps

3.3.3 The Enumeration phase

The main responsibilities of the GIS Unit will be three-fold:

- To create and print the **EA Fieldwork maps** for the enumerators with the necessary EA boundary, imagery backdrop and vector data backdrop and locational features such as Place Name and Landmark information depicted**.**
- To plan certain **logistics activities**, such as the number of enumerators needed per District, number of questionnaires needed per area, types of vehicles needed etc. The rollout of materials can also be monitored using the GIS. **Progress maps** can be created on a weekly basis.
- The **progress of enumeration** itself can be monitored at an EA level with regular progress **thematic maps** printed to show enumeration progress. Problematic areas can therefore easily be identified.

3.3.4 The Data Processing phase

- The flow of materials back to the data processing center can be monitored at EA level and the GIS used to print progress maps

3.3.5 The Analysis and Dissemination phase

It is during this phase that the true power of GIS comes to the fore since it will enable the NSO to analyze and disseminate its statistics taking into account both the attribute and spatial context.

- The relevant census data can be populated and linked into the **GIS database** (EAs) and **various types of analysis** can be done in conjunction with the statistical analysis division. Due to the use of GIS, spatial analysis will now become possible where it was previously not possible.
- The results of the spatial analysis can then be **disseminated** with the database analysis in the form of **maps, tables and graphs**. A new **Census Atlas** can also be created.
- Due to accurate imagery base map and accurate census mapping, analysis and dissemination and product possibilities are increased and also delivers more relevant statistics. Dissemination can also be done using GIS web based techniques and systems.
- By having both the 1998 and 2008 census databases available, the NSO would now be able to spatially link, compare and analyse the two sets of data.

The GIS Unit will therefore form an integral part of the whole Census process.

4. Recommendations

Recommendations will be constructed along the following headings:

- Short term goals
- Long term goals
- Hardware requirements
- Software requirements
- Data requirements
- Human resource requirements
- Administrative requirements
- Institutional context
- Management requirements
- External assistance and training
- Maintenance and Support
- Inter-governmental Coordination
- Risks

The following operational and mission goals have been identified for the GIS Unit. They have been broken down into short and long term goals.

4.1 Short Term Goals (Next 2 Years)

The immediate short term goal is to successfully complete Census Mapping operations, specifically the creation and printing of EA maps. However, other short term goals will include the following:

- Creating a strategy which plans the functions and aims of the GIS Unit for the next five years in order to keep it sustainable and making it a corporate service provider for the NSO as a whole.
- The NSO must negotiate with the Surveyor General's department to obtain the scanned 1:50000 topographic sheets or at least the hardcopy maps so that they can scan and georeference the maps themselves. A data sharing agreement must be put in place since the selling of data to each other is unacceptable.
- Building an accurate geodatabase and redigitizing administrative and EA boundaries where necessary to fit the base data. This is essential since thematic mapping and spatial analysis requires exact and accurate topology and inaccurate thematic maps will never be accepted by either the Malawi users or the international community.

- Obtain the relevant hardware (data server) and IT infrastructure (networking) in order to facilitate the building of a proper data warehouse. Thus, create a functional Local Area Network (LAN) at the GIS Unit office
- To undergo the necessary **training and skills transfer** to be able to implement the strategy of making the GIS Unit a corporate service provider for the whole organization.
- Complete the printing of the A4 and A3 EA maps while creating Adobe pdf files for every map
- Educate senior managers and line divisions in the potential and use of GIS in statistical agencies.
- Providing proper census support during the enumeration and processing phase
- Populating all relevant **survey information** (such as the Malawi Living Standard Survey, Maternal Mortality Survey, Health and Education Surveys, Agricultural Survey etc.) from various line units into the attribute database in order to do data linking and spatial analysis and dissemination
- To create a **Master Sample frame** on which longitudinal and other surveys can be planned and implemented for the next 5 years.
- Outfit the remaining members of the GIS Unit team with PCs and software.
- The creation of an extensive **Census Atlas** for the 2008 Population Census, focusing on small area statistics.

