Measuring availability and accessibility coverage. Results of the GIS capacity and data availability analysis: Malawi

Promoting an equity and health systems approach towards treatment access and responses to HIV and AIDS in Southern Africa: a joint project between the World Health Organization (WHO), REACH Trust Malawi and the Southern African network on Equity in Health (EQUINET)

December 2006

1. Introduction and Objectives

As part of the equity project there is a need to measure the availability and accessibility coverage offered by the ART care delivery system in the country. The complexity of the processes and data that needs to be integrated in order to measure availability and accessibility coverage highlighted the potential to use the capacities of a Geographic Information System (GIS) to measure accessibility coverage in Malawi.

The willingness of Malawi to take advantage of the GIS capacity and dataset availability resulted in a preliminary analysis of availability and accessibility coverage for the ART care delivery system conducted in July 2006.

The objective of this report is to present the results of this analysis before proposing a set of recommendations aimed at:

- Establishing connections between the main institutions using GIS which could perform the technical work in the future,
- Improving the quality and level of completeness of the already existing GIS data
- Exploring the possibility of establishing a link between this work and the GIS component of the country Health Management Information System (HMIS).

2. Process followed for the analysis

2.1 Data

Two types of information are generally used in order to measure availability:

- the size of the population,
- the quantity of resources available for delivering an intervention. This might include: number of health facilities, number of personnel, availability of technology (drugs, equipment, etc.).

This information might be presented as national figures or disaggregated according to the administrative structure of the country.

In order to measure accessibility coverage we need the geographic location of the information used in measuring availability as well as:

- the geographic distribution of the traveling time that a patient takes according to a specific traveling scenarios. This layer is created on the basis of:
  - a Digital Elevation Model (DEM) which contains the distribution of the altitude
  - the landcover
  - the transportation network (depending on the traveling scenario),
  - the natural barriers to movement (also depending on the traveling scenario)
- the delimitation of the administrative boundaries for data visualization and decision making.

In addition, certain statistics need to be attached to the health facility database. This concerns parameters that are needed in order to estimate the population coverage capacity of the health facilities. These are:

- for small facilities such as health centers:
  - number of health workers
  - number of patients seen in one average day
  - number of days worked per year
  - average number of outpatient visits per capita per year
- for larger facilities such as hospitals:
  - number of beds
  - average occupancy rate
  - number of working days in the year
  - average number of inpatient admittances per capita per year
  - average length of stay

Information on the transportation media used by the patient is also needed together with the associated traveling speed to reach the service providers.

2.2. GIS Capacities

Specific GIS capacities and skills are also necessary in order to compile, integrate and homogenize the data in a GIS and then apply the necessary models, such as AccessMod [1]. The minimum necessary capacities and skills for this work are:

- GIS software availability.: ESRI ArcView 3.2, ESRI Spatial Analyst extension
- GIS skills: at least one GIS technician able to handle the above mentioned software.

Some additional capacities could also be necessary depending on the availability and/or interoperability of the georeferenced data. This includes:

- access to GPS devices
- satellite images treatment software.

2.3 Methods of Enquiry in the Country

A short form (see Annex I) was developed in order to get information regarding the *GIS capacity* of each institution visited or contacted as well as their connection with the rest of the GIS community within the country.

At the same time, the question of the availability of the GIS data was raised , and, where possible, the corresponding data, or at least a sample of it, was collected. Finally, questions to determine which other methods had already been used in the country in order to measure accessibility coverage were also asked.

The form has been filled and the additional information have been obtained either direct a meeting which took place during the stay in Malawi last July or through exchange of emails.

The direct meeting took place with the following institutions and persons:

- The University of Malawi:
    - Department of Geography (Mr Thokozani Kanyerere, Mr Zuze Dulani)
    - Center for Social Research (Mr Sidon Konyani)
- the National Statistical Office (Mr Derek Zanera, Ms Mercy Kanyuka)
- the Ministry of Lands, Department of physical planning and surveys (Mr Alik Kanyangala, Mr Jeff Mzembe, Mr Christopher Sikonde)
- the Ministry of Health (Mr Chris Moyo, Mr Patrick Naphini)
- the Malawi Diffusion and Ideational Change Project (MDCI) (Mr Peter Fleming and colleagues)
- the CDC Country Office (Mr John Aberle-Grasse)
- the UN Habitat Country Office (Mr J. Chome)
- the WHO Country Office (Dr Limbambala)

The institutions and persons contacted by email have been:

- REACH Trust (Ms Ireen Makwiza)
- Lighthouse (Mr Andreas Jahn and Mr Max Boxshall)

Some additional entities have not been contacted during this process:

- the Local Government
- the Lilongwe and Blantyre Water Board
- the Ministry of Agriculture
- the Lilongwe City Assembly
- the Geological Survey of Malawi
- the department of Forestry
- the MaiMwana Project
- the Community-Partnerships for Sustainable Resource Management in Malawi - Phase II project (COMPASS II)
- the National Aid Counsel (NAC)
- Malawi Vunerability Asssessment Committee (MVAC)
- Land Resource and Conservation Department (LRCD) in the Ministry of Agriculture
- Water Sanitation Collaborative Council (WSCC)
- National Roads Authority (NRA).

These institutions have been identified through the report requested by the Decentralisation Secretariat in 2004 (Chinula et al., 2004) or through the use of the form (Annex 1).
Reference to the Secretariat report findings has been made where appropriate in this report.

