A Report of the Consultancy on

MAPPING AND CHARACTERISING WATER POINTS IN MBETI SOUTH LOCATION, MBEERE DISTRICT

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EXECUTIVE SUMMARY

Water as a resource is critical to all forms of life in addition to supporting economic development of many nations. In Kenya, water is important because it supports agricultural development, power generation, industrial growth, livestock development, recreation and sports among other services. However, water availability has over the years has been declining and it is estimated that the trend will continue unless drastic measures are taken to counter the situation. Among the factors responsible for the current scenario are improper management, increased demand from the increasing population, climate change, degradation of catchments, pollution and misuse of available amounts. Moreover, there has been institutional, financial and managerial constraints that have made the situation worse leading to a large number of people in the rural areas go without adequate supply of water.

The realisation of the above challenges led the government to introduce reforms within the water sector through the Water Act 2002 and devise strategies for enhancing effective water resource management and utilisation. The reforms comprised dividing the country into five drainage basins and creating institutions for enhancing better provision of water and sewerage services to all parts of the country. They include the Water Services Regulatory Board (WASREB) with the mandate of setting standards and regulating the sub-sector; Water Resources Management Authority (WRMA) for the management of water resources; the Water Appeal Board (WAB) for adjudicating on water disputes; Water Services Boards (WSBs) with defined areas of operation to efficiently and economically provide water services; Water Services Trust Fund (WSTF) to finance pro-poor investments; and Water Services Providers (WSPs) to act as agents in the provision of water and sewerage services utilizing acceptable business principles in their operations. The Ministry only oversees the whole water sector through policy formulation, coordination and resource mobilization.

To evaluate the effectiveness of the reforms in enhancing water delivery, the Institute of Economic Affairs (IEA) contracted CETRAD to map and characterise all the water points in Mbeti South location in Mbeere District which falls under the Tana Water

Service Board. The location was selected and agreed upon between CETRAD and the client.

Based on the provided Terms of Reference, CETRAD organized field visits to map the spatial distribution of water points using GPS technology. Interviews and consultations were also carried out with water point owners, Ministry of Water and Irrigation officials in the district, management of group owned water points, and other key resource persons with the aim of gathering information about the water points.

Through the study it became evident that the population in Mbeti South location obtains water from a variety of sources. A total of 610 water points were mapped and they include springs, shallow wells, boreholes, piped installations, earth and concrete dams, river abstractions and water tanks. Using GIS technology, the distribution maps of these water points were generated and it emerged that the distribution is skewed with the upper region (northern and north-eastern) being well served than the other parts of the location. Possible reasons for the skewed distribution are that the upper zone has high population density as a result of immigration from the neighbouring districts and this creates high demand for water; and that the soils are relatively favourable for agriculture but limited by water scarcity. The later drives the farm owners to invest in water development such as shallow wells. Similarly, the zone is in proximity to Embu district and has benefited from the piped water system supplied by EWASCO.

From the 610 water points mapped, detailed information through interviews and discussions was only obtained for 549 of the water points. This information was included in the analysis while the rest, mainly river abstractions, was excluded. The results indicated that shallow wells are the majority (63.4%) followed by piped installations (22.6%). Most water points (64.7%) existed for more than a year before the study was carried. Analysis further showed there has been an increase in the number of water points constructed or implemented over the years from 1980s with the greatest increase being witnessed after the year 2000. Partly this is attributed to the water reforms in the sense that individuals have taken up the challenge of participating in water development as provided in the reforms.

Of the 549 water points, only 38.1% are registered with the District Water Office while the rest are not. Similarly, only 22.2% are metered for the purpose of controlling use and applies to piped installations by EWASCO. Therefore, control on use or misuse of water cannot be effectively enforced in the current status. This also means that a lot of potential revenue that could be generated through water sales is lost.

The mode of abstraction varied with the type of water point in question and included powered pumping, hand pumping, use of hand operated systems, piped taps, pulling using rope and bucket, and use of cans and buckets for surface water sources. However, since most water points (68%) derived their water from below ground aquifers (through boreholes and wells) the pull system using bucket and rope was the most common (45.4%). This was followed by piped taps (23.7%). All in all it emerged that the abstraction methods currently employed are manual in nature and would be a hindrance to water access for women, children and the aged who might not be able to operate the manual systems effectively.

Based on average figures of water abstracted from the various types of water points, the study established that the highest volume of water is abstracted from river Rupingazi using portable pumps and used for irrigation purposes. Similarly, there is high abstraction from boreholes, earth dams and springs owing to their use by groups of people. This is unlike the piped installations used by one or a few households, and whose use is regulated through user costs.

In terms of ownership, 86% of the water points are privately owned while 5.8% are group owned and managed through committees. For the privately owned ones, 76.9% are in households headed by men implying that men are much more likely to influence decisions on water development than women. An assessment on the location of water points showed that 62.7% are in agricultural fields and 24.8% in homesteads suggesting that agricultural production through irrigation is a major drive behind water points' interventions. It also emerged that the high incidence of private ownership and location in agricultural fields could be limiting factors to water access by the public.

Most water points (80%) were operational by the time of spot check and interviews revealed that 58% of them usually have water throughout the year. By the time of spot check 89.6% had water but at varying quantities. Despite the water availability, which implies that water could be accessed in most water points by then, there is the challenge of travelling for it since it is collected at source in 91% of the cases due to lack of distribution systems.

The main uses of obtained water are domestic; livestock watering and irrigation but these vary from one water point to the other. Women appear to be the major beneficiaries of these water points based on their numbers in the location. However, due to associated financial requirements through membership or the need to pay for the bills, the study cannot rule out the possibility of financially disadvantaged households being denied access to water. This is especially so for the unemployed, the old and single women households with limited financial sources. Measures are therefore required to invest in supply systems that would enhance affordability by such groups, if not at no cost.

It also emerged that Mbeti South location does not have an elaborate sewerage system. Instead households commonly use pit latrines (permanent/semi-permanent). Interviews revealed that 74% of the households own one and it is therefore deducible that there is proper waste disposal which reduces the chances of water points' contamination through overland flow of waste. However, there is need to consider the siting of latrines in relation to wells to minimise incidences of possible ground water contamination through leakage of effluents.

Funding for the water points is/was derived from a variety of sources: donor agencies, government, CDF, community, church and private funding. However, majority (84%) of the water points are privately funded, which also implies that the management is vested in such individuals or households. Management committees exist in 4.9% of the group owed water points. The composition of the committee comprises both males and females, which illustrate the gender representation in water management. The average number of females in the committees was however high (6) than that of men (4) because women are highly associated with water issues.

Based on cleanliness, protection, and the operationalisation of the drawing system most water points can be classified as fairly managed (48%). 80% of them provide clean and non-saline water that can be assumed to be fit for human needs. Nevertheless, appropriate protection is required especially for the wells to avoid pollution or contamination through dust and overland flow as it emerged that most water users do not treat it before use.

These study findings elicit various policy interventions and the need for further research. The study recommends the need to determine the recharge rate of ground water aquifers in order to guide the development of wells for sustainable water provision; mobilising people and sensitising them on the best practices for water management and use; ensuring water sources are legal and metered to facilitate efficient use, minimise wastage and raise revenue for enhancing water resources development; investing in more friendly water drawing systems to enable women and children access water with ease; investing in more public water points to supply affordable water to all with minimal cost especially in consideration of the financially disadvantaged groups; enhancing water storage and distribution to reduce distances travelled in search of water; and sensitising the community on water sources management, protection and effective waste disposal to avoid contamination, possible disease outbreaks and accidents.

Abbreviations & Acronyms

CDF	Constituency Development Fund
CETRAD	Centre for Training & Integrated Research for ASAL Development
EMBEWASO	Embu-Mbeere Water & Sewerage Company
EWASCO	Embu Water & Sewerage Company
GIS	Geographic Information Systems
GPS	Global Positioning System
IEA	Institute of Economic Affairs
IWRMS	Integrated Water Resources Management Strategy
MDGs	Millennium Development Goals
NEMA	National Environmental Management Authority
TORs	Terms of Reference
TWSB	Tana Water Services Board
UNICEF	United Nations Children Education Fund
WAB	Water Appeal Board
WASREB	Water Services Regulatory Board
WHO	World Health Organisation
WRMA	Water Resources Management Authority
WSBs	Water Services Boards
WSPs	Water Services Providers
WSSS	Water Supply and Sanitation Service
WSTF	Water Services Trust Fund
GW	Ground Water
SW	Surface Water

Acknowledgement

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CETRAD also expresses vote of thanks to all parties who made the field data collection a success. In this regard, CETRAD acknowledges the support by the Mbeti South local leadership in implementing the study; personnel from Government Departments and residents of Mbeti South Location who in one way or the other contributed to the successful implementation of the study. We sincerely thank Mr. Francis Njiru and Mr. Samuel Kamau of Mbeere District Water Office for providing information relating to water development and major water points in the district; Mrs Esther Njura and Mrs Bilia Kina of the Ministry of Agriculture, Gachoka Division; Mr. Ernest Nyagah, Muraru area local leader; and Mrs. Daisy Nyaga for the support and accompanying the data collecting team in the field. We particularly feel indebted to Mrs. Esther Njura and Mr. Ernest Nyaga for persevering long working hours and sometimes under difficulty conditions.

CETRAD cannot forget the enormous contribution by the Mbeti South community through cooperation and availing the much needed information. Were it not for the willingness and the co-operation by all the above named parties, the field data collection would not have been a success.

1.0 Introduction

1.1 Water resources in Kenya: An overview

Water is an important natural resource that is vital for all forms of life and their existence. To human beings, water development, management and utilization form the backbone of the socio-economic fabric. Water as a resource is vital for economic development due to its support for agricultural development, energy generation, municipal and commercial needs, livestock development, industrial growth, wildlife and recreational activities among many other services. In Kenya, water is important for the survival of its citizens and the economic development since the country relies heavily on agricultural production. However, with an increasing population and expanding industrial sector, demand for water is constantly rising and this poses the challenge of managing the available water resources in a sustainable and integrated manner in order to meet this demand.

Water resources in Kenya are categorized as surface or ground water (SW or GW). The surface sources include rivers, dams, lakes, ponds, wetlands, and water pans among others while ground water sources comprise the drilled boreholes and wells. According to NEMA (2003) the amount of renewable surface water in Kenya is estimated at 19500 million m^3 or 650 m^3 per capita, but this is expected to drop to 250 m^3 per capita in 2025 when the population is projected to rise to 60 million. Hence, Kenya is categorized as a water scarce country; with much of the water resources being characterized by high spatial and temporal variability (UN-Water, 2006).

The surface water resources are grouped into five basins namely the Rift valley, lake Victoria, Tana River, Athi River and Ewaso Ng'iro basin and their potential for water varies as shown in table 1.

Table 1: Major river basins and their potential (NEMA, 2003)

Basin Name	Area	Mean annual rainfall (mm)	Annual basin discharge/BCM
Lake Victoria	46229	1370	13.8
Rift Valley	130452	560	3.26
Athi	66837	740	1.31
Tana	126000	700	3.7
Ewaso Ng'iro	210226	410	0.34

The groundwater resources, on the other hand, vary in both quantity and quality and from basin to basin. They comprise 14% of the total water resources and are estimated at 619 million cubic meters, of which 69% and 31% are located in shallow and deep aquifers, respectively (NEMA, 2003).

The capacity for water resources to meet the various needs has been over-stressed and this has led to scarcity. In other instances the available water is not fit for consumptions going by the safety standards. Various reasons can be advanced for this and they relate to population increase, climate change, environmental degradation, weak and inadequate institutional capacities, and the growing poverty levels in the country.

The rapid population increase has subjected the limited water available to a lot of pressure in efforts to meets the various needs. The increased demand and use has resulted in a large number of people being unserved both in rural and urban areas. Climatic variability and change has also significantly altered the rainfall patterns and amounts thereby affecting the replenishment rate of water bodies. Coupled with wanton environmental degradation, especially in the main water catchments; changing land use patterns, wastage, misuse and pollution, the water problem has become even more critical. This is evidenced by the drying up of rivers, receding or dwindling lake levels, siltation of dams such that they can't hold the expected capacities, and degradation of water qualities in many sources.

For many years, The Ministry of Water Resources was mandated with the management and provision of water. The Ministry was however faced by many challenges to ensure effective water conservation and management or the total lack of autonomous institutions that could manage water supply effectively. Similarly, as a result of many years of economic non-performance, poverty levels increased and revenue collections declined. Consequently, the water sector was faced with inadequate financial resources to sufficiently maintain and/or expand the water distribution systems while the existing ones became dilapidated and unreliable. As a result, by the year 2000, less than half of the rural population had access to potable water and only about two thirds of the urban population had access to potable and reliable water supplies.

After realizing the above mentioned problems and the challenge of providing sufficient and clean water to its citizens by year 2000, the government initiated policy reforms geared towards improving water access to all parts of the country. The reforms were implemented in the assumption that they will improve accessibility to clean water and better sanitation.

Among the major reforms introduced through the Water Act 2002 was the establishment of several institutions and delegation of responsibilities in water resources management and provision; community participation in both the water management and development by allowing for the establishment of Water Resources Users Associations to serve as fora for conflict resolution and for integrated resources management in catchment areas; and the integrated water resources management along river basins, which led to the demarcation of the country into five major drainage basins based on hydrological boundaries. The five drainage basins are 1) the Lake Victoria Drainage Basin; 2) Rift Valley Drainage Basin, 3) Athi River Drainage Basin, 4) Tana River Drainage Basin, and 5) Ewaso Ng'iro North Drainage Basin.

1.2 The Tana River Drainage Basin

The Tana River drainage basin has Tana River as the main river and numerous tributaries that originate from Mount Kenya, Aberdare Ranges and the Nyambene Hills. The river has a stretch of over 1000 kilometres and drains the southern and eastern slopes of Mount Kenya and the eastern slopes of the Aberdare Ranges. It has an annual mean discharge of five billion cubic meters obtained from its 126 000 km^2 catchment area.

The Tana River Basin carries several agro-ecological zones and therefore agricultural production varies based on the diverse potentials in the basin. The high potential zone around Mt. Kenya and Aberdare ranges is favourable for production of coffee, tea, pyrethrum, wheat, barley, dairy, sheep and poultry. The medium potential zone is favourable for maize, sunflower, beans, and some poultry, sheep and dairy activities. The low potential zone has millet, cotton, tobacco and sorghum as the main crops. The irrigation potential is estimated at 132 000 hectares though only part of it is irrigated. Different types of irrigation schemes are found within the basin which includes the small-scale group based schemes for horticulture, floriculture and sometimes subsistence crops production; individual schemes providing nurseries for high cost crops such as macadamia, floriculture and ornamental crops; as well as public irrigation schemes managed by government agencies (Hirji, 1996).

The main use of water in the basin is hydro-electric power generation. The use for power generation does not take into consideration that most households lack adequate access to clean water. Coupled with the high water demand for irrigation in the upper part of the basin resulting from an increasing population, a greater challenge to water availability and access in the lower parts is created. This has resulted in many cases of conflicts over water utilization due to competing interests. Among the conflicts is water scarcity and lack of distribution systems, which stems from uneven distribution of water in the basin both seasonally and across locations. Therefore, water services providers within the basin are expected to ease such conflicts by availing enough quantities to meet demand. This study evaluates water resources in Mbeti South location of Mbeere District with a focus on categories of water points, their spatial distribution, usage, location, gender balance in water resources management and access, and sanitary conditions among others.

1.3 Mbeere District

1.3.1 Geographic location & topography

Mbeere district is one of the thirteen districts in Eastern province having been curved out of Embu district in 1996 (Republic of Kenya, 2001). It borders Embu to the northwest, Mwingi to the east, Machakos to the south and southeast, Meru south to the north, Tharaka to the NE and Kirinyaga to the west. The district has four divisions, namely; Mwea, Gachoka, Evurore and Siakago. The district has one local authority, the Mbeere county council and two constituencies: Siakago and Gachoka. Geographically, the district lies between latitude 0° 20’ and 0° 50’ South and longitude 37°16’ and 37°56’ East, covering an area of 2097 square kilometres (see figure 1).