4.2 Long Term Goals (Up to 2012)

To act as a **corporate service provider** to all the divisions within the NSO by:

- Playing an essential part in the analysis and dissemination of the Census 2008 information
- Designing and implementing a **poverty mapping program** on small area level (lower than district level)
- To create a definitive **Locality Name boundary** set derived from the EA boundaries
- Continuing to produce accurate **EA maps for survey taking**
- Continually investigating new ways of **analyzing** economic and socio-demographic statistics in the **spatial context**
- Spatially linking the 1998 and 2008 census datasets so that time series and comparative analysis becomes a possibility.
- Leading the **statistics advocacy campaign** to the users through innovative analysis and dissemination techniques
- Fostering relationships with the Surveyor General as the leading data provider to the NSO meaning that **data can be shared** between the two organizations free of charge.
- To use the data warehouse for custom or institutional spatial and attribute analysis as well as it being the base for future web application and dissemination platforms.
- To create a **web based dissemination application** through which derived reports, graphs, maps and statistics can be posted/ downloaded by internal and external users, thereby increasing data accessibility. Moreover, the website should have a live spatial GIS interface with basic view, query and print capability.

Moreover, the following goals also need to be achieved and are inter-dependent on the ones stated above:

- Continuous training and skills transfer to improve in-house capacity to do spatial and statistical analysis and dissemination.
- Proper institutional support regarding maintenance of the GIS Unit equipment and software and sustainability regarding training and funding support.
- Creating a specific GIS Unit maintenance and support line item in the annual NSO budget.

4.3 Hardware requirements

As noted, compared to some other African countries, the GIS Unit at the NSO has relatively adequate hardware resources. However, there is some area that needs attention.

- The current compliment of Personal Computers will only be sufficient for another two years, especially since most of the PCs are already four years old. The NSO should therefore budget to replace at least three PCs every year.
- Moreover, the current staff compliment which is without personal computers should receive PCs as well as PC usage introduction training as soon as possible.

The following items needs to be acquired before census mapping can commence effectively:

Personal Computers
15 additional PCs with the following minimum specifications:

Processor:	Pentium D with a 3.4 Gigahertz processor
Storage space:	120 Gig hard disk space
Memory:	1 Gig RAM
Monitor:	17 Inch LCD
Additional:	DVD ROM and minimum 2 USB Ports.

The current printer allocation is sufficient, but care must be taken that their consumables are budgeted for during inter-censal years.

A high end data server is necessary since the GIS Unit need to store all the spatial and attribute data in one place where it can be accessed by all. Spatial data is valuable and cannot be stored disparately on individual PCs and disks. This of course also means that all PCs have to be networked to each other and the printers, thus, a functional LAN while at least two high-speed internet connections must be available.

The following are guidelines on the specification and cost of a high end data server:
Specifications:

Server Tower Proliant ML310 G4 DC Xeon 3050
2.13GHz – 1x2Mb SATA
512Mb (1x512Mb) 1P CDRom STD F DD Opt HP SATA Controller-R
Memory 2 GB 667 MHz DDR2 PC-5300 Unbuffered advanced (1x2GB)
DL320 G5ML110 G4ML310 G4
500 GB Pluggable SATA HDD x 5 SI
HP Smart Array P400/512 Controller, LA
Carepack

Estimated Cost: $8400

Additional hardware items to be purchased specifically for networking the GIS Unit would be:

- One 30 port HUB at the GIS Unit office which will enable the necessary networking of the GIS Unit. Estimated cost: $2000.
- Necessary cabling and fly leads to create a Local Area Network (LAN).
- UPS Units: A least 8 Units at $350 per unit

The current GPS equipment compliment at the NSO is sufficient.

4.4 Software requirements

The current software available to the GIS Unit is not sufficient. At least two types of GIS software will be necessary not only for the census mapping exercise but also to serve the GIS Unit in the future. Geomedia Professional software is necessary to do the actual data integration and heads up digitizing in an effective and accurate way. The consultant has provided the Unit with free copies of old software which the Unit can use in the mean time, but it is not sufficient in the long run and only a

stop gap measure. At least two copies of Geomedia Professional 6 will therefore have to be procured if possible.

Most of the staff is conversant and comfortable with ArcGIS and therefore the recommendation for further GIS software will be to acquire at least 20 licenses of ArcGis 9.2. The acquisition of necessary software can be phased in, therefore not all software licenses need to be acquired at once. If cost does become a barrier, another option would be to acquire concurrent or multi-user licenses. The advantage is that the license lies on a server and can be activated from a remote desktop. However, only one person at a time can access the license. If for example, you have 10 multi-user licenses, it means that all 25 staff members has access to the software, but only 10 at a time can access it. The Unit management needs to decide whether this is a viable option, since it would require a reliable network, IT support and a preferable a dedicated server. The GIS data server can be used for this purpose, if it is acquired.

