

CONDUCTING WATER AND SANITATION SURVEY USING PERSONAL DIGITAL  
ASSISTANTS AND GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGIES IN  
RURAL ZIMBABWE

by

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CO-SUPERVISOR: DR F G NETSWERA

JUNE 2011

I declare that **CONDUCTING WATER AND SANITATION SURVEY USING PERSONAL DIGITAL ASSISTANTS AND GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGIES IN RURAL ZIMBABWE** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

A handwritten signature in black ink, appearing to be 'R. Ntozini', written on a light-colored background.

**SIGNATURE**

(Robert Ntozini)

**DATE: 23 June 2011**

# CONDUCTING WATER AND SANITATION SURVEY USING PERSONAL DIGITAL ASSISTANTS AND GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGIES IN RURAL ZIMBABWE

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## **Abstract**

Access to clean water and improved sanitation are basic human right. This quantitative, descriptive study sought to establish current water and sanitation coverage in Chirumanzu and Shurugwi districts in Zimbabwe and develop methods of assessing coverage using Geographic Information Systems. Google Earth was used to identify homesteads. Personal digital assistant-based forms were used to collect geo-referenced data on all water points and selected households. Geospatial analysis methods were used to calculate borehole water coverage.

Using Google Earth, 29375 homesteads were identified. The water survey mapped 4134 water points; 821 were boreholes; and only 548 were functional. Functional borehole water coverage was: 57.3%, 46.2%, and 33.5% for distance from household to water point of within 1500 m, 1000 m, and 500 m respectively. Sanitation coverage was 44.3%, but 96% of the latrines did not meet Blair Ventilated Pit latrine standards.

## **KEY CONCEPTS**

Personal Digital Assistant, Geographic Information System, Geographic Position System, geo-referenced data, geospatial analysis, Blair Ventilated Pit latrine.

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## *Dedication*

*To my family, friends and colleagues*

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## List of abbreviations

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BVIP	Blair Ventilated Improved Pit
CSO	Central Statistics Office
CSV	Comma Separated Value
DDF	District Development Fund
DEHO	District Environmental Health Officer
DMO	District Medical Officers
EHT	Environmental Health Technician
FNC	Food and Nutrition Council
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
JMP	Joint Monitoring Programme
KML	Keyhole Markup Language
MDGs	Millennium Development Goals
MICS	Multiple Indicators Cluster Survey
MIMS	Multiple Indicators Monitoring Survey
MoH&CW	Ministry of Health and Child Welfare
NAC	National Action Committee
NGO	Non-governmental Organisations
PDA	Personal Digital Assistant
PEHO	Provincial Environmental Health Officer
PMD	Provincial Medical Director
RWSN	Rural Water Supply Network
SD	Secure Digital
UN	United Nations
UNICEF	United Nations Children's Fund
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WMDC	Windows Mobile Device Center
ZDHS	Zimbabwe Demographic and Health Survey
ZimStat	Zimbabwe Statistics
ZIMVAC	Zimbabwe Vulnerability Assessment Committee
ZVITAMBO	Zimbabwe Vitamin A for Mothers and Babies

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# Chapter 1

## Orientation of the study

### 1.1 INTRODUCTION

A water and sanitation survey is an onsite review of the water source or sanitary facility, and the facilities, equipment, operation, and maintenance of the water or sanitary system (<http://www.dec.state.ak.us/EH/dw/dwmain/what-survey.html>). Water and sanitation are surveys conducted to assess the coverage of water and sanitation facilities in a given geographic area. Zimbabwe Vitamin A for Mothers and Babies (ZVITAMBO) is a research organisation working in the field of child nutrition and prevention of mother to child transmission of HIV. The organisation will conduct a randomised clinical trial to investigate child growth under different water, sanitation and nutrition interventions in two rural districts in Zimbabwe. The trial will involve provision of sanitary facilities and equalisation of access to water throughout the two districts by rehabilitating broken water points and drilling new boreholes where water coverage is low.

The last water inventory survey in Zimbabwe was conducted by United Nations Children's Fund (UNICEF) and the government in 2004 (UNICEF 2004). During the last six years economic conditions deteriorated in Zimbabwe so much that there may be a substantial change in water and sanitation coverage figures now as compared to what it was like eight years ago. To conduct the clinical trial ZVITAMBO requires current and accurate estimates of the true water and sanitation coverage in the two districts where the trial will be conducted. The problem of outdated water, sanitation and hygiene (WASH) statistics and imprecise water coverage statistics prompted the researcher to investigate methods of performing a rapid assessment of WASH facilities and methods of calculating more representative water coverage estimates in rural Zimbabwe. The value of obtaining such information benefits both the communities in the districts and the government and its WASH implementation partners as it can unlock resources into the WASH sector which otherwise would not be accessible. To meet the millennium development goals on sanitation and water, Zimbabwe needs tools for rapid

assessment and analysis of WASH data in order to direct appropriate attention various to regions in time.

## **1.2 BACKGROUND TO THE PROBLEM**

Access to safe water and improved sanitation are basic human rights (Sphere 2004:55). Both globally, regionally and nationally, provision of water and sanitation facilities to rural communities usually get less attention as compared to urban communities where piped water and sewer systems are provided. According to Rural Water Supply Network (RWSN 2010:2), globally 136 million (2%) of urban population has no access to improved drinking water compared to 780 million (11%) of rural population and in sub-Saharan Africa 272 million (35%) rural dwellers have no access to safe water compared to 54 million (7%) of urban population. In Zimbabwe the estimated proportion of rural population without improved water supplies is 30% and rural water is mainly collected from shallow wells, deep wells and boreholes but often from streams, rivers and dams (UNICEF 2004).

In rural Zimbabwe access to protected public water sources (boreholes and deep wells) is normally provided through government departments and other WASH implementation UN agencies and NGOs like UNICEF and Oxfam. Maintenance of water sources is usually coordinated by a government department, the District Development Fund (DDF), which also keeps an inventory of water sources and trains a network of pump minders to look after the installed boreholes. The water inventories are now many years out-of-date and the pump minders are no longer functional in many districts.

In Zimbabwe the approved improved sanitation facilities for rural areas is the Blair ventilated improved pit latrine (BVIP), however, this model of latrine is relatively expensive to build for most rural families whose income is usually quoted as less than a dollar a day. Construction of BVIP latrines was subsidised by the government and WASH sector NGOs over the last two decades, however due to the declining local economy over the past ten years and global economic collapse of 2007 and its fall out ([http://en.wikipedia.org/wiki/Financial\\_crisis\\_of\\_2007%E2%80%932010](http://en.wikipedia.org/wiki/Financial_crisis_of_2007%E2%80%932010)), it was harder to source for funding for WASH services from donor nations and UN agencies. Very few latrines were constructed during these last ten years, many existing facilities have



filled up and some collapsed during incessant rains of 2000 when Cyclone Eline struck Zimbabwe ([http://www.thezimbabwean.co.uk/index.php?option=com\\_content&view=article&id=34421:cyclone-eline-the-scars-remain-a-decade-later&catid=31:weekday-top-stories&Itemid=30](http://www.thezimbabwean.co.uk/index.php?option=com_content&view=article&id=34421:cyclone-eline-the-scars-remain-a-decade-later&catid=31:weekday-top-stories&Itemid=30)).

Many professionals such as scientists, professors, or physicians, including public health workers have left the country in search for greener pastures in neighbouring countries and worldwide because of political turmoil in the country and failure of the local economy to pay them a living wage, often coined as Africa and Zimbabwe brain drain, hence like all other health sector divisions, maintenance of existing WASH facilities has continued to decline (<http://unpan1.un.org/intradoc/groups/public/documents/AAPAM/UNPAN025752.pdf>). The shortage of skilled man power in the public health sector has led to a decline in monitoring and updating of WASH inventories over the last decade. For optimum implementation of WASH interventions, up-to-date statistics on coverage and access are required by both government and WASH implementation partners in order direct appropriate resources to maximise benefits.

There is no clear and agreed definition of rural access to safe water. Different organisations, agencies and countries use various definitions based one or more of three factors namely: distance, time and quality (Hirotugu & Takusei 2003; [http://www.unesco.org/water/wwap/wwdr/indicators/pdf/F4\\_Access\\_to\\_safe\\_drinking\\_water.pdf](http://www.unesco.org/water/wwap/wwdr/indicators/pdf/F4_Access_to_safe_drinking_water.pdf)). Many WASH coverage estimates in Africa do not take into account distances travelled to fetch water as these data are not easily available, instead they use a proxy for water access (Mapping a Healthier Future Uganda 2009:20; UNICEF 2004). The method of data collection and analysis of water coverage used in the Zimbabwe WASH Inventory Atlas of 2004 uses a proxy for water access based on village level population and number of village level water points and does include distance to water source. Villages in rural Zimbabwe are not well defined as in urban areas, the villages can cover land areas that differ greatly and population densities within villages can vary widely hence the same number of water points in two same size villages with same populations can represent very different levels water access when defined by distance.

The principal cause of the cholera outbreak of 2008-9 in Zimbabwe and other Southern African countries was mainly due to inadequate access to safe water and improved sanitation ([http://www.who.int/csr/don/2008\\_12\\_02/en/index.html](http://www.who.int/csr/don/2008_12_02/en/index.html); [http://en.wikipedia.org/wiki/2008%E2%80%932009\\_Zimbabwean\\_cholera\\_outbreak](http://en.wikipedia.org/wiki/2008%E2%80%932009_Zimbabwean_cholera_outbreak)).

The epidemic started in urban centres but soon spread to rural areas as city residents moved to rural areas and infected the unprotected water sources. This points to the importance of closer monitoring of water and sanitation activities in communities.

Personal digital assistant (PDA), are pocket-sized hands held computing devices, typically having a display screen with touch input and miniature keyboard ([http://en.wikipedia.org/wiki/Hand-held\\_computer](http://en.wikipedia.org/wiki/Hand-held_computer)). PDAs allow for data capturing in the field at the point of data collection into pre-programmed data collection forms so that there is no need to fill in paper questionnaires and coding of results. Data captured on PDAs is downloaded via cable or transmitted to a remote computer over wireless or cellular signals. This method of electronic data collection allows for rapid analysis of data so that interim results are available immediately and monitoring of fieldwork is made easier (Joubert & Ehrlich 2009:114).

Geographic information system (GIS), or geographical information system, is any system that captures, stores, analyzes, manages, and presents data that are linked to location (<http://en.wikipedia.org/wiki/GIS>). GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts (<http://www.esri.com/what-is-gis/index.html>). GIS can be used to calculate water and sanitation coverage and display them on maps. Some GIS packages are sold commercially while others are free open source. Google Earth is one popularly used GIS package that can be used for visualising geo-referenced data in a virtual globe which is a three dimensional computer model of the earth that allows a user to move around the earth by altering the position and viewing angle (<http://www.google.com/earth/index.html>).

The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS), based on 24 communication satellites orbiting the earth. The system provides reliable location, defined by **latitude** (an imaginary line that crosses the earth's surface parallel to the Equator, measuring how far north or south of the Equator a place is located), **longitude** (an imaginary line that crosses the earth's surface running from

north to south, measuring how far east or west of the prime meridian a place is located), and **altitude** (the perpendicular height of a point on or near the Earth measured from sea level), at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites ([http://en.wikipedia.org/wiki/Global\\_Positioning\\_System](http://en.wikipedia.org/wiki/Global_Positioning_System)). GPS receivers are electronic devices that receive radio signals from three or more GPS satellites to determine their geographic positions.

The use of PDAs as data collection tools has been documented in many health studies (Shortliffe & Cimino 2006:76; Fletcher, Erikson, Toomey & Wagenaar 2003). In public health PDAs have been used in several studies including some in Zimbabwe as in the Zimbabwe National Nutrition Survey and the Demographic and Health Survey of 2010. The methods of collecting geographic-referenced data using PDAs with GPS receivers have been documented as in the Malaria Indicator Survey of 2005 (<http://www.measuredhs.com/pubs>). The use of GIS in analysing water access has not been fully exploited. Studies like Mapping a Healthier Future in Uganda uses GIS to create maps indicating access to water but the data used in the analysis are not accurate enough to measure true water access.

Chirumanzu and Shurugwi are two neighbouring districts in the central Midlands province of Zimbabwe. Both districts are primarily rural with small urban centres, Mvuma and Shurugwi respectively. According to the Zimbabwe Central Statistics Office (now ZimStats), in 2002 Chirumanzu had a total population of 70431 and land area of 4761 km<sup>2</sup> and Shurugwi had 88 390 of which 16863 (19%) were urban with land areas of 3471 km<sup>2</sup> and 37 km<sup>2</sup> respectively (see table 1.1) (CSO 2002). The low population density and few access roads in the rural areas make collecting data on access to water and sanitation facilities a slow and resource intensive process requiring a lot of travelling to visit individual households and water sources which are often not easily accessible.

For the purpose of this study only rural districts without piped water and with no sewage connection are considered because the ZVITAMBO intervention will include the provision of BVIP latrines to households and the rehabilitation of public boreholes and deep wells.

### 1.3 STUDY SITE

Chirumanzu and Shurugwi are two neighbouring districts in the central Midlands province of Zimbabwe with land area measuring 4761 km<sup>2</sup> and 3471 km<sup>2</sup> respectively (see figure 1.1). Both districts are primarily rural with small urban centres, Mvuma in Chirumanzu and Shurugwi town in Shurugwi. According to Zimbabwe Statistics (ZimStat), formerly known as the Central Statistics Office (CSO), in 2002 Chirumanzu had a total population of 70431 and Shurugwi had 88390 of which 16863 (19%) were urban (see table 1.1) (CSO 2002).

**Table 1.1 Characteristics of study area (CSO Census: 2002)**

District	Population	Households	Area (sq km)	Population density (per sq km)	Household density (per sq km)
Chirumanzu	70431	16412	4761	15	3.4
Shurugwi Rural	71482	15452	3471	21	4.5
Shurugwi Urban	16703	4273	37	452	115.5

The low population density and few access roads, which are often impassable during rainy season due to flooding, make data collection in rural areas laborious. Data collection for assessing access to water and sanitation facilities is a slow and resource intensive process requiring a lot of travelling to visit individual households and water points, which are often not easily accessible by road.

For the purposes of this study only rural districts, where there is no piped water or sewage connection, are considered because they present a unique challenge that demands solutions. Further the ZVITAMBO clinical trial, which is the immediate consumer of the results, will be conducted in the same rural districts. Trial interventions will include the provision of BVIP latrines to households and the rehabilitation of public water sources and requires that their geographic positions be known.



Figure 1.1 Map of the study site (map was created by the researcher using Quantum GIS)

## **1.4 RATIONALE FOR THE STUDY**

The researcher wishes to update the water and sanitation coverage statistics and to create a toolset of free software packages and analytic methods that can be used for rapid and reliable assessment of water and sanitation coverage in rural areas. The researcher wishes to develop methods of calculating accurate coverage statistics using GIS tools.

## **1.5 SIGNIFICANCE OF THE PROBLEM**

The findings of this study can be readily utilised by ZVITAMBO in the implementation of a randomised clinical trial involving sanitation and water improvements with child growth outcomes that is will be conducted in the two districts. The findings can be utilised by the two districts in terms of their water and sanitation planning for future projects and to direct WASH implementing partners to the rightly deserving areas. These findings can be used by the rest of the country to perform rapid assessment of WASH facilities and any other health related assessment that require mapping of data in rural communities. The findings of this study could increase knowledge on the methods collecting and analysing water and sanitation data to assess coverage in rural areas.

## **1.6 STATEMENT OF THE PROBLEM**

A water and sanitation survey conducted in December 2004 estimated sanitation coverage at 38% and 56%, and access to a protected water source was estimated to be 76% and 84% in Chirumanzu and Shurugwi districts respectively (UNICEF 2004). However, due to the substantial economic decline in the country over the last 8 years these are now estimated by local experts to be lower. Current water and sanitation coverage statistics are unknown, but are required in the ZVITAMBO clinical trial to balance the randomisation of clusters on water and sanitation access across the two districts.

The problem is thus, there is poor access to current information on access to water and sanitation in the two districts to enable the mapping of access to water and sanitation in terms of geographic distance based methods using geographic information systems.

From the above problem statement the questions below need answers:

- What proportion of households is within a given distance to ANY water source?
- What is the median distance between households and the nearest water source of any kind?
- What is the proportion of non-functional water sources
- What proportion of households has access to an improved sanitation facility?
- What effort, in terms of time, equipment, manpower and training, is required to collect required data and analyse it to answer the above questions?
- What recommendations will be made to Chirumanzu and Shurugwi districts for future assessments?

### **1.7 AIM OF THE STUDY**

The aim of this study is to update statistics on distance based access to water (protected or any water source), and access to improved sanitation for Chirumanzu and Shurugwi districts in the Midlands province of Zimbabwe. Also to identify and/or adapt GIS tools and methods that can be used for rapid assessment of geo-spatial coverage of water and sanitation resources in rural areas, perform the assessment using such tools and document the resources and effort required to perform such an assessment.

### **1.8 OBJECTIVES**

The main objectives of this research are:

- To determine the proportion of households within given distances of any water source
- To determine the median distance between households and the nearest water source of any kind
- To determine the proportion of non-functional water sources
- To determine the proportion of households that has access to an improved sanitation facility
- To determine what effort, in terms of time, equipment, manpower and training, is required to collect required data and analyse it to answer the above questions

- To make recommendations to Chirumanzu and Shurugwi districts for future assessments

To achieve the objectives set above, the researcher realised that the following data was required and the method of collecting it:

- Data on the geographic coordinates of all water points in the two districts – collected in a water point survey
- Data on the geographic coordinates of all households in the two districts – collected using a desk study of maps
- Data on households and their access to sanitation facilities – collected in a household survey

The lack of accurate current water and sanitation coverage statistics and maps that show physical distribution of water points in the entire country, especially in the two districts where ZVITAMBO will be operating, prompted the researcher to investigate methods of conducting WASH surveys efficiently and rapidly to create the desired datasets. The readiness of the district personnel to assist in the study, and utilise the data generated in their own planning, made the researcher realise the importance of such data to the country.

## **1.9 DEFINITION OF TERMS**

For the purposes of this study, the following terms are used as defined below:

### **Geographic Information System (GIS):**

*Wikipedia* (<http://en.wikipedia.org/wiki/GIS>) defines geographic information system (GIS), or geographical information system, as any system that captures, stores, analyzes, manages, and presents data that are linked to location.

In this study GIS refers to Google Earth and Quantum GIS which are both free software packages for capturing, storing, analyzing, managing, and presenting data that are linked to location.



**Personal Digital Assistant (PDA):**

*Wikipedia* ([http://en.wikipedia.org/wiki/Hand-held\\_computer](http://en.wikipedia.org/wiki/Hand-held_computer)) defines personal digital assistant (PDA), as pocket-sized hands held computing devices, typically having a display screen with touch input and miniature keyboard.

In this study PDA refers to the HP iPAQ 210 hand held computer.

**Water access:**

*According to the World Bank* (<http://www.worldbank.org/depweb/english/modules/environm/water/index.html>) defines access to water as being measured by the number of people who have a reasonable means of getting an adequate amount of water that is safe for drinking, washing, and essential household activities, expressed as a percentage of the total population.

In this study, people with access to water are people living in households that are within 500m, or 1000m, or 1500m of a water source.

**Water coverage:**

*According to United Nations (UN) Millennium Development Goals (MDGs)* (<http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=32>), water coverage refers to the proportion of the population using improved sources of drinking water which include piped water into dwelling, plot or yard; public tap/standpipe; tube well/borehole; protected dug well; protected spring; and rainwater collection.

In this study, water coverage refers to area proportion of the population living within 500 m, or 100 m, or 1500 m of a water source.

**Sanitation coverage:**

*According to UN MDGs* (<http://unstats.un.org/unsd/mdg/Metadata.aspx?IndicatorId=32>), sanitation coverage refers to the proportion of the population using improved sanitation which includes flush or pour-flush to piped sewer system, septic tank or pit latrine; ventilated improved pit latrine; pit latrine with slab; and composting toilet.