3. Result of the Analysis

3.1 Completion of the survey

The form and the data, when applicable, have been received from 10 of the 11 institutions/entities contacted. The only information that was missing at the time of this analysis is the one for the Center for Social Research at the University of Malawi.

If the response rate is good it is important not to forget that many other potential key stakeholders have not been part of this exercise.

3.2 Measuring accessibility coverage

The discussion which took place with the MOH and the CDC Country office indicated that catchment areas have so far mostly been designed under the form of circles centred on the health facilities. Additional discussions still need to take place in order to find out more about the methods which are currently been used in the country for measuring accessibility coverage.

The existence of research on measuring accessibility coverage performed by Dai Hozumi (JICA) was mentioned several times during the various interviews, but it has still not been possible to find a copy of the final report that came out of this research.

In summary, the institutions and persons visited expressed an interest in looking at GIS based methods for measuring accessibility coverage in Malawi, and in the particular tool mentioned, AccessMod [1] . This request was not tied exclusively to the equity in access to ART project but was seen to be of benefit for other interventions as well. Much of the data to be collected, the capacities to be developed and the tools to be used, would remain the same for other health treatments and services.

3.3 GIS capacity

The information collected through use of the form (Annex 1) already allows us to have a first picture of the GIS Capacity available in the country in terms of staff, software and hardware (Annex II) remembering that this certainly represent an underestimation as not all the identified institutions have been contacted (see section 2.3).

3.3.1 Software

The panel of software used is quite large. ESRI products dominate (e.g. ArcView) and the use of freeware is limited (e.g. DeveInfo). The interviews also highlighted the fact that some

people at the University would in fact be able to use other software (e.g. Oasis, MapInfo and ILWIS) but that their limited resources did not allow then to purchase licenses for these products. It is nevertheless important to underline the fact that advanced tools for the treatment of satellite images have so far only been located at the Department of Survey.

3.3.2 Hardware

In terms of specific hardware, the availability of large size plotter, digitizing tables and GPS devices provides the necessary ingredients for this work.

3.3.3 Different actors

GIS Technical skills are available in most of the interviewed entities. Some discussions also indicated that additional capacities might be available in institutions that were not part of this short survey (the National Aids Commission (NAC), for example) and that some of the capacity identified in 2004 through the preparation of the GIS Strategy for Local Assemblies might still be in place.

It is then important to underline the existence of the Malawi Geographic Information Council (MAGIC) and its secretariat, the National Spatial Data Centre (NSDC), which are semi-autonomous and self-financing coordinating agencies for the development of a National Spatial Data Infrastructure (NSDI) for Malawi. Their function is not envisaged as replacing the GIS-related activities of other agencies. Rather the opposite, their purpose is to assist other agencies to develop spatial data, which is used in an organized framework. For the moment, these bodies are operating under the Department of Survey but discussions are currently taking place in parliament regarding their autonomy. The following departments are members of the Council for the moment:

- Land resource
- Forestry
- Survey
- Agriculture.

Both the Ministry of Health and the Ministry of Education have also been invited to be part of the council but have so far not replied to the invitation.

3.3.4 Formal tertiary education

Another asset to be mentioned is the existence of two courses in Health Geography / Medical Geography for the undergraduate at the University of Malawi, namely::

1. Health Geography and Development in third year where mostly theories and concepts are taught such as Introducing Geographies of health, Tradition Medicine, Health and Environment, Health and Culture, Health and Migration Health Inequalities, Health Care Provision and Utilization.
2. Advanced health Geography course in the fourth year, which covers topics such as Environmental health, Diseases Diffusion, Geographical aspects of the emergence of infectious diseases, and the political ecology of disease .

These are completed as part of a degree on Health and Development which covers topics like urbanization and health in developing countries, the health of women beyond maternal and child health, spatial analysis of child health, the health of elderly people, development change and human health .

Finally, a GIS and Remote sensing course for the undergraduates and a masters level course are at disposal of the students at the Department of Geography and Earth Sciences.

3.3.5 Summary of capacity assessment and networks

This analysis confirmed to us that the necessary technical and research capacity needed for improving the GIS layers and applying AccessMod is available in the country. There nevertheless remains more information to be collected in order to make sure that the necessary Remote Sensing capacity would be available as well. This capacity might, for example, be available in the institutions not part of this small survey.

The survey also allowed us to look at the connections that already exist between institutions. Two aspects have been analysed:

- question 1: who knows whom ?
- question 2: who works with whom in the context of GIS related activities ?

Given that we did not have access to a full listing of persons involved in GIS activities at the time of the visit in the country ,it was difficult to interpret the results obtained for the first question. Therefore, only the result to question 2 are is reported here (Figure 1) as a first indication of the working connections that do already exist in Malawi.