The topography is typically of undulating upland that slopes from the northwest to southwest direction. Altitude ranges between 500 and 1,200 meters above sea level on the Tana River basin. The slope is however broken by the existence of a few hills such as Kiambere, Kiang’ombe, and Kianjiru which rise above the general height. The southern part is covered by the Mwea plains. Five permanent rivers serve the district, namely: Tana, Rupingazi, Thuci, Thiba and Ena all flowing in a general south-easterly direction.

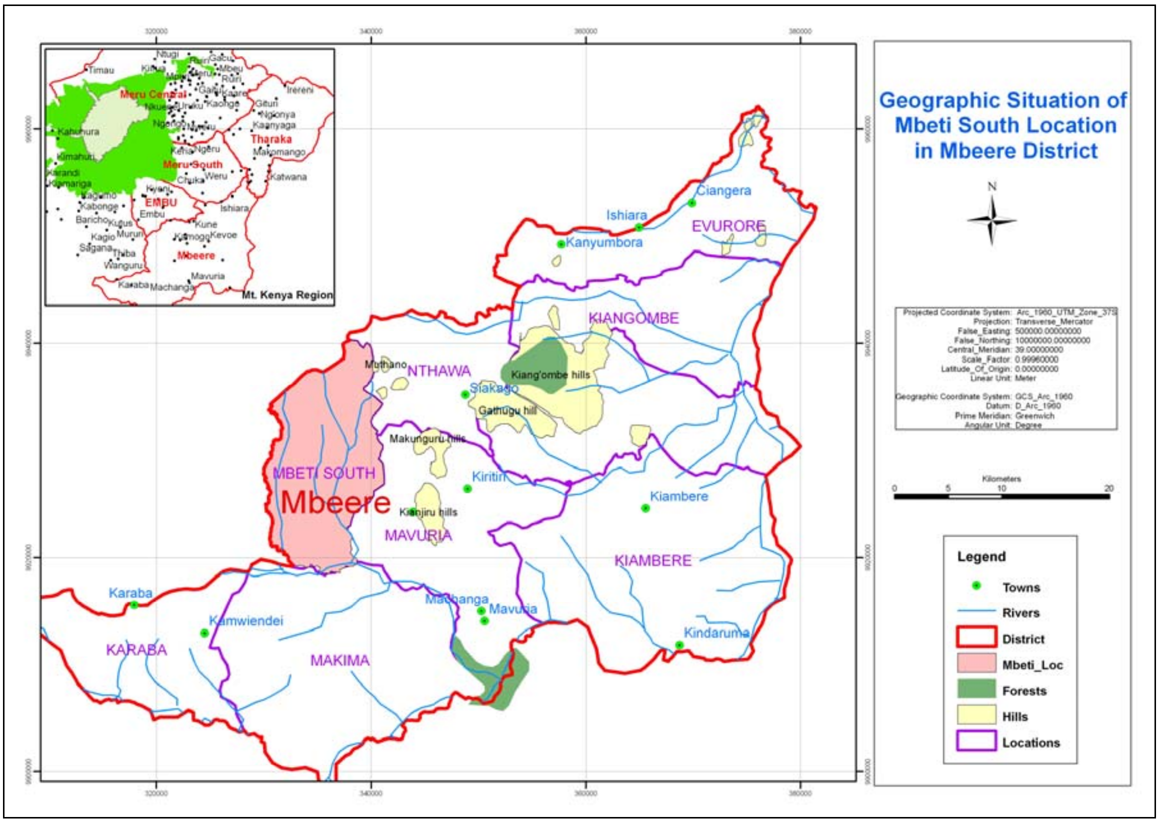

Figure 1: Mbeere district and the locations (Author, 2009)

1.3.2 Rainfall Patterns & Temperatures

Rainfall is bimodal in nature with annual averages of between 640 and 1110mm (Republic of Kenya, 2001). The rains are however not very reliable because most parts receive less than 500mm per annum. The long rains are experienced between April and June, while the short rains fall from October through December. The average rainfall figures are relatively high but the rainfall is erratic in nature causing it to be highly unreliable. Moreover, the erratic nature of the rainfall tends to increase surface runoff which coupled with poor farming practices accelerates soil erosion and formation of gullies. Droughts are also common in the area.

Temperatures range between 20 and 32 degrees centigrade. August is normally the coldest month with 15 degree centigrade while March is the hottest with temperatures above 30 degrees. Because of the high temperatures, the district experiences high evapo-transpiration throughout the year. This has the implication of low humidity in most regions of the district except where large water masses exist i.e. around Kiambere, Kindaruma, Masinga and Kamburu dams.

1.3.3 Natural Resources and Land uses

The soils range from chromic Cambisols to rhodic Ferralsols and Luvisols with varying degree of stoniness, rockiness and soil depth (Njoroge & Gicheru, 1995). The rainfall, soils and temperature significantly influence the type of natural vegetation. Generally, the vegetation is of savannah type although several forest patches including Kianjiru and Kiambere forests exist (Mbugua, 2002; Kamau, 2004). Olson (2004) reports that in the 1950s and 1960s the vegetation mostly comprised of bush land and grassland due to grazing and burning. This is because the Mbeere people were traditionally pastoralists who kept livestock and some shifting cultivation for survival. The situation has however changed as people get sedentary. Coupled with changes in land use and tenure, the vegetation has significantly been manipulated.

Surface and sub-surface water remains one of the greatest natural resources. This is due to the existence of five perennial rivers. Other water resources are found in hydroelectric dams along Tana River and used for electricity generation. But despite the presence of the abundant water resources, water availability for domestic consumption and livestock has remained a major problem due to the capital outlay required to tap this water. The few existing boreholes produce saline water.

Natural forests also occur and are estimated at 3700 hectares. They are however not gazetted and the Mbeere County Council has entrusted the Forest Department to manage them.

1.3.4 Demographic and Poverty Characteristics

Human population has remained low for a long period but has currently been on the increase (Chira, 2003; Gicimbi, 2002). The 1989 population census indicated that the district had a population density of 65 persons per square kilometre. It later increased to 85 persons per square kilometre with an average family size of 6 persons per household by 1999. The Republic of Kenya (2001) and KNBS (2008) indicate the demographic distribution according to the 1999 Population and Housing Census as shown in table 2 with the proportion of male gender being 48% compared to that of female at 52%.

Table 2: The 1999 demographic characteristics in the four divisions

Division	Male	Female	Total	HHs	Area (Sq km)	Density
Siakago	16656	17674	34330	7852	367.3	93
Evurore	16674	20077	36751	7677	410.0	90
Gachoka	28772	30330	59102	12905	800.3	74
Mwea	19693	20987	40680	8602	514.9	79
Total	***81885***	***89068***	***170863***	***37036***	***2092.5***	***82***

Source: Republic of Kenya, 2001, statistics

Table 2 further shows that the most densely populated divisions are Siakago and Evurore with 93 and 90 persons per km^2, respectively while the least populated is Gachoka with 74 persons per Km^2. However, the population density has been increasing over the years as a result of high population density in the neighbouring high potentials districts pushing the landless people to the more marginal areas in Mbeere District. This has led to the current population estimate of over 203,000 persons (Wamwangi, Macharia & Kisingu, 2008). This kind of migration is reported by Southgate & Hulme (1996) to increase agricultural practices that are incompatible with the unstable and fragile arid environment. This has led to significant reduction in the natural vegetation due to cultivation, overgrazing, fuel wood and charcoal production (Mbugua, 2002; Sindiga, 1984).

Generally, the majority of the population is poor, with about 60 per cent of its population living below the poverty line (Arid Land Resource Project Management II). In terms of poverty dynamics, Evurori Division has the highest number of poor people followed by Mwea, Siakago and Gachoka, respectively (Republic of Kenya, 2001). Majority of the poor are found in Ndurumori and Kiangombe Locations in Evurori Divisions; Makima and Riakanau in Mwea Division; and Mutitu, Muminji Kiambere and Mutuorare in Siakago Division.

1.3.5 Livelihood Systems

Because of its marginal nature, the district has two main livelihood sources from which the population derives its livelihood. These are the mixed farming and agro-pastoralism, and marginal mixed farming. 48 % of the population relies on mixed farming while 52 % on marginal mixed farming (Wamwangi, Macharia & Kisingu, 2008). Within the mixed farming zone, maize, beans, green grams, sorghum and millet are grown. Green grams are mainly grown as a cash crop. In the agro-pastoral zone, households keep indigenous cattle, sheep and goats (shoats), poultry and practice bee keeping. Most agriculture in the district is geared towards subsistence although some small-scale horticultural activities are found in parts of Gachoka division (Mbugua, 2002). Interestingly, agricultural activities mostly rely on the short rains that fall between October and December. Table 3 summarizes the main agro-climatic zones and the kind of crops grown while figure 2 shows the distribution of agro-ecological zones.

Table 3: Agro- Climatic zones of Mbeere

Agro-ecological zones	**Altitude (m)**	**Mean Annual Temperature (^oC)**	**Annual mean rainfall (mm)**
UM 4 Sunflower Maize zone	1280 -1400	20.0-20.7	960-1100
LM 3 Cotton	1070-1280	20.7-22.0	900 - 1100
LM 5 lower midland Livestock- millet	830 - 1130	21.7 – 23.5	700 -900
IL 5 Lowland Livestock-millet	760 – 830	23.5-23.9	640-780

Source: Oslon, 2004

Pastoralism, on the other hand, is practiced across the district but the land under which it's practiced is surrounded largely by cultivated farms. It's only on the lower eastern zone where tracts of land remain for pastoralism due to its marginal nature (Mbugua, 2002).

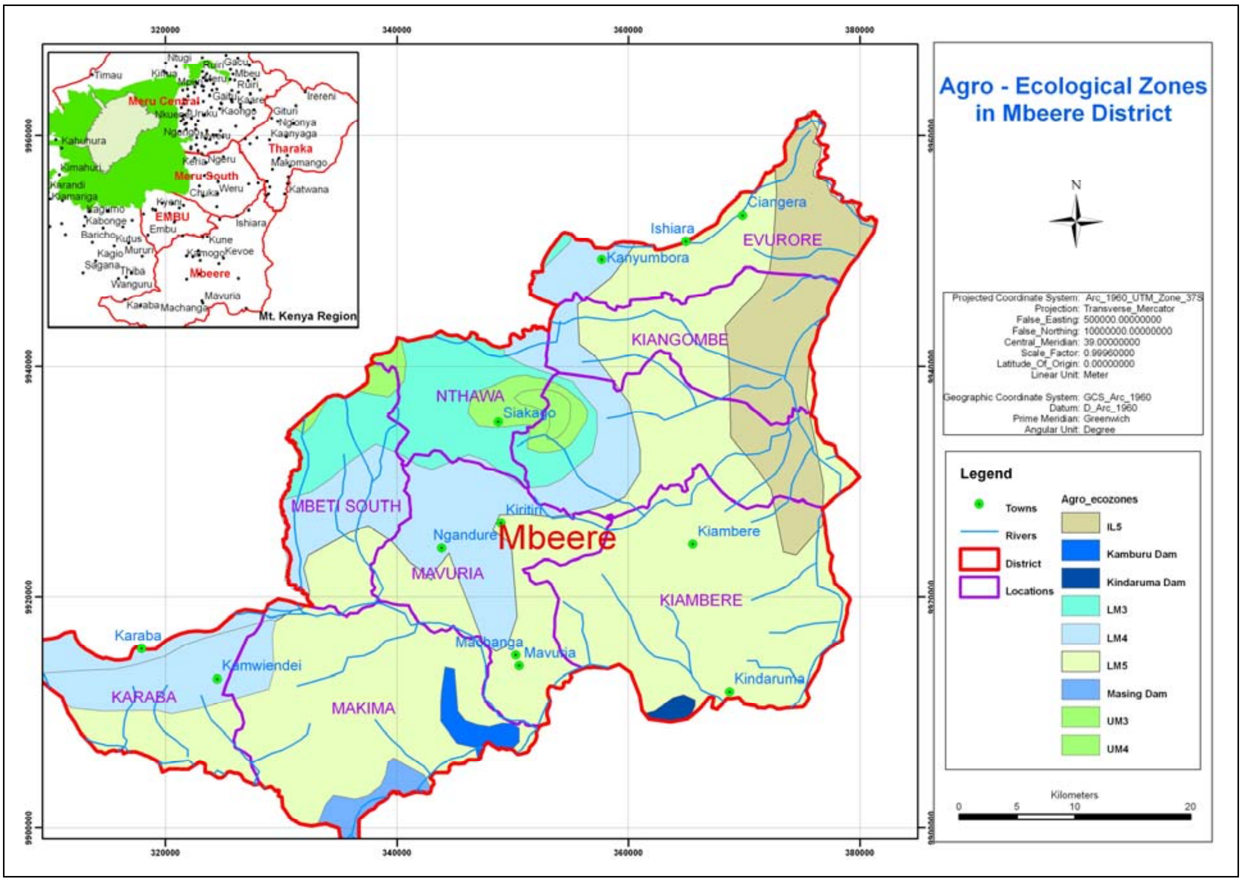

Figure 2: Agro-ecological zones in Mbeere district (CETRAD, 2008)

1.3.5 Selection of Study Site

Like other rural communities around the global south that face critical challenges with availability of adequate water of acceptable quality (WHO/UNICEF, 2000), the situation in Mbeere has been wanting despite the various interventions implemented in the past. The situation is similar to other rural areas in Kenya where only 31% of the population have access to improved water supply (WHO/UNICEF, 2000). This study aimed at assessing the current status of water distribution and accessibility in an attempt to understand if water reforms have had positive impacts on the local residents. Mbeti South location was selected for the assessment based on: 1) high population density due to influx of immigrants from other districts, 2) budget and time constraints, and 3) the existence of a variety of water projects/sources as revealed through discussions with the Ministry of Water and Irrigation personnel in the district. The latter fulfilled the desire expressed by the client of assessing a location with a variety of water points. The details of the findings are provided in the results section.

1.4 Water Development in Mbeere district

The history of water development in Mbeere district dates back many years before its creation in 1996. Before 1996 water projects were implemented within the scope of the greater Embu district in which Mbeere formed the Embu east region. In the 1970's the government initiated the Ena-Siakago water supply which runs up-to-date. This was later to include the Ishiara water supply in the 1980's. However, the government water supply was skewed with many areas of the current Mbeere district having no water. Partly, this is attributed to the fact that priority was for areas with higher population density.

In 1980's massive interventions were undertaken through drilling of boreholes and construction of concrete dams by the Plan International in a bid to distribute water resources evenly in the district. However, the mode of intervention had minimal local participation which negatively impacted on the sustainability after the donor's exit. This is because the local community had little say in the location of the water projects and some of the critical water points were located on private lands. This latter reason posed a great challenge to water accessibility by the public due to conflicting property rights. Secondly, although some community members were trained on the day-to-day running of the boreholes, the sheer lack of effective participation led to mismanagement and the eventual malfunctioning of some boreholes. In the same decade, the Catholic Church intervened by drilling boreholes in institutions affiliated to its faith, which was partly carried out in collaboration with the Ministry of Water. Among the projects implemented then was the Kanyuambora water project.

The 1990's saw a huge investment in community water projects with the support by the government and external donors including the Catholic Diocese. Projects such as Maathai Kavaci water project, Ngunyumu water project and Kune water project were initiated. These are termed community projects in the sense that community was to have a greater responsibility in their day-to-day running despite having received tremendous financial support from the government and donors. The management was put in the hands of local community with personnel from the Ministry of Water only providing technical support where necessary. Though the projects are still operational, they have over the years faced numerous challenges that have limited their capacity to cater for the growing human population.

As a result of the above challenges and the growing demand for water by the rapid increasing population especially through immigration from the neighbouring high potential districts, individual interventions are on the rise. Household shallow wells have become common in some parts of the district to cater for domestic purposes and in other instances to facilitate agricultural production.