In this study, sanitation coverage refers to the proportion of households with a functional BVIP latrine.

**Geographic distance:**

*Wikipedia* ([http://en.wikipedia.org/wiki/Geographic\\_distance](http://en.wikipedia.org/wiki/Geographic_distance)) defines geographical distance as the distance measured along the surface of the earth.

In this study, geographic distance is defined as the straight line distance between a household and a water point

**Geospatial analysis:**

*Wikipedia* (<http://en.wikipedia.org/wiki/Geospatial>) defines geospatial analysis as – operations such as map overlay (combining two or more maps or map layers according to predefined rules), simple buffering (identifying regions of a map within a specified distance of one or more features, such as towns, roads or rivers) and similar basic operations.

In this study, geospatial analysis refers to the manipulation of geo-referenced data using GIS software and methods.

**Geo-referenced data:**

*Food and Agriculture Organisation* (<http://www.fao.org/docrep/003/x2465e/x2465e0h.htm>) – geo-referenced data are data which are connected to a specific location on the earth's surface.

In the study, geo-referenced data which are collected and linked to geographic coordinates of the place where they are collected and can be plotted on a map.

**Water and sanitation survey:**

A water and sanitation survey is an onsite review of the water source or sanitary facility, and the facilities, equipment, operation, and maintenance of the water or sanitary system (<http://www.dec.state.ak.us/EH/dw/dwmain/what-survey.html>).

In this study, water survey refers to the onsite inspection of a water source, testing its functionality and recording of its geographic coordinates.

In this study, sanitation survey refers to the onsite inspection of a household sanitation facility – a BVIP, testing its functionality and recording of its geographic coordinates.

### **1.10 ASSUMPTIONS**

According to Burns and Grove (2003:41) assumptions are statements that are taken for granted or are considered true, even though they have not been scientifically tested. This study is based on the following assumptions:

- Households will fetch drinking water from the protected water source with the shortest geographic distance
- Households will fetch water for use (other than drinking) from any water source with shortest geographic distance
- Individuals in a household will use an improved sanitation facility if it is available to that household

### **1.11 RESEARCH APPROACH**

According to Polit and Hungler (1995:11), the research approach refers to the researcher's overall plan for obtaining answers to the researcher's questions and for testing the research hypothesis. In this study the researcher adopted a quantitative approach because the factors that contribute to measurement of water and sanitation coverage, such as median distance between household and the nearest water source, or the proportion of households with access to improved sanitation facilities could be measured quantitatively.

### **1.12 RESEARCH DESIGN**

According to Burns and Grove (2003:42), research design is a blueprint for the conduct of a study that maximises control over factors that could interfere with the study's desired outcome. The research design was descriptive, and descriptive statistics together with graphs and maps were used to present the research findings.

### 1.12.1 Population

According to Burns and Grove (2003:43), the population is all elements (individuals, objects, or substances) that meet certain criteria for inclusion in a study. In the study the population comprised of all households and all public and private water sources in the two districts of Chirumanzu and Shurugwi. In the last population census conducted in 2002, the population in Chirumanzu and Shurugwi districts was 70431 and 71482 respectively, comprising of 16412 and 15452 households (CSO 2002). In 2004 (the last water inventory conducted) there were 2721 water sources in Chirumanzu and 1758 in Shurugwi – not counting streams, rivers and dams (see table 1.2) (UNICEF 2004).

**Table 1.2 Total number of water points in Chirumanzu and Shurugwi districts in 2004 (UNICEF 2004)**

District	Water source type											
	Borehole		Deep Well		Shallow Well		Family Well		Spring		Tap Stand	
	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF
Chirumanzu	290	81	53	3	369	49	1517	172	87	4	83	13
Shurugwi	178	31	112	65	192	63	924	181	5	1	6	0
<b>Total</b>	<b>468</b>	<b>112</b>	<b>165</b>	<b>68</b>	<b>561</b>	<b>112</b>	<b>2441</b>	<b>353</b>	<b>92</b>	<b>5</b>	<b>89</b>	<b>13</b>

F=functional, NF=non-functional

### 1.12.2 Sample and sampling

A sample is a subset of the population selected for a particular study, and sampling is the process of selecting a group of elements (individuals, objects, or substances) with which to conduct a study Burns and Grove (2003:43). In this study, the researcher selected all water sources and all households for determining water coverage, and used probability sampling to select a sub-sample of households included in the sanitation coverage study (Joubert & Ehrlich 2009:189).

### **1.13 DATA COLLECTION**

According to Burns and Grove (2003:45), data collection is the precise, systematic gathering of information relevant to the research purpose or the specific objectives, questions, or hypotheses of a study. The researcher used a structured approach to collect data for both water coverage and sanitation coverage surveys, using structured questionnaires/checklists. For the water inventory survey the researcher utilised services of public health engineers, environmental health technicians, and District Development Fund water technicians. The enumeration teams visited all water points, performed functionality tests, and interviewed on site key informants who had local knowledge of the characteristics and usage of the water point. For the sanitation, enumeration was performed by environmental health technicians, who made direct observations of the presence and status of sanitation facilities at each household.

### **1.14 DATA COLLECTION INSTRUMENT**

In research a data collection instrument is a tool used by a researcher in collecting the data (Polit & Hungler 1995:310). In this study the researcher used two methods of data collection; for field surveys - using pre-programmed personal digital assistants with attached GPS receivers, to capture data on observations and interviews, and to log the geographic position of each observation point; for the desk study of maps, use of Google Earth, a free internet GIS software, to analyse and map homesteads from satellite imagery. The water and sanitation survey questionnaires are based on the World Health Organization (WHO) and UNICEF water and sanitation questions (WHO/UNICEF 2006).

### **1.15 DATA ANALYSIS**

Burns and Grove (2003:45) state that data analysis is conducted to reduce, organize, and give meaning to the data. In this research quantitative responses were collected and software packages used for organizing, tabulating and graphic presentation of the data (Polgar & Thomas 2008:143). Descriptive statistics, including medians with their inter-quartile ranges, and percentages and proportions with their confidence intervals were calculated. Spatial data were analysed using GIS analysis methods including overlaying, buffering and intersect methods were used to produce spatial coverage

maps. Statistical calculations were performed using Stata/SE for Windows version 10.0 and GIS analysis was performed using Quantum GIS version 1.5.0.

## **1.16 RELIABILITY AND VALIDITY OF THE RESEARCH INSTRUMENT**

Reliability is concerned with the consistency of the measurement technique, the stability of repeated measures, and agreement between measurements by multiple raters (Burns & Grove 2003:270). If a questionnaire is administered at different times on the same subject by the same or different interviewers and the responses differ, then the questionnaire may not be reliable.

To enhance reliability of methods and tools, the researcher developed the questionnaire/checklists in wide consultation with water and local sanitation experts, and adapted questions from tested instruments (WHO/UNICEF 2006).

Burns and Grove (2003:198) state that the validity of a research study is a measure of the truth or accuracy of the findings. The validity and reliability of measurement instruments and statistical methods of analysis strengthen the truthfulness of findings.

The researcher ensured validity of instruments used by following:

- The researcher referred to Core Questions on Drinking-Water and Sanitation for Household Surveys (WHO/UNICEF 2006) and adapted the questions in consultations with water and sanitation experts.
- The questionnaire/checklists were constructed according to objectives of the study.
- The PDA program interface was programmed to follow the layout of the questionnaires as closely as possible to simplify data-entry.
- The instruments were pilot-tested in similar setting to the study area and reviewed as required.
- All enumerators were trained to standardise methods and clarify questions

The researcher ensured the validity of the study following these (Polit & Hungler 1995:701):

- Undertaking a comprehensive literature review
- Bringing together different loose ideas into a study framework
- Selecting an appropriate design

### **1.17 ETHICAL CONSIDERATIONS**

According to Polit and Hungler (1995:701) ethics deals is a system of moral principles that is concerned with the degree to which research procedures adhere to moral, legal and social obligations to the study participants. In chapter 3 ethical considerations of the study are discussed in detail.

### **1.18 LIMITATIONS OF THE STUDY**

The findings of this study are limited to the two districts – Chirumanzu and Shurugwi. Recommendations based on these findings may not be relevant to other districts in Zimbabwe and other countries. Studies using different research paradigms such as qualitative approach may obtain different findings.

### **1.19 OUTLINE OF THE STUDY**

Chapter 1 describes the brief background to the problem, the purpose and research approach, the research design and methodology used in the study.

Chapter 2 discusses the literature review conducted for the study.

Chapter 3 describes the research design and methodology in detail.

Chapter 4 describes the data analysis and interpretation of findings.

Chapter 5 concludes the study and briefly discusses the limitations of the study. Recommendations for practical use and further research areas are also discussed.

## **1.20 CONCLUSION**

Access to water and improved sanitation are fundamental components for healthy human living. Rural communities in Zimbabwe still lack this basic necessity for life and the magnitude of the problem is not known. Methods of calculating access to water are not accurate enough for use at district level. This chapter outlined the background to the problem in Zimbabwe, the purpose and the significance of the study. It also describes the research design and methodology used for the study and defines key terms used in the study. Chapter 2 discusses the literature review conducted for the study.



## **Chapter 2**

### **Literature review**

#### **2.1 INTRODUCTION**

This chapter discusses the literature review conducted by the researcher on the importance of environmental health, methods of assessment of rural water and sanitation in Zimbabwe and other parts of the world. The aim of the literature search was:

- To familiarise the researcher with the scope of environmental health field of study focussing on rural water and sanitation in Zimbabwe
- To identify current and past trends in environmental health assessments focussing on water and sanitation and to examine existing studies on water and sanitation assessment
- To summarise research based knowledge for practice
- To guide development of a study that ZVITAMBO will conduct in the study area, to increase the evidence in the field of water and sanitation, and to guide the conduct of future water and sanitation assessments

#### **2.2 ZIMBABWE ENVIRONMENTAL HEALTH SYSTEMS IN RELATION TO WATER AND SANITATION**

For an effective rural water and sanitation programme, there is need to get commitment of resources from governments, non-governmental organisations (NGO), United Nations (UN) agencies, local community leaders and the community.

##### **2.2.1 The National Health Strategy for Zimbabwe**

In 2009, the Ministry of Health and Child Welfare (MoH&CW) published a strategic document, the National Health Strategy which sets the national health agenda for the next five years, 2009-2013. In this document the MoH&CW highlighted priority areas that needed urgent attention and set goals, objectives and implementation strategies for

addressing them. One of the priorities under determinants for health was environmental health promotion. The goal was to contribute towards the creation of a safe and healthy environment through strengthening of environmental health services. One of the objectives was to increase access to safe water and sanitation (NHS 2009:213).

### **2.2.2 The Environmental Health Administrative structure**

In Zimbabwe the Environmental Health Department is embedded within the MoH&CW. The department is represented at all levels including national, provincial and district. The existence and function of each department within the ministry of health is defined by an act of parliament (Zimbabwe Public Health Act 2003:Ch 15:09).

At national level the Environmental Health Department is headed by the Director for Environmental Health. Environmental health policies are set at national level and the organisational structure of the Environmental Health Department is as follows; Minister of Health and Child Welfare heads the ministry, his deputy, the Permanent Secretary for Health, the Principal Director for Preventive Services and the Director for Environmental Health reports to the minister in that order. Below the Director for Environmental Health are two deputies, one responsible for Water, Sanitation and Waste Management and the other is responsible for Port Health and Food Safety ([http://www.mohcw.gov.zw/index.php?option=com\\_content&view=article&id=17&Itemid=24](http://www.mohcw.gov.zw/index.php?option=com_content&view=article&id=17&Itemid=24)).

At provincial level the Environmental Health Department is headed by provincial environmental health officers (PEHOs) who reports to the provincial medical director (PMD). The PEHO ensures implementation of government environmental health policies within the province and supervises districts in that province. The districts are headed by district medical officers (DMOs) and the district environmental health department is headed by district environmental health officer (DEHO) reporting to the DMO. Implementing environmental health procedures in the community are the environmental health technicians (EHTs) who perform the inspections of sanitary facilities and water sources in the districts ([http://www.mohcw.gov.zw/index.php?option=com\\_content&view=article&id=13&Itemid=4](http://www.mohcw.gov.zw/index.php?option=com_content&view=article&id=13&Itemid=4)).

The Environmental Health Department represents the ministry in the National Action Committee (NAC) for Rural Water and Sanitation which provides overall leadership in

water, sanitation and hygiene and in coordinating allocation of funding, resources, donors and NGOs (<http://www.wsscc.org/countries/africa/zimbabwe/wash-sector-glance>).

### **2.2.3 Environmental health personnel**

A suitably trained and well motivated workforce is a prerequisite for a successful rural WASH programme as working conditions in rural areas can be challenging. With a vacancy level of 61% for environmental health technicians by December 2008 (NHS 2009), Zimbabwe was in no position to deliver effective WASH programmes in rural areas and to assess the state of existing WASH facilities using this skeletal staffing.

## **2.3 ASSESSMENT OF WATER AND SANITATION COVERAGE**

### **2.3.1 Zimbabwe Statistics: The main source of country statistics**

Zimbabwe Statistics (ZimStat) is the main body responsible for collecting country statistics in Zimbabwe (<http://www.zimstat.co.zw/>). ZimStat conducts the most comprehensive data collection on the population through censuses which are conducted once in every 10 years. The last census was conducted in 2002 (CSO 2002). Data collected during a census includes water and sanitation indicators including the household's main source of drinking and cooking water, distance to the water source, and type of toilet facilities.

According to the water and sanitation report in Tanzania (Water and Sanitation in Tanzania 2002), indicates that surveys are not consistent in their measurement of effort to fetch water. ZimStat collects these data by asking respondents about their water fetching burden and the reliability of these data is questionable as most people cannot estimate distance and time accurately and mapping methods may need to be used to calculate distances ([http://conflict.lshtm.ac.uk/page\\_160.htm](http://conflict.lshtm.ac.uk/page_160.htm)).

Operationally, ZimStat WASH data from the censuses poses challenges that are associated with the frequency of their collection, every 10 years is too infrequent as WASH trends occur more rapidly. Hence for MDG reporting purposes, the Joint Monitoring Programme for Water Supply and Sanitation (JMP), uses other sources of

data, such as the Zimbabwe Demographic and Health Surveys (ZDHS) for compiling country comparisons on MDG achievements (<http://www.wssinfo.org/en/definitions-methods/data-sources/>).

For operational and research purposes, WASH data from ZimStat census are inadequate for evaluating geographical based access hence other data sources should be considered.

### **2.3.2 Zimbabwe Demographic and Health Survey**

Zimbabwe Demographic and Health Survey surveys are nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition (<http://www.measuredhs.com/aboutsurveys/dhs/start.cfm>). ZDHS surveys collect data every 5 years from a sample of selected sentinel sites, on a wide range of social and economic issues including health and the environment. Data collected on WASH include main source for drinking water and main source for other purposes (CSO 2007:339). The sample for the ZDHS was designed to provide population and health indicator estimates at the national and provincial levels (CSO 2007:3); hence for operational and research purposes it is inadequate to answer questions of water access at district level.

### **2.3.3 WASH ATLAS Zimbabwe**

The WASH ATLAS Zimbabwe is another source of WASH data in Zimbabwe. It however only provides an overview of WASH implementing organisations that have been active in Zimbabwe in both development and emergency in a given period, in addition to the Government activities (UNICEF 2009). The ATLAS is designed to improve evidence-based planning in the Water and Sanitation sector and data are collected for the WASH ATLAS by self-reporting organisations active in the given areas. There may be self reporting biases in the way organisations compile their reports. WASH activities are reported by district and ward level, but limited to activities performed in the reporting period hence cannot be used as an inventory of all water sources or sanitation facilities in the ward. The ATLAS presents geographical distribution of implemented activities and not water points so cannot be used for research into water access where the object is to show distance to water points.

### **2.3.4 WASH Inventory ATLAS Zimbabwe**

The WASH Inventory ATLAS Zimbabwe is probably the most comprehensive inventory of rural water sources in the country. Village level data on primary water supply and basic sanitation in rural areas of Zimbabwe was collected and later aggregated to ward level and translated into district level, ward, district, provincial, and national reports (WASH Inventory ATLAS Zimbabwe). Theoretical water coverage and coverage index statistics are presented at ward level in this data source. The method of calculating coverage was based on village populations and number of water sources in a village and assumes that a village has uniform water access. The data were collected in a once off survey in 2004 and for operational purposes may be too out dated to use for current WASH programmes. For research purposes, these data cannot answer the distance from household to water source question, hence are inadequate to use in calculating geographical water coverage.

### **2.3.5 Other sources of WASH data in Zimbabwe**

There are several other surveys that generate WASH data including the following:

- Zimbabwe Vulnerability Assessment Committee (ZIMVAC) (FNC)
- Multiple Indicators Monitoring Survey (MIMS) (UNICEF & MICS)
- Zimbabwe National Nutrition Survey (FNC & ZimStat)

All the surveys reviewed use the same assessment tool used by the ZimStat and ZDHS, hence they collect the same type of data – only the samples are different.

### **2.3.6 The GAP in WASH data analysis**

All the available primary WASH data sources do not collect data with sufficient precision to enable the calculation of geographical water coverage. New strategies and methodologies need to be considered. Since coverage is a geographic concept, the use geographic information systems (GISs) could be used to calculate more representative water coverage statistics.

## **2.4 GEOGRAPHIC INFORMATION SYSTEMS**

### **2.4.1 Overview of geographic information systems**

Geographic information system (GIS), or geographical information system, is any system that captures, stores, analyzes, manages, and presents data that are linked to location (<http://en.wikipedia.org/wiki/GIS>). GIS can be used to calculate coverage, using geospatial analysis methods, and display results on maps. Some GIS packages are sold commercially while others are free open source.

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts (<http://www.esri.com/what-is-gis/index.html>).

Google Earth is one popularly used GIS package that can be used for visualising geo-referenced data in a virtual globe (<http://www.google.com/earth/index.html>).

### **2.4.2 Using geographic information systems in Public Health**

Tak Ting and Shui (2008) in their methodology paper demonstrated the use of GIS-based methodology for measuring district-based coverage in Hong Kong. They calculated coverage zones for health centres excluding uninhabitable areas.

Noor, Alegana, Gething and Snow (2009) mapped all health service centres in Kenya in order to create a spatial database of national health facilities and determine geographic access to health centres. Global positioning system was used to geo-reference the health facilities and a GIS used to plot maps showing health access levels.

Graves (2008), carried out a comprehensive literature review of literature related to GIS, healthcare access and health outcomes. She summarises the range of uses of GIS in healthcare and their effectiveness as analytical tools for evaluating health access and other outcomes, and as effective data management tools. She also point out that the ability of GIS systems to overlay layers of data enables interpretation beyond that seen with traditional research and statistical methods.

### **2.4.3 What is needed for geographic information systems to work?**

In order to be able to use GIS software to calculate water coverage, geo-referenced survey data must be available, and these data are not routinely collected in current WASH surveys in Zimbabwe.

## **2.5 COLLECTING GEO-REFERENCED DATA**

### **2.5.1 Global Positioning System**

The Global Positioning System (GPS) is a space-based global navigation satellite system based on 24 communication satellites orbiting the earth, that provides reliable location (latitude, longitude, altitude) at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites ([http://en.wikipedia.org/wiki/Global\\_Positioning\\_System](http://en.wikipedia.org/wiki/Global_Positioning_System)). GPS receivers are electronic devices that receive radio signals from three or more GPS satellites to determine their geographic positions (latitude, longitude and altitude). GPS receivers can be used with personal digital assistants to collect geo-referenced field data in surveys.

### **2.5.2 Collecting data with personal digital assistants**

Personal digital assistants (PDAs), are pocket-sized hand held computing devices, typically having a display screen with touch input and miniature keyboard ([http://en.wikipedia.org/wiki/Hand-held\\_computer](http://en.wikipedia.org/wiki/Hand-held_computer)).