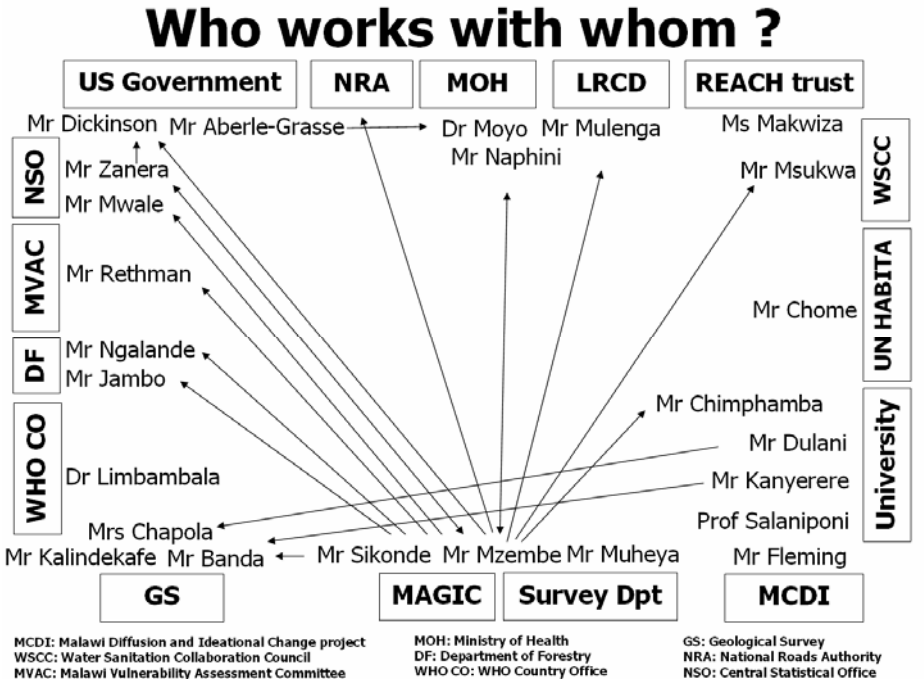

Figure 1 - GIS working connections between the surveyed entities

Potential working relations not connected to GIS are not reported here. It is also important to keep in mind that this figure is just a snap shot in time that would need to be regularly updated in order to remain representative of the situation observed in the country.

This preliminary result already indicates the existence of an important knowledge hub located in the Malawi Geographic Information Council (MAGIC). It also seems to indicate that even if there is a lot of GIS capacities in place, only limited working relationships have so far been established between these institutions.

3.4 Data availability

This following sections reports on the availability of the layers of information needed for the application of AccessMod ©, namely:

- the geographic distribution of the population
- the geographic location of the health facilities providing ART care
- a Digital Elevation Model (DEM)
- the landcover
- the road network
- the river network
- the delimitation of the administrative boundaries.

Priority has been given to data produced within the country to which other known sources have been added.

3.4.1 Population

The unique known provider of disaggregated population data within the country is the National Statistics Office (NSO).

The actual data set comes from the 1998 census and goes down to the Enumeration Area (EA) level.

The NSO is now planning the 2008 Census which will also be georeferenced. The preparation for this census is a major reason why there are a large number of GIS technicians currently working at the NSO. They are creating a new data set containing the location of all the villages, churches, health facilities, roads, and rivers to be used as landmarks for the delimitation of the new Enumeration Areas for the Census (14'000 to 15'000).

Other datasets produced outside the country are also available (e.g. Landscan [2] or GPW [3] dataset). The advantage of these datasets is that they are based on the census data and already in a format that is suitable for the application of AccessMod (1 km resolution RASTER grids). Nevertheless, as the distribution of the population is based on a model using data attached to vector based layers, there would be a need to check the validity of the resulting population distribution on the ground.

An important way to improve these datasets when looking at measuring accessibility coverage would be to have access to the location of each village with the corresponding population attached to it. This information could for example be found in gazetteer but the ones that are available (e.g. NIMA) are quite old (1995) and no population is attached to each village. The preparation exercise being undertaken for the 2008 census involves identifying the location of each village in Malawi but does not link any population data to it. This information might nevertheless be used at some stage to redistribute the population figures to be collected in 2008 at the level of the Enumeration Areas.

3.4.2 Location of the Health facilities and attached information

Two health facility censuses have been performed by the MOH with the support of JICA between 1999 and 2003. These censuses used GPS devices for locating all the public health facilities in Malawi.

In view of the coming census, the National Statistical Office has also been collecting the location of the health facilities. If this data collection exercise presents the advantage of locating the public as well as private infrastructure it unfortunately do not collect more information than the name of the each facility which represent a major limitation towards its in the context of the present work.

Two other elements remains to be identified:

- which facilities do and do not provide ART care.
- whether the Health facility census included the collection of the information necessary for calculating the population coverage capacity of each facility (see section 2.1) and how complete and up-to-date this information is.

3.4.3 Digital Elevation Model

The Survey Department has developed a 100 m resolution Digital Elevation Model (DEM) generated on the basis of the contours digitized from the 1:250,000 map series.

Other coarser sources of DEM, produced outside the country, are also available for Malawi, such as:

- GTOPO 30 (1 kilometer resolution) [4]
- SRTM 90 (90 meters resolution) [5].

GTOPO30 was derived from several raster and vector sources of topographic information. In the case of Malawi data coming from a Digital Terrain Elevation and the Digital Chart of the World dataset [6] have been mixed to produce the final result. Caution should therefore be exercised when using this particular source.

The SRTM 90 dataset has been collected from space during the Shuttle Radar Topography Mission (SRTM) conducted in February 2000 by NASA. Even though some caution has to be exercised with regard to possible artefacts in the resulting grid, this dataset is more reliable than the GTOPO30 dataset and also much more compatible with the other satellite based datasets mentioned in this report.

3.4.4 Landcover

The Department of Forestry does own a landcover layer for Malawi for 1992. Both the dataset itself and more information about the dataset (e.g. method of creation) still needs to be obtained. It has for the moment not been possible to include it in the analysis conducted for this report. It might be that this missing dataset corresponds to part of the one describing the Global land cover characteristics [7]. This database layer is based on the one-kilometre AVHRR NDVI satellite images composites, which make this dataset compatible with other satellite based datasets mentioned in this report.