Unit management also needs to decide whether it will be necessary to equip al 25 staff members with software and whether situations will arise where they will all be using the software at once. Suitable software vendors will be able to provide detailed quotations and advice once these decisions have been made.

The type, amount and cost of the necessary software can be summarised as follow. Please note that the costs indicated are tentative only and will vary from vendor to vendor and according to exchange rate fluctuations:

SOFTWARE	**MAINTENANCE LICENSE NEEDED**	**LICENSING COST**	**TRAINING NEEDED**	**# OF LICENSES**	**ESTIMATED COST IN USD**
Geomedia Professional 6 - **Optional**	Yes	$7,900.00	Yes	2	$15,800.00
ArcGis 9.2 (Including Spatial Analyst and Geostatistical Analyst) Single user license	Yes	$3,200.00	Yes	20	$64,000.00
ArcEditor – Single user license	Yes (Concurrent)	$9,200.00	Yes	2	$18,400.00
ArcPress - **Optional**	Yes (Concurrent)	$1,400.00	Yes	1	$1,400.00
Adobe Acrobat Professional	No	$1,000.00	No	1	$1,000.00
Total					**$100,600.00**

Due to the number of software licenses to be acquired, yearly maintenance costs were not included. However, if possible, the NSO must ensure that **maintenance** for software is paid so that the necessary upgrades are available for free. Software can be bought in stages and everything does not need to be acquired at once.

Dissemination maps and reports should not only be done in hardcopy but also digital formats. It is very difficult to disseminate maps in digital formats since the end-user loading the digital files will also need GIS capability. One can store maps directly from GIS in other formats but sometimes resolution is lost while the files can also be large and unmanageable.

Adobe Acrobat .pdf format files are easy to use since little resolution is lost and the files are small. Moreover, the software to read the files can be downloaded for free from the Internet. It is an ideal tool to disseminate maps and reports digitally, as well as to store files for future use. In the short term, the free .pdf writer software can be used, but it has limited functionality. It would therefore be advisable in the long run to acquire the full Adobe Acrobat professional package. This software can be

used by the whole of the NSO to disseminate maps and reports digitally to many different users, thereby also contributing to the profile of statistics in Malawi.

Software indicated as optional should only be acquired if the funds are available, it is not essential software but will boost the functionality of the Unit.

4.5 Data requirements

GIS is data. The amount of benefit any organization will receive from a GIS is directly linked to the relevancy and quality of the data in the database as well as the skills of the persons analyzing and interpreting the data.

Data requirements fall into two categories:
Primary data (Geographic Base data)
Secondary data (Data created from the cartographic base and analysis of data)

Primary data

Primary data constitutes satellite imagery, aerial photography, town plan maps as well as topographic maps in digital format. The GIS Unit at the NSO has almost no primary data. That is why it is imperative for the NSO to make a data sharing or cooperation deal with the Surveyor Department so that the GIS Unit can have access to and use the 1:50000 topographic scanned and georeferenced map sheets.

The fact of the matter is that the current cartographic base is not sufficient or ideal for accurate mapping. Another possibility for the long term is if the NSO acquires high resolution satellite imagery which can function as their new geographic base. It is more current and accurate than 1:50000 topographic maps and it is a national asset which can serve different spheres of government.

Secondary data can consist of the following:

Secondary data required

Type of secondary data	Spatial/Attribute data	To be created/Existing
Census 1998 data	Attribute/Spatial	Existing
Completed surveys data	Attribute/Spatial	To be created
Future survey data	Attribute/Spatial	To be created
User-specific data	Attribute	Existing or to be created
New data created though analysis	Attribute or spatial	To be created
EA boundaries	Spatial	Existing
Administrative boundaries	Spatial	Existing
Locality Name boundaries	Spatial	Existing
Statistical boundaries	Spatial	To be created
Landmark data (Health centers, clinics, schools etc.)	Spatial	Existing

The amount and types of secondary data in the database really depends on the type of analysis one does, as well as the possibilities of new data creation from existing resources.

As noted before, your data is very important, therefore, the database design should be done in such a way that data could be easily integrated, stored and retrieved.