PDAs allow for data capturing in the field, at the point of data collection, into pre-programmed data PDA-based data collection forms eliminating the need to fill in paper questionnaires. Data captured on PDAs is downloaded via cable or transmitted to a remote computer over wireless or cellular signals. This method of electronic data collection allows for rapid analysis of data so that interim results are available immediately and monitoring of fieldwork is made easier (Joubert & Ehrlich 2009:114).

The WHO Public Health Mapping Group (2003) published guidelines for data collection in the field using GPS technology. The document gives an analysis of equipment required to set up a data-collection system utilising GPS mapping.

In a progress report for The World Food Programme, McKay and Mu'ammam (2007) explained the benefits of collecting GPS-tagged data using PDAs in terms of speed and accuracy compared with traditional data capture methods.

Bernabe-Ortiz, Curioso, Gonzales, Evangelista, Castagnetto, Carcamo, Hughes, Garcia, Garnette and Holmes (2008) showed that PDA-based data collection can be as effective as paper based surveys and achieve more complete data in self reporting surveys.

Ping Yu, De Courten, Pan, Galea and Pryor (2009), developed and tested an open source PDA-based data collection tool and found PDAs to be more effective than paper for public health surveys.

## **2.6 ASSESSMENT OF WATER AND SANITATION COVERAGE**

### **2.6.1 Ethics of collecting geo-referenced data**

Sherman and Fetter (2007) published confidentiality concerns with mapping sensitive survey data using GPS. They pointed out that geo-referenced data offers opportunities for unintended violating confidentiality of respondents by unmasking respondents' identity through location identification using mapping. They proposed applying location masks to coordinates to disguise the true locations for sensitive data as a way of keeping respondent's confidentiality.

## **2.7 CONCLUSION**

This chapter discussed the literature reviewed on methods used for collecting and analysing water and sanitation data. The literature indicated that the common method of collection data on water and sanitation access was asking about time to fetch water



never measured actual distance to water source. Geospatial analysis could be the answer to calculating access to water based on distance.

In Zimbabwe, the environmental health strategy and administration are in place, what is required is to train personnel to take on new challenges such as how to collect and analyse geo-referenced data.

Chapter 3 discussed the research design and methodology.

## **Chapter 3**

### **Research design and methodology**

#### **3.1 INTRODUCTION**

This chapter describes the research design and methodology, the target population, accessible population and the sample. The chapter also describes data collection and analysis.

#### **3.2 DELIMITATION OF THE STUDY**

The study focuses on conducting water and sanitation coverage surveys in two rural districts of Zimbabwe, Chirumanzi and Shurugwi in the Midlands province.

#### **3.3 RESEARCH APPROACH**

According to Polit and Hungler (1995:11), the research approach refers to the researcher's overall plan for obtaining answers to the researcher's questions and for testing the research hypothesis.

In this study the researcher adopted a quantitative, descriptive study of conducting water and sanitation coverage surveys in two rural districts in Zimbabwe using electronic field data capture equipment and analysing the data using GIS technology.

##### **3.3.1 Quantitative research**

According to Burns and Grove (2003:27), quantitative research is "a formal, objective, rigorous, systematic process for generating information about the world". Polit and Hungler (1999:712) described quantitative research as the investigation of phenomena that can be measured precisely and quantified.

The quantitative research process includes specific and detailed steps that are logically linked. These steps include the design, measurement, sample selection, data collection,

and statistical analysis (Burns & Grove 2003:30). In this study the researcher considered a quantitative approach because it involves the systematic collection of measurable data using structured data collection tools and analysis using statistical and other mathematical methods such as those used in GIS which include layering, and buffering. These were the characteristics of the study (Polit & Hungler 1999:193):

- The study began with ideas obtained from literature and the researchers own experience of how the concepts were interrelated.
- The researcher used structured procedures and formal instrument, questionnaires/checklists, to collect data.
- The researcher collected data under strict control using a copy of the same instrument for each observation.
- The researcher used precise measuring instruments to quantify measurable data.
- The questionnaire/checklist consisted of closed-ended questions and water and sanitation engineers and environmental health officers were consulted to ensure their validity.
- Statistical procedures were used to analyse the numerical data obtained from the checklist.

### **3.3.2 Descriptive study**

According to Burns and Grove (2003:200), a descriptive research study design aims to gain in-depth information about the characteristics of subjects within a particular field of study. The purpose a descriptive study is to provide a picture of a phenomenon in its natural state. It may be used to develop theories, identify problems with current practice and make judgments, quantify the extent of a health problem, or determine what others in similar situations are doing.

Characteristics of a descriptive study design are as follows (Houser 2008:325):

- The researcher can collect data as numbers or words.
- The researcher can collect data via observation, questioning, available data, projective techniques, and physical assessment or tests (Brink & Wood 1998:293).

- The results of a descriptive study will provide detailed information on the phenomenon under study.

### 3.4 STUDY POPULATION

According to Burns and Grove (2003:43), the population is all elements (individuals, objects, or substances) that meet certain criteria for inclusion in a study. In the study two populations were targeted; the population of households in Chirumanzu and Shurugwi districts, and the population of water sources in the two districts.

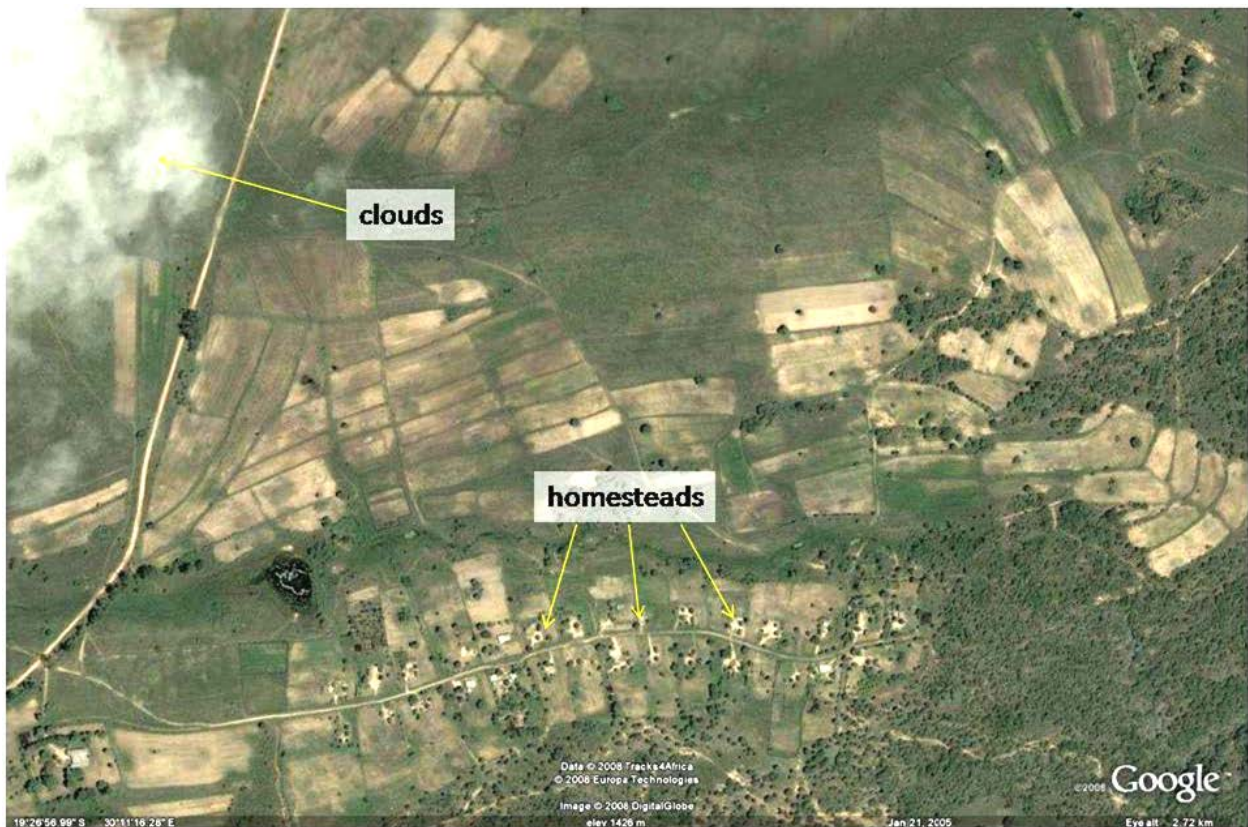
#### 3.4.1 Households

At the last population census in 2002 the population in Chirumanzu and Shurugwi districts was 70431 and 71482 respectively comprising of 16412 and 15452 households (see table 3.1) (CSO 2002).

The study population was all households in the two districts and the accessible population was all visible homesteads that could be clearly identified from Google Earth terrain maps of the two districts (see figure 3.1) (<http://www.google.com/earth/index.html>).

**Table 3.1 Target and accessible population of Chirumanzu and Shurugwi districts (CSO 2002 and Google Earth).**

District	Population (2002)	Households (2002)	Homesteads (Google Earth)
Chirumanzu	70431	16412	15925
Shurugwi Rural	71482	15452	13450



**Figure 3.1 A picture of a village in Chirumanzu district (Google Earth)**

### **3.4.2 Water sources**

In 2004, the last comprehensive water inventory conducted, there were a total of 4479 water sources in the two districts, 2721 in Chirumanzu and 1758 in Shurugwi – not counting streams, river and dams (see table 3.2) (UNICEF 2004). The study population was all water sources in the two districts including those in the 2004 survey and any additional ones that could be identified during the survey.

**Table 3.2 Total number of water points in Chirumanzu and Shurugwi districts in 2004 (UNICEF 2004)**

District	Water source by type and functional status												Total
	Borehole		Deep Well		Shallow Well		Family Well		Spring		Tap Stand		
	F	NF	F	NF	F	NF	F	NF	F	NF	F	NF	
Chirumanzu	290	81	53	3	369	49	1,517	172	87	4	83	13	<b>2721</b>
Shurugwi	178	31	112	65	192	63	924	181	5	1	6	0	<b>1758</b>
<b>Total</b>	468	112	165	68	561	112	2,441	353	92	5	89	13	<b>4479</b>

F=functional, NF=non-functional

### 3.5 SAMPLING

Sampling is the process of selecting a group of elements (individuals, objects, or substances) with which to conduct a study (Burns & Grove 2003:43). In this study two sampling methods were used; probability sampling was used to select households for the household sanitation survey because the total number of households in the two districts was large. The total population of water sources was selected for water coverage assessment because the number of water points was small.

Brink and Wood (1998:292) state that if the purpose of a study is to describe characteristics of the population then probability sampling techniques are necessary for external validity. The researcher used simple random sampling, which is a sampling method that gives every member of the population an equal chance of being selected to the sample, to select a representative sample of ten percent (10%) of households in the two districts. All households identified in the study area were listed entered in a computer database, then using a statistical package, Stata, a random sample of 10% of the households was selected using the *sample* macro command.

For a descriptive study design, Brink and Wood (1998:292) says that the ideal sample is the total available population if the study population is small. The researcher used the total population of water sources because the number of water sources was small and could be accessed.

### 3.5.1 Samples

A sample is a subset of the population selected for a particular study (Burns & Grove 2003:43). Three samples were selected from the population for the study as follows:

(a) *Homesteads*

A total of 29375 homesteads were identified from Google Earth terrain maps. In Chirumanzu district 15925 homesteads were identified and in Shurugwi district 13450 homesteads were identified.

(b) *Household sanitation*

Ten percent (10%) of the homesteads identified on Google Earth were selected for the household sanitation survey. A total of 2938 homesteads were selected of which 1593 and 1345 were in Chirumanzu and Shurugwi districts respectively.

(c) *Water sources*

A total of 4134 water sources were identified in the two districts (see table 3.3).

**Table 3.3 Total number of water sources in each district by type of water source**

District	Borehole	Deep Well	Shallow Well	Family Well	Spring	Tap Stand	Total
<b>Chirumanzu</b>	413	29	405	1531	65	75	<b>2518</b>
<b>Shurugwi</b>	408	73	221	907	4	3	<b>1616</b>
<b>Total</b>	821	102	626	2438	69	78	<b>4134</b>

### **3.5.2 Sample size**

#### *(a) Homesteads*

The sample consisted of all homesteads that could be clearly identified on Google Earth satellite images of the districts. A small section of both districts had low resolution satellite images of the terrain and it was hard to identify homesteads clearly. In some areas of Chirumanzu there was cloud cover over the terrain on the satellite images and the researcher could have missed some homesteads. A small area to the west of Shurugwi had older images that had not been updated recently such that the researcher could have missed more recent settlements in those areas.

#### *(b) Household sanitation*

A statistician was consulted on the selection of an adequate sample to estimate sanitation coverage in the two districts.

#### *(c) Water points*

The sample consisted of all the water points that could be accessed during the survey. Although some water points could not be accessed because they were in locked premises, they were deemed not as important in assessing water coverage since they were restricted to the majority of the village population where they were located hence their contribution to water access was limited.

### **3.5.3 Inclusion criteria**

Burns and Grove (2003:234) state the inclusion criteria are those characteristics that subjects or elements must possess to be part of the target population. To be included in this study:

- Homesteads had to be in either of the two districts of Chirumanzu and Shurugwi Rural
- Homesteads had to be clearly visible on Google Earth satellite images
- Households had to be staying in one of the identified homesteads
- Water points had to be in either of the two districts of Chirumanzu and Shurugwi



## **3.6 DATA COLLECTION**

Due to the complexity of this study, data was collected from several dissimilar sources, and hence multiple data-collection approaches were adopted (Brink & Wood 1998:300). A desk study of available data on maps and the internet was employed to identify and plot homesteads. A structured data-collection approach using electronic field data capture methods was adopted for the water and household sanitation surveys.

The observational desk study approach was chosen because it yields vast quantities of accurate data when the data source does not change quickly with time. Data can be validated by multiple observers and from other sources as methods of triangulation (Wood & Ross-Kerr 2011:125). The structured data-collection approach was chosen because it offers a systematic method of standardising questions and collecting consistent data from a large number of subjects (Houser 2008:329). Both data-collection approaches generate data that are easy to analyse using statistical methods (Brink & Wood 1998:293).

### **3.6.1 Data-collection hardware and software**

Field data was collected using personal digital assistants (PDA) that were pre-programmed with survey questionnaires and linked to global positioning satellite (GPS) receivers for recording geographic coordinates.

The researcher chose this method of data collection, using handheld computers, for the following reasons (Joubert & Ehrlich 2009:115) (Ping Yu et al 2009):

- It is quicker than paper in the field
- Coding of responses is automated on capturing
- Navigation aids like skip patterns depending of responses input are enforced in the programming and reduce inapplicable responses to questions
- Quality control checks and data validation rules are enforced at source
- GPS coordinates are captured directly from the GPS units hence there are no transcription errors
- A timestamp variable is automatically added to saved data enabling a new dimension of viewing data at analysis
- Interim results are available for analysis immediately

- Monitoring of field operation is made easier
- Data collection teams enjoyed using PDA-based forms and made the teams put extra effort in their work

### **3.6.1.1 The PDA**

The PDA used for data collection was the HP iPAQ 211 (see figure 3.2) (<http://www.hp.com>). This PDA was chosen by the researcher for this study for the following characteristics:

- It has a large screen making it easier to use in the field
- It uses touch input for data entry making it faster to enter responses
- It runs on Windows mobile making it easier to find programming tools to build data entry programs
- It has Bluetooth wireless making it easier to connect to other devices without using cables
- It takes Secure Digital (SD) memory cards which make it easy to store large amounts of data and to backup data
- It has a long battery life making it last a long time between charges
- The battery can be replaced while in the field making it extend data collection period when working in rural areas where there is no electricity
- It is reasonably priced making it affordable in resource poor settings

### **3.6.1.2 The GPS unit**

The GPS units used in this study was the Globalsat BT-386i GPS Bluetooth unit (see figure 3.2) (<http://www.usglobalsat.com/>). The GPS unit was chosen by the researcher for the following characteristics:

- It has a good position accuracy (<10 m), making it ideal for the mapping exercise in this study
- It can take GPS readings even in poor environmental conditions
- It has a short warm-up time before taking readings ensuring data capture takes minimum time
- It uses Bluetooth 2.0 wireless connection to interface with other devices making it easier to connect to PDAs without using cables

- It has a very long battery life (10 hours) making it ideal for use in rural areas
- It has a small form factor making it easy to carry around



**Figure 3.2 Data-collection hardware (a) HP iPAQ 211 PDA (<http://www.hp.com>), (b) Globalsat BT-368i Bluetooth GPS receiver (<http://www.usglobalsat.com/>)**

### **3.6.1.3 Data-collection software**

Data-collection software was developed using CyberTracker version 3, freeware software for programming smartphones and handheld computers to collect geographic-referenced field data (<http://www.cybertracker.org/>). CyberTracker has been successfully used in public health research projects such as in mapping health indicators and health infrastructure in Indonesia (<http://healthpslp.cdu.edu.au/>).

The researcher selected CyberTracker for the following characteristics ([http://www.cybertracker.org/index.php?option=com\\_content&view=article&id=14&Itemid=23](http://www.cybertracker.org/index.php?option=com_content&view=article&id=14&Itemid=23)):

- It is free software making it ideal for use in resource limited settings
- It is easy to develop data capture forms making it easy to use with minimum training by persons having little computer experience
- It is easy to download captured data from CyberTracker database to other databases systems

- It integrates GPS data with other captured data transparently making it easy to collect geo-referenced field data effortlessly
- It records accuracy level with each GPS reading and allows positioning averaging to improve accuracy of GPS readings
- It can record the track taken by an enumerator between sightings making it possible to reconstruct an accurate path taken by the enumerator and hence measure data-collection effort
- It supports collecting multimedia data e.g. pictures and sound
- It runs on Windows, PocketPC, Windows Mobile and PalmOS making it available to the widest range of mobile devices

### 3.6.2 Mapping homesteads

A number of steps were following to accomplish the mapping of all homesteads in the study area using Google Earth and the internet.