The land cover layer created for the purpose of the Landscan database (see the population section) represents another source that has been considered here. The advantage of this layer of information is that it is directly compatible with the Landscan population distribution grid and does integrate part of the Global land cover characteristics database. Its main disadvantage is the way it has been generated is poorly documented.

3.4.5 Road and river network

Two sources of data have been identified for both the road and the river network:

- The one produced by the Survey Department
- The one currently collected by the NSO.

The Survey Department has developed a further two datasets:

- the 1:50'000 scale which is based on 10m resolution panchromatic Spot images for the year 2000
- the 1:250'000 scale dataset.

There is a cost associated with the use of both datasets. For the 1:50'000 scale dataset the cost is of 200 Kwa/Mb (the total road network has a size of 75 Mb and the river network reaches 192 Mb) while for the 2nd dataset only the data transfer cost is charged.

For the analysis used in this report, the 1:50'000 dataset from the Survey Department and the data coming from the NSO covering the TA of Kilupula in the district of Karonga (Northern Region) have been used.

It is also important to mention that National Road Roads Authority (NRA) might have access to an other source of road data that have not been included in the present analysis.

Other sources of data, produced outside the country, are also available. For the context of this analysis only the Global Insight Database [8] has been considered as being the source most used within WHO.

3.4.6 Administrative boundaries

The Survey Department does produce and maintain an administrative boundaries dataset.

To complement this dataset, another project, called the Survey Department and the Second Administrative Level Boundaries dataset project (SALB) [9] is currently working to update the historical changes observed in the country since 1990 at the 1st sub national level and, since 2000, at the 2nd sub national level. The project is also producing a set of GIS format maps, one for each change observed since January 2000, that would be available to the public for thematic mapping purposes.

3.4.7 Other interesting dataset

Through its data collection exercise for the 2008 Census, the National Statistical Office is also collecting the location of many features such as schools, churches/mosque, post offices, and trading centers,and this covers the whole country.

This dataset might represent an important asset for assessing accessibility to education, market places. Unfortunately the content of the attribute dataset is, like for the health facilities, limited to the name of the infrastructure.

3.5 Accuracy and level of completeness of the GIS Data

In order to produce reliable results when applying AccessMod, or any other model using a GIS, it is necessary to use information layers that are compatible in terms of projection, scale, level of accuracy and level of completeness.

The first difficulty in this process is often the lack of metadata. Creating and keeping a metadata record for each layer is still not necessarily a habit for many agencies. In the case of Malawi, the main data producers have a good knowledge of their data characteristic (e.g. projection, scale) even if this information is not necessarily stored in metadata records.

Measuring the accuracy and the level of completeness of the georeference data is only possible if we have a reference that can be used for comparison. The availability, at the Survey Department, of 10m resolution panchromatic Spot images for 2000 covering all the country could provide us with the ground reference that we are looking for.

Nevertheless, as it has not been possible to use these images outside of the country, the present analysis is done using the free global seamless mosaic of Landsat Enhanced Thematic Mapper Plus (ETM+) images which is, for example, accessible from the University of Maryland web site [10]. Each of the ETM+ scenes part of this dataset, collected between April 2003 and June 2005 for the most recent set, presents an approximate size of 170 x 183 kilometers (106 x 115 miles) with a spatial resolution of:

- 15 meters for the panchromatic (band 8)
- 30 meters for the visible and near-infrared (bands 1-5 and 7)
- 60 meters for the thermal infrared (band 6).

As reported by the NASA, the positional accuracy of the GeoCover-Ortho 1990 dataset is below 50 meter (Dykstra & Storey, 2004) .

This accuracy has been confirmed using a GPS device to take coordinates along the road between Zomba and Lilongwe. All the 37 points collected on the way (example in Figure 2) falls on the road followed.

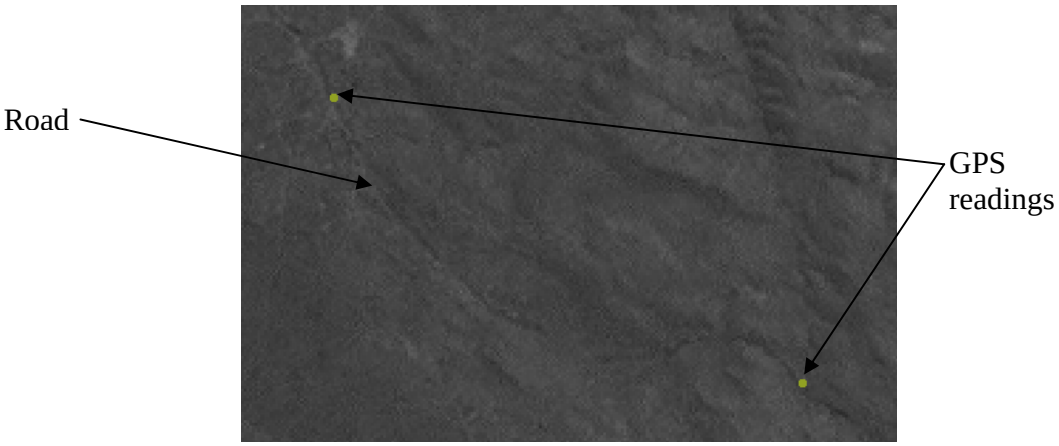

Figure 2 - Overlay of the GPS coordinates taken along the road between Zomba and Lilongwe on top of the 15 meter panchromatic Landsat image

These two results as well as the good resolution of these images gives us the possibility to assess the level of accuracy of the different layers presented in this report.