4.6 Database design

Proper database design and implementation is imperative for the effective operation and sustainability of any GIS. It is therefore important to ensure that the spatial database is designed correctly from the beginning. Currently, the skill does not exist at the GIS Unit to do this. They would therefore need to make use of external technical assistance in this regard.

The following requirements must be met:

- **Understand the data before designing the database**: For the database to be designed correctly, one must understand the structure, content and parameters of the data itself.
- **In simplicity lies art**. Do not overcomplicate the database design and do not over normalize.
- Have separate databases for census and relevant survey data. Never combine data sets across different domains or with different data collection parameters or indicators.
- Make sure data is easily accessible.
- Preferably, only one person should have read/write access to the database and that should be the **Database Administrator (DA).**
- The DA will be responsible for maintaining and managing the database
- Other users will have read only access. The reason is to protect the integrity and accuracy of the database. Too many persons with read/write access to a database will lead to missing, inaccurate and corrupt data.
- The database should have an open and flexible design into which new data can easily be integrated
- For a start, **MS Access** will be an adequate platform to implement the database. However, as the data volume grows and more users want access to the data, other platforms, such as SQL Server or Oracle Spatial Cartridge have to be considered.

Currently, the knowledge base is not existent at the NSO regarding integrated spatial and attribute database design. Thus, GIS database design. The NSO will have to **source** this skill from outside. Care should be taken to appoint companies which have a **proven track record** in GIS as well as spatial database design and implementation for statistics agencies in particular; otherwise the system will not function optimally.

4.7 Human Resource requirements

The human resources managing and operating the GIS will be vital, since their **skill and imagination** will determine the effectiveness and usefulness of the system. At the moment, the staffing at the GIS Unit is more than sufficient. However, since most of them have only fieldwork experience, their general skill levels regarding GIS as a holistic technology and various software and methodological processes are not sufficient. Moreover, they have limited skill regarding database design and management, especially database design for statistical analysis. These skills must be taught in an integrated and sustainable manner, with hands on experience being the best task master. Specific training options will be discussed in the **training section.**

4.8 Sustainability

GIS is an ever changing and evolving subject matter field. In order to achieve long-term sustainability with regard to staff skills, it is advisable to provide the staff with the means to go through formal GIS training. This will only apply to staff that has not had formal GIS training. Very good distance learning courses exists for GIS. ESRI provides very good on-line self study training courses which is a definity option and is detailed further in the Training section.

The GIS Unit can only successfully act as a corporate service provider once they have sufficient **institutional support** from the NSO as a whole. Proper institutional support and a sufficient annual funding allowance to the GIS Unit with regard to consumables and training will ensure the sustainability of the unit as well as continued effective service delivery to the various line function divisions within the NSO.

More detail on this in the training section.

4.9 Administrative requirements

Administrative requirements deal with the following issues:

4.9.1 Office space and furniture

As noted before, current office space is not sufficient, especially if all the necessary hardware for all the staff members is acquired. The NSO indicated that office space is available. The GIS Unit will have

to move to this new office when the necessary hardware becomes available so that the necessary IT networking infrastructure can be done as well.

4.9.2 IT support

According to the GIS Unit, current IT support is not sufficient. Since the GIS runs on a sophisticated technological platform, it is necessary for the IT Department to deliver effective service to the GIS Unit. As noted, there is no networking in the office itself and only four very unreliable and slow internet access points.

Once all the new equipment is installed and operational, it will be necessary for the IT division to create a Local Area Network (LAN) at the GIS Unit in order to link all the workstations as well as the plotter and printers together. This is essential if the Unit is going to function correctly specifically with regards to map creation and printing operations.

4.10 Institutional context

Institutional re-organization will have to take place with regard to the GIS Unit and its functions within the NSO. The role of the unit must be re-defined as a corporate service provider to the NSO with the following services in mind:

- Spatial data and digital map provider to all divisions and external users
- Spatial database custodian responsible for new data creation and maintenance
- Custodian of the Master Sample frame responsible for its maintenance, Secondary Sampling Unit creation according to relevant survey needs and updating
- Responsible for all spatial analysis according to NSO divisional and external user needs (for economic and socio-demographic data). Analysis to be done in conjunction with relevant unit expertise.
- Responsible for Census Cartography revision and maintenance
- Responsible for GIS attribute data integration, updating and maintenance
- Responsible for spatial analysis and graphic dissemination of the Census Atlas
- Responsible to host the spatially enabled web application spatial database.