With the ascension of the NARC government to power in 2002 and the need to provide clean water to the public, interventions through the Constituency Development Fund (CDF) have led to projects such as Kianamu water project and the yet to be completed Minoori water project. Similarly, period 2002 to 2008 have seen the emergence of small community projects being supported through the CDF although their coverage is small. There are two additional government supported projects planned for implementation, namely; Mbeti South water project to cover Mbeti South location and Riakanau water project to cover part of Mwea division.

Besides these water projects, the introduction of water services boards through the Water Act 2002 has had positive impacts on the district in that water supply companies such as Embu Water and Sewerage Company (EWASCO), Embu-Mbeere Water and Sewerage Company (EMBEWASCO) and Muthathari Water project continue to expand and provide water to several parts of the district without the limitation of administrative boundaries.

The notable fact about water resources development in Mbeere district is that the projects distribution is skewed to benefit the central region and areas neighbouring Embu district. As such the Siakago, Ishiara and Nthawa areas are relatively better off while other regions have limited water supply. This is because some of the projects utilize the already existing distribution systems making it cost effective. The notable skewed distribution of water supply is irrespective of the fact that Mbeere district is strategically located with two major rivers (Thiba-Rupingazi and Ena) flowing through it. The district has adequate water resources but the distribution system remains the greatest challenge. Therefore, ensuring that every part of the district has adequate water supply requires a re-emphasis on the spatial distribution priorities.

1.5 Objective and scope of the mapping exercise

The consultancy project aimed at mapping water points in Mbeere district with focus on Mbeti South Location.

The mapping exercise was guided by the Terms of Reference (TORs) provided by the Institute of Economic Affairs (IEA), under which the following were to be captured and presented within the project outputs:

- An inventory of existing water projects within the Tana Water Services Board (TSWB) and categorized on basis of use and source
- Data collection on water usage within the supply area and whether the system is over or under stretched;
- Land use of the area based on agro-ecological conditions;
- Collection, analysis and compilation of data relating to water utilization within the supply area;
- Review data obtained from key informants and local sources;
- Provide GIS generated maps of the water projects distribution with their corresponding attributes information; and
- Verify the information through a feedback discussion with the Ministry of Water and Irrigation and TSWB;

Under the above TORs, the following categories of water points were considered and mapped during the field survey:

- Surface dams
- Sub-surface dams
- Concrete dams
- Water pans
- Rock catchments
- Boreholes
- Shallow wells
- Water springs
- River abstractions
- Public water tanks
- Piped water system

The TORs spelt out the attributes information to be considered for the above water points as follows:

- ✓ Project identification and location
- ✓ Year of installation/construction/protection
- ✓ Purpose/uses: original and present
- ✓ Source of water
- ✓ Source of funding, including community component where applicable
- ✓ Ownership: public, institutional, private etc
- ✓ Status: legal or illegal depending on type of water point.

Further to this, the TORs spelt out the need to capture information about

A) Water and sanitation coverage under which the following details were to be considered:

- ✓ Proportion of rural population with access to safe water supply[1]
- ✓ Proportion of the rural population using improved sanitation facilities[2]
- ✓ Condition of the system: fully functional/partial functional/ non-functional
- ✓ Duration with water: all year round/seasonal (specifying months)
- ✓ Functionality of the sewerage system[3]
- ✓ Proportion of rural population connected to a sewerage system[4]
- ✓ Proportion of delivery points delivering water at time of spot checks[5]

B) Irrigation

- ✓ Total area of productive land under irrigation in hectares[6]
- ✓ Water use efficiency in irrigation[7]

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[1] Safe water was defined as water fulfilling the water quality standards as specified in the Kenya Standards for Drinking Water Quality. Improved drinking water sources comprise piped water into dwelling, plot or yard; public tap/standpipe; tube-well/borehole; protected dug well; protected spring and rain water collection.

[2] Improved sanitation facilities are the safe disposal of or hygienic management of human excreta. Improved sanitation facilities are defined as flush or pour-flush to; piped sewer system, septic tank or pit latrine; pit latrine with slab; ecosan/composting toilet and mobilets

[3] This is defined as the proportion of those connected to sewerage systems where the network is functioning and the system provides adequate treatment and disposal in an environmentally sound manner and in accordance with the effluent standards. A functioning sewer network is an operational system without blockages excluding temporary blockages cleared by normal maintenance within one month

[4] Connected to a sewerage system is defined as persons using water closets for human excreta disposal and waste water disposal connected to water borne sewerage systems.

[5] Number of water delivery points delivering water as expected at time of spot-checks divided by the total number of functional /not functional water delivery

[6] Calculated as the total area covered by irrigation where farmers are actively cropping.

- ✓ Total area of productive land under water control/drainage in hectares[8]

C) Water resource management
- ✓ Method of abstraction and conveyance (for river abstractions)
- ✓ Abstracted SW/GW volume complaint to regulation[9]
- ✓ Total water storage capacity (in cubic meters)[10]
- ✓ Total water storage capacity per capita (in m^3/capita)[11]
- ✓ Actual and potential/permitted amount and actual amount abstracted of the capacity/yield/flow of water system
- ✓ Number of beneficiaries/livestock units/acreage under irrigation
- ✓ Rehabilitation required of water system

1.6The implementing team

The field survey was carried out by the following persons:

1. Zacchaeus Kinuthia — NRM, GIS & Remote Sensing
2. David Warui — Surveying & GIS
3. Francis Karanja — Environmental Science & GIS

1.7 Methodologies, Tools and Activities

Varied methodologies were employed for gathering the required information and data. Similarly, appropriate tools to enable information/data gathering were developed and utilized. To ensure that all the requirements and information needed as per TORs were captured, the mapping exercise was planned and executed in phases.

1.7.1 Inception phase

The inception phase comprised the period after the communication from IEA of the award to implement the water point mapping project, to the official signing of the contract. Discussions were held with the client in order to clarify some of the issues highlighted in the TORs for purposes of developing a common understanding. This was conducted through a meeting between the Director, CETRAD and the client.

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[7] Gauged on internationally established indicators
[8] Calculated as total area covered by water control/drainage where farmers are actively cropping
[9] That is, surface or ground water abstracted vs the permitted amount for abstraction
[10] The water storage capacity in artificial water storage structures of above $5000m^3$
[11] The water storage capacity in artificial water storage structure of above $5000m^3$ divided by the total population in Kenya

During the same time, the responsibilities and roles of each party were identified and elaborated, an exercise that culminated with the signing of the contract between IEA and CETRAD, giving the latter the mandate to implement the project.

1.7.2 Preparatory phase

The preparatory phase involved gathering information about the spatial distribution of water projects in the district and selecting a representative location for field survey. A visit to Mbeere Water Office in Siakago was made with the view of gathering in-depth information about water projects distribution in the district. Based on information provided, and the interest expressed by the client of covering a location with a wide range of water projects, Mbeti South was identified and agreed upon by CETRAD and the client.

Similarly, during the preparatory phase the necessary materials were sourced and field data gathering tools generated in agreement to attribute information agreed with the client. The data collection tool (questionnaire) as annexed was shared with the client for agreement.

1.7.3 Field data collection

Data collection commenced in October 2008 and was carried out in two and a half weeks. The target was to map and collect attribute information regarding water points in Mbeti South location in Mbeere district. The field phase was carried out by the team previously stated in collaboration with local leadership and personnel from government departments working in the location.

With the assistance of local leadership and personnel from government departments, contacts were made with the management of the various water projects and visits made to the various sites for interviewing. Similarly, individual households with private water points were visited for interviews.

The geographical coordinates of the water points were recorded using hand held GPS sets for purpose of appropriate geo-referencing. Attributes information were gathered through consultations and discussions with water points management, owners or other relevant respondents using the generated questionnaire. Photography was also emphasized to pictorially document the nature of existing water points.

1.7.4 Analysis and generation of outputs

After the field survey, the gathered data and information were coded and data entry using Ms-excel and SPSS done. Analysis was then carried out and this involved organizing the data collected using the GPS sets and the questionnaire into manageable database that enabled the link between spatial and attribute information. Using ArcGIS software version 9.1 and 9.2 the GIS layers were created and generated into maps. This draft report summarizes the results of the study findings.

1.8 Layout of the Report

The report is organised into several chapters. Chapter 1 gives an overview of water resources in Kenya, the objective, the methodologies employed in field data collection, and the background information about Mbeere district. Chapter 2 provides the spatial distribution maps of the various water points mapped in Mbeti South Location. The maps are generated using GIS technology. Chapter 3 provides the characteristics of the water points and the sewerage situation in the study area. Chapter 4 outlines the operation status, funding and management aspects. Chapter 5 provides the water standards, protection and challenges. Chapter 6 provides the synthesis and policy implications of the study and Chapter 7 gives the conclusions and recommendations.

2.0 Spatial Distribution of Water Points in the Location

In understanding the spatial distribution of water points in Mbeti South location, the collected spatial information was generated into layers and then overlaid to create GIS maps. The water points distribution maps were categorized according to source (ground vs. surface sources) as well as by type. The generated maps showed disparity and skewedness in the spatial distribution of water points with the upper part of the location having more water points compared to the lower zone, which is relatively drier.

Various factors were attributed to the observed spatial distribution. First, the upper region is densely populated, which creates demand for more water sources. According to the 1999 Population Census statistics (table 4) the upper zone of the location which comprises Gachoka and Kiamuringa sub-locations had population densities of 93 and 90 persons/km2 compared to the lower zone (Gachuriri sub-location) with 65 persons/km^2. However, the population densities are expected to have changed since then. Secondly, most occupants of the upper zone are immigrants from wetter districts and faced with the challenge of water unavailability, they have made concerted efforts to seek for alternative water sources. More so, due to favourable soils, agricultural development has progressed than in the lower part creating demand for irrigation water, especially for khat production. As a result, numerous shallow wells have been sunk to supply water for irrigation.

Table 4: Population by Sex, Households, Area and Density for Mbeti South Location

Sub-location	**Males**	**Females**	**Total**	**Households**	**Area**	**Density**
Gachoka	2661	2683	5344	1149	57.5	*93*
Gachuriri	2209	2327	4536	1337	69.3	*65*
Kiamuringa	1941	1874	3815	835	42.6	*90*
Mbeti South Location	***6811***	***6884***	***13695***	***3321***	***169.4***	***81***

Source: Republic of Kenya, 2001

Recently, the upper zone has benefited from water provision by the water service provider, EWASCO. Since the Water Act 2002 allows for water service provision in the respective drainage basin without the limitation of administrative boundaries, EWASCO had taken the advantage of emerging market and lack of competitors to extend water provision to Mbeere district. Hence, the upper zone due to its proximity to Embu district benefited from the projects water supply.

Figure 3 shows the spatial distribution of all the mapped water points while figures 4 to 11 show the distribution of each category of water points. Figures 12 and 13 categories the water points based on ground and surface sources.

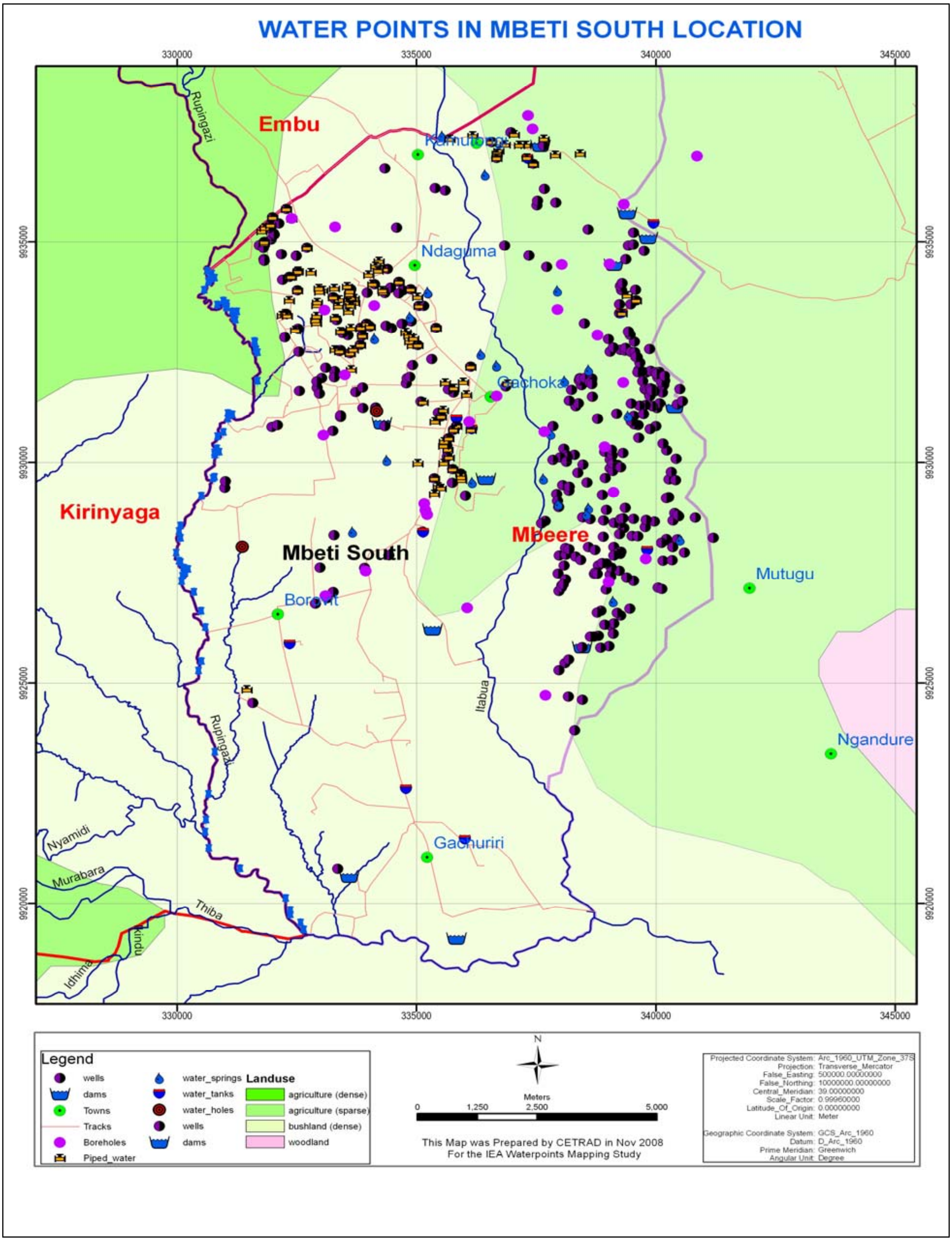

Figure 3: Spatial distribution of all water points in the location; (Source: CETRAD, 2009)