In addition to that the fact that the ETM+ scenes are more recent than the Spot images should also allow us to have an estimation of the level of completeness of these layers.

The characteristics of the projection generally used by the Survey Department and the National Statistical Office (NSO) are the following:

- Projection: Transverse Mercator
- Spheroid: Clarke 1880
- Central meridian: 33
- False Easting: 500'000
- False northing: 10'000'000
- Reference latitude: 0
- Scale: 0.996.

The analysis made on the vector format layers (roads, rivers, health facilities and administrative boundaries) is presented separately from the one performed on the raster format ones (population, DEM and landcover).

3.5.1 Analysis on the vector layers

Some of the layers needed to be reprojected before being able to perform the analysis.

The characteristics of the projection provided by the Survey Department for their layers of information are the following:

- Projection: Transverse Mercator
- Spheroid: Clarke 1880
- Central meridian: 33
- False Easting: 500'000
- False northing: 10'000'000
- Reference latitude: 0
- Scale: 0.996

Using these parameters did not provide good results when reprojecting the different vector layers to match the projection of the ETM+ Landsat scenes (UTM 1983, Zone 36). This issue is well known by the Survey department and it has therefore been necessary to consider different values for two of the above mentioned parameters when using the data coming from the Survey Department in order to obtain a good result, namely:

- False Easting: 500'330
- False northing: 9'996'300.

The information layers coming from the National Statistical Office (NSO) have been reprojected using the same parameters. Nevertheless, as illustrated later in this document it also seems that different parameters needs to be used in order to un-project the data collected by the National Statistical Office. Unfortunately, it has so far not been possible to find the correct modifications to be applied.

3.5.1.1. Road and river network

After reprojection, the overlay of the different sources of information available for the road network (see section 3.4.5) on the satellite images give result such as the one shown in Figure 3 for small part of the TA of Kilupula in the district of Karonga.

Figure 4 present the same type of overlay but this time for the different source available for the river network.

In both Figure the roads and rivers that could be manually extracted from the satellite image are presented in blue as a reference.

Figure 3 - Extract of the road network for Malawi with in Yellow: the one coming from the Survey Department; in Green: the one coming from the National Statistical Office and in Red: Global insight database; Blue: the one extracted from the satellite image.

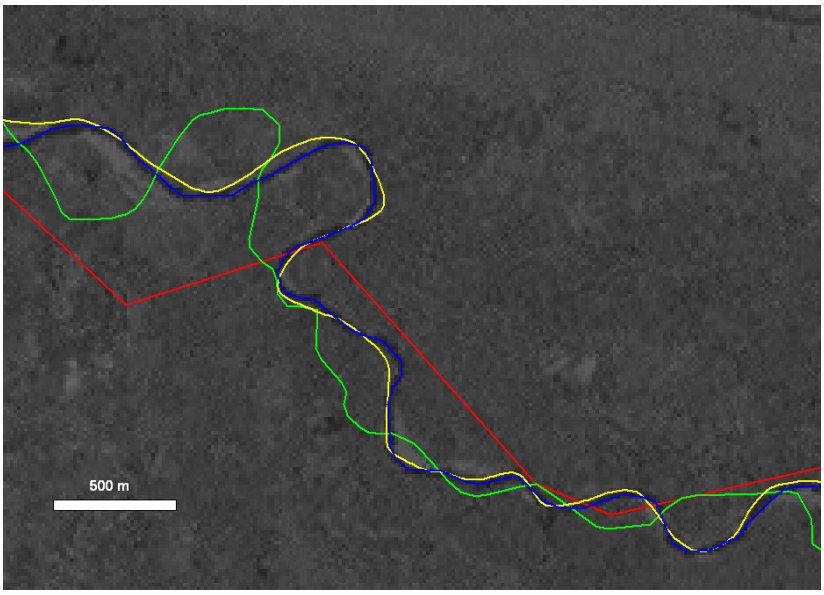

Figure 4 - Extract of the river network for Malawi. Refer to Figure 2 for the explanations of the colors.

As we can see on these figures, important differences are observed, in terms of accuracy, among the available datasets. Several reasons might be at the origin of these differences such as the scale and projection of the original data set. In both cases the dataset coming from the Survey Department appears to be the most accurate.

Because of the quality of the ETM+ image it has unfortunately not been possible to have a good estimation of the level of completeness for these layers.

Applying AccessMod, or any other method, using a road or a river network that would be too far from the reality would produce unreliable results (Ebener et al, 2004). There would therefore be a need to further check the level of completeness and accuracy of the existing road and river network dataset currently available for the country.

3.5.1.2 Location of the health facilities

Looking at the health facilities locations collected through the MOH Census and more recently by the NSO on top of the road network coming from the Survey Department (Figure 5) we can observe that for this particular TA:

- There are more facilities in the NSO database (10) than in the Health Facility census performed by the MOH few years ago (1) for this TA. This is firstly explained by the fact that the NSO is also collecting the location of private facilities. Some new facilities might also have been created since 2003.
- The location of the facilities seems to match with the road network. The use of GPS devices during both exercise is at the origin of this result
- Contrary to the road and river network there is a good match between the two source of information regarding the location of the Kaporo Dispensary. The reason for this might be linked to the fact that the road and river network data have not been collected using GPS devices
- There is a difference in Nomenclature between the Census and the data from the NSO. If the NSO talk about the Kaporo Dispensary, the census describe it as being the Kaporo primary health center.