#### (a) *Digital maps of study area*

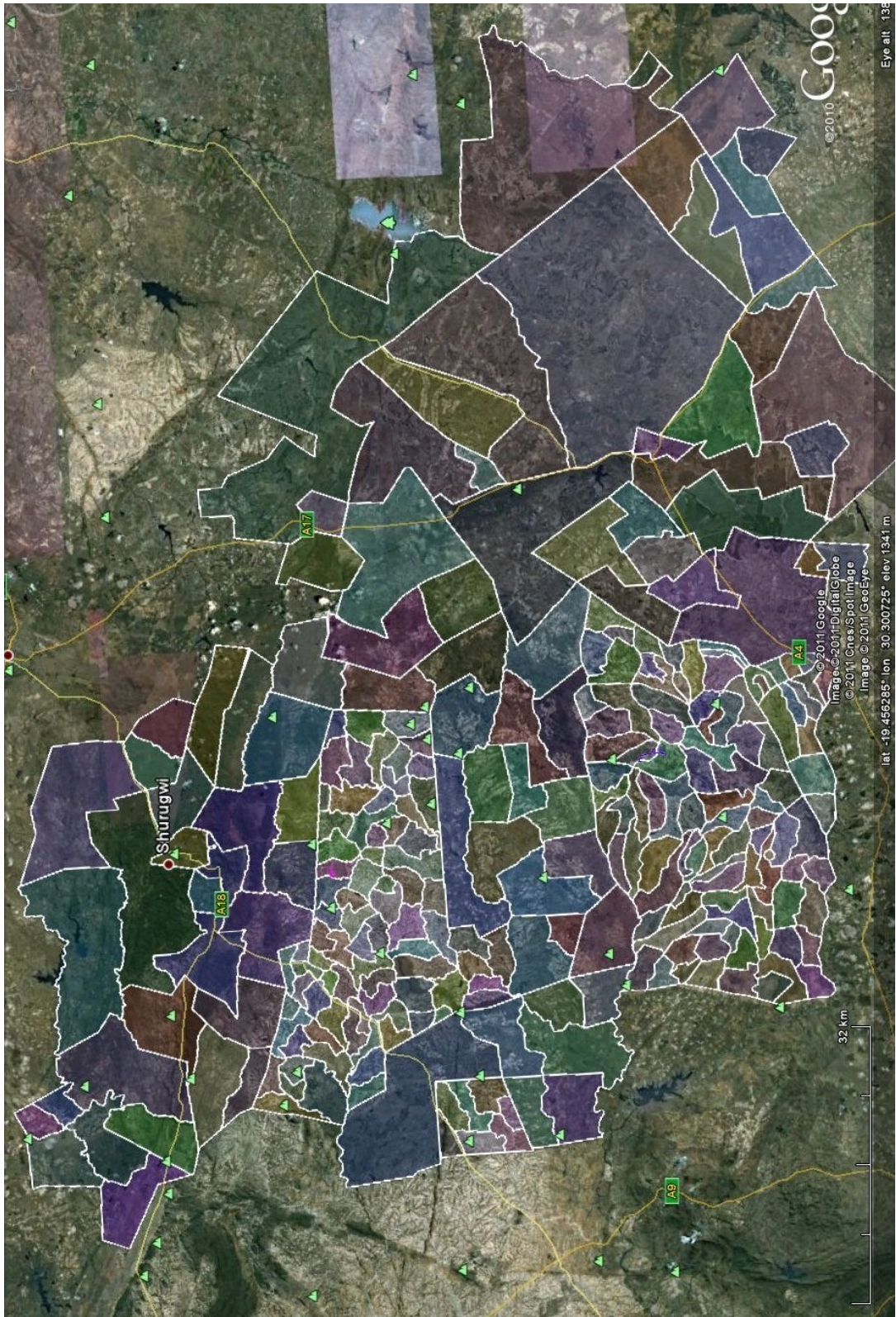
The researcher obtained digital maps of the two districts from the Central Statistics Office in ESRI shape file format ([http://en.wikipedia.org/wiki/Shape\\_file](http://en.wikipedia.org/wiki/Shape_file)). The maps included administrative boundaries: districts, wards and census enumeration areas.

#### (b) *Export to Google Earth*

The district shape files were converted to Keyhole Markup Language (KML) files ([http://en.wikipedia.org/wiki/Keyhole\\_Markup\\_Language](http://en.wikipedia.org/wiki/Keyhole_Markup_Language)) using Quantum GIS (<http://qgis.org/>), an open source GIS software package, which are compatible with Google Earth. The KML files were then loaded into Google Earth to display the administrative boundaries overlaying the satellite imagery (see figure 3.3).

Figure 3.3 shows a Google Earth image of the study area showing an overlay of administrative boundaries for Chirumanzu and Shurugwi districts. The white boundaries demacate census enumeration areas.



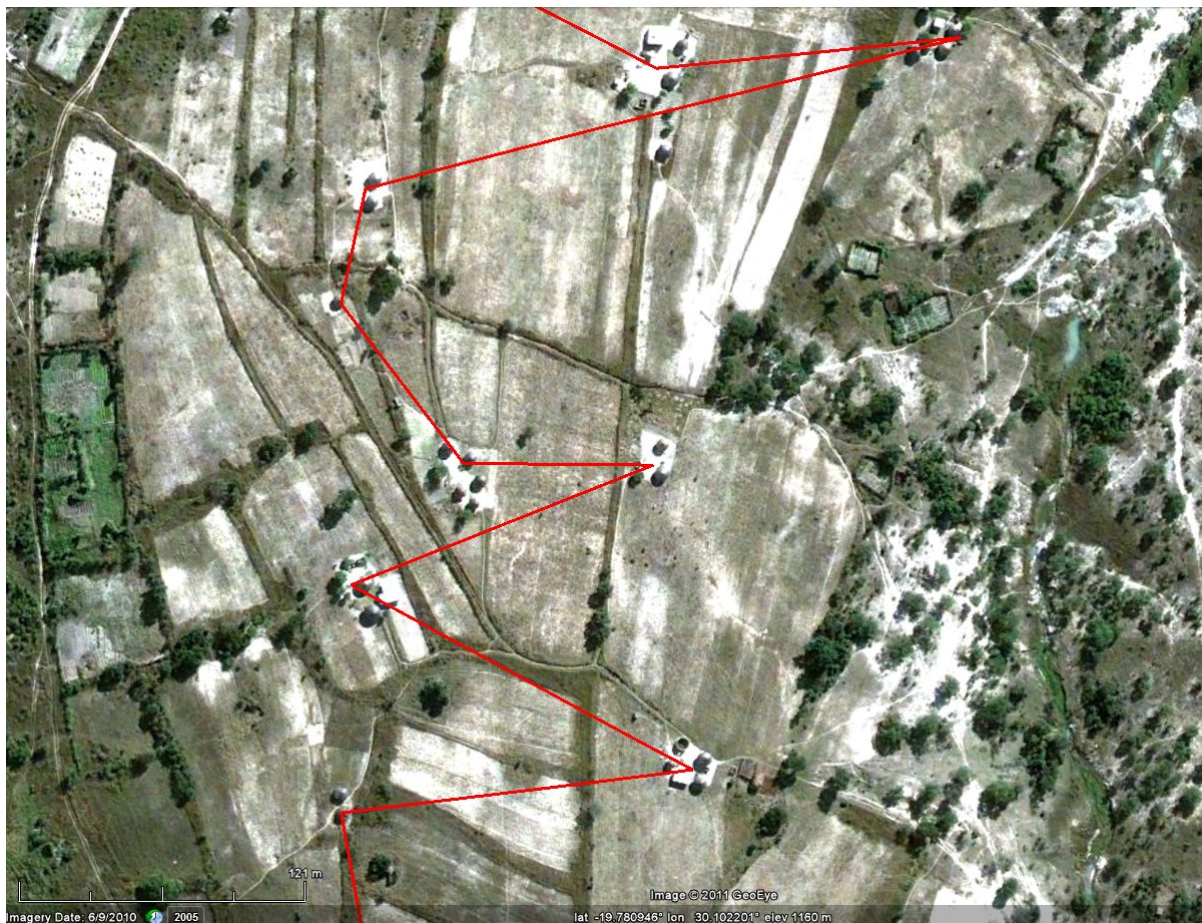


**Figure 3.3 An overlay of administrative boundaries for Chirumanzu and Shurugwi districts (Google Earth)**



(c) *Digitising homesteads*

The researcher, with assistance from a trained data entry assistant, spent four weeks using high resolution monitors and high speed broadband internet identifying all homesteads in the study area and marking their positions using the 'ADD PATH' tool in Google Earth. This tool creates a line with multiple vertices (polyline) where each vertex marks the geographic position of a homestead (see figure 3.4) ([http://earth.google.com/outreach/tutorial\\_annotate.html#prereq](http://earth.google.com/outreach/tutorial_annotate.html#prereq)). The accuracy of this method of mapping has been demonstrated by Stillman (<http://google-earth-plotter.googlecode.com/files/Journal%20Paper.pdf>). Figure 3.4 shows marking homesteads in Google Earth using the 'ADD PATH' tool. The vertices of the polyline correspond to the geographic position of each homestead.



**Figure 3.4 Marking homesteads  
(Google Earth)**

(d) *Creating the homestead GIS layer*

The paths marking the positions of homesteads were exported from Google Earth and saved as KML files. The KML files were processed using a computer program the researcher created, extracting the position coordinates (latitude, longitude) of each homestead, and saved as a comma separated value (CSV) file containing the list of all homesteads in the study area (see table 3.4). The list of homesteads was imported into Quantum GIS where and saved as a shape file ready for spatial analysis and display.

**Table 3.4 Sample list showing geographic coordinates of homesteads logged from Google Earth showing**

<b>_ID</b>	<b>Longitude</b>	<b>Latitude</b>
1	30.43698128	-19.72396102
2	30.43726394	-19.72434083
3	30.43773295	-19.72413509
4	30.43757385	-19.72378383
5	30.43616895	-19.72438700

**3.6.3 Survey of household sanitation**

In the survey of water points, the researcher worked with the following team:

- 22 Environmental Health Technicians (EHT) from the Ministry of Health Environmental Health Department from both districts who assessed household sanitation.

The researcher found EHTs suitable for this survey because:

- it is their regular job to inspect latrines
- they are knowledgeable with different types of latrines
- they have motor cycles for transport
- they already work in the study districts

- 2 Public health engineers from a water and sanitation organisation working in both districts that trained the teams and supervised the survey and provided expert advice to the researcher about sanitation issues.

### **3.6.3.1 Household sanitation survey checklist**

The observational checklist (see appendix E) was considered a suitable tool for the following reasons (Burns & Grove 2003:283):

- It is used to indicate whether a condition or object being studied is present, for example whether a latrine is present or not
- When used with rating scales allows an observer to rate each event providing more information about a subject than a yes/no response

Data was collected using methods described by Brink and Wood (1998:293); by direct observation and physical examination of the latrines. Using these methods enabled the researcher to characterize each latrine accurately. The use of open-ended questions was kept minimal to enhance data analysis since these data were obtained from a large sample (Burns & Grove 1998:358).

The checklist covered the following aspects:

#### *(1) Household location and identification*

These questions covered details of the household's descriptive and geographic location which include: district name, ward number, village name, household sampling ID number, and the GPS coordinates.

#### *(2) The presence and status of a Blair Ventilated Improved Pit (BVIP) latrine*

These questions covered details of whether a BVIP latrine was present at the household and how full it was.



(3) *Ventilation*

These questions covered details of the ventilation: was ventilation fitted, whether it was working, and whether it had a fly screen fitted. The efficacy of the ventilation was assessed using the smoke test ([http://www.akvo.org/wiki/index.php/Single\\_Ventilated\\_Improved\\_Pit](http://www.akvo.org/wiki/index.php/Single_Ventilated_Improved_Pit)).

(4) *Presence of any other latrine*

This question recorded the presence of any other type of latrine other than a BVIP at the household.

(5) *Other observations*

This is the only open-ended question to record any other unforeseen details that could be noted about sanitation facilities at the household.

### **3.6.3.2 Assessing the latrines**

(a) *Teams*

Latrine assessment was done by EHTs who worked in pairs. Each team worked in a designated area and assessed all sampled homesteads in their area. The team used a motorcycle to travel within the area and to the district hospital.

(b) *Permission and confidentiality*

Permission to conduct the survey was obtained from the rural district councils. Permission to enter homesteads was obtained from any adult found at the homestead. Written informed consent was not obtained for this survey as no persons were involved the study. Confidentiality was maintained by not recording any details of persons found at the homestead.

*(c) Sensitisation*

Villagers were sensitised in advance of the pending sanitation assessment in their areas through local leaders at meetings organised by the researcher and local Ministry of Health staff in the district.

*(d) Equipment*

Each team carried the following equipment for assessing water points:

- A motorcycle capable of carrying a passenger
- A PDA/GPS set to record survey data
- A spare battery for the PDA
- Fire making apparatus (matches and flammable materials) for testing latrine ventilation

A spare PDA/GPS and battery was kept in each district hospital as a backup in case of failure of the field units (Joubert & Ehrlich 2009:115).

*(e) Training*

The researcher and public health engineers trained the survey supervisors and enumerators on the following survey procedures (Joubert & Ehrlich 2009:122):

- How to administer the sanitation survey checklist using the PDA
- How to navigate to selected homesteads by their GPS location
- How to use a random number generator to break tied homesteads
- How to use and troubleshoot minor PDA/GPS problems
- How to perform the smoke test

*(f) Locating homesteads*

Sampled homesteads were located by selecting the homestead closest to the GPS location in the sample. GPS navigation was used to guide a team to a selected

location. If more than one qualifying homestead was found near the location then the homesteads were given numbers and simple random sampling, using a random number generator in the PDA, was used to select the homestead to survey.

*(g) Update meetings*

During the survey teams met twice a week at the district hospitals for the following:

- To download data from PDAs to a central database
- To charge PDA and GPS batteries
- To update the PDA program if it was updated
- For the researcher to verify that all data-collection equipment was working well
- To share any challenges and success faced in the field

*(h) Data downloading*

Sanitation survey data was downloaded from each PDA onto a desktop PC using Windows Mobile Device Center (WMDC) and the CyberTracker database. WMDC is software that enables handheld devices to connect to computers running on Windows operating systems and synchronise data with the computer

<http://www.microsoft.com/downloads/en/details.aspx?FamilyID=46f72df1-e46a-4a5f-a791-09f07aaa1914&displayLang=en>).

### **3.6.4 Survey of water points**

In the survey of water points, the researcher worked with the following team:

- 22 Environmental Health Technicians from the Ministry of Health Environmental Health Department from both districts who assessed other water points excluding boreholes and deep wells. The researcher found EHTs suitable for this survey because:
  - it is their regular job to inspect water sources
  - they are knowledgeable about different types and locations of water sources
  - they have motor cycles for transport
  - they already work in the study districts

- 4 Water engineers from the District Development Fund (DDF) offices, 2 from each district, who assessed boreholes and deep wells. The researcher found DDF Water engineers suitable for this survey because:
  - it is their regular job to drill and maintain boreholes
  - they are knowledgeable with different types of boreholes, abstraction units and how to assess them
  - they have motor vehicles for transport
  - they already work in the study districts
  
- 2 Public health engineers from a water and sanitation organisation working in both districts that trained the teams and supervised the survey.

#### **3.6.4.1 Water point survey questionnaire/checklist**

A questionnaire/checklist was used to collect data in a structured data-collection approach (see appendix F). Data was collected using methods described by Brink and Wood (1998:293); by questioning key informants, direct observation, physical examination of the water source, and performing some tests. Using these methods enabled the researcher to characterise each water point accurately. The use of open-ended questions was kept minimal to enhance data analysis since these data were obtained from a large sample (Burns & Grove 1998:358).

The questionnaire covered the following aspects:

##### *(1) Water point location and identification*

These questions covered details of the water point's descriptive and geographic location which include: district name, ward number, village name, water point name and identification number, and the GPS coordinates.

##### *(2) Key informant details*

This section covered details of key informants interviewed, name, designation and the level they represent in the community.

*(3) Usage and ownership*

These questions covered usage and ownership of the water point, how many households used the water point and who owned it, and were there any restrictions governing its use.

*(4) Water point characteristics*

These questions covered the physical characteristics of the water point: type of water source, abstraction unit used, measured total depth and static water level, its seasonality, and whether it was protected or not.

*(5) Functionality test and rehabilitation effort*

This section covered functionality status of the water point: the functionality test used, the classification derived from the test results, recorded possible reasons for it not functioning properly, and captured some estimates of labour and materials required to bring the water point to fully functional status.

*(6) Other observations*

This was the only open-ended question to record any other unforeseen details that could affect availability of water at the water point.

**3.6.4.2 Mapping the water points**

*(a) Teams*

Boreholes and deep wells were assessed by DDF engineers while all other sources were assessed by EHTs. Both DDF engineers and EHTs worked in pairs. All teams

worked in a given area to do a clean sweep of the water points in the area before moving on.

*(b) Permission and confidentiality*

Permission to conduct the survey was obtained from the rural district councils. Written informed consent was not obtained for this survey as no human subjects were involved in the study. Name and designations of key informants interviewed were not considered confidential since no other personal details were recorded and they were the responsible persons for those water points in the community.

*(c) Sensitisation*

Local leaders, key personnel involved in the maintenance of water points in the district, and villagers were sensitised in advance of the water point assessment through meetings organised by the researcher and local Ministry of Health staff in the district.

*(d) Locating water points*

Village health workers in each ward were asked to prepare lists of water points in their area in advance. The survey teams visited each water point, assessed its status, recorded its GPS coordinates and noted any rehabilitation materials that may be required if it was not fully functional.

*(e) Interviewing key informants*

Key informants were identified in each district, ward and village as people who had sufficient knowledge of the water points in an area: these included among others pump minders, village health workers, ward councillors, district maintenance officers, school heads, or village headmen. One or more available key informant was informally interviewed by the enumeration team at the water point and provided the following details: water point name, estimated number of households fetching water, water point class, restrictions on use, seasonality, and possible reasons for not functioning. More than one key informant was preferred as a means of getting more accurate data. Wood

and Ross-Kerr (2011:125) state that validity of data in an unknown setting is established through triangulation of sources.

*(f) Equipment*

Each team carried the following equipment for assessing water points:

- A motorcycle for EHTs or 4 wheel drive vehicle for the water engineers
- 1 PDA/GPS set to record data and a spare battery for the PDA
- Water level meter for measuring total depth and water level in the well
- 20 litre plastic test bucket for testing functionality of water point
- Spare parts catalogue (see appendix G)

*(g) Training*

The researcher and public health engineers trained the survey supervisors and enumerators on the following survey procedures (Joubert & Ehrlich 2009:122):

- How to administer the water survey checklist using the PDA
- How to select credible key informants
- How to use the water level meters
- How to perform the water point functionality tests
- How to use the PDA stopwatch for timing functionality test
- How to use the parts catalogues to identify required parts for rehabilitation

*(h) Update meetings*

During the survey teams met twice a week at the district hospitals for the following:

- To download data from PDAs to a central database
- To charge PDA and GPS batteries
- To update the PDA program if it was updated
- For the researcher to verify that all data-collection equipment was working well
- To share any challenges and success faced in the field

*(i) Data downloading and backup*

Water point survey data was downloaded from each PDA onto a desktop PC using WMDC and the CyberTracker database. A backup of the PC database was kept on an external hard drive in case of data loss on the main computer (Joubert & Ehrlich 2009:115).

### **3.7 DATA ANALYSIS**

Burns and Grove (2003:46) state that data analysis is conducted to give meaning to data by reducing and organising it using appropriate techniques. Selection of data analysis tools and techniques is guided primarily by the research objectives, or questions and the type of data collected. According to Polit and Hungler (1995:40), limitation of the study should always be taken into account in the data analysis because if not done the results of the study may not answer the research problem satisfactorily. As this study was quantitative, descriptive statistical and GIS methods consisting of tables, diagrams, graphs and maps were used. Graphs, tables and maps summarising the data should reflect the truth about the data (Joubert & Ehrlich 2009:138). The researcher and a GIS expert at ZVITAMBO performed the statistical data analysis and geo-spatial analysis, using Stata/SE for Windows Version 10.0 and Quantum GIS Version 1.5.0 Tethys.

### **3.8 RELIABILITY AND VALIDITY**

#### **3.8.1 Reliability of the research instruments and methods**

Reliability is concerned with the consistency of the measurement technique, the stability of repeated measures, and agreement between measurements by multiple raters (Burns & Grove 2003:270). If a questionnaire is administered at different times on the same subject by the same or different interviewers and the responses differ, then the questionnaire may not be reliable.

To enhance reliability of methods and tools, the researcher developed the questionnaire/checklists in wide consultation with water and sanitation experts including the members of the WASH cluster.



Burns and Grove (2003:42) defines a pilot test as smaller version of the proposed study using similar settings and subjects conducted to refine the methodology. Research instruments were extensively pilot tested in Gweru Rural, a neighboring district with similar settings to the study area.

### **3.8.2 Validity of the research instruments and methods**

Validity is a measure of how the instruments are able to measure what it is designed to measure (Burns & Grove 2003:274).

The research instruments used were considered valid for the following reasons:

- The researcher referred to Core Questions on Drinking-Water and Sanitation for Household Surveys (WHO/UNICEF 2006) and adapted the questions in consultations with water and sanitation experts.
- The questionnaire/checklists were constructed according to objectives of the study.
- The PDA program interface was programmed to follow the layout of the questionnaires as closely as possible.