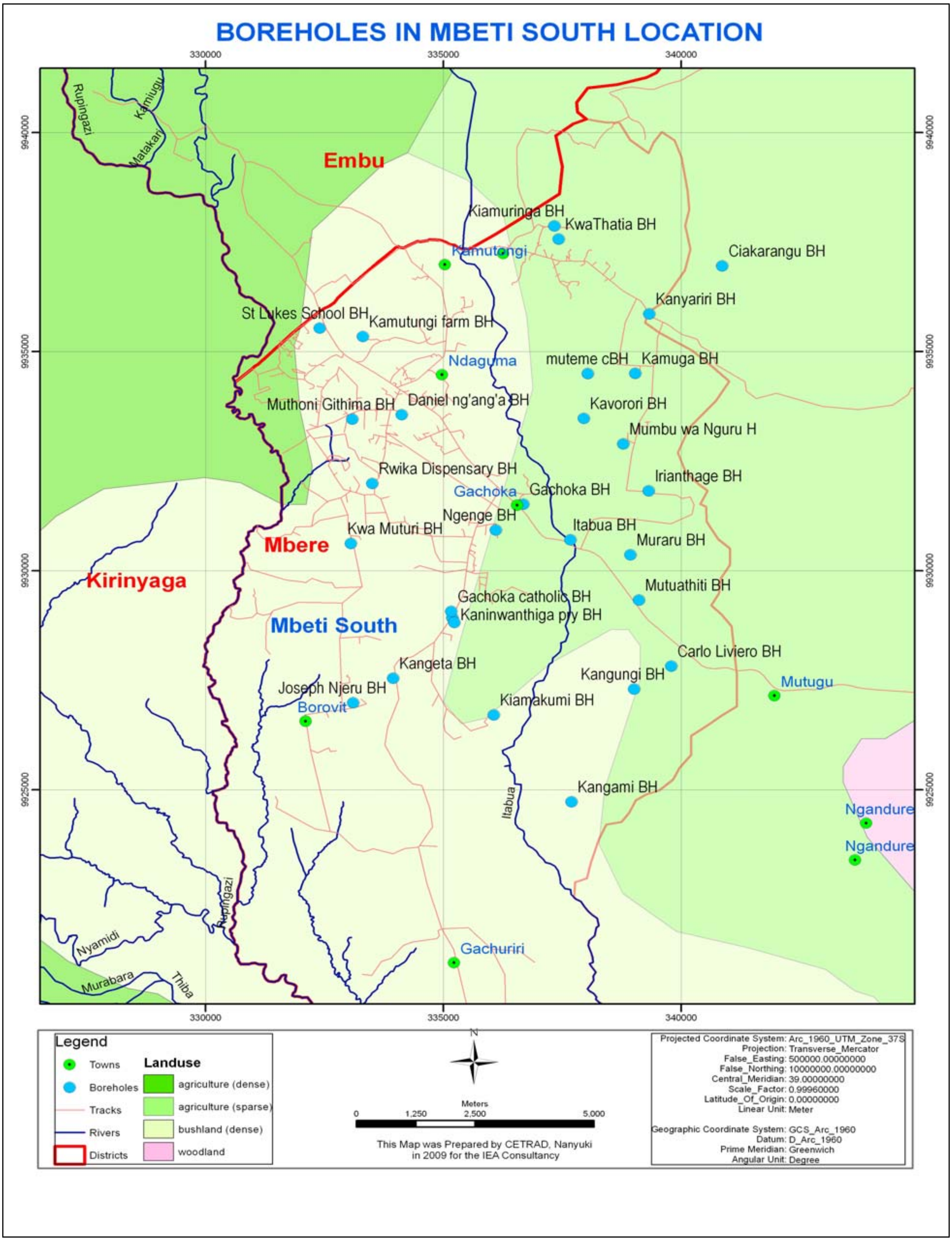

Figure 4: Spatial distribution of boreholes in the location; (Source: CETRAD, 2009)

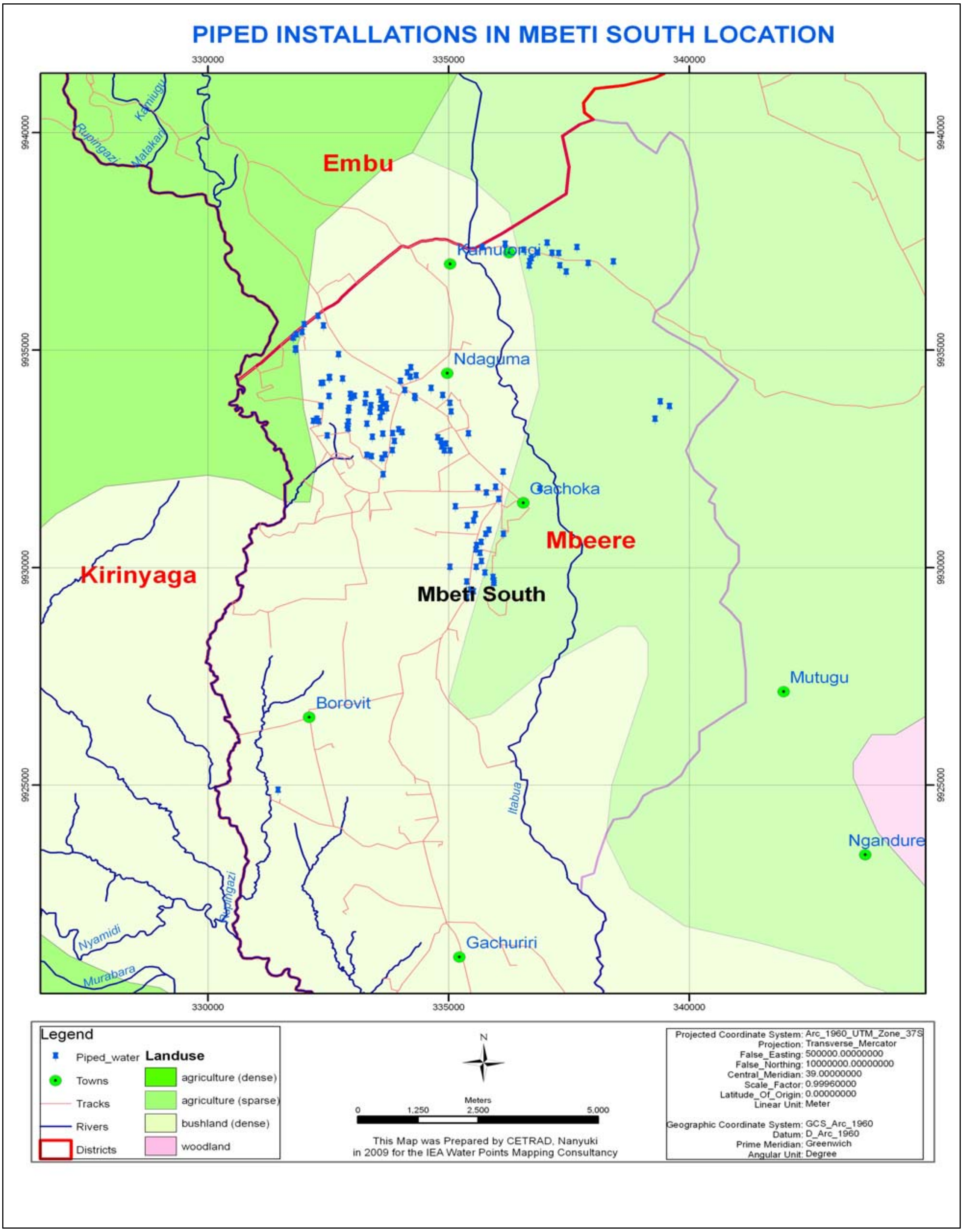

Figure 5: Spatial distribution of piped installations in the location; (Source: CETRAD, 2009)

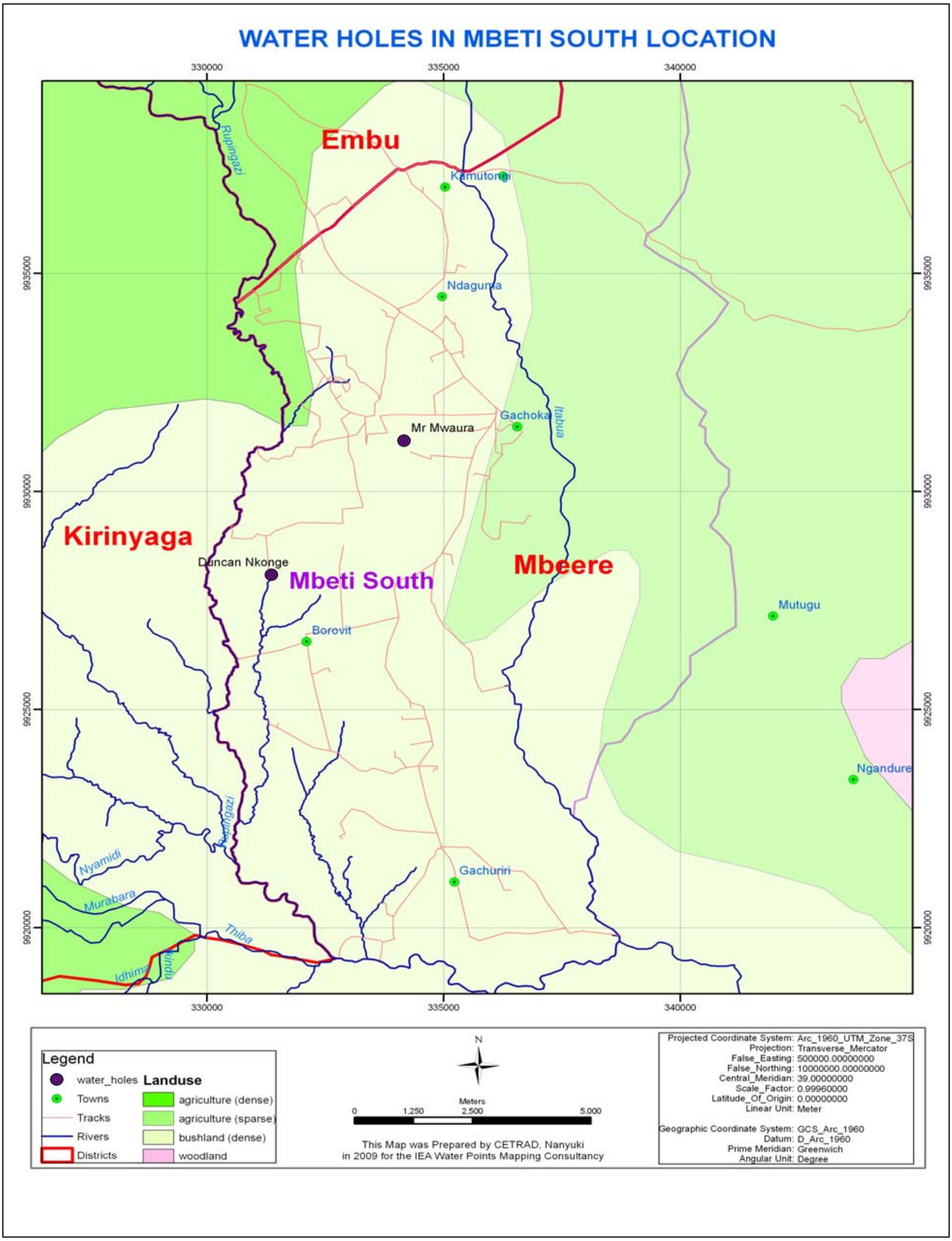

Figure 6: Undeveloped water holes in the location; (Source: CETRAD, 2009)

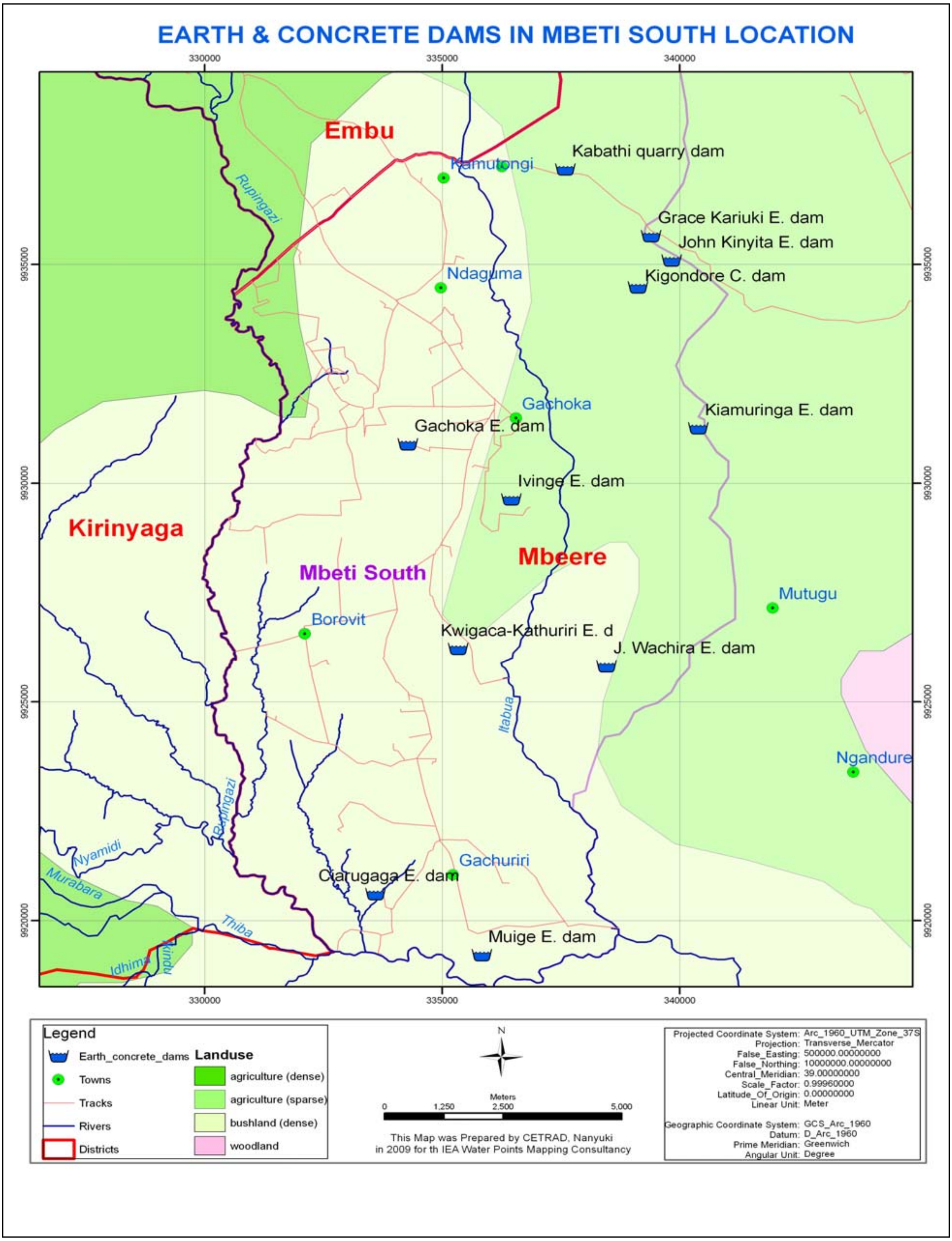

Figure 7: Concrete and earth dams in the location; (Source: CETRAD, 2009)

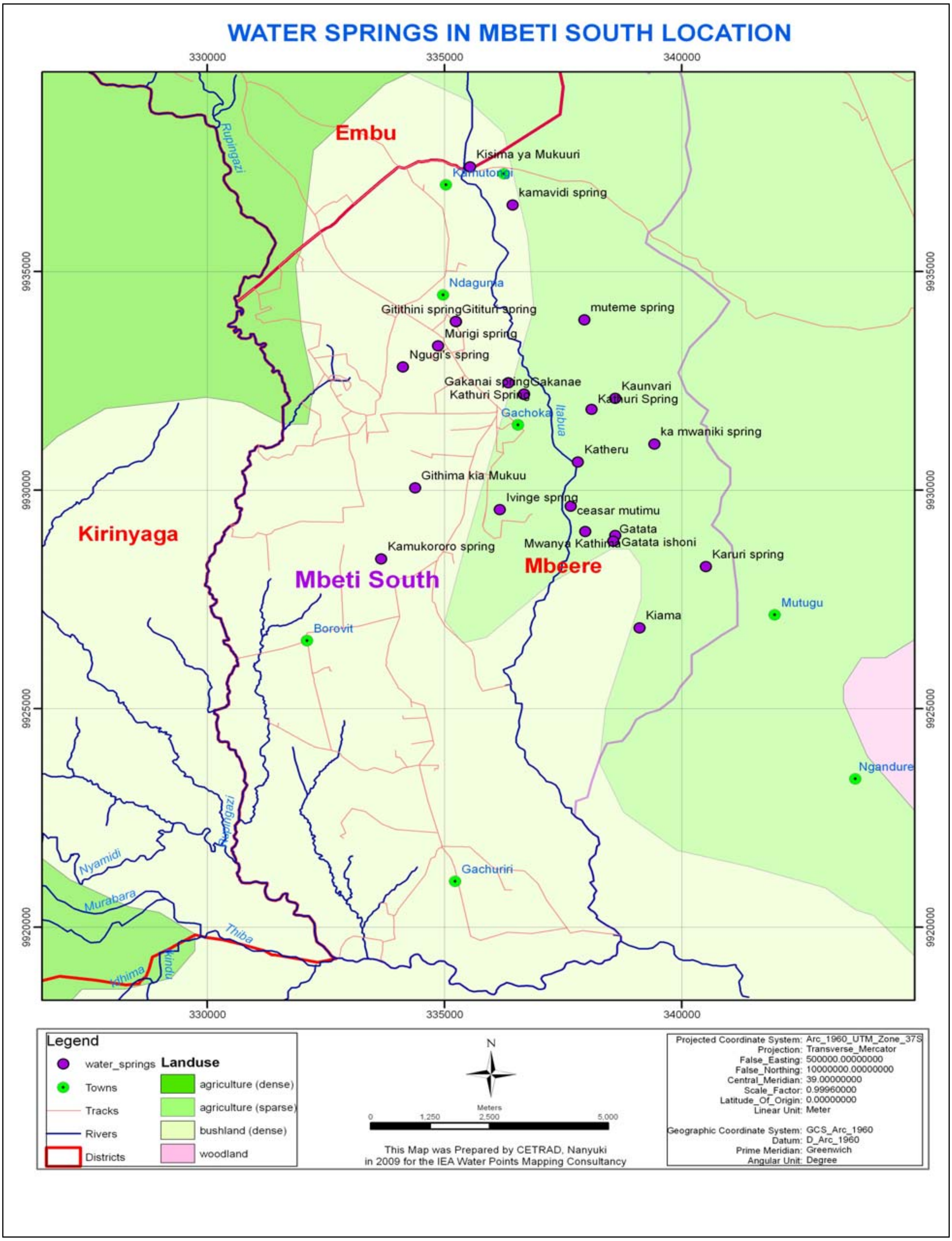

Figure 8: Spatial distribution of water springs; (Source: CETRAD, 2009)