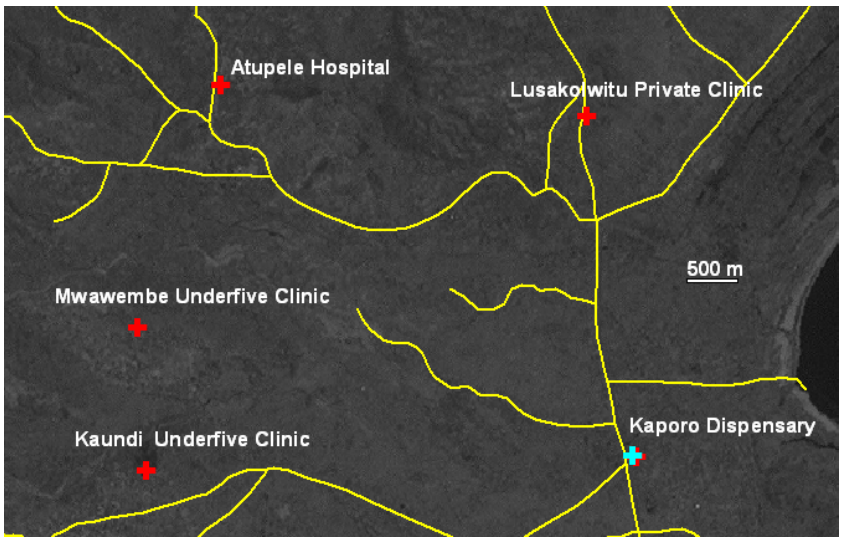

Figure 5 - Location of the health facilities part of the Health facility census performed by the MOH (in light blue) and the one collected by the NSO (in red) on top of the road network coming from the Survey Department

3.5.1.3 Administrative boundaries

Regarding the administrative boundaries, the new dataset under preparation by the Survey Department for the SALB project being not accessible at the time of this study we only looked at the one at disposal. For this analysis, the fact that some limits between district do correspond to rivers has been used to check the accuracy of this layer. Figure 6 present one example of such comparison for an area located in the central part of Malawi between the district of Lilongwe and Dowa.

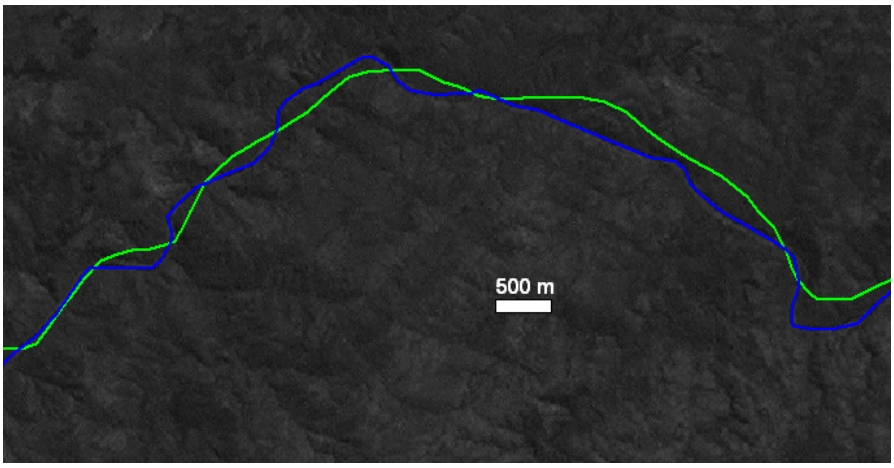

Figure 6 - Example of difference existing between the district boundaries layer available at the time of the analysis (in green) and the river observed in the corresponding 15 m ETM+ Landsat satellite image (in blue).

As we can see in Figure 6, the difference observed between the district border and the rivers itself is not very big and largely remains within the error that can be expected when working at the 1:1'000'000 scale (scale considered in SALB).

This shift might nevertheless be important when matching the resulting of the accessibility coverage analysis back to the administrative structure. This issue should therefore be addressed and a solution been found.

3.5.2 Analysis on the raster layers of information

Before performing the analysis on the raster layers of information it has been necessary to project all of them to make them match the projection of the ETM+ Landsat scenes. In this case the operation was easier as all these layers are provided unprojected.

The result of this analysis is presented in the following sections.

3.5.2.1 Population distribution grid

for the population distribution grid, it has been possible to measure the shift that exists between the water bodies as observed in the satellite image and the same bodies as observed within the Landscan population distribution grid. Figure 7 gives an example of such shift for a small area touching the south part of lake Malawi.

Despite the difference in the resolution between the two datasets, this shift leads to population being located over the surface of the lake (in the west part of the image) and other potentially populated areas being not reported in the population distribution grid (in the east part of the image). This unfortunately confirms the incompatibility of the 2003 landscan population dataset with the other dataset extracted from satellite images.