### **3.8.3 Validity and reliability of the study**

Burns and Grove (2003:198) state that the validity of a study design is a measure of the truth or accuracy of the findings. The validity and reliability of measurement instruments and statistical methods of analysis strengthen the truthfulness of findings. The researcher ensured the validity of the study following these (Polit & Hungler 1995:701):

- Undertaking a comprehensive literature review
- Bringing together different loose ideas into a study framework
- Selecting an appropriate design
- Defining operational definitions of concepts and selecting valid and reliable measurement instruments and procedures
- Ensuring agreement between the research questions, objectives, data collection and analysis and recommendations
- Ensuring validity and reliability of collected data

- Ensuring validity of data analysis methods

### **3.9 ETHICAL CONSIDERATIONS**

According to Polit and Hungler (1995:701) ethics deals is a system of moral principles that is concerned with the degree to which research procedures adhere to moral, legal and social obligations to the study participants. Pursuant to this, the researcher obtained the necessary permissions to conduct the study from relevant authorities. As the study did not involve human subjects it was not necessary to obtain informed consent for this study. The researcher however observed the rights of respondents to self-determination, privacy, confidentiality and fair treatment where there was contact with people.

#### **3.9.1 Permission to conduct the study**

Permission was also obtained from the provincial medical director of the Midlands province to conduct the study in Chirumanzu and Shurugwi (see appendix A). Permissions to conduct the survey was also obtained from research and ethics committee of the University of South Africa, Medical Research Council of Zimbabwe, Research Institute of McGill (see appendices B, C, D).

#### **3.9.2 Informed consent**

The researcher did not need to obtain informed consent for the study as it had no invasive contact with human subjects. When it did, in the case of key informants, the subjects were public figures whose job was to compile such information such that it was not deemed confidential. Moreover multiple informants could be interviewed such that information obtained could not be attributed to any one individual.

#### **3.9.3 Human rights**

Burns and Grove (2003:166) state that human rights are claims and demands that have been justified in the eyes of an individual or by the consensus of a group of individuals. The researcher explained to the district authorities and respondents why it was

important to conduct this study. How the districts would benefit from the findings because recommendations would be implemented to improve fair distribution of water resources and to direct other WASH implementing organisations and government to under-served areas.

### **3.10 CONCLUSIONS**

In this chapter the research design and methodology issues were discussed, the different populations and samples were dealt with; the research instruments and data collection techniques employed were explained and ethical considerations explored. In the homesteads mapping study the subjects were any homesteads that could be identified from Google Earth satellite images of the two study districts of Chirumanzu and Shurugwi. In the water point mapping study the subjects were any accessible public and private water points in the study districts of Chirumanzu and Shurugwi and respondents were key informants found for each water point. In the household sanitation survey the subjects were the households and there were no respondents in this survey.

Chapter 4 discusses the data analysis and interpretation of results.

## Chapter 4

### Data analysis and interpretation

#### 4.1 INTRODUCTION

This chapter discusses the data analysis and interpretation of results.

The study wished to establish the following:

- To determine the proportion of households within given distances of any water source
- To determine the median distance between households and the nearest water source of any kind
- To determine the proportion of non-functional water source
- To determine the proportion of households that has access to an improved sanitation facility
- To determine what effort, in terms of time, equipment, manpower and training, is required to collect required data and analyse it to answer the above questions
- To make recommendations to Chirumanzu and Shurugwi districts for future assessments

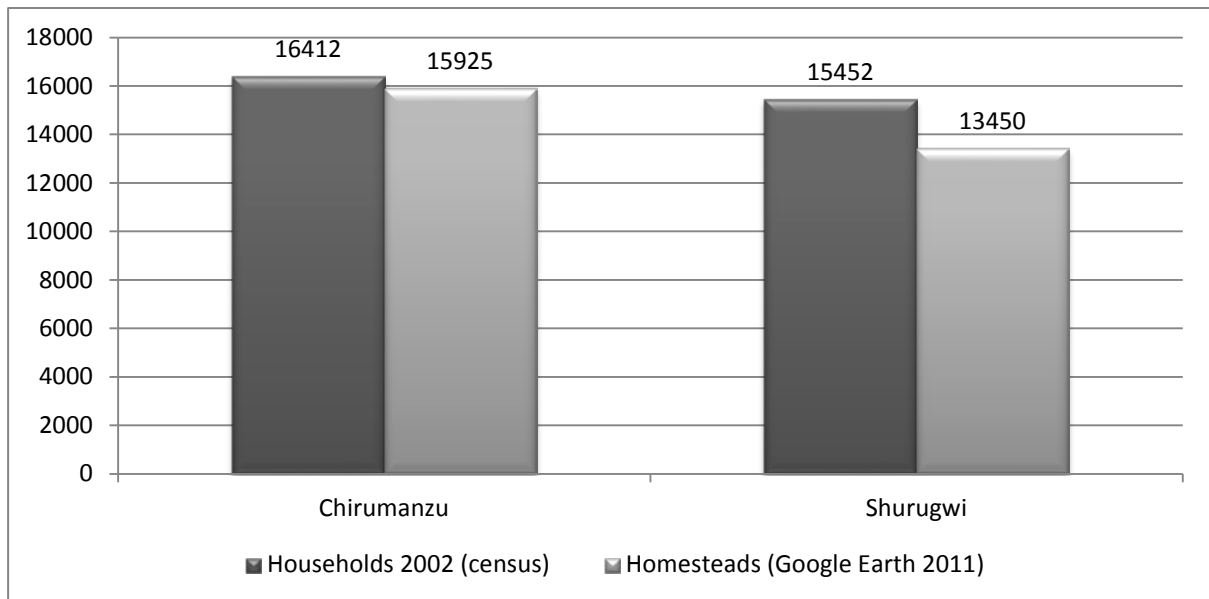
To answer the above questions, three investigations were conducted as follows:

- A desk study of Google Earth maps to establish the special distribution of settlements in the study area.
- A water point survey to establish the special distribution of water sources and the characteristics of each water point in the study area
- A sanitation survey to establish the proportion of household with functioning BVIP latrines in the study area.

## 4.2 MAPPING OF HOMESTEADS USING GOOGLE EARTH

### 4.2.1 Homesteads

A total of 29375 homesteads (15925 in Chirumanzu and 13450 in Shurugwi) were identified through Google Earth. Figure 4.1 represents the distribution of homesteads identified and the number of households in the 2002 census.



**Figure 4.1 Homesteads identified on Google Earth and households in the 2002 census by district**

Homesteads identified by the desk study were very close to the number of households in the 2002 census, 29375 (92%) in total where 15925 (97%) were identified in Chirumanzu and 13450 (87%) in Shurugwi. The results show that Google Earth can be used as a tool to enumerate the number of households in the study area.

#### 4.2.2 Spatial distribution of homesteads

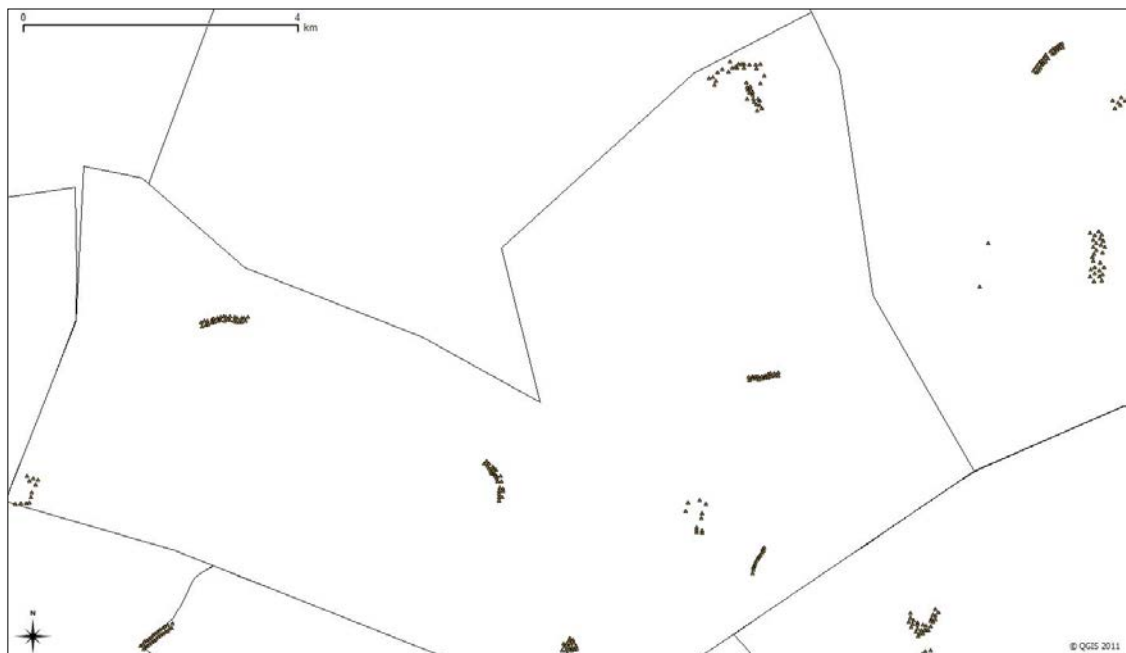
The settlement pattern in the study area is shown in figure 4.2. In the figure the contrast between densely and sparsely populated areas can be clearly seen. This correlates well with the known land use pattern in the two districts where older communal lands have higher density settlements with no clear boundary between villages while in newer resettlement areas homesteads are clustered in villages with large open spaces between each cluster.



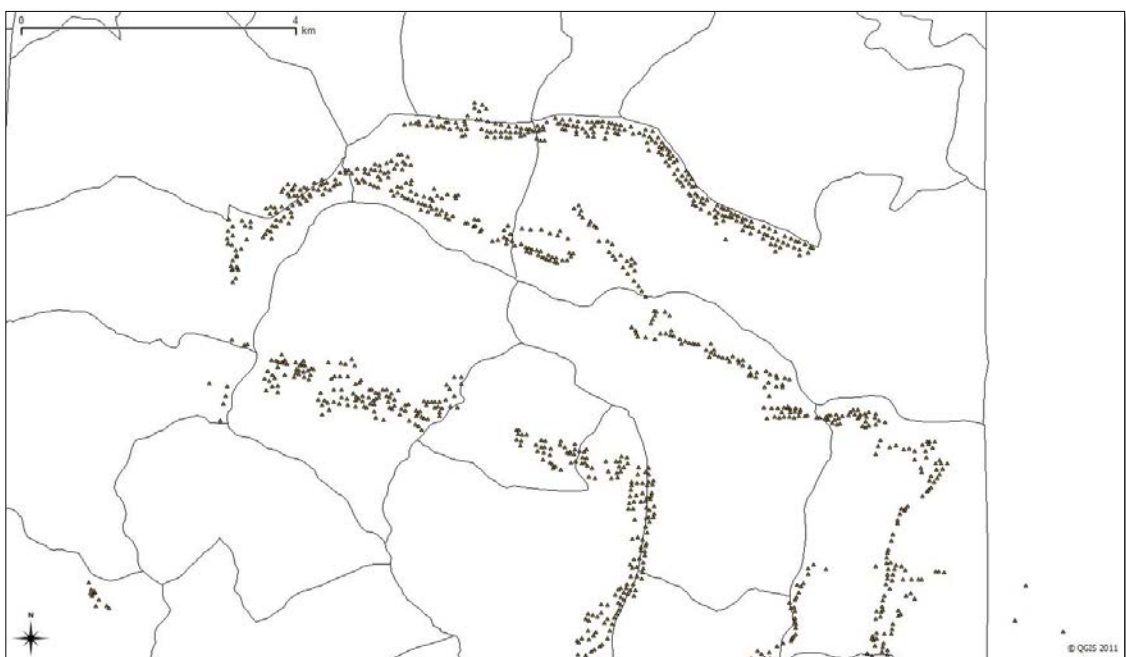
**Figure 4.2 Settlement patterns in the study area. The dots denote homesteads**

### 4.2.3 Contrasting settlement patterns

The two settlement patterns denoted in figure 4.3 present unique problems when planning health service provision in the different areas.



**A**



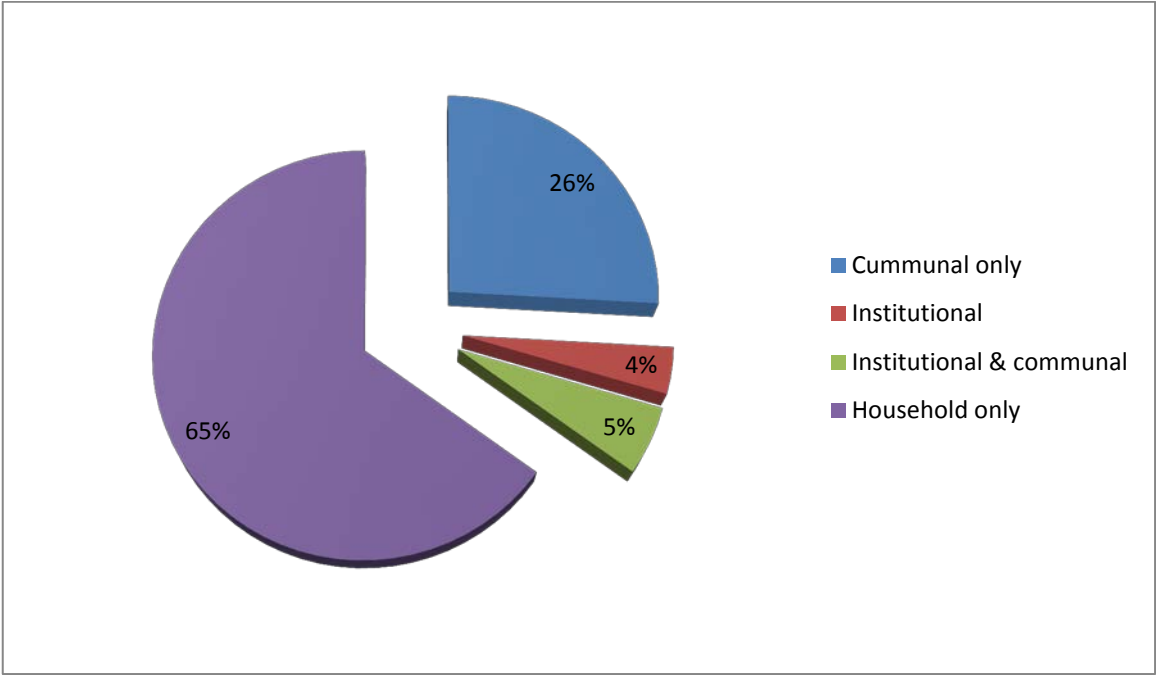
**B**

**Figure 4.3 Settlement patterns in (A) Ward 12 Tokwe 4 resettlement areas, Chirumanzu and (B) Ward 16 Tongogara RDC, Shurugwi**

### 4.3 WATER POINT SURVEY

#### 4.3.1 Water point class

A total of 4134 water points were located in both districts, their ownership is depicted in figure 4.4.



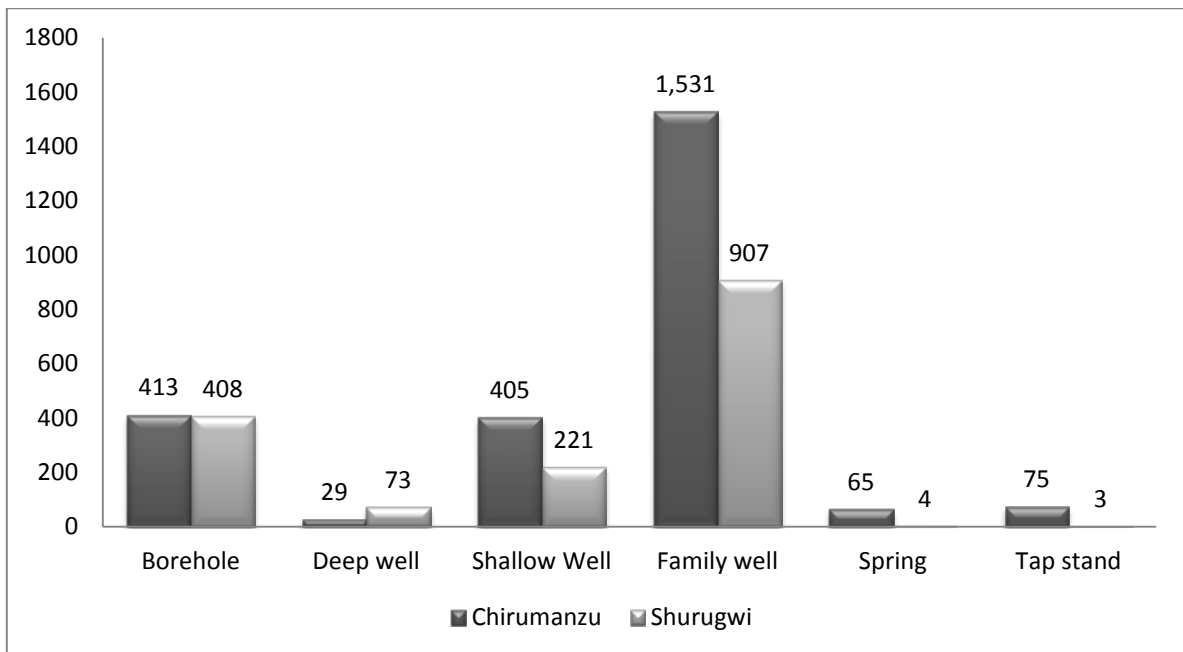
**Figure 4.4 Distribution of water points by type of ownership**

Privately ownership of water points was very common accounting for 65% of water points in the two districts. These were mostly shallow family wells dug by households near their homesteads. Communal water points were installed by council and other WASH partners, accounting for 26% of all water points in the two districts. Institutions, including schools and hospitals shared 5% of the water points while the balance was owned by institutions only.

#### 4.3.2 Water point type

A total of 4134 water points were located and mapped in both districts, 821 were boreholes. It can be seen in figure 4.5 that family wells were the most dominant source of water in both districts with Chirumanzu having 1531 and Shurugwi 907.

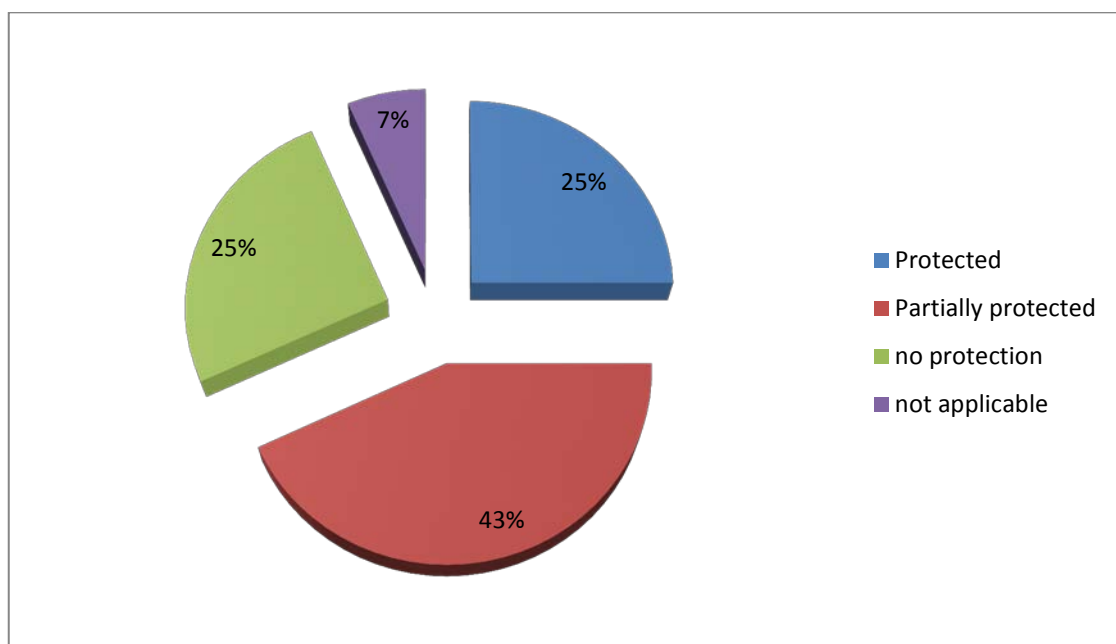




**Figure 4.5 Distribution of water sources in Chirumanzu and Shurugwi by type**

### 4.3.3 Protection

Of the water points inspected, figure 4.6 shows their protection status. Most of the water points, 43% were partially protected while only 25% were fully protected from environmental contamination.