4.11 Management requirements

For the GIS Unit to be sustainable in the long run, a **common vision and effective management** will be necessary, not only within the unit itself, but also from the NSO principals.

It will be the responsibility of the NSO top management and the GIS Unit management to promote and advocate spatial statistics and the benefits and applications of GIS not only internally but also to external users. Care should be taken to involve GIS in all NSO data collection, analysis and dissemination processes where relevant. The unit itself should be effectively managed to ensure staff motivation and advancement opportunities with regard to capacity building and skills transfer.

4.12 External assistance

External assistance can be broken up into the following categories:

4.12.1 Financial

Financial assistance with definitely be needed from the **donor community**, specifically with regard to hardware, software and training provision. As noted, the UNFPA is involved with the NSO in the provision of hardware and software for census activities. Sustainably running the unit over time means that there are certain **monthly maintenance costs involved**, such as the acquisition of toner for the printer and plotter, printing paper, CDs and DVDs, software maintenance and printer maintenance costs. These costs will eventually have to be part of the NSO's monthly budget.

These funds will be essential to keep the unit running, otherwise it will become a white elephant. With the unit in operation and advocating spatial statistics through graphic and map dissemination to other government departments, its profile will be raised which will increase the NSO's chances of extra budget allocations concerning the unit's maintenance costs.

4.12.2 Technical and maintenance support

External technical assistance will be needed with regard to the following:

- GIS software and spatial analysis and dissemination.
- Data warehouse design and implementation
- Raster imagery georeferencing, clipping and edge matching
- Satellite imagery use, processing and GIS integration (possible)
- Census Atlas creation and poverty mapping

It will be advisable for the NSO appoint one firm to do all of the above since it is essentially one action and process with inter-dependencies.

4.13Training

It is essential that training not only focuses on the theoretical aspects but that due consideration is provided to practical and hands-on training.

Since the main GIS software to be used will be ArcGis 9, it is very important that all staff members understand the software. Moreover, most of the staff members have very little formal knowledge or training in geography or GIS. It is therefore essential to provide them with the necessary background and specialist training in the software. ESRI hosts various GIS and software specific on-line training courses on their website. Some courses require broad band connectivity. Below are the courses as deemed necessary by the consultant, a summary of its contents, its duration and cost. Not all staff members will be required to do all the courses. Specialised courses can be reserved for the most promising staff (the 6-8 best suited for specialized training). These staff members can informally train the rest of the staff in specialized procedures.

The list provided below are by no means definitive and the GIS Unit staff management can browse the available courses at the following link:

http://training.esri.com/gateway/index.cfm?fa=search.results&cannedsearch=8

Specific ESRI on-line courses for all staff members

Course	Course Type	Course details	# of Hours	Cost
Getting started with GIS	Self Study (Virtual Campus)	Geographic information systems (GIS) have changed the way many governments and organizations conduct business, solve problems, and plan for the future. This course provides a foundation for understanding what a geographic information system is and the possibilities it offers for discovering patterns, relationships, and trends. You learn how GIS maps are different from other types of paper and digital maps, what makes the data used in a GIS unique, and how to use GIS software to obtain information and create meaningful maps. In interactive exercises and activities throughout the course, you work with ArcGIS software and see how a GIS supports problem solving in many different contexts.	9	Free
Learning ArcGis Desktop	Self Study (Virtual Campus)	ArcGIS Desktop software is an integrated system that includes all the tools needed to get the most out of a GIS. This course introduces fundamental concepts of GIS and the major functionality contained within ArcGIS Desktop software. In course exercises, students follow the GIS analytical process and work with a variety of tools to solve realistic problems. This course emphasizes practical GIS skills.	24	$182 per trainee
Basics of the Geodatabase model	Self Study (Virtual Campus)	The geodatabase is the latest data model created by ESRI for representing real-world features and storing geographic data. This course introduces the basic components of a geodatabase—tables, feature classes, feature datasets, and relationships. Together, these components form the building blocks needed for geographic data input, query, display, and analysis. Students learn how geographic data is stored in each of the four components.	3	$26 per trainee
Creating, editing and managing geodatabases for ArcGis Desktop	Self Study (Virtual Campus)	The geodatabase is the ESRI data model that allows features to be modeled more realistically than ever before. This course covers all the basics and introduces the more advanced functionality that makes the geodatabase such a powerful data model. Students will be able to get started working with geodatabases right away and understand the range of functionality that the geodatabase offers.	12	$52 per trainee
Turning data into information using ArcGis 9	Self Study (Virtual Campus)	Along with the explosive growth of GIS over the last decade, a considerable increase in the availability and use of digital sources of spatial data has occurred. Producing new and useful information from spatial data requires a thorough understanding of their limitations and the methods used to process them.	18	$130 per trainee
Working with Map	Self Study (Virtual	ArcView users can use map topology to perform a host of topological	3	$26 per trainee