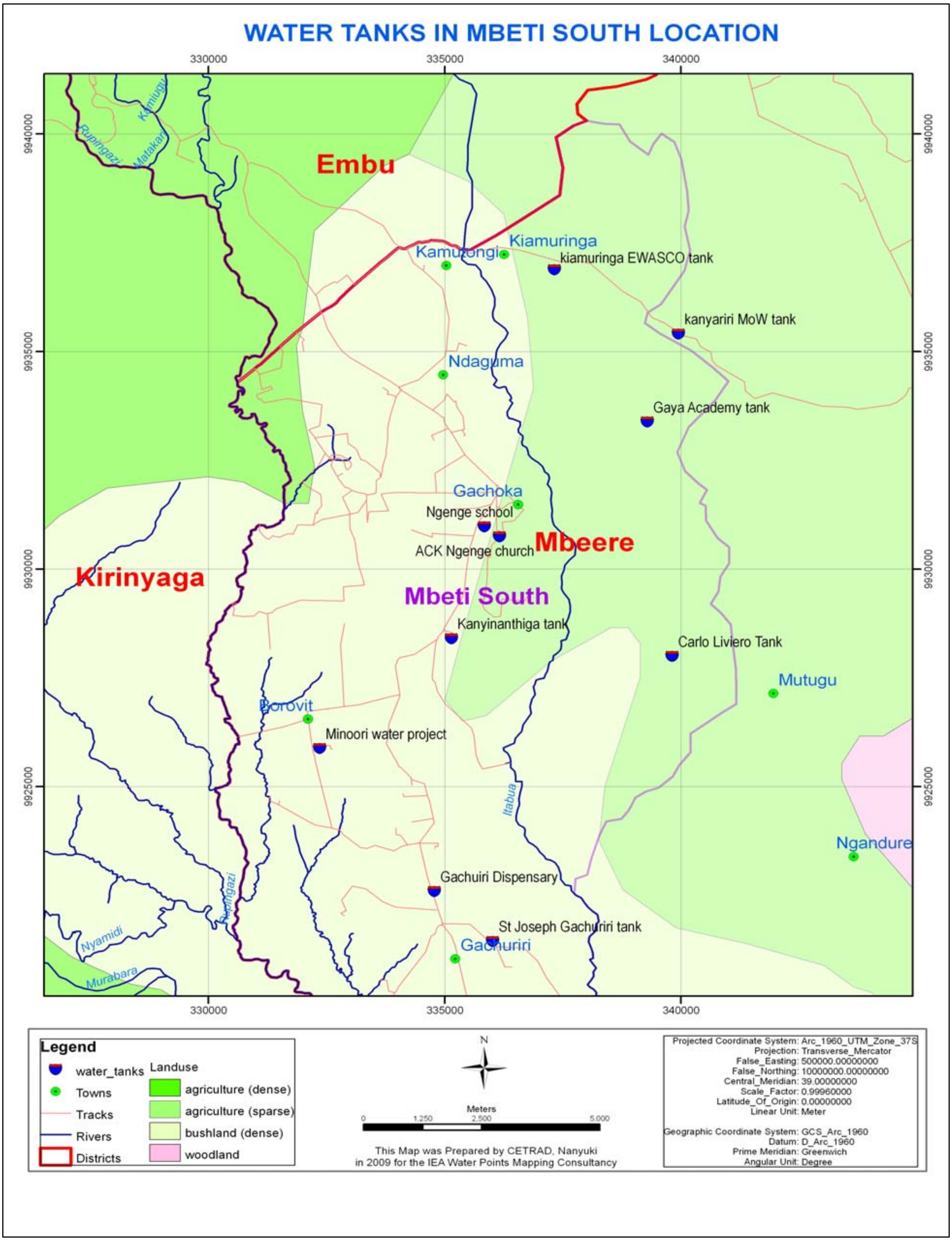

Figure 9: Spatial distribution of water tanks; (Source: CETRAD, 2009)

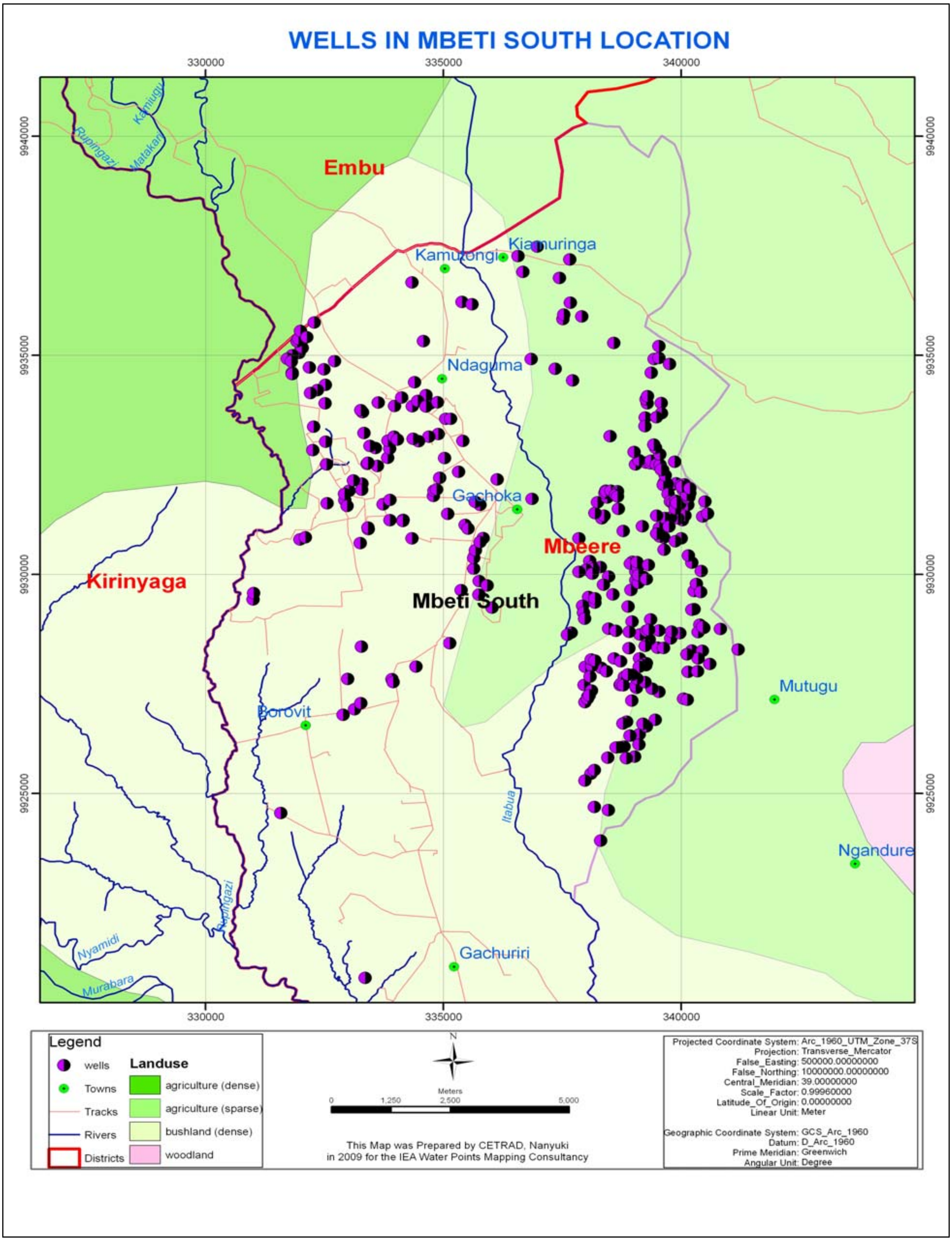

Figure 10: Spatial distribution of water wells; (Source: CETRAD, 2009)

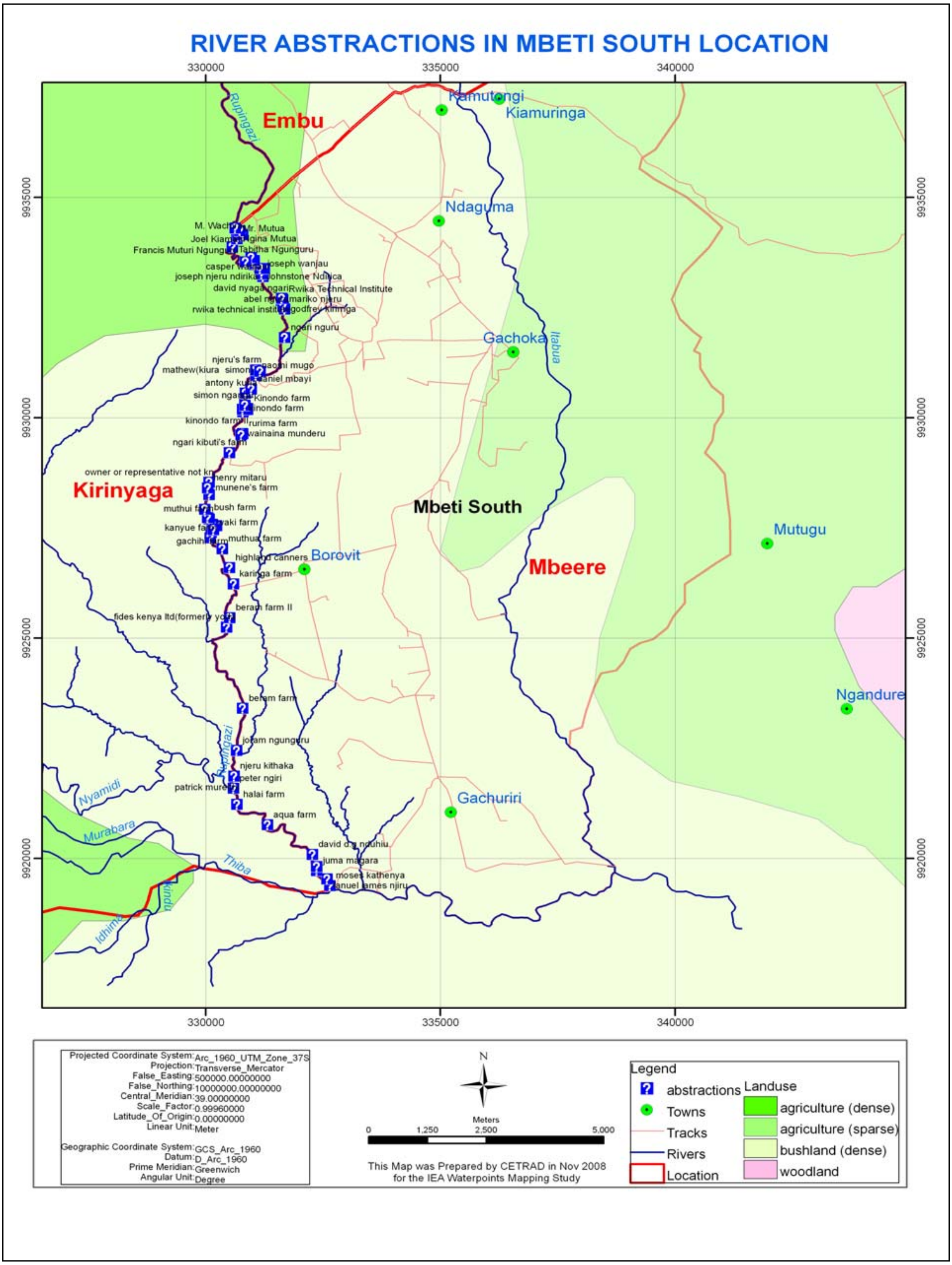

Figure 11: River abstractions along Rupingazi River; (Source: CETRAD, 2009)

The following two figures summarize the mapped water points into ground and surface based sources.

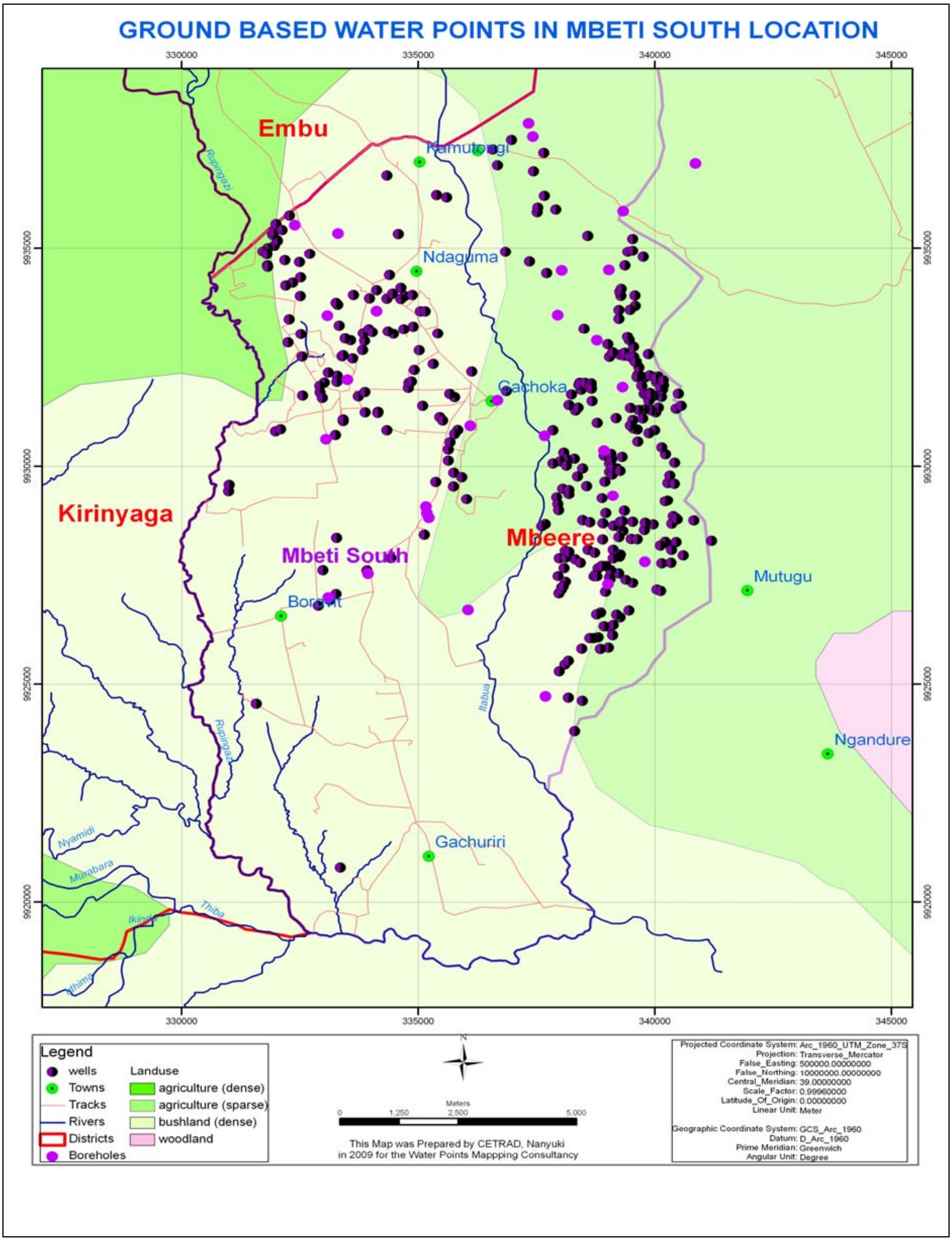

Figure 12: Spatial distribution of ground based water sources; (Source: CETRAD, 2009)