**Figure 4.6 Water point protection status**

**4.3.4 Restriction**

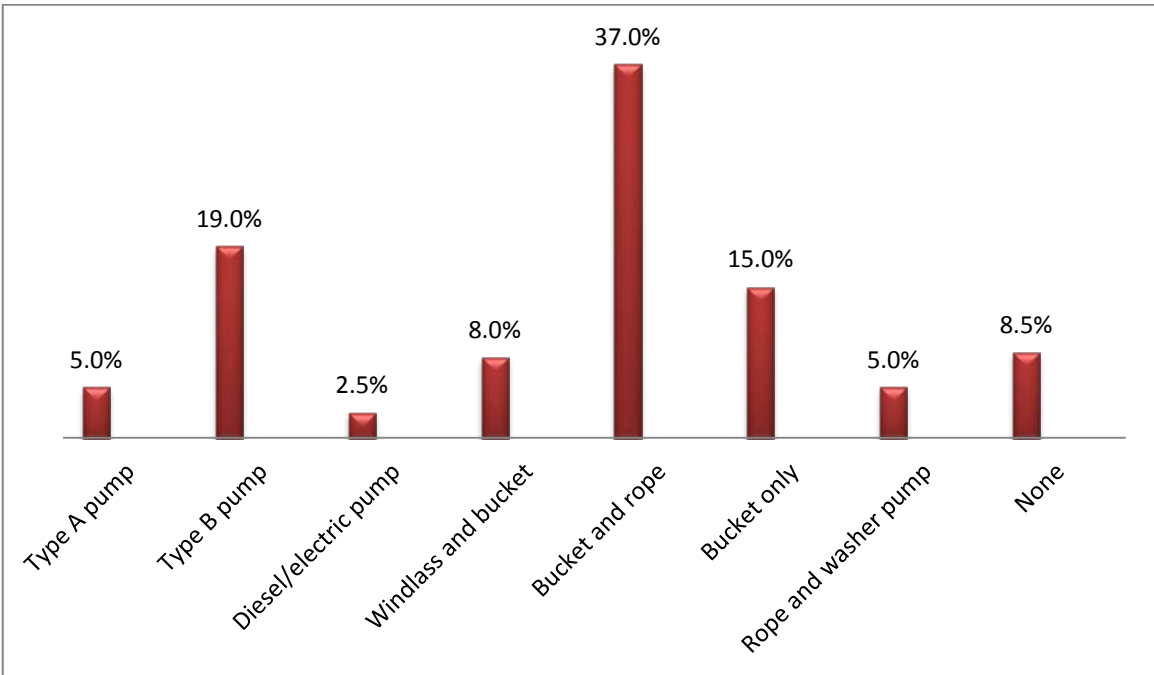
Only 16% of the water points had restricted access, most of the restricted ones being owned by private institutions. This confirms the normal cultural practice in Zimbabwe where water is usually given freely to anyone.

**4.3.5 Seasonality**

Of the water points assessed, 47% had evidence of seasonality the dry months ranging from August to October. Again most of the seasonal water points were shallow family wells.

**4.3.6 Abstraction unit**

The range of water lifting devices found during the survey is depicted in figure 4.7.



**Figure 4.7 Types of abstraction units used in Chirumanzu and Shurugwi**

The bucket and rope was the most common abstraction unit (37%) mainly used on shallow wells. The type B pump (19%) is the standard District Development Fund issue

replacing type A pumps which are being phased out. Motorised pumps are rare (2.5%) and are only used at institutions.

#### 4.3.7 Functionality

Of the combined total of 821 boreholes located in the two districts, 263 (32%) were not fully functional. Of those broken, 142 boreholes were in Chirumanzu comprising 34.4% of the total in the district while the balance making up 29.7% of Shurugwi boreholes were broken-down. Table 4.1 shows the distribution and functional status of boreholes by district.

Compared the 2004 figures, the number of boreholes has increased by over 200 new boreholes but the proportion broken has increased diluting the benefit. This could be an indication of installation of inferior materials or lack of maintenance, or both.

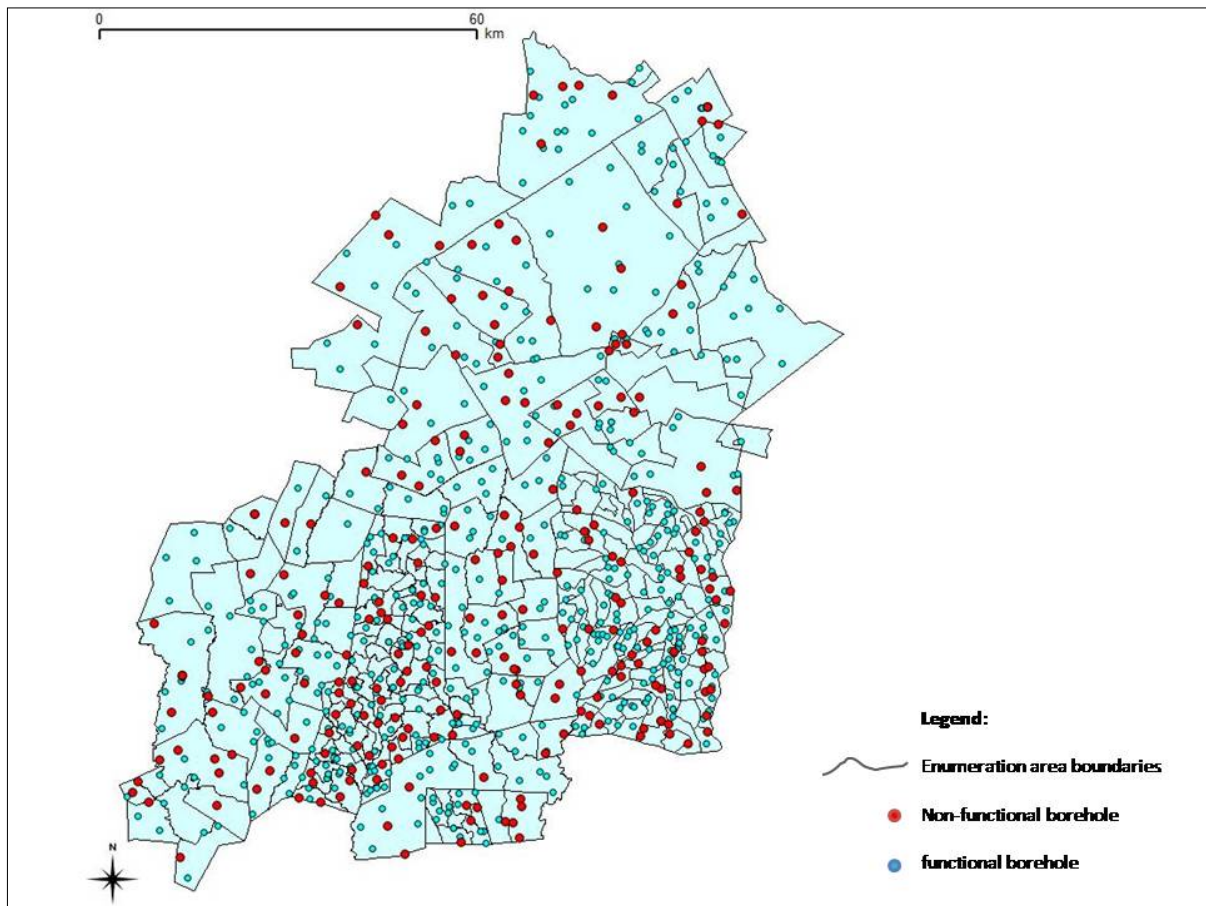
**Table 4.1 Total number of boreholes by functionality status**

District	Borehole		Total N (%)
	F N (%)	NF N (%)	
Chirumanzu	271 (48.6%)	142 (54.0%)	<b>413 (50.3%)</b>
Shurugwi	287 (51.4%)	121 (46.0%)	<b>408 (49.7%)</b>
<b>Total</b>	548 (100%)	263 (100%)	<b>821 (100%)</b>

## 4.4 WATER COVERAGE SPATIAL ANALYSIS

### 4.4.1 Spatial distribution of boreholes

Figure 4.8 denotes the spatial distribution of boreholes in Chirumanzu and Shurugwi. It can be seen that the density of boreholes is less dense in the northern parts where land use is primary commercial and resettlement farming.



**Figure 4.8 Location of boreholes in the study area by functionality**

#### **4.4.2 Boreholes relative to settlement pattern**

Adding the homesteads layer over the boreholes reveals the distribution of boreholes relative to human settlement patterns in the study area. Figure 4.9 denotes the location of boreholes relative to inhabited places in Chirumanzu and Shurugwi. It is worth noting that some in areas there are boreholes but no visible homesteads, these are irrigation boreholes in farming areas.



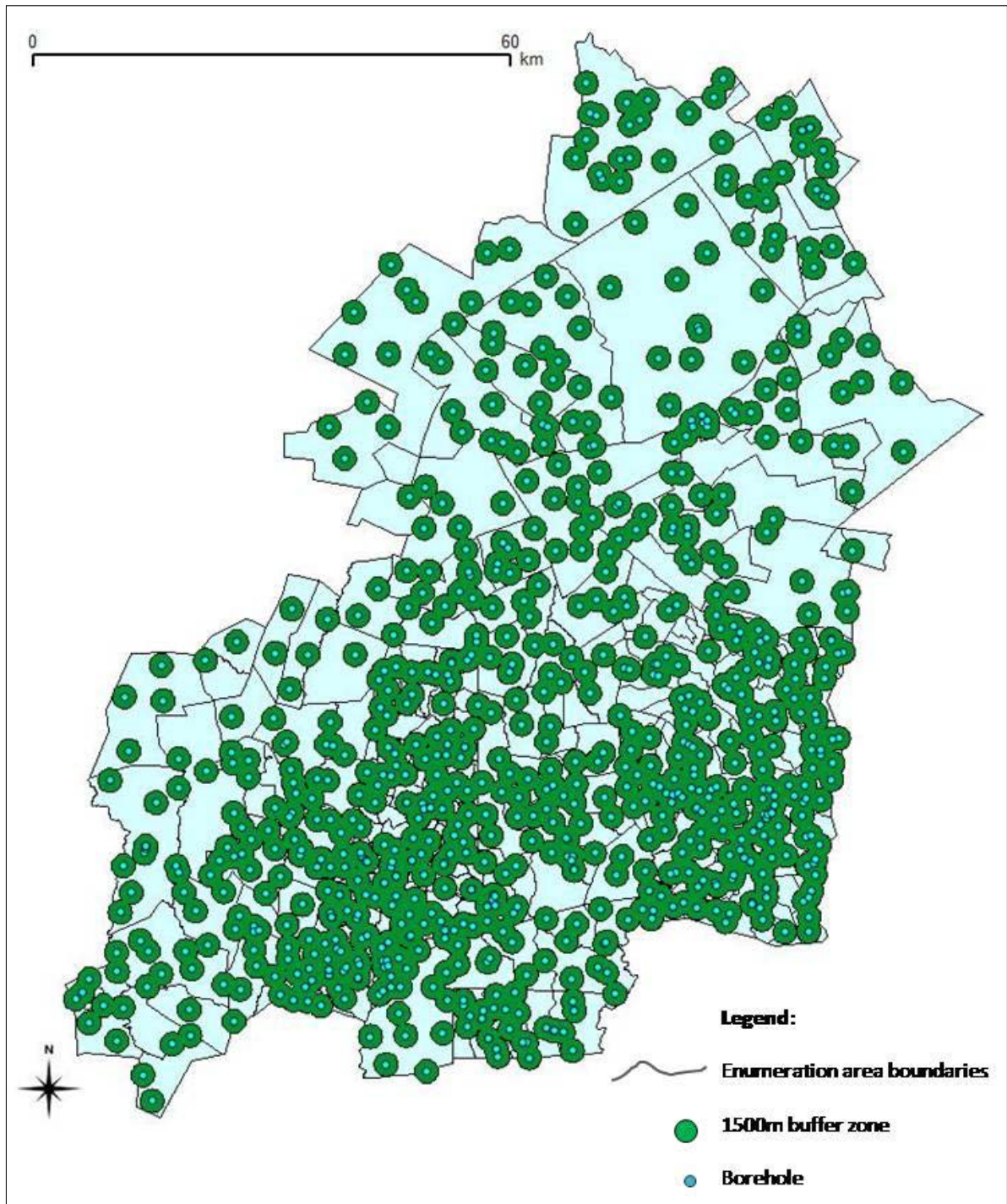
**Figure 4.9 Borehole locations in relation to inhabited areas in the study area**

#### **4.4.3 Proportion of households within 500, 1000 and 1500 m of a borehole**

By adding a buffer zone of 1500 m around each borehole, the proportion of households with 1500 m of a borehole was calculated.



Figure 4.10 shows the buffer zone of 1500 m around each borehole in Chirumanzu and Shurugwi. Households located in the buffer zone have access to borehole water within 1500 m.



**Figure 4.10 Zones with access to a borehole within 1500 m**

Tak Ting and Shui Shan (2008) demonstrated this method of calculating coverage by creating buffer zones around a health service point. A total of 22193 households in both

districts were within 1.5km of a borehole, giving mean coverage of 75.6% 95% CI (75.1-76.0) across the two districts. By applying buffer zones of 500m and 1000m around each borehole, access to a borehole within 500 m and 1000 m was also calculated and table 4.2 summarises the results.

**Table 4.2 Borehole coverage by distance from household in each district**

District	Households	500 m			1000 m			1500 m		
	N	n	%	95% CI	n	%	95% CI	n	%	95% CI
Chirumanzu	15925	6524	41.0%	40.2-41.7	9425	59.2%	58.4-59.9	12643	79.4%	78.8-80.0
Shurugwi	13450	6201	46.1%	45.3-47.0	8070	60.0%	59.2-60.8	9550	71.0%	70.2-71.8
Total	29375	12725	43.3%	42.8-43.9	17495	59.6%	59.0-60.1	22193	75.6%	75.1-76.0

95% CI were calculated using Binomial confidence intervals

By applying more stringent definitions of access to a borehole, the coverage was reduced from 75.6% where 22193 households were within 1.5 km of a borehole to 43.3% where 12725 households were within 500 m of a borehole.

**4.4.4 Adjusting coverage for non-functional boreholes**

In the preceding sections borehole coverage was calculated using all boreholes in the two districts, however, of the 821 boreholes located, 262 (32%) were broken-down. Adjusting for non-functional boreholes, the analysis was repeated only including fully functional ones, the effective coverage is summarised in table 4.3.

**Table 4.3 Functional borehole coverage by distance from household in each district**

District	Households	500 m			1000 m			1500 m		
	N	n	%	95% CI	n	%	95% CI	n	%	95% CI
Chirumanzu	15925	5591	35.1%	34.4-35.9	7465	46.9%	46.1-47.7	9268	58.2%	57.4-59.0
Shurugwi	13450	4250	31.6%	30.8-32.4	6106	45.4%	44.6-46.2	7564	56.2%	55.4-57.1
Total	29375	9841	33.5%	33.0-34.0	13571	46.2%	45.6-46.8	16832	57.3%	56.7-57.9

95% CI were calculated using Binomial confidence intervals

The effective functional borehole coverage was 57.3% with 95% CI (56.7-57.9) where 16832 households were within 1.5km of a functional borehole. When access criteria were set at 500m distance to a borehole, coverage was as low as 31.6% in Shurugwi where 4250 households were within the distance.

#### **4.4.5 Median distance between household and nearest borehole**

The median distance between households and the nearest borehole was calculated using the distance matrix function in Quantum GIS whereby the shortest distance between each household and the surrounding boreholes was determined by the GIS and the median distance calculated from these distances. The median distance was 1521 m with a range of 387 to 1905 m.

### **4.5 SANITATION SURVEY**

#### **4.5.1 Response rate**

The target sample size for this survey was 2938 households, 2893 (98.4%) of the households were located and assessed. Of those assessed 1582 (99.3%) of the target sample were in Chirumanzu and 1311 (97.5%) were in Shurugwi.

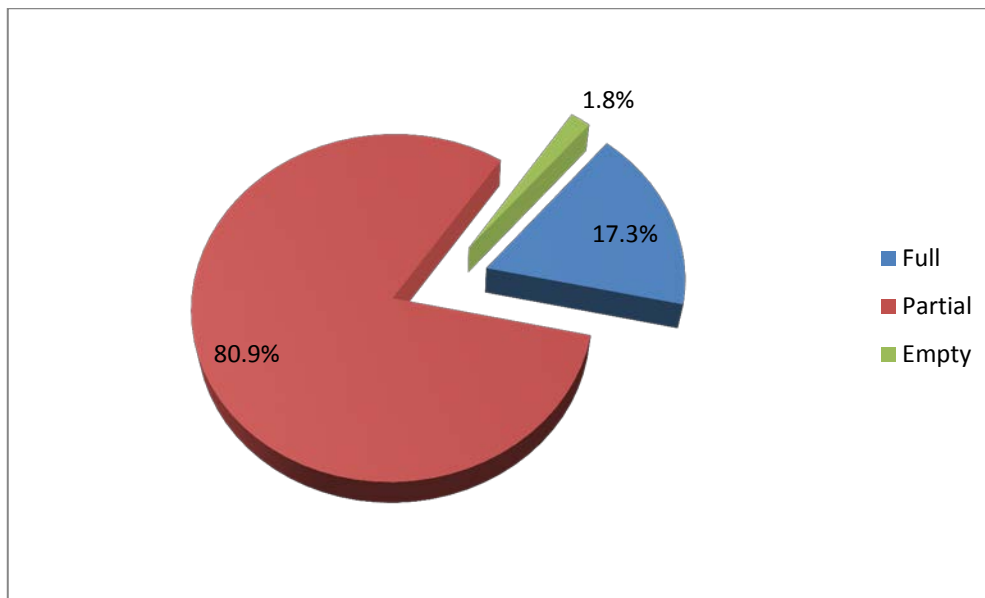
#### **4.5.2 Proportion of households with a BVIP latrine**

Of those assessed, 1282 (44.3%) 95% CI (42.5 – 46.1) had a BVIP at the household. In Shurugwi the proportion was higher, 616 (47.0%) 95% CI (44.2 – 49.7) and in Chirumanzu lower, 664 (42.0%) 95% CI (39.5 – 44.4).

#### **4.5.3 Status of BVIP latrines**

When the status of the BVIP latrine was assessed, 1036 (80.9%) were partially full. Figure 4.11 shows the distribution of latrine status.





**Figure 4.11 Latrine status**

#### **4.5.4 Proportion of ventilated BVIP latrine**

Almost all, 1229 (96%) of the BVIP latrines had ventilation fitted but only 196 (16%) of them passed the ventilation test. This shows that most latrine builders do understand the concept of a BVIP latrine but just replicate the shape.

#### **4.5.5 Proportion of ventilated BVIP latrine**

Again only 40 (3.3%) of all BVIP latrines found had a fly-screen. This really reveals the status of the coverage and quality of sanitation in the districts where over 96% of the structures did not pass inspection tests.

#### **4.5.6 Other types of latrine**

There were 162 (5.5%) other types latrines which were not BVIP. These were mostly temporary latrines made of grass and pole in newly resettled areas and flush toilets in peri-urban areas like Lalapansi and Chaka areas.

## **4.6 WHAT IT TOOK**

### **4.6.1 Google Earth mapping**

The mapping of homesteads took 4 weeks of two people digitising, verifying and extracting the homestead coordinates into a database.