Topology in ArcGis	Campus)	edits that do not require the use of geodatabase topology. Map topology is a basic form of topology used on simple features in a map during an edit session. These features may be stored in either a shapefile or a personal geodatabase feature class. With map topology you can simultaneously edit features that overlap or touch. This focused course provides an overview of map topology and gives ArcView users a foundation for working with map topology tools.		
Understanding GIS queries	Self Study (Virtual Campus)	Queries are an important component of geographic analysis and problem solving. This course teaches how to construct spatial and attribute queries using ArcGIS software. The basic elements of a query are defined and query-building tools are introduced. Using these tools, analysis can be performed, complex questions can be answered, and geographic problems can be solved.	3	$26 per trainee

Specific ESRI on-line courses for selected staff only

Course	Course Type	Course details	# of Hours	Cost
Geoprocessing with ArcGis desktop	Self Study (Virtual Campus)	Geoprocessing is a primary function of a GIS. ArcGIS Desktop software provides hundreds of tools for processing geographic data as well as ModelBuilder, a graphical environment for visualizing and executing workflows. This five-module course teaches practical strategies for using the ArcGIS geoprocessing framework to accomplish GIS workflows. Students work with geoprocessing tools to create and organize workspaces, prepare data for analysis, and perform GIS analysis tasks, then learn how to streamline processes using models and scripts. Students also learn how to create custom geoprocessing tools and document custom tools, scripts, and models. This course provides a solid foundation in the ArcGIS Desktop geoprocessing framework and emphasizes hands-on practice through software exercises.	15	$104 per trainee
Understanding Map Projections and Coordinate Systems	Self Study (Virtual Campus)	Accurately representing features found on the earth's three-dimensional surface on a flat piece of paper or computer screen is a huge logistical problem-one whose solution involves mathematics, human ingenuity, and ever-evolving technology. In a GIS, map projections and coordinate systems are used to map real-world features. This six-module course introduces the fundamental concepts behind map projections and coordinate systems. Essential characteristics of all map projections—aspect, perspective, and distortion—are discussed. The emphasis is on theory, but students gain practical experience working with ArcGIS software to apply map projections, modify their properties, and manipulate data stored in different coordinate systems. This course does not teach the mathematics behind individual map projections.	18	$130 per trainee
Introduction to ArcGis 9 Geosptatistical Analysist	Self Study (Virtual Campus)	With ArcGIS Geostatistical Analyst, GIS users can explore, visualize, and create sophisticated optimal prediction surfaces, as well as statistical surfaces of probability and standard error. This free course introduces some fundamental concepts of geostatistics and teaches how to create and compare interpolated surfaces.	3	Free
Learning ArcGis Spatial Analyst	Self Study (Virtual Campus)	ArcGIS Spatial Analyst software supports a broad range of sophisticated spatial modeling and analysis applications. This course teaches how to use ArcGIS Spatial Analyst to produce and control raster data. Students create a variety of raster surfaces including hillshade relief maps, slope and aspect surfaces, and density and distance surfaces. In course	18	$130 per trainee

		exercises, students work within the ArcGIS geoprocessing environment to create, execute, and automate spatial analysis workflows.		

The timeframe for the on-line software training is as soon as time and funds are available. After the Census enumeration have been finalized time should be available for training. If funds are an issue, it should be budgeted for in the next financial year and can take place anytime from September. Aside from the software training, specialized subject matter specific training will also be necessary. The following training have been decided upon in consultation with the NSO staff and should be provided by relevant subject matter specialists. Cost will depend on how the differing courses are structured and when each course will take place as well as the entity providing the training.