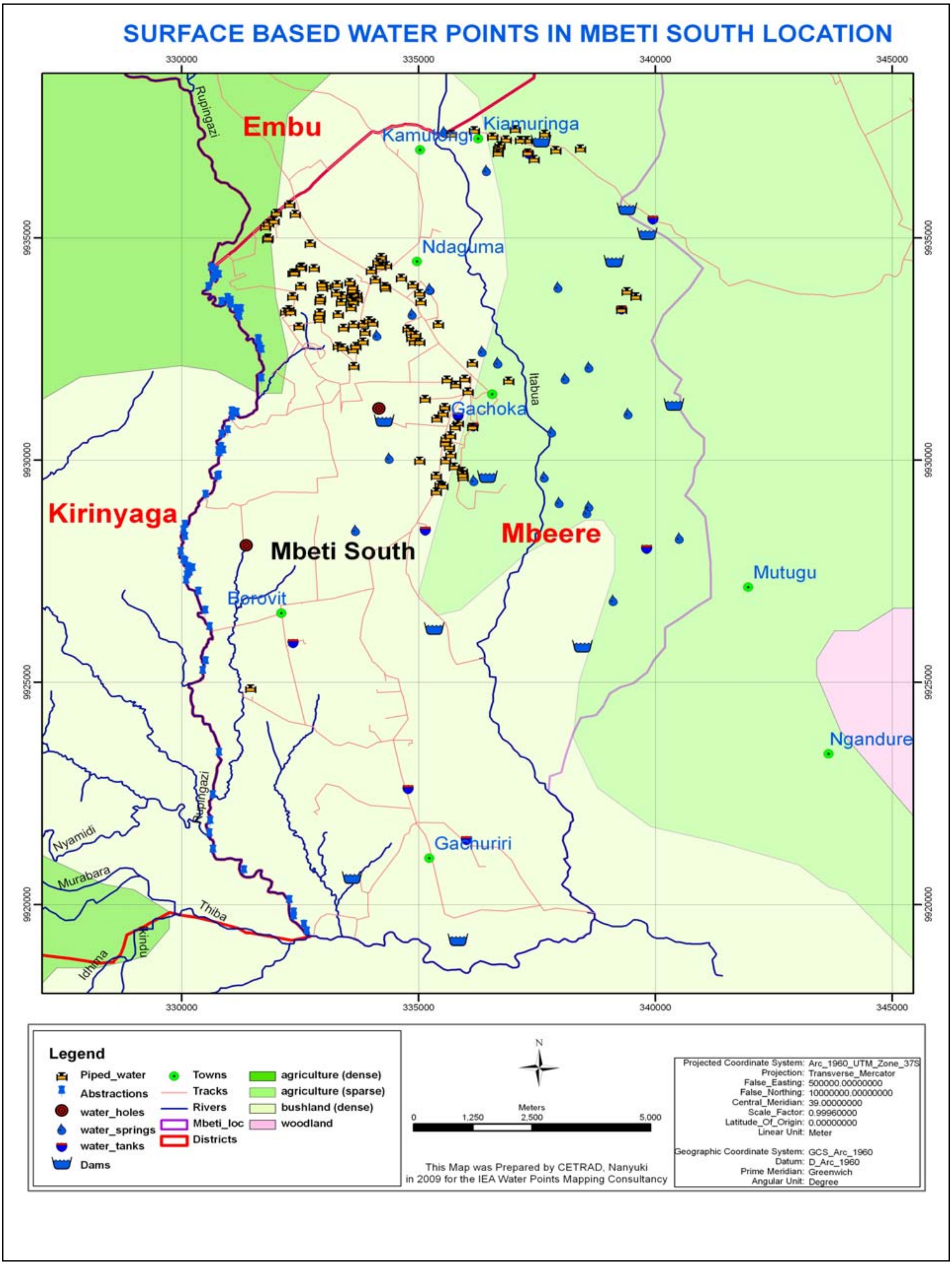

Figure 13: Spatial distribution of surface based water points; (Source: CETRAD, 2009)

3. Characterisation of water points and sewerage systems

3.1 Types of Water points in Mbeti South location

A total of 610 water points were mapped during the exercise and include earth and concrete dams, boreholes, water springs, shallow wells, water tanks, river abstractions and piped water installations. However, it wasn't possible to gather detailed information about river abstractions as owners were unavailable for comments or the persons encountered (mostly hired labourers) were uninformed. Most farms abstracting water from Rupingazi River are hired by people from outside and is therefore difficult tracing them. Other abstractions were not in use by the time of spot check and we therefore excluded such water points in our analysis. It is worth noting that the analysis presented in this report draws from 549 water points that include two river abstractions that we managed to gather in-depth information. However, the generated GIS maps are based on all the 610 water points mapped during the study.

Figure 14 summarises the proportions of water points mapped. The figure indicates that shallow wells are the most prevalent (63.4%) followed by piped water installations (22.6%). This is because many households have undertaken private interventions in water supply by sinking wells or installing the piped water.

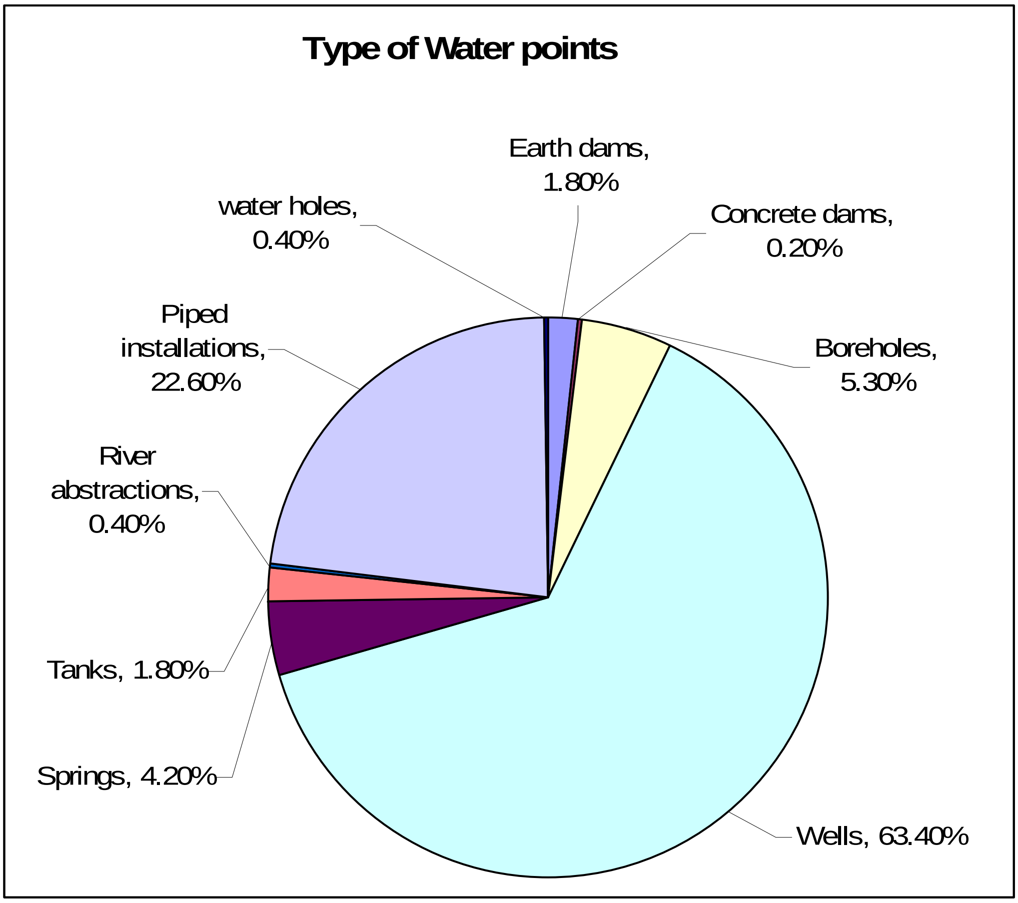

Figure 14: Percentage distribution of water points in the location; (CETRAD, 2009)

3.2 Status and year of establishment

A majority of the water points (64.7%) existed for more than a year while a sizeable number (21.7%) were new installations (by EWASCO). Most piped water installations were only a few months old having been put in place in year 2008.

Figure 15 shows the year of construction/installation/rehabilitation/conservation and the number of water points established per particular year. The figure shows an increasing trend in the number of water points over the years. The first major intervention was in 1989 during which the Plan International aided the construction of several boreholes in the district. The numbers almost remained steady in the 1990's but started increasing after the year 2000. However, a drastic increase is observed in 2008 due to piped water installations. The increasing trend after the year 2000 can be explained by the fact that there has been high immigration to the district in the last 10 years. The immigrants are mostly from high potential areas that are well served by rivers or other water sources. Therefore, faced by the challenge of water scarcity, most households had to seek for private water supplies by sinking wells on their farms for domestic and other needs. Moreover, there is drastic change in land uses in the district with many households adopting khat production as a cash crop. Due to its constant requirement for watering, households engaged in its production have resulted to constructing wells to meet the water demand.

Table 5: Status of water points

Status	Frequency	Percent	Cumulative Percent
Newly constructed (2008)	41	7.5	7.5
Newly installed (2008)	118	21.5	29.0
Rehabilitated	3	0.5	29.5
Constructed (before 2008)	355	64.7	94.2
Installed (before 2008)	7	1.3	95.4
Non-rehabilitated/ undeveloped	23	4.2	99.6
Conserved	2	0.4	100.0
Total	549	100.0	

Source: Author calculations

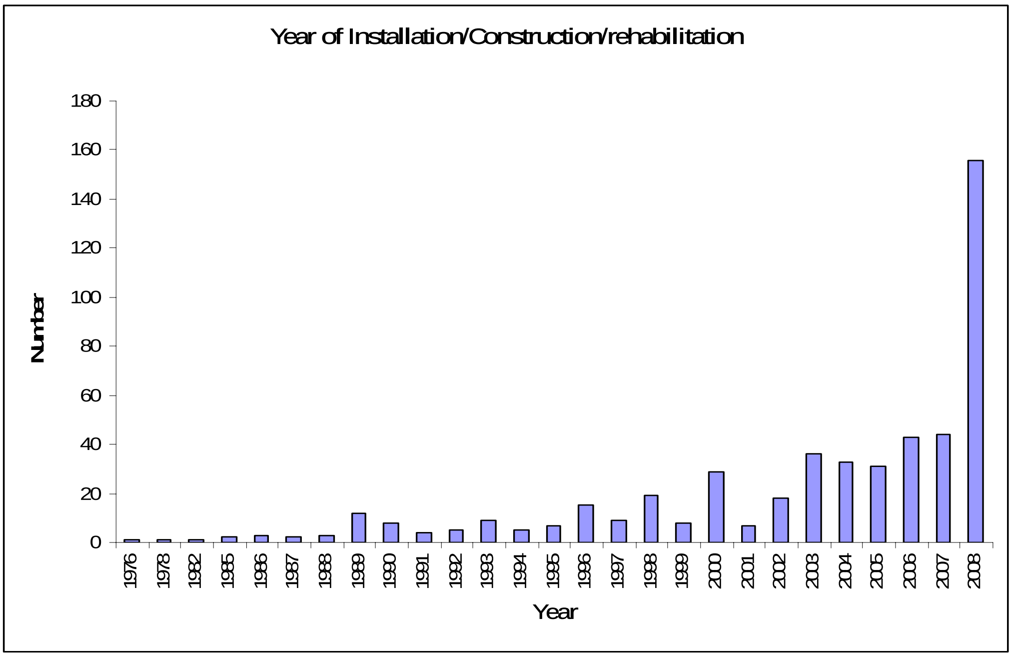

Figure 15: Pattern of water points' establishment (Source: Author calculations)

3.3 Registration and metering of water points

Out of the 549 water points, only 38.1% are registered or legal in nature while the rest are not. Legality/registration for this case implies that their existence is known by the water authorities. The registered water points comprise the boreholes, some river abstractions and some earth dams. The piped water installations are also legal in that they are authorised by the water service provider and the water user pays for it. This is unlike for the case of shallow wells where no records or information is kept by the water department. This is because there is no regulation governing shallow wells development. The implication of this is that some areas are well served by unauthorised water sources than is known in government records. Such a situation could be misleading when prioritising for water development especially if priority is based on population statistics than on available water sources. This can be illustrated by the current scenario in which areas connected to EWASCO piped system have other water sources than is the case in the south. This is probably because the people are relatively well off and can pay for the service (see distribution maps in Chapter 2).

Metering is necessary in enhancing efficient water use since users have to pay for what they utilise. However, only 22.2% of the water points are metered and this applies to piped installations by EWASCO for billing purposes. The rest of the water points are not. The implication is that control over water use or misuse cannot be effected. Similarly, the potential revenue generation is lost unless water authorities put in place fast measures to meter all water points especially those abstracting from River Rupingazi.

3.4 Mode of abstraction and amounts abstracted

Varied abstraction methods were recorded as shown in figure 16. All boreholes have hand pumps installed but shallow wells employ a range of methods that include bucket and rope pull system (the most common), powered pumping, wooden/metallic hand operated system and hand pumping. Piping as an abstraction method applies to piped installations, in some water tanks and earth dams to connect the reservoir and point of water collection. Water pumping using portable pumps is the main abstraction method used along Rupingazi River owing to the terrain involved. Buckets and small cans are used to draw water from springs and water holes. The categorization of the methods used for each type of water point is shown in table 6.

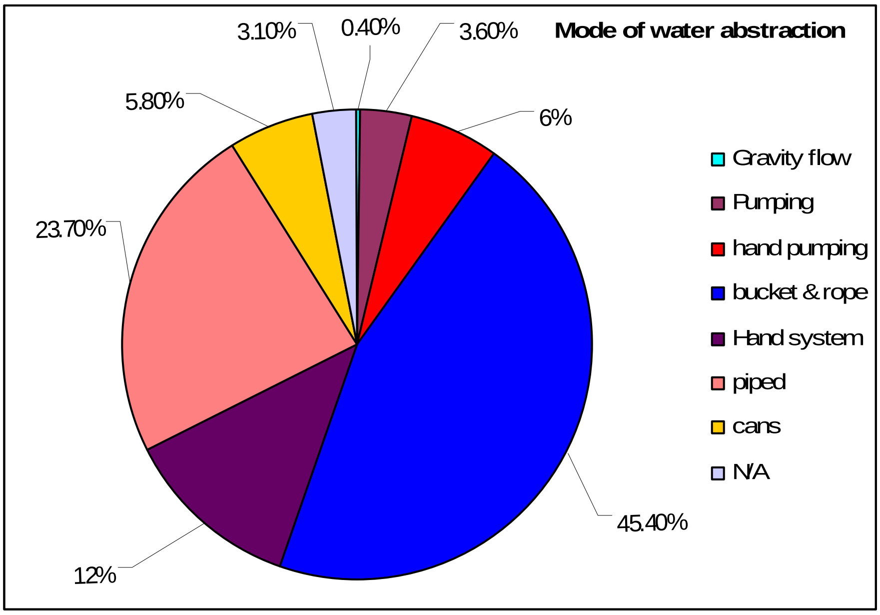

Figure 16: Methods of abstraction employed (Source: Author calculations)

Table 6: Categorization of abstraction methods with types of water points

	Mode of abstraction								
	gravity flow	pumping	hand pumping	bucket & rope	hand operated system	piped	using cans	N/A	Total
Surface Earth dams	0	1	0	2	0	2	4	1	10
Concrete dams	0	0	0	0	0	0	0	1	1
boreholes	0	3	23	0	0	0	0	3	29
shallow wells	0	13	10	242	65	0	8	10	348
water springs	0	0	0	4	0	0	18	1	23
water tanks	2	1	0	0	0	6	0	1	10
River abstractions	0	2	0	0	0	0	0	0	2
piped installations	0	0	0	1	1	122	0	0	124
undeveloped water holes	0	0	0	0	0	0	2	0	2
Total	2	20	33	249	66	130	32	17	549

Source: Author calculations

The amount of water abstracted vary with the type of water point, the pattern of water availability, mode of abstraction, water use, number of people using the water point, and cost implications. Because boreholes are used by groups of people, large quantities were estimated to be abstracted daily. Similarly was the case with wells used for irrigation. Use of metered piped water is restricted due to cost implications and many respondents indicated using it for drinking, watering livestock and to some extent for kitchen gardening purposes. Moreover, for water points with effective water drawing systems (i.e. for boreholes and wells), more water was abstracted compared to those that used other tedious manual systems like rope and bucket pull system.