### **4.6.2 The surveys**

#### ***4.6.2.1 Water point survey***

The water point survey took 3 months to accomplish with 13 teams of enumerators working in pairs and two supervisors.

#### ***4.6.2.2 Sanitation survey***

The sanitation survey took 6 weeks to complete with 11 teams of enumerators working in pairs and 2 supervisors.

### **4.6.3 Survey training**

Teams were trained in three days, one day practical, on survey methods and the use of personal digital assistant for data collection.

### **4.6.4 Data analysis**

There was no lag-time data collection and analysis, data were available for analysis soon after downloading from the PDAs –each download took less than a minute.

### **4.6.5 Personnel**

Personnel involved in the study were:

- 1 x data entry assistant
- 2 x public health engineers
- 22 x environmental health technicians

- 4 x water engineers/technicians

#### **4.6.6 Equipment**

Equipment used in the study included:

- 11 x motor cycles
- 3 x 4-wheel drive vehicles
- 15 x personal digital assistants and spare batteries
- 15 x GPS receivers
- 2 x desktop personal computers and external hard drives
- 1 x notebook computer

#### **4.7 CONCLUSIONS**

Chapter 4 discussed the analysis and interpretation. The statistical and spatial data analysis showed that:

- Personal digital assistants can be easily used to collect useful geo-referenced data in rural Zimbabwe
- Google Earth can be used as a tool to create population density maps faster and cheaper than most surveys
- Geo-spatial analysis can be used to refine coverage estimates to better match real access to resources
- Water coverage is relatively high in the two districts but it depends on the definition of access used
- The distance to a nearest borehole for most households is within 1500 m of their homes
- There are many non-functional boreholes in the districts, which if fixed could raise the water access level to above 70% improving chances of reaching millennium goal 7.
- There is low sanitation coverage but even lower quality latrines that meet sanitation standards

- With the right equipment and training, environmental health personnel already working in the rural districts can be employed to collect, in a reasonable length of time, geo-referenced data that can be analysed using GIS methods to update water and sanitation coverage estimates.

Chapter 5 discusses the findings and limitations of the study and makes recommendations for practice and further research.

## Chapter 5

### Findings, limitations and recommendations

#### 5.1 INTRODUCTION

This chapter summarises the study, presents the findings, discusses the limitations of the study and makes recommendations for practice and further research.

#### 5.2 SUMMARY OF THE STUDY

The aim of this study was to update water and sanitation statistics for Chirumanzu and Shurugwi districts in the Midlands province of Zimbabwe and to develop tools that could be used for rapid assessment of geo-spatial coverage of water and sanitation resources in rural areas.

The researcher conducted an exhaustive literature review and consulted with many experts in water, sanitation and hygiene to gain an understanding of the challenges faced by the sector. The researcher also reviewed many government policy documents to get insight into why water and sanitation statistics are not up-to-date.

The main objectives of this research were:

- To determine the proportion of households within given distances of any water source
- To determine the median distance between households and the nearest water source of any kind
- To determine the proportion of non-functional water sources
- To determine the proportion of households that had access to an improved sanitation facility
- To determine what effort, in terms of time, equipment, manpower and training, is required to collect required data and analyse it to answer the above questions
- To make recommendations to Chirumanzu and Shurugwi districts for future assessments

To answer the above objectives, the study was conducted in four parts:

- (i) A desk study using Google Earth to map population density in Chirumanzu and Shurugwi districts
- (ii) A water point survey to create a water point density map
- (iii) A water coverage spatial analysis using Quantum GIS
- (iv) A sanitation survey to assess access to improved sanitation facilities

The Google Earth desk study was conducted at the ZVITAMBO offices in Harare over a 4 weeks period, mapping all homesteads visible on satellite imagery. Data were then exported to Visual dBase database for analysis.

Field data were captured at source using HP iPAQ 211 personal digital assistants with Globalsat BT-368i Bluetooth GPS receivers attached and running a survey forms program developed in CyberTracker Version 3. Data were then downloaded from the personal digital assistants onto a CyberTracker database on a personal computer using Windows Mobile Device Center. Data were finally exported from CyberTracker into Visual dBase database for analysis.

All data were analysis using using Stata/SE Version 10 for statistical analysis and spatial analysis using Quantum GIS Version 1.5.0 Tethys.

### **5.3 FINDINGS**

The findings are discussed according to the four parts presented above.

#### **5.3.1 Mapping homesteads using Google Earth**

The findings revealed that Google Earth can be used as a feasible and cost effective tool for conducting surveys to map population density in rural areas.

Comparing with the 2002 census data, 92% of homesteads were identified in Chirumanzu and Shurugwi.

The spatial population distribution map created matched known land use patterns in the Chirumanzu and Shurugwi; the distinct settlement patterns found in established rural areas and relatively new settlements found in resettlement areas could be clearly seen.

According to United Nations Institute for Training and Research (<http://www.unitar.org/unosat>), UNOSAT is collaborating with Google to produce better and more accurate maps to help humanitarian projects reduce time spent hunting for data and invest it in analysis.

### **5.3.2 Water point survey**

A total of 4134 water points were mapped in the two districts, 65% of these were privately owned by households, 26% were owned publicly owned and the remaining 9% are were linked to institutions.

The most common source of water accounting for 59% of all water points was a family well, 63% of these were found in Chirumanzu. By their definition, family wells are privately owned which agrees with the ownership data obtained.

Only 25% of water sources had acceptable protection against environmental contamination, the majority (43%) had partial protection and 25% had no protection at all.

Access to water was generally not restricted, only 16% of the water points had some restriction. These were mainly institutional boreholes where communities could not access water and some private wells in individual back gardens.

Between months of August and October, the dry months of the year, up to 47% of the shallow wells dry up. This could change the water access pattern and usage dramatically during the year.

The predominant type of water abstraction unit is a bucket and rope (37%) which is synonymous with the much common shallow family wells. Most boreholes are fitted with Type B bush pumps which have a 19% prevalence in the area.

Boreholes are equally distributed between the two districts but a third of them were not functional. The proportion of non-functional boreholes was 54% in Chirumanzu and 46% in Shurugwi.

### **5.3.3 Water coverage**

Water coverage statistics were calculated using boreholes only, first using all the boreholes in the districts then using only functional boreholes. Water coverage when defined as 1500m to the nearest borehole was as high as 79% in Chirumanzu, but applying stricter criterion reduced coverage to 59% at 1000m from the nearest borehole, then to a low 43% for households within 500 m of a borehole.

Including only functional boreholes reduced water coverage at 1500m to the nearest borehole from 75% to 57% in the district. Applying stricter criteria of 500m puts water coverage at 33.5% across the two districts.

The median distance to the nearest borehole was 1521 m ranging from 387m to 1905m.

### **5.3.4 Sanitation survey**

Of the total of 2938 household selected for the sanitation survey, 98.4% were located and assessed – again highlighting the usefulness of Google Earth in mapping population density in rural areas.

Sanitation coverage was assessed at 44.3% in the two districts but Shurugwi had a slightly higher proportion at 47% coverage.

Eighty-one percent (81%) of the BVIP latrines were partially full, indicating that they were constructed within the last 10 to 15 years – the design life of a BVIP is 15 years (Morgan 1990).

Most (96%) of the latrines had a ventilation pipe fitted but 16% had ventilation actually functioning and further more a mere 3.3% had a fly-screen fitted.

A small number 5.5% of households had another type of latrine other than a BVIP and these were mostly temporary structures in the new resettlement areas.



### **5.3.4 Measuring the effort**

The mapping of homesteads took 4 weeks of two people digitising and verifying the work. The water point survey took 3 months to accomplish with 13 teams of enumerators working in pairs and two supervisors. The sanitation survey took 6 weeks to complete with 11 teams of enumerators working in pairs and 2 supervisors. Teams were trained in three days, one day practical, on survey methods and the use of personal digital assistant for data collection. There was no lag-time data collection and analysis, data were available for analysis soon after downloading and each download took less than a minute.

Personnel involved in the study were:

- 1 x data entry assistant
- 2 x public health engineers
- 22 x environmental health technicians
- 4 x water engineers/technicians

Equipment used in the study included:

- 11 x motor cycles
- 3 x 4-wheel drive vehicles
- 15 x personal digital assistants and spare batteries
- 15 x GPS receivers
- 2 x desktop personal computers and external hard drives
- 1 x notebook computer

## **5.4 LIMITATIONS OF THE RESEARCH**

The study was restricted to Chirumanzu and Shurugwi in the Midlands province of Zimbabwe there the results may not be generalised to other areas. However the methods used to conduct the study can be used in other rural areas to conduct similar studies.

## **5.5 PRACTICAL SIGNIFICANCE OF THE STUDY**

The findings will be used in the ZVITAMBO hygiene and sanitation cluster randomised trial to be conducted in the study area. These findings will also be made available to the rural district councils of Chirumanzu and Shurugwi and to the district hospitals' environmental health departments in both districts; to the Ministry of Health and Child Welfare; and to other water and sanitation partners in the country.

The findings should influence how water and sanitation survey statistics, or any other data, are collected in rural areas. The findings should also influence how coverage statistics are calculated and should impact on training needs of environmental health personnel.

## **5.6 RECOMMENDATIONS FOR FURTHER RESEARCH**

The researcher recommends that further research be conducted into

- the use of technology to solve health problems in resource constrained settings
- the use of geographic information systems in solving health problems
- further uses of Google Earth in public health

## **5.7 RECOMMENDATIONS FOR PRACTICE**

Based on the findings of and experiences on this study, the researcher makes following recommendations:

- Introduce the use of electronic field data-collection tools so save time and money
- Encourage the use of modern technology to motivate health staff in rural settings
- Google Earth should be used more often as a mapping tool to solve health problems
- The use of geographic information systems should be encourage as spatial analysis can reveal hidden patterns in data
- Water coverage definition must be specific for a given problem as different definitions define different levels of access

- Sanitation coverage statistics can be very misleading as having a latrine might not imply access to improved sanitation
- Supervision of latrine construction should be stronger to ensure compliance with standards

## **5.8 CONCLUSION**

The study showed how to use GIS to calculate water coverage statistics which include proportions within given distance of water sources and mean and median distances of households to water sources. The study also showed how geo-referenced household location datasets can be constructed using Google Earth. The study showed how PDAs can be used to collect household and water point datasets rapidly and analyse them using GIS. The study documented the time and effort, people, equipment and training required to perform the water and sanitation assessment in two rural districts. Results of the study compare well with other water coverage assessments but go beyond what all other assessments have done by allowing modelling of water access using distance which has never been done before in the districts, country and probably the region and beyond. The study found that the use of technology solutions for field data collection and analysis in rural settings can speed-up decision making in critical health problems. Efforts to introduce innovative solutions should be promoted and encouraged to motivate and retain health personnel in rural health centres. The researcher believed that the use of geographic information systems can play a pivotal role in solving public health problems.

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[http://www.mohcw.gov.zw/index.php?option=com\\_content&view=article&id=13&Itemid=4](http://www.mohcw.gov.zw/index.php?option=com_content&view=article&id=13&Itemid=4)

[http://www.unesco.org/water/wwap/wwdr/indicators/pdf/F4\\_Access\\_to\\_safe\\_drinking\\_water.pdf](http://www.unesco.org/water/wwap/wwdr/indicators/pdf/F4_Access_to_safe_drinking_water.pdf)

<http://www.unitar.org/unosat>

<http://www.usglobalsat.com/>

[http://www.who.int/csr/don/2008\\_12\\_02/en/index.html](http://www.who.int/csr/don/2008_12_02/en/index.html)

<http://www.wssinfo.org/en/definitions-methods/data-sources/>

<http://www.wsscc.org/countries/africa/zimbabwe/wash-sector-glance>

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**APPENDIX A**

**PERMISSION LETTER FROM PROVINCIAL MEDICAL DIRECTOR  
MIDLANDS PROVINCE**



Telephone: +263-4-798537 - 60  
Telegraphic Address:  
"MEDICUS", Harare  
Fax: +263-4-794734  
(702293 FHP)  
Telex: MEDICUS 22211ZW



Reference:  
Ministry of Health and Child  
Welfare  
P. O. Box CY1122  
Causeway  
HARARE

7 December 2010

THE PROVINCIAL ADMINISTRATOR  
MIDLANDS PROVINCE

Dear Mrs Chitiyo

REF: OPERATIONS OF ZVITAMBO WITH RESPECT TO  
PROJECTS IN SHURUGWI AND CHIRUMHANZU.


You must already be aware that Zvitambo has been supporting Ministry of Health and Child Welfare in Zimbabwe, in the Midlands Province in Particular. Their support has been in the area of Vitamin A Supplementation for pregnant women and children in Chirumhanzu and then later to Prevention of Mother to Child transmission of HIV in Shurugwi and Chirumhanzu. This support has seen the province attaining high coverage of the said interventions.

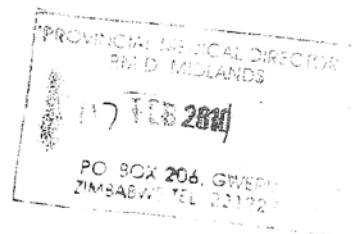
Currently, Zvitambo has got funding for an intervention study project to find out the relationship of sanitation to malnutrition in children which may start some time this year. This study which is set to take place in Shurugwi and Chirumhanzu will involve among other activities the construction of toilets and resuscitation of portable water points in the study population.

I therefore request your indulgence to allow Zvitambo to carry out these civil works as far as they relate to the said project. In carrying out these works they will be guided by the Rural District Council and Ministry of Health (Environmental Health Technicians) who I understand are all by now clear of this project.

Please find attached a self explanatory e-mail from Zvitambo.

Thank you

  
DR. A CHIMISORO  
PROVINCIAL MEDICAL DIRECTOR - MIDLANDS  
Cc: DA - Shurugwi  
DA - Chirumhanzu



**APPENDIX B**

**CLEARANCE CERTIFICATE FROM UNIVERSITY OF SOUTH AFRICA**

UNIVERSITY OF SOUTH AFRICA  
Health Studies Research & Ethics Committee  
(HSREC)  
College of Human Sciences

CLEARANCE CERTIFICATE

Date of meeting: 19 April 2010 Project No: 31222617

Project Title: **Conducting water and sanitation survey using PDS and GPS technologies in rural Zimbabwe**

Researcher: **Ntozini, R**

Supervisor/Promoter: **Prof LI Zungu**

Joint Supervisor/Joint Promoter: **Dr G Netswera**

Department: **Health Studies**

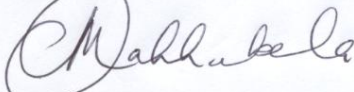
Degree: **MPH**

DECISION OF COMMITTEE

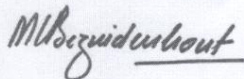
Approved

Conditionally Approved

Date: 19 April 2010



**Prof ON Makhubela-Nkondo**  
RESEARCH COORDINATOR: DEPARTMENT OF HEALTH STUDIES



**Prof MC Bezuidenhout**  
ACADEMIC CHAIRPERSON: DEPARTMENT OF HEALTH STUDIES

PLEASE QUOTE THE PROJECT NUMBER IN ALL ENQUIRES



## **APPENDIX C**

**APPROVAL FROM MEDICAL RESEARCH COUNCIL OF ZIMBABWE**

Telephone: 791792/791193  
Telefax: (263) - 4 - 790715  
E-mail: [mrcz@mrczimshared.co.zw](mailto:mrcz@mrczimshared.co.zw)  
Website: <http://www.mrcz.org.zw>

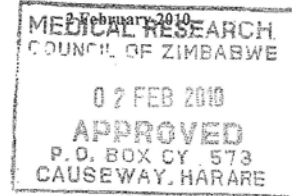


Medical Research Council of Zimbabwe  
Josiah Tongogara / Mazoe Street  
P. O. Box CY 573  
Causeway  
Harare

**MRCZ APPROVAL LETTER**

Ref: MRCZ/A/1534

**Dr. Jean Humphrey**  
ZVITAMBO  
No. 1 Borrowdale Road  
Harare  
Zimbabwe



**RE: Sanitation/Hygiene and Nutrition Intervention for Infant Health**

Thank you for the above titled proposal that you submitted to the Medical Research Council of Zimbabwe (MRCZ) for review. Please be advised that the Medical Research Council of Zimbabwe has **reviewed** and **approved** your application to conduct the above titled study. This is based on the following documents that were submitted to the MRCZ for review:

- a) Study protocol, Version 2, dated 7 January 2010.
- b) Informed consent forms, Shona, Version 2, dated 7 January 2010.
- c) Informed consent forms, English, Version 2, dated 7 January 2010.
- d) EBF Community Questionnaires English, Version 2, dated 7 January 2010.
- e) EBF Community Questionnaires Shona, Version 1, dated 7 January 2010.
- f) Infant feeding Questionnaire for Health workers Version 2, dated 7 January 2010
- g) Feeding survey for mothers Birth to 6 months infants, Version 1, Shona and English & January 2010
- h) Survey of water points Version 1, dated 21 September 2009.
- i) Survey of sanitation facilities, Version 1, dated 21 September 2009.
- j) Recruitment script Shona version 2, dated 7 January 2010.

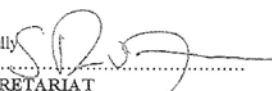
APPROVAL NUMBER : MRCZ/A/1534

This number should be used on all correspondence, consent forms and documents as appropriate.

- APPROVAL EFFECTIVE DATE : 2 February 2010
- MRCZ MEETING DATE : 26 November 2009
- EXPIRATION DATE : 1 February 2011
- TYPE OF MEETING : Full Council

- After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the MRCZ Offices should be submitted one month before the expiration date for continuing review.
- SERIOUS ADVERSE EVENT REPORTING: All serious problems having to do with subject safety must be reported to the Institutional Ethical Review Committee (IERC) as well as the MRCZ within 3 working days using standard forms obtainable from the MRCZ Offices.
- MODIFICATIONS: Prior MRCZ and IERC approval using standard forms obtainable from the MRCZ Offices is required before implementing any changes in the Protocol (including changes in the consent documents).
- TERMINATION OF STUDY: On termination of a study, a report has to be submitted to the MRCZ using standard forms obtainable from the MRCZ Offices.
- QUESTIONS: Please contact the MRCZ on Telephone No. (04) 791792, 791193 or by e-mail on [mrcz@mrczimshared.co.zw](mailto:mrcz@mrczimshared.co.zw).
- Other
- Please be reminded to send in copies of your research results for our records as well as for Health Research Database.
- You're also encouraged to submit electronic copies of your publications in peer-reviewed journals that may emanate from this study.

Yours Faithfully

  
.....  
MRCZ SECRETARIAT  
FOR CHAIRPERSON  
MEDICAL RESEARCH COUNCIL OF ZIMBABWE

**PROMOTING THE ETHICAL CONDUCT OF HEALTH RESEARCH**

Registered with the USA Office for Human Research Protections (OHRP) as an International IRB (Number IRB00002409 IORG0001913)

**APPENDIX D**

**APPROVAL FROM MCGILL UNIVERSITY**



L'Institut de recherche  
du Centre universitaire de santé McGill  
The Research Institute  
of the McGill University Health Centre

July 17, 2009

Dr. Brian Ward  
MUHC - MGH  
Room L10-3091  
Montreal, Quebec H3G 1A4

**Re: MUHC Authorization to Conduct Human Subjects Research Study 09-033-GEN  
entitled "Sanitation / hygiene and nutrition interventions for infant health"**

Dear Dr. Ward:

We are writing to confirm that the above-referenced study was submitted for all institutional reviews required by McGill University Health Centre policy.

The Research Ethics Board (REB) has notified us that ethical approval to conduct your study has been provided.

In addition, all Site Specific Assessments (SSA) received favorable reviews and therefore, you are authorized to conduct the study at the MUHC.

Please refer to the MUHC Study Code **09-033-GEN** in all future correspondence relating to this study.