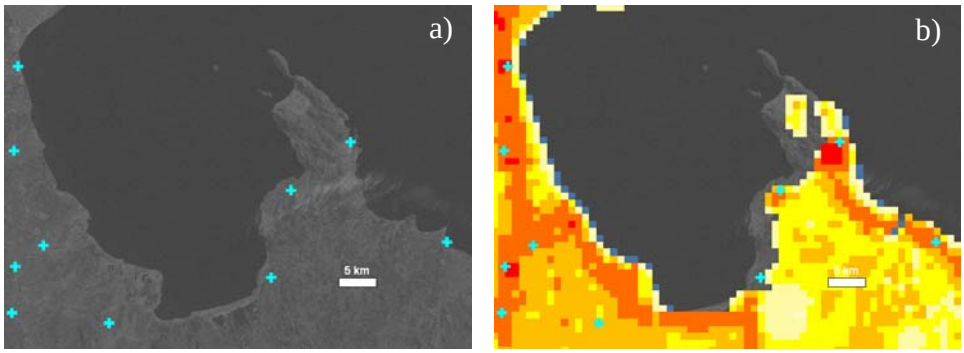

Figure 7 - a) 15 meter landsat scene with the health facilities form the census. b) same image on which the Landscan 2003 population grid has been overlaid

3.5.2.2 Digital Elevation Model (DEM)

For the Digital Elevation Model (DEM), a very rough estimation of the quality of the georefencing of the SRTM 90 dataset is obtained by looking at the quality of the overlay that exists between the river network and a certain range of altitude in the mountainous part of the country. In Figure 8 for example we can see that the river network indeed pass by the middle of the valleys observed in the SRTM 90 DEM. The same type of analysis should be performed on the DEM produced by the Survey Department

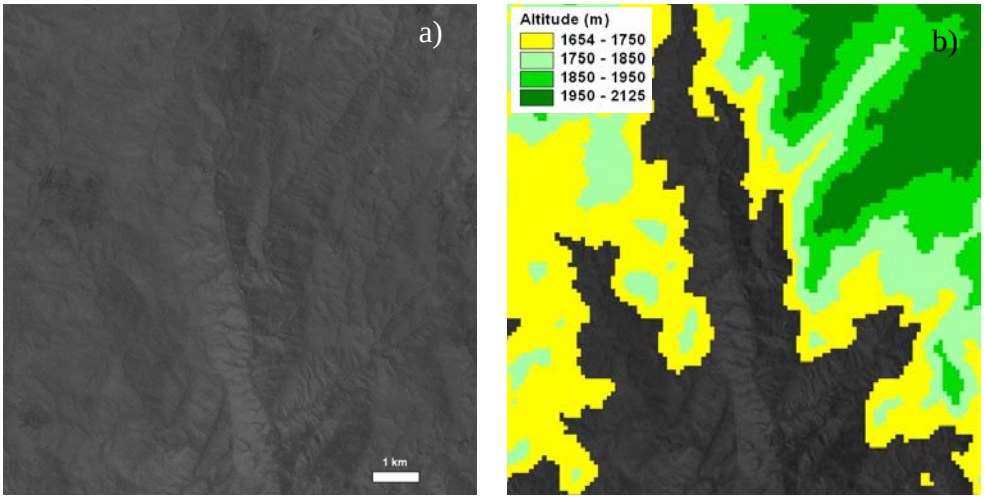

Figure 8 - a) 15 meter Landsat scene b) same image on which the SRMT90 data has been overlaid (the altitude is in meter)

3.5.2.3 Landcover

Regarding landcover, the fact that the Landscan population distribution grid is based on the Landscan landcover directly means that the shift observed for the population in Figure 7 also applies to the landcover layer. A problem in the documentation regarding the projection did not allowed us to perform the analysis for the Global land cover characteristics database for the moment. An analysis such as the one presented in Figure 7 or 8 should also be performed on the landcover grid developed by the Department of Forestry.

4. Conclusions of the Analysis

There is definitively an interest to look at the possibility of applying AccessMod, or any similar model, to determine accessibility coverage in Malawi and see how this could add value to the method used so far. Interest has also been expressed, by the HIV AIDS unit at the CDC Country Office, to use GIS for looking at population density issues as well as the service and prevention areas.

The analyses in this document show that **a large amount of good quality data are already available in the country.** Yet some improvements are needed:

(a) In terms of health facility location, there is a need to see how the current data collection process performed by the NSO could be leveraged in order to update the health facility census performed in the country between 1999 and 2003. This operation would mean that some field work would be necessary in order to collect the attribute information needed by the MOH.

(b) More information would also need to be collected in order to make sure that the necessary Remote Sensing capacity would be available as well.

(c) The integration analysis showed that some further analysis and work will need to be performed in order to improve and/or complete several of the information layers (roads, rivers, population, administrative boundaries). The objective would be to improve the information layers to obtain results that would be suitable for decision

making. In this regard the availability of the combination of the Spot mosaic and the free global seamless ETM+ Landsat mosaic could offer the necessary ground reference for starting the improvement of the existing layers.

In terms of GIS capacity, the small survey conducted in Malawi for this report has only revealed part of the country's GIS capacity, not only in terms of software and hardware, but also in terms of skills. Yet this capacity is already more than sufficient to perform necessary technical work as well as to apply the selected model for measuring accessibility coverage.

This survey also demonstrated the low level of working interactions that exist among the different institutions using GIS in their work. These connections would need to be strengthened and appropriate funding obtained in order to perform the necessary technical work.

Recommendations on next steps and the potential support that WHO could offer in this regard are presented in the next section.

5. Recommended Next Steps

The first recommendation is to create a working group, under the umbrella of the Malawi Geographic Information Council (MAGIC), made of GIS technicians from the following institutions:

- the Ministry of Health,
- the Survey Department,
- the National statistical Office,
- the National AIDS Council,
- the National Roads Authority,
- the Department of Forestry,
- the University of Malawi,
- the CDC Country Office,
- the WHO Country Office.