The study estimated the amount abstracted by taking into consideration the number of people using the water point, and the number of 20litre jericans or 200litre drums each user draws per day. For cases where it was not feasible to establish due to variations, an average was used based on the provided range. This implies that the values provided in this study are estimated amounts and are summarized in table 7.

Table 7: Summary of water quantities abstracted from the water points

Type of water point	No of water points	Average amount abstracted (Litres)	Standard deviation
Water Springs	19	3189.47	3589.75
Wells	332	808.07	1408.78
waterholes	2	465.00	49.50
Piped installations	123	419.51	979.68
Earth dams	10	3270.00	5847.40
boreholes	24	4905.00	5478.07
River abstractions	2	8000.00	9899.50
water tanks	9	186.67	263.25

Source: Author calculations

The statistics show that river abstractions, boreholes, earth dams and water springs in that order recorded the highest abstracted amounts. River abstractions are normally used for irrigation and hence large quantities of water are abstracted. Boreholes, earth dams and water springs are used by groups of people. Wells, water holes and piped installations are marginally used simply because they mostly serve one or a few households. Water tanks on the other hand showed the least abstracted amount because they are owned by institutions and rarely used by public. From this analysis, it can be concluded that the usage of boreholes, water springs and earth dams could be overstretched because of the large number of people they are serving and the fact that some have water at certain times of the year owing to weather conditions.

The standard deviations in the table show that the amount abstracted varied highly for the categories of water points. Water points used by groups of people (water springs, earth dams and boreholes) had higher standard deviations showing the high variation in abstracted amounts between the existing water points in that category. The average amount abstracted from piped installations was low despite being the main source of clean water. This is due to cost implications. A cost of KShs 3/= per 20litre can was charged for accessing water from a private piped installation.

3. 5 Ownership and gender aspects

Most water points are privately owned (86.0%) and only 5.8% are group owned. For group owned water points, community members organized themselves and set certain requirements to be met in order to access water from a particular water point. Such requirements include registration with the group and contributing the monthly fee. In other instances, the requirements include initial registration and contributing when called upon in case there is need for the water point repairs. The membership requirement was a limiting factor to water access in that some households (financially disadvantaged) opted for distant water points where conditions are favourable (cheap or no cost). A total of 30 group owned water points were recorded and affiliated to either a borehole, a spring or a well. Membership range varied between 20 and 200 people with a mean of 66 people and standard deviation of 46. The size of the group tended to depend on the area being served and the availability of other water sources.

Public access to privately owned water points is dependent upon the willingness of the owner to provide water freely or at a cost. The institutional category comprises water points belonging to schools, dispensaries or churches whose use is also restricted. It is therefore deducible that water accessibility in Mbeti South location is conditional in the sense that certain requirements have to be met or there is investment in own water supply.

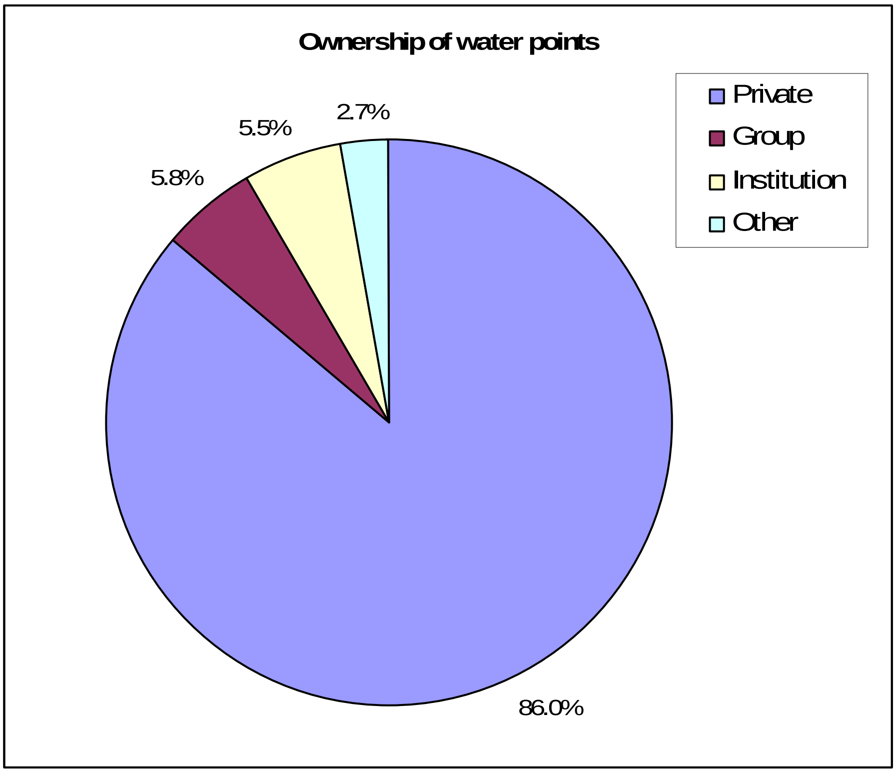

Figure 17: Ownership of water points; (Source: Author calculations)

The study further considered the gender aspect in water point ownership and management. Of privately owned water points 76.9% are headed by males while 9.1% are headed by women. The implication of this is that men are likely to influence on the decisions about water development than women. In the remaining 14% owned and managed by groups, the gender influence depends on the composition of the management committee. It happened that the number of women sitting in these committees is higher than that of men since water issues are closely associated with women.

Table 8: Gender perspective in private owned water points

Category	Frequency	Percent
Male	422	76.9
Female	50	9.1
N/A	77	14.0
Total	549	100.0

Source: Author calculations

3.6 Location and its influence on access to water

Generally, Mbeere district is a semi-arid district but carries a variety of land uses. The main ones in the study area are settlement, agriculture, grazing and bush land. We considered the location of each water points and it emerged that most are located in agricultural fields (62.7%) and near settlements (24.8%). The location of water point is generally influenced by the use. Since wells are mainly used for irrigation they are located in cultivated fields while piped installations commonly used for domestic purposes are in homesteads. Table 9 summarizes the land use in which the mapped water points are located.

Table 9: Location of mapped water points

Location of water point	Frequency	Percent
settlement	136	24.8
agriculture	344	62.7
grazing	30	5.5
bush land	23	4.2
other	16	2.9
Total	549	100.0

Source: Author calculations

In terms of distribution across the agro-ecological zones, most water points are located within zones LM3 and LM4 (figure 18). In UM4, which border Embu district, water points are few probably due to the fact that this is a relatively wetter zone that receives quite some good amount of rainfall to support agricultural activities. In LM3 and LM4 the soils are good for agricultural production but there is water scarcity demanding high interventions in water development. In the LM5 zone the water points are very few and this could be attributed to two factors: low population density and hence low water demand; and relatively poor soils that cannot support adequate agricultural production to warrant investment in water points. As a result, households in this zone travel for long distances in search of water.

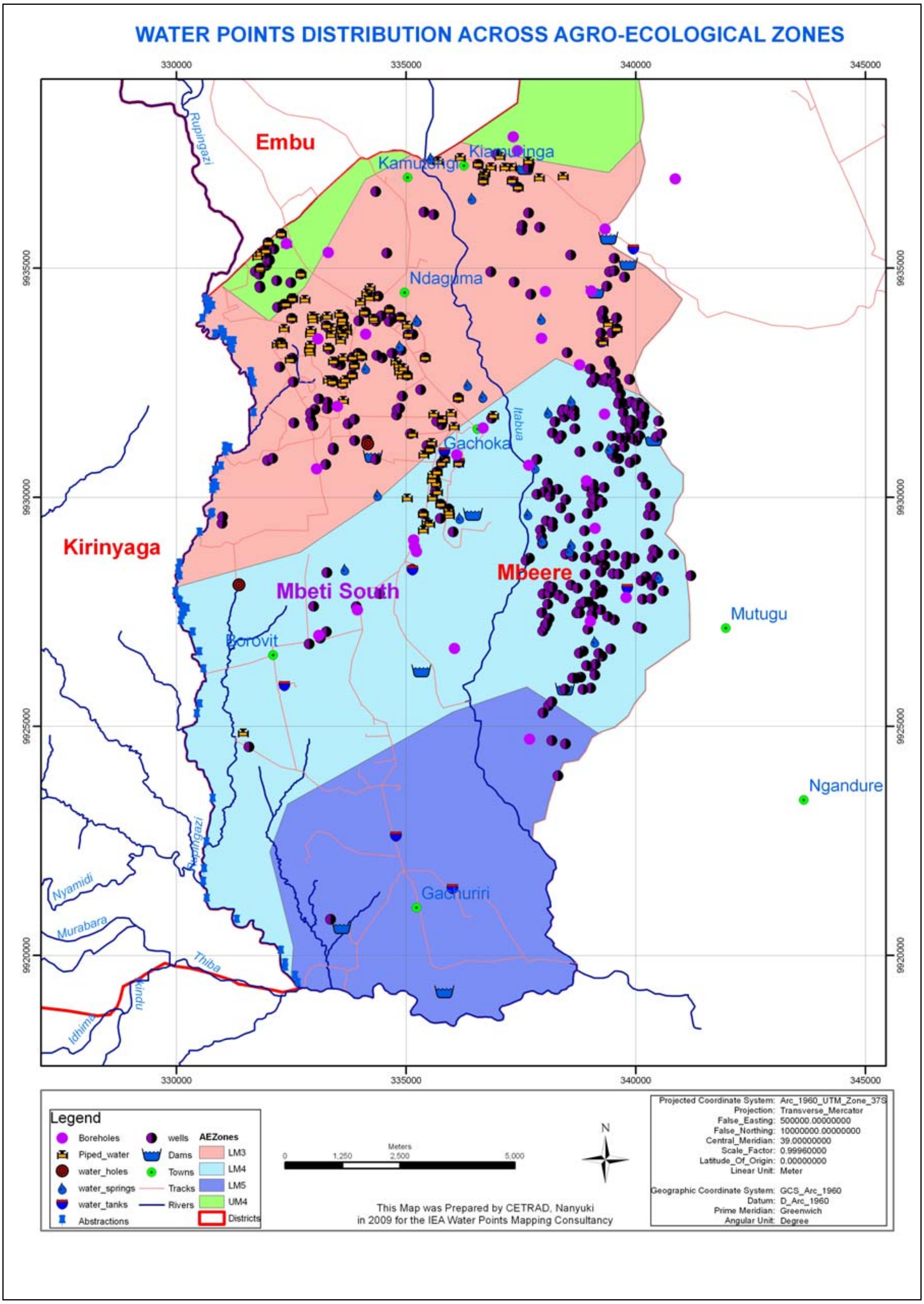

Figure 18: Distribution of water points across the agro-ecological zones (CETRAD, 2009)

56.5% of the private water point owners indicated that ownership and location is a major challenge to water access by public. This is because of cost implications through increased use and in maintaining the water points. The remaining 43.5% allowed the public to access water either freely or at a cost. They also expressed no gender or age preference in terms of who fetches the water provided there is caution not to damage the water drawing system or dump objects in the well.

Further observations showed that both males and females participate in water collection. While women and children were fetching mainly for domestic purposes, men were mainly doing so for livestock and irrigation. Men normally use bicycles and ox-carts to carry the water cans while women carry them on their back (see plate 5, 12 and 13 in the annex). Thus, water collection in the location is a collective responsibility for both sexes.

3.7 Distances to water points

Distance to water points is a major determinant to water access since it influences the time taken and amounts that can be fetched at any single trip. Using GIS technology, we evaluated the distances between any two similar water points (boreholes, Earth dams, springs and water holes) for purposes of evaluating the maximum distances a household could travel to access water. It emerged that the distance between earth dams ranged between 0.8km and 5.8km with an average of 3.07km and a median of 3.5km. For boreholes the range was between 0.2km and 5km with an average of 1.6km and median of 1.5km; while for springs it was between 0.3km and 3.1km with an average of 1.4km and median of 1.3km. The two water holes on the other hand are 4.1km apart.

Water points are not evenly distributed in the location and therefore households have to cover varying distances in search of water. From the statistics above, the average distance between earth dams is greater than that between springs, boreholes or water holes. However, the distance between boreholes is very critical in this study because most households without alternative water supply have to visit boreholes especially during the dry season when water quantities in most other water points decline. The importance of distance to boreholes is in that it influences the time taken and quantities drawn since there are no water distribution systems. This underscores the need for investing in water distribution infrastructure to ease access.

3.8 Water sources, availability and point of collection

The water points derive water from ground aquifers or surface based processes. However, the majority are ground based (68.5%) and comprise the boreholes and wells. The rest are surface based obtaining water from rivers, surface runoff, springs or a combination of these. Earth dams normally collect surface run off during the wet season and store it for use during the dry season. Some wells are also constructed in a way to allow surface run off into them especially if their recharge rate is low. Table 10 summarizes the main water sources for the mapped water points.

Table 10: Sources of water for the water points

Source	Frequency	Percent
Below ground	376	68.5
River	9	1.6
Spring	16	2.9
Surface runoff	7	1.3
Pumped	1	0.2
Roof harvesting	6	1.1
Piped system	117	21.3
Ground water & surface runoff	3	0.5
N/A	14	2.6
Total	549	100.0

Source: Author calculations

A good number of the water points (58.5%) normally have water throughout the year, 16.6% are seasonal while the remaining 25% did not apply since they were still under construction or initiated in the course of 2008. Correlation analysis indicated a strong relationship between source of water (ground/surface) and the availability through out the year ($r = 0.733^{**}$, $P \leq 0.05$).

An examination on water availability per day indicated that 75% had water throughout the day. This observation resulted from the fact that some of the seasonal water points have water throughout the day when functional. Another 13.5% provides water during some hours of the day. This is because some boreholes are operational in the mornings and evenings while allowed to recharge during the day. Another 7.8% have water only in a few days per week such as piped installations supplied by the Muthathari water project. Similarly, some respondents indicated that the EWASCO piped installations have water occasionally.

Water availability during the spot check showed that 89.6% of the water points had water (see table 11). However, the quantities varied from one water point to the other. Those located along depressions (especially wells, springs and boreholes) had more water. The interesting thing is that groups owned water points (boreholes, wells, earth dams) had some water by the time of spot check indicating that even if households had to cover some distances in search of water, they were assured of getting it even during the dry season. This is however dependent on the set requirements governing the various water points.