**Important Note:** You are required to advise the MUHC once the study has been initiated. Please complete the Study Status Report to indicate the date the study became active and forward as an email attachment to the REB, and to the Research Institute of the MUHC.

On behalf of the MUHC, we wish you every success with the conduct of the research.

Sincerely,

Miguel Burnier, MD, PhD  
Associate Director for Clinical Research  
The Research Institute of the McGill University Health Centre

cc: REB Study File  
RI MUHC Study File

## **APPENDIX E**

### **HOUSEHOLD SANITATION CHECKLIST**



**ZVITAMBO/OXFAM**  
**HOUSEHOLD SANITATION SURVEY DATA COLLECTION FORM**

DISTRICT CODE: \_\_\_\_\_ WARD NUMBER: \_\_\_\_\_

Assessor ID: \_\_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_ Time: \_\_\_:\_\_\_ HH No: \_\_\_\_\_

1. Homestead ID (from sampling): \_\_\_\_\_

2. GPS coordinates (4 decimal degrees): Longitude \_\_\_\_\_° Latitude - \_\_\_\_\_°

3. Presence of BVIP?

1-Yes       2-No

4. How full is it?

1 - nearly full       2 - nearly half full       3 - near empty

5. Is ventilation pipe fitted?

2-No       1-Yes

5a. Smoke test:

1 -passed       2 -failed

5b. Functioning fly screen:

1 -yes       2 -no

6. Any other latrine?

1-Yes       2-No

7. Any other observations?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## **APPENDIX F**

### **WATER SURVEY QUESTIONNAIRE**

**ZVITAMBO/MoHCW/OXFAM  
WATER SOURCE SURVEY DATA COLLECTION FORM**

Assessor ID: |\_|\_|\_|\_|\_| Date: |\_|\_|/|\_|\_|/|\_|\_|\_|\_| Time (24hr): |\_|\_|:|\_|\_|

DISTRICT CODE: |\_|\_| WARD NUMBER: |\_|\_| VILLAGE: \_\_\_\_\_

**Key Informants:** **National District Ward Village**

- |    |            |                   |        |                       |                       |                       |                       |
|----|------------|-------------------|--------|-----------------------|-----------------------|-----------------------|-----------------------|
| a) | Name _____ | Designation _____ | Level: | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b) | Name _____ | Designation _____ | Level: | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c) | Name _____ | Designation _____ | Level: | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d) | Name _____ | Designation _____ | Level: | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

1. Water point identification: a) ID: |\_|\_|\_|\_|\_| b) Name: \_\_\_\_\_

2. GPS coordinates (5 decimal degrees): a) Long: |\_|\_|. |\_|\_|\_|\_|\_|° b) Lat: -|\_|\_|. |\_|\_|\_|\_|\_|°

3. Estimate number of HH using water point: |\_|\_|\_|\_|\_|

4. Water point class:  1 Communal only  2 Institutional  3 Institutional & communal  4 Household only

5. Water point type:  1 Borehole  2 Deep Well  3 Shallow Well  
 4 Tap Stand  5 Spring  6 Dam  
 7 Stream  9 Other: \_\_\_\_\_

6. Measured depth: a) Total depth: |\_|\_|\_|\_|. |\_|\_| m b) SWL: |\_|\_|\_|\_|. |\_|\_| m

7. Is it protected?  1 Yes  2 Partial  3 No  4 N/A

8. Is it restricted?  1 Yes  2 No  3 Other: \_\_\_\_\_

9. Is it perennial?	9a) Select month WITHOUT water:
<input type="radio"/> 1 Yes (goto 10)	<input type="checkbox"/> 1 Jan <input type="checkbox"/> 2 Feb <input type="checkbox"/> 3 Mar <input type="checkbox"/> 4 Apr
<input type="radio"/> 2 No (goto 9a) →	<input type="checkbox"/> 5 May <input type="checkbox"/> 6 Jun <input type="checkbox"/> 7 Jul <input type="checkbox"/> 8 Aug
	<input type="checkbox"/> 9 Sep <input type="checkbox"/> 10 Oct <input type="checkbox"/> 11 Nov <input type="checkbox"/> 12 Dec

10. Abstraction unit:  1 Type A pump  2 Type B pump  3 Diesel/electric pump  
 4 Windlass and bucket  5 Bucket and rope  6 Bucket only  
 7 Rope & washer pump  8 None  9 Other: \_\_\_\_\_

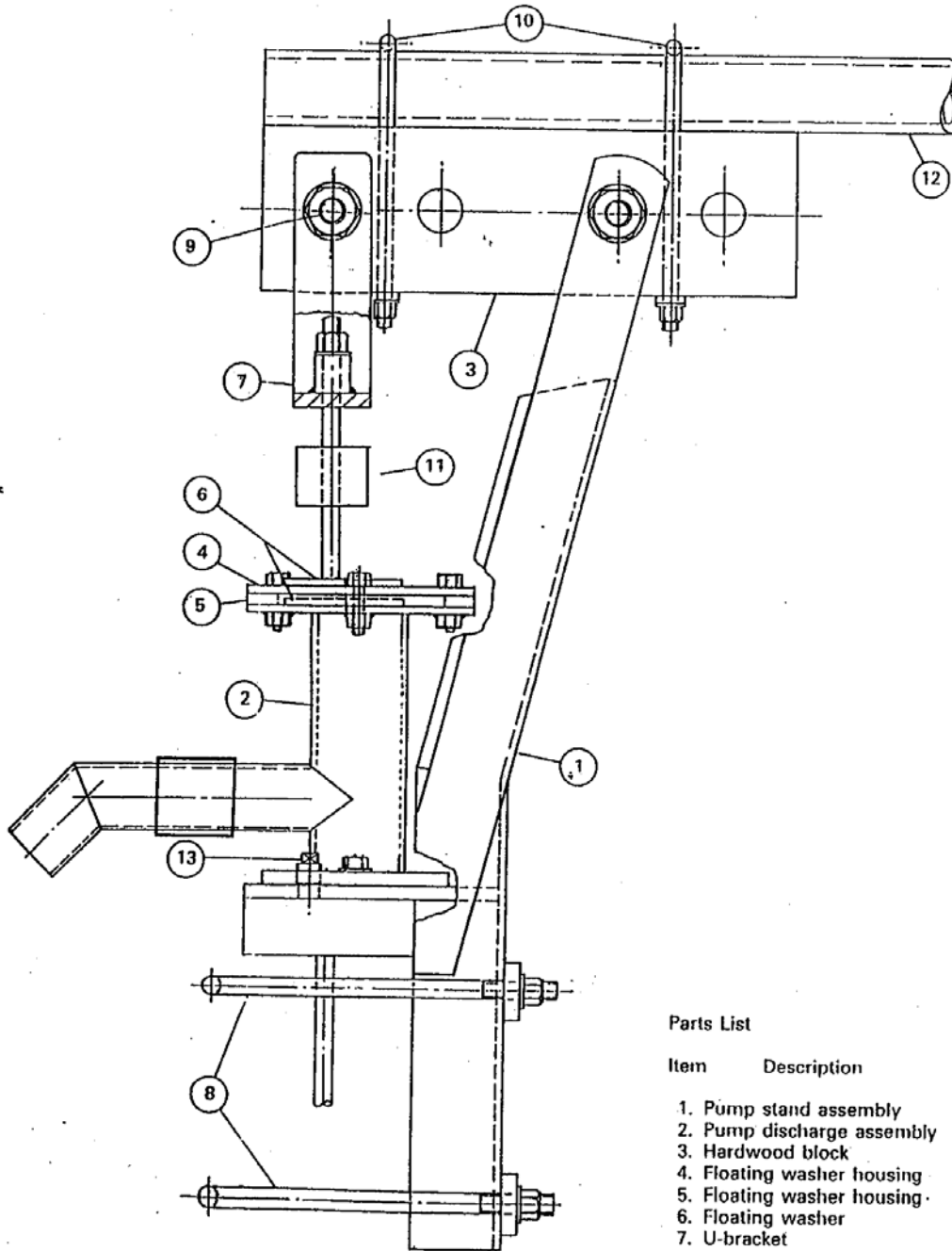




## **APPENDIX G**

### **WATER POINT SURVEY PARTS CATALOGUE**

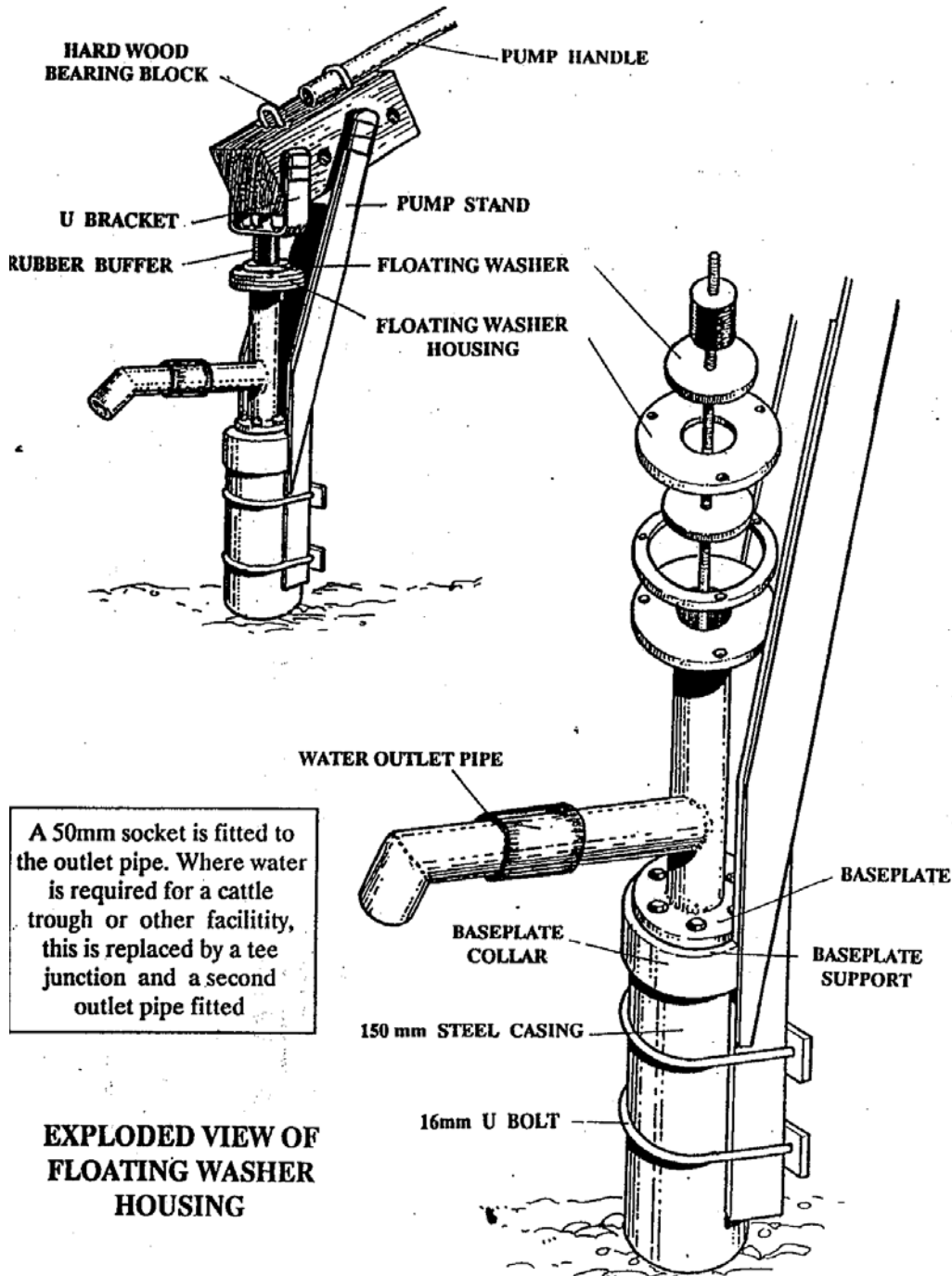
## THE "B" TYPE BUSH PUMP HEAD



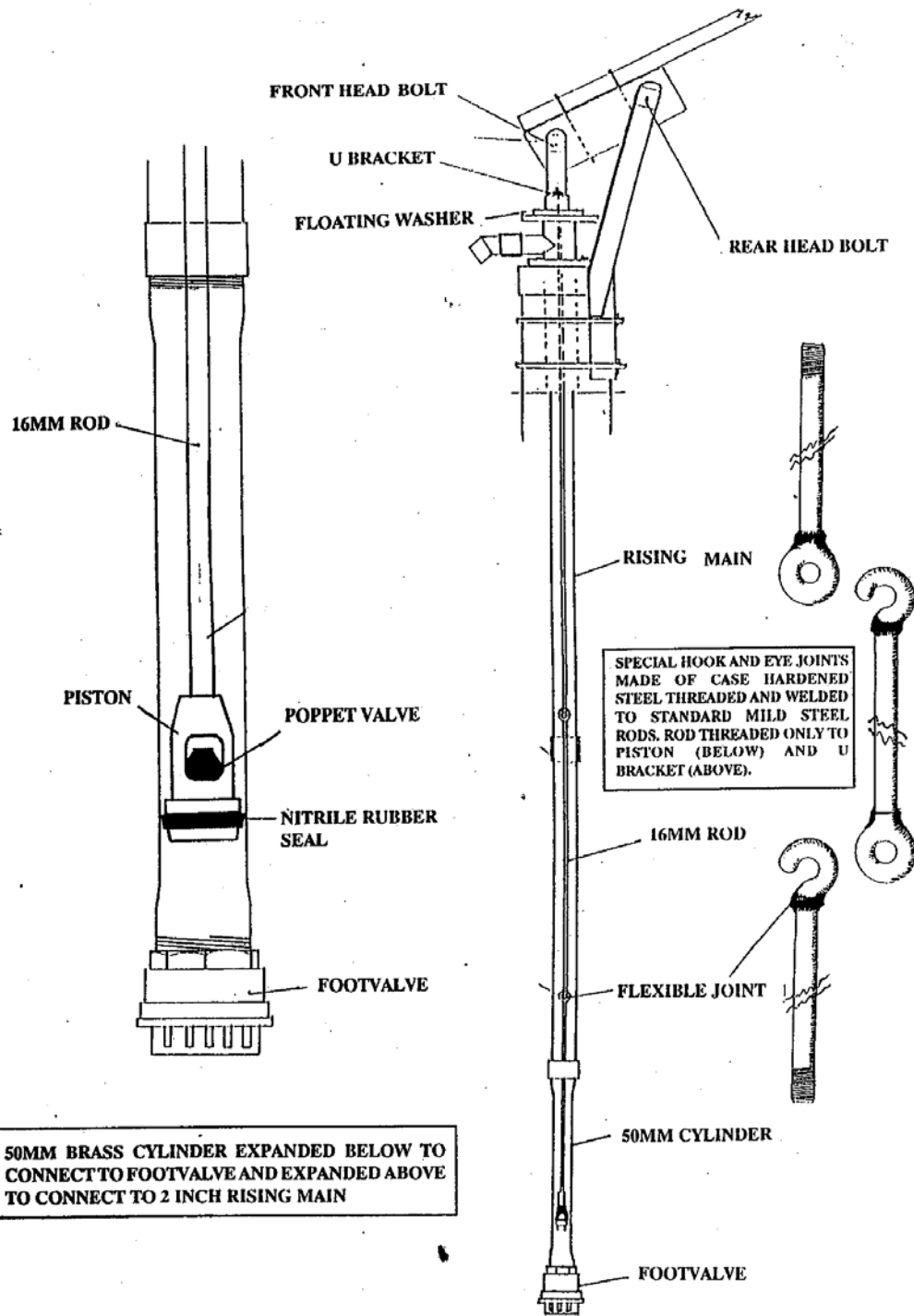
### Parts List

Item	Description
1.	Pump stand assembly
2.	Pump discharge assembly
3.	Hardwood block
4.	Floating washer housing
5.	Floating washer housing
6.	Floating washer
7.	U-bracket
8.	U-bolt
9.	Hinge pins
10.	U-bolt
11.	Rubber buffer
12.	Handle
13.	M20 plug

# PARTS OF THE PUMP HEAD

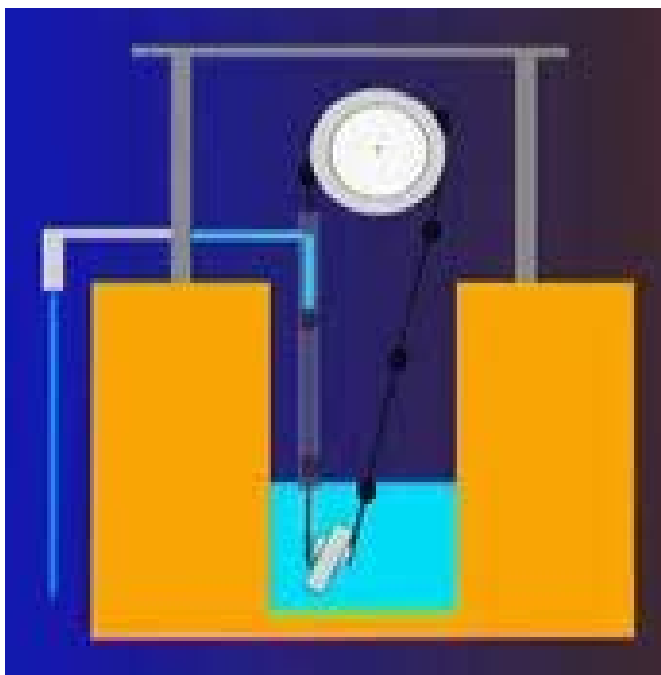


# "DOWN THE HOLE COMPONENTS"





## Rope and Washer Pump/Elephant Pump



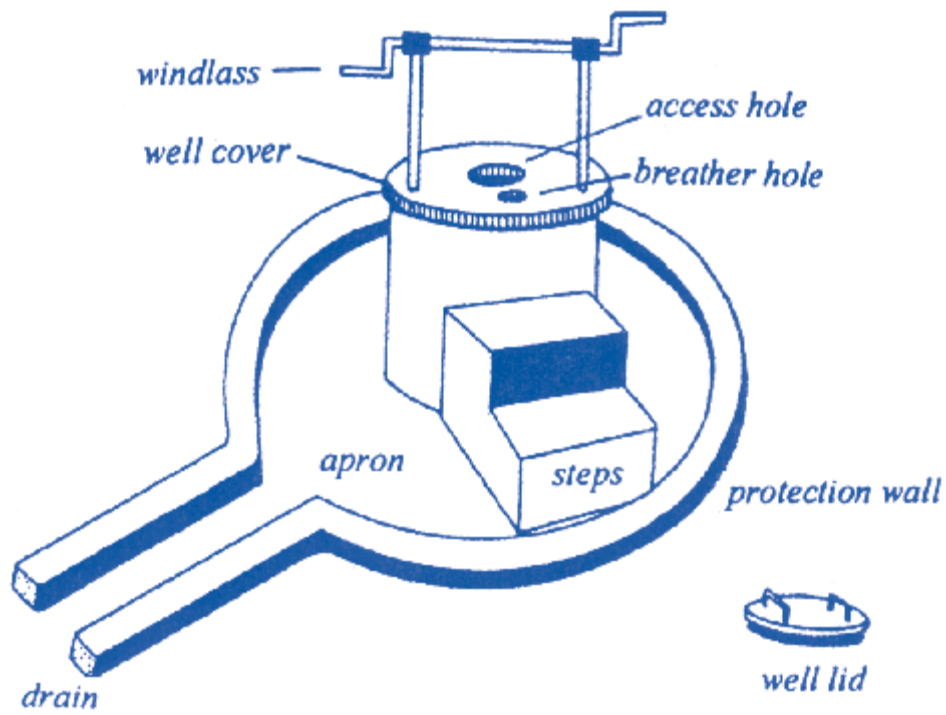
**Type B Bush Pump**



**Bucket Only**



## Bucket and Windlass





## Joma Pump (Sand Abstraction)