Additional members, identified in a later stage could join this first set of institutions. This working group would serve to improve the connections between the different GIS institutions identified in the country.

This working group's terms of reference would include:

- operationalizing the necessary GIS framework
- discussing a potential workplan for the improvement of the available datasets and the application of AccessMod focussing initially on the monitoring of equity in access ART provision as a case study.

It is proposed that the Ministry of Health takes the lead of this working group with the support of the National Spatial Data Centre (NSDC).

The issues that this group will discuss as well as the technical work that might emerge from it being not only of interest for the present project but potentially at the origin of material (data, protocols, standards, etc.) to be used in many other context it is recommended that the working group use this opportunity to integrate new members in MAGIC towards the creation of a Spatio-Temporal Data Infrastructure (STDI) for Malawi. It is also recommended that the Ministry of Health look at this as an opportunity not only to be linked to this process but also as a possible way to strengthen the Geographic and Time components of its Health Management Information System (HMIS).

A second recommendation, depending on funding availability, is for WHO to provide some support to the working group through the monitoring equity in ART provision project. More specifically WHO could help in:

- the organization and agenda development for the first meeting of the working group,
- transferring its experience acquired through the AccessMod [1] and SALB [9] projects
- supporting the workplan of activities for the improvement of the available datasets
- facilitating the access to data (e.g. Landsat Mosaic)
- assisting in the writing of a proposal to donors to support the technical work.

References

Publications

Chinula R., Chome J., Kamela H. (2004): GIS Strategy for Local Assemblies in Malawi. Report of the consultancy done on behalf on behalf of the Decentralisation Secretariat of the Ministry of Local Government and Rural Development of the Malawi Government

Ebener, S., El Morjani, Z., Black, M., Alexakis, E., Martin, Diaz A., Vanasse, A., Hemiari, A. (2004): "Measurement of Accessibility to Health Care, Part II: GIS development', Poster presented at the 6th GEOIDE Annual Scientific Conference, La Chaudière, Ottawa, Canada, May 30 - June 1, 2004.

Web sites

[1] AccessMod web site: http://www.who.int/kms/initiatives/accessmod/en/index.html

[2] Landscan database: http://www.ornl.gov/sci/landscan/landscan2004/index.html

[3] Gridded Population of the World (GPW): http://sedac.ciesin.columbia.edu/plue/gpw

[4] GTOPO 30: http://edcdaac.usgs.gov/gtopo30/gtopo30.asp

[5] SRTM 90: http://srtm.csi.cgiar.org/

[6] Digital Chart of the World (DCW):http://ortelius.maproom.psu.edu/dcw/

[7] Global land cover characteristics database: http://edcsns17.cr.usgs.gov/glcc/

[8] Global Insight database: http://www.europa-tech.com/

[9] SALB web site: http://www3.who.int/whosis/gis/salb/salb_home.htm

[10] Global Landsat Mosaic at the University of Maryland: http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp

Annex I - Form developed for collecting the institutional GIS Capacity and connection information

Institutional capacity and connections for Malawi	**Date:**	

Name of the institution:	
Postal address:	
General phone number	
Fax Number	
Contact person (please indicate name, phone number and email address):	
GIS projects (additional documents might be attached)	

GIS Staff	**Number**		
	Degree	**Licence**	
		master	
		PhD	

GIS/RS software at disposal (please indicate the version)	**ArcView**	
	ArcGIS	
	List of ESRI Extensions	
	ArcInfo	
	MapInfo	
	DevInfo	
	HealthMapper	
	Epi Info	
	SIGEpi	
	Manifold	

	Idrisi	
	Erdas	
	Others	
Hardware at disposal	**nbr of computers**	
	plotter(s) (with size)	
	digitizing table	
	others	
Nbr of GPS devices at disposal and model (e.g. Garmin eTrex)		

Connections with other institutions regarding GIS activities		**Name and email address of the GIS person you are in contact with at:**	**Name and email address of the GIS person you are working with at:**
	Ministry of Health		
	National Statistic Office		
	Department of Surveys		
	University of Malawi		
	WHO Country Office		
	CDC Country Office		
	CDC country Office		
Please indicate here other connections you might have			

Annex II - GIS capacities at disposal in July 2006

Entity		GIS technician	Software	Special Hardware	Nbr of GPS
WHO Country Office		None	None	None	None
Ministry of Health		1	ArcView 3.2, Devinfo, HealthMapper	A0 plotter	37 (one for each district)
University	Department of Geography	5	ArcView 3.2, ArcGIS 9.0, spatial analyst extension	None	None
National Statistical Office		26	ArcView 3.2, ArcGIS 8.0	A0 plotter, 3 A0 digitizing table, 1 A4 scanner	30
CDC Country Office		2	ArcView 3.2, Epi Info	None	None
Department of Survey		8	ArcView 3.3, ArcGIS 8.0, Catalynx 1.2, ERDAS Imagine 2.8, IDRISI Kilimanjaro	2 A0 plotter, 2 A0 Digitizing table, 1 AO Scanner	3 (Leica) + 2 hand helds
The MCDI project		1 (when in MWI)	ArcView 3.3, ArcGIS 9.1, network and spatial analyst extension	None	10
UN Habitat		None	None	None	None
EQUI-TB Knowledge Programme		1	None	None	1
Lighthouse		1	ArcView 3.1, network analyst extension	None	1
Total		45	9 different software	3 large size plotter, 5 large size digitizing tables, 1 big size scanner	82