Training courses	Trainee participants	Course details	Duration	Tentative implementation
Specialised Census analysis and thematic mapping	Selected GIS Unit staff Demographic analysis staff	Spatially analyzing census data, mapping results, spatially linking 1998 and 2008 census data and doing comparative and time series analysis. Census Atlas creation. Database creation	10 days	September to November 2008
Poverty Mapping	Selected GIS Unit Staff	Spatial analysis and dissemination with regard to poverty mapping	5 Days	February 2009
Master Sample creation and GIS based survey methodology	All GIS Unit Staff Survey staff	Compiling a spatial Master Sample and GIS based survey methodology	5 Days	February 2009
Remote sensing use and imagery interpretation	All GIS Unit Staff Fieldwork staff	Image processing and manipulation operations; interpretation	2 Days	March 2009
MS Access training	All GIS Unit Staff	Basic MS Access use	3 Days	March 2009

Short, practical based training courses can only achieve so much. It is therefore necessary to implement a long term formalized training strategy, if funding allows it. As mentioned, on line distance based training courses do exist which can be implemented at the NSO GIS Unit. This will however only be feasible once all the necessary hardware, software and IT Infrastructure, especially reliable internet access, exists.

MS Access training is necessary since the personal geodatabases that will be created are in Access format. In order to build basic validation rules, create relationships and manipulate data even further, basic knowledge of MS Access will be necessary.

Care should be taken that the implementation partner/s has relevant and extensive experience in GIS implementation with regard to socio-demographic and economic statistics within African countries as well as a proven training and successful implementation track record.

4.14 Maintenance and support

To effectively run the GIS Unit, maintenance and support will be necessary concerning the following issues:

Software support, especially for the GIS software. On-line support is provided for GIS software, especially if the yearly maintenance fee is paid, which means upgrades and new versions are provided for free.

IT support. The NSO will have to develop effective IT capacity internally for the whole organization.

4.15 Inter-governmental coordination

The NSO cannot grow as an organization if it does not have the technical and financial **support from its government**. Moreover, specific coordination with certain departments will be essential to the **effective service delivery** from the NSO. **The following departments are crucial:**

- **The Surveyor General**: It is imperative that a good relationship exists between the NSO and the Surveyor General. A culture of **data sharing** must be developed. As aforementioned, this is unfortunately not the case with government departments having to buy data from each other.
- **The Department of Health** and other departments gathering economic or socio-demographic data: A culture of mutual cooperation and data sharing must also be cultivated with these departments since effective decision and policy making depends on the free exchange of information between government departments.

4.16 Risks

The following risks are involved with regard to the successful and sustainable operation and service delivery of the GIS Unit at the NSO:

4.16.1 Inadequate implementation imperative

It is all good and well to send a consultant to assess the situation and draw up a report. The proof of the pudding will however be in moving this process forward, implementing processes such as the **acquisition of the necessary equipment and software and implementing the training.**

The NSO will also have to be **pro-active** in their advocacy of a spatial statistics and should make a concerted effort to garner the necessary support from inside the organization. The relevant management decisions will therefore have to be made to set up the implementation imperative and drive the process forward.

4.16.2 Inadequate governmental support

In order to make the unit sustainable, it will be necessary to have full government support regarding technical and financial assistance. The donor community cannot provide everything in the long run. The NSO therefore has to make sure that the necessary governmental assistance is there in order to draw up and fund the GIS Unit running costs in the short and long term budgets.

4.16.3 Inadequate sustainability

A common vision and management imperative must be formed at the NSO in order to make the GIS sustainable and to gather the most benefit from the GIS Unit. Processes must be put in place to make GIS part of the planning and implementation strategies of all the line units in order for every unit to gain maximum benefit.

4.16.4 Failure to reach short-term goals

The GIS Unit must have the full support of the rest of the NSO line divisions if it is to achieve the short-term goals. The goals should be time-boxed and implemented aggressively. Without the short term goals implemented the long term goals cannot be achieved.

4.17 Conclusion

The main obstacle facing the GIS Unit is the one which is faced by the NSO as a whole – lack of adequate and sustained funding and operational support. It is therefore essential that all effort is made to approach relevant donors and other sources of funding in order to obtain the necessary financial support, without which, the true potential of the GIS Unit at the NSO will never be reached.