Table 11: Water availability by time of spot check

	water availability currently			
	yes	no	N/A	Total
Surface Earth dam	7	3	0	10
Concrete dam	1	0	0	1
borehole	25	0	4	29
shallow well	310	31	7	348
water spring	20	3	0	23
water tank	8	0	2	10
River abstraction	2	0	0	2
piped water system	117	7	0	124
undeveloped water hole	2	0	0	2
Total	492	44	13	549

Source: Author calculations

Water is normally collected at source in 91.4% of the water points. In the remaining proportion the water is either piped through gravity to a collection point or pumped to a storage facility. This implies that most households have to travel for water as there lacks distribution systems to deliver water from wells, boreholes, springs, water holes and dams to households. Only the EWASCO system is currently having a distribution system to deliver water to households.

3.9 Depth and capacity of water points

The study considered the depth of wells, water holes and boreholes and the capacity of existing water tanks. Results indicated variation in depth for wells and boreholes. Boreholes are relatively deeper than wells. Water holes are too shallow and normally scooped in areas with high water table (table 12). Among the reported factors that influence depth of wells are the level of water table, excavation costs, existence of hard rock beneath, technology and intended water use. Since it is generally expensive to dig and construct a well for most households, many tend to excavate up to the point of encounter with water irrespective of whether it's the optimal depth. This is likely to have implications on yield potential and can explain the seasonality or low recharge rate experienced in some during the dry season.

Table 12: Depth statistics for wells, boreholes and water holes

Depth	Number	Average	Stdev	Min depth	Max depth
Boreholes	27	172.15	75.84	50	400
Wells	335	42.04	29.81	5	320
water holes	2	5.5	0.71	5	6

Source: Author calculations

The water capacity for earth dams and water tanks was also estimated (see table 13). The average water capacity for earth and concrete dams was attributed to the fact that only a few could hold large quantities of water. The rest and especially those privately owned had limited capacity due to construction cost and the fact that they were meant to collect runoff water.

Table 13: Estimated storage capacity of tanks and dams

	number	average	min	max
Tanks	10	46200	6000	100000
Dams	11	29454	2000	70000

Source: Author calculations

3.10 Water uses and cost implications

There were varied reasons for investing or initiating a water points. Among the overriding intentions were to provide water for domestic uses (22.8%); domestic and livestock watering (33%); or for domestic use, livestock watering and irrigation (28.4%) as shown in table 14. However, there have been changes in the way these water points are used currently. The major current use is for domestic, livestock and irrigation purposes (47.4%) which illustrates the sheer fact that households are in need of not only meeting domestic water needs but also for income generation or enhancing food security through irrigation. Many water point owners have initiated kitchen gardens or growing food crops using irrigation. Similarly, khat production for market is expanding among the inhabitants and is a major drive for the establishment of shallow wells. Those relying on piped water expressed dissatisfaction in that they cannot undertake serious irrigation due to cost implications and regulations set by EWASCO.

Table 14: Initial and current water uses in the location

Uses	**Initial use (number)**	**Initial use (%)**		**Current use (number)**	**Current use (%)**
Domestic	125	22.8		50	9.1
Livestock watering	2	0.4		5	0.9
Irrigation	9	1.6		4	0.7
Domestic & livestock watering	181	33.0		128	23.3
Domestic, livestock watering & irrigation	156	28.4		260	47.4
Domestic & commercial	1	0.2		1	0.2
Domestic & irrigation	48	8.7		57	10.4
Domestic, commercial & irrigation	0	0.0		8	1.5
Others	18	3.3		16	2.9
N/A	9	1.6		20	3.6
Total	549	100.0		549	100

Source: Author calculations

The study further categorized the water points according to the number of households served and it emerged that most water points (418) are used by less than 10 households. Only a few (4) serve more than 100 households (see table 15). The 61 water points not serving any household comprise those owned by institutions (e.g. dispensaries, churches, Technical Institute and schools) where public is not allowed to draw water and those under construction or non-functioning.

Table 15: Estimated households using the water points

Households range	No. of Water points serving	Total households served	Average households per water point
0	61	0	0
1 – 10	418	1022	2.44
11 - 100	66	2634	39.91
101 and above	4	490	122.5
	549	***4146***	***7.55***

Source: Author calculations

With an estimated population of 16648 persons as provided by the 1999 population census statistics, the analysis showed that shallow wells and boreholes provided water to a relatively fair proportion of the population (Table 16). For instance, shallow wells serve 57.87% of the population followed by boreholes with 50%. The proportions were estimated on basis of water point category because many households draw water from a variety of sources and summing up would provide erroneous results.

Table 16: Proportion of population accessing water

Water points		**Benefiting HHs**	**Females**	**Males**	**Population**	**Estimated % of total population**
Earth & Concrete dams	Total	410	1460	979	2439	14.65
	Average	*37*	*133*	*89*	*222*	
Boreholes	Total	1318	5036	3296	8332	50.05
	Average	*47*	*170*	*113*	*283*	
Shallow Wells	Total	1429	5584	4054	9634	57.87
	Average	*4*	*16*	*12*	*28*	
Springs	Total	663	2421	1612	4033	24.23
	Average	*32*	*115*	*85*	*192*	
Water Tank	Total	1	320	281	601	3.61
	Average	*0*	*46*	*40*	*86*	
River Abstractions	Total	0	15	25	40	0.24
	Average	*0*	*15*	*25*	*40*	
Piped System	Total	309	1946	1852	3797	22.81
	Average	*3*	*16*	*15*	*31*	
Water Holes	Total	16	63	43	106	0.64
	Average	*8*	*32*	*22*	*53*	

Source: Author calculations

In terms of gender, the estimated number of females using water from the various water points was slightly higher than that of men. Field enquiry indicated that the average number of females using the water points is relatively higher than that of men.

Table 17: Population proportion benefiting from the water points

Type of Water point	Mean population	Mean female pop.	Mean male pop.
Surface Earth dam	269	161	108
Concrete dam	15	7	8
borehole	287	174	114
shallow well	28	16	12
water spring	192	115	85
water tank	86	46	40
River abstraction	40	15	25
piped water system	31	16	15
undeveloped water hole	53	32	22
Total	***54***	***32***	***23***

Apart from human consumption, livestock watering and irrigating production were estimated. Table 17 provides the estimated livestock and irrigated agricultural lands by use of the various types of water points. The figures show that dams, boreholes, shallow wells and springs play a major role in livestock watering unlike water tanks that are mainly used for institutional needs (schools, dispensaries and technical institutes) purposes.

The shallow wells and earth dams play an important role in irrigation especially in growing of khat for market. Piped water is also being increasingly used to initiate kitchen gardens for growing vegetables irrespective of cost implications, inadequate water quantities and usage regulations by the service provider, EWASCO. Adequate supply of piped water is likely to induce more households to produce food crops through irrigation as a way of enhancing their food security.

Table 18: Water uses for livestock watering and irrigation

Water points		**Cattle**	**Sheep /Goats**	**Pigs**	**Chicken**	**Potentially Irrigated (ha)**	**Actively irrigated (ha)**
Earth & Concrete dams	Total	4805	8866	0	0	50	50
	Average	*437*	*806*	*0*	*0*	*5.54*	*5.54*
Boreholes	Total	5771	9997	100	0	15	15
	Average	*249*	*430*	*4*	*0*	*0.68*	*0.68*
Shallow Wells	Total	3349	5636	50	130	542.26	132.77
	Average	*10*	*16*	*0*	*1*	*1.64*	*0.52*
Springs	Total	3487	6307	0	0	8.20	0.70
	Average	*159*	*287*	*0*	*0*	*0.75*	*0.08*
Water Tank	Total	0	0	0	0	0.00	0.00
	Average	*0*	*0*	*0*	*0*	*0.00*	*0.00*
River Abstractions	Total	30	50	0	20	16.00	16.00
	Average	*15*	*25*	*0*	*10*	*8.00*	*8.00*
Piped System	Total	794	1421	18	130	21.10	21.10
	Average	*6*	*12*	*0*	*1*	*0.17*	*0.17*
Water Holes	Total	23	85	0	0	4.2	4.2
	Average	*12*	*43*	*0*	*0*	*2.1*	*2.1*

Source: Author calculations

The cost of accessing water varied with the supply system. Those connected to the EWASCO piped system are charged per unit used and billed on monthly basis. One cubic metre of water is charged at KShs 26/=, which was considered expensive by many respondents. An assessment of the amounts paid by 93 respondents showed a range of between KShs 250/= (the basic minimum due to standing charges) and KShs 8000/=. The average monthly pay was KShs 867/= and a median of KShs 350/=. This is relatively expensive considering that many households in rural areas have limited sources of income to enable them foot the bills. The cost of accessing water from other sources varied. For instance, for water points with organised management the cost ranged between KShs 10/= and 50/= per month, which was set to cater for repairs and any development of the water point. On the contrary, water points with ineffective or no management, water is freely accessed. However, their reliability is low due to negligence and lack of proper maintenance.

3.11 Sewerage situation in the location

Mbeere district has no major networked sewerage systems even in the existing towns (Njiru, Personal Comm.). Therefore, no detailed information was gathered about sewerage systems. The study focused on the existence of latrines in homesteads visited for water points mapping. Since some households own more than one water point, we considered the existence of latrines in the 477 homesteads/farms where the water points are located. Out of these, 74% had latrines and 16.6% did not have. The remaining 9.4% applies to public lands/bush land where some water points are located. Only a few homesteads/households had flush type of toilets. The observation is however lower than the 91.7% reported by Wamwangi, Macharia and Kisingu (2008).

The status of latrines varied from one household/farm hold to the other and this can be attributed to the financial status. A few households (22.6%) had permanent latrines (those with concrete floor and well covered using iron sheets, wood or stone walls) while 51.4% have semi-permanent kind of latrines (those with earth or wooden floor and walls covered using mud, wood or sacks). The implication of this observation is that most households have a point for waste disposal which minimises the incidences of water points' contamination through run-off processes. Nevertheless, the possibility of contamination of water points (especially wells) through underground leakage cannot be ruled out depending on where they are sited.

4. Operational status, Funding and Management

4.1 Operational status

Over 80% of the water points were fully functional by the time of spot check. This is shown in figure 19 below. Table 19 shows the operational status of the various categories of water points. One earth dam was non-operational in the sense that it was poorly constructed and could not retain water even during the wet season due to high percolation. It emerged that it has never been used since construction despite having been constructed using the Constituency Development Fund (CDF). The other two had dried up due to weather conditions. The not-yet operational category are those still under construction.

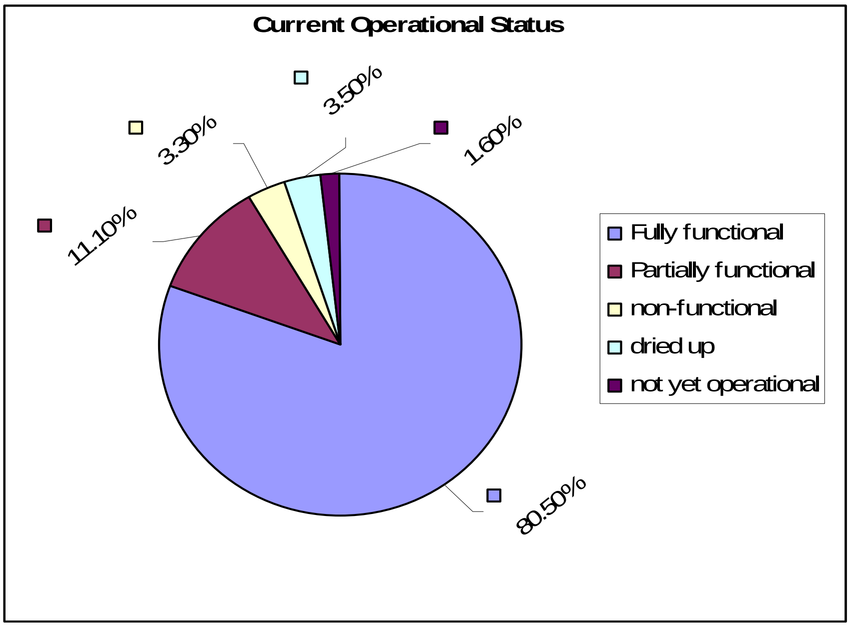

Figure 19: The operational status of water points (CETRAD, 2009)

Table 19: Operational status for the various categories of water points

	fully operational	partially operational	non-operational	dried up	not yet operational	Total
Surface Earth dams	6	1	1	2	0	10
Concrete dams	0	0	1	0	0	1
boreholes	23	2	4	0	0	29
shallow well	264	50	11	15	8	348
water springs	17	4	0	2	0	23
water tanks	7	1	1	0	1	10
River abstractions	2	0	0	0	0	2
piped water installations	121	3	0	0	0	124
water holes	2	0	0	0	0	2
	442	61	19	18	9	549

Source: Author calculations

4.2 Funding water projects and the role of community

The Water Act 2002 provides for community participation in water resources management through management existing water points or by providing funds for development. An assessment of funding sources for the various water points in the location showed that a majority are privately funded (84%) and managed (see table 20). Support by public, government, donor agencies and community was minimal.

Table 20: Sources of funding for the water points

	Frequency	Percent
Donor	24	4.4
Government	8	1.5
Church	4	0.7
NGO	4	0.7
Community	13	2.4
Private	461	84.0
CDF	2	0.4
Other	17	3.1
N/A	16	2.9
Total	549	100.0

Source: Author calculations

Shallow wells and piped installations are privately funded, earth dams and water tanks are supported by the government and CDF while boreholes were donor funded (table 21).

Table 21: Cross-tabulation between funding and type of water points

Water point	**Source of funding**									
	Donor	**Government**	**Church**	**NGO**	**Community**	**Private**	**CDF**	**other**	**N/A**	**Total**
Surface Earth dam	1	3	0	0	0	4	1	0	1	10
Concrete dam	1	0	0	0	0	0	0	0	0	1
borehole	16	0	1	3	7	1	0	1	0	29
shallow well	3	0	0	0	2	340	0	3	0	348
water spring	0	0	0	1	4	4	0	1	13	23
water tank	3	3	1	0	0	0	1	2	0	10
River abstraction	0	0	0	0	0	1	0	1	0	2
piped water	0	2	2	0	0	111	0	9	0	124
water holes	0	0	0	0	0	0	0	0	2	2
Total	24	8	4	4	13	461	2	17	16	549

Source: Author calculations

4.3 Management of water points

The management of water points varied with ownership. Private management was common due to high number of privately owned water points. The owners are responsibility for the day-to-day running of the water points. Management committees for group owned water points were reported in 27 (4.9%) instances managing boreholes & earth dams. Institutional management applied to water points owned by schools, dispensaries, and the institutes. Table 22 summarizes the categories of management recorded while 23 show the cross-tabulation between funding and operational status.

Table 22: Categories of water point management

Category	Frequency	Percent
Management Committee	27	4.9
Management by owner/private	468	85.2
Management by institution	24	4.4
other	12	2.2
no management	18	3.3
Total	549	100.0

Source: Author calculations

Table 23: Cross-tabulation between source of funding and operational status

Funding source	Current Operational status					
	fully operational	partially operational	non-operational	dried up	not yet operational	**Total**
Donor	18	2	3	0	1	**24**
Government	7	0	0	1	0	**8**
Church	4	0	0	0	0	**4**
NGO	2	1	0	1	0	**4**
Community	13	0	0	0	0	**13**
Private	372	54	11	16	8	**461**
CDF	0	0	2	0	0	**2**
other	14	1	2	0	0	**17**
N/A	12	3	0	1	0	**16**
	442	61	18	19	9	549

Source: Author calculations

The management committee comprise both men and women. An assessment showed that in 16 of the committees, the number of women was higher than that of men. The average number of women in the committees was 5.5 (6 persons) while that of men was 4.4 (4 persons). Reports indicated that some groups deliberately opted for this because water issues are central to women than to men. This indicates not only the gender balance but also the level of women involvement in water management.

The composition of the management committee however is determined by the group members using the water point. The groups employ secret ballot or acclamation during public meetings for consensus. In some instances special consideration is also given to the various villages using the water point when constituting the committee. In such cases, representatives of the various villages constitute the committee. While having a management committee in place to man the affairs of the water point is crucial, there lacks regulations to govern them especially on the time span the committee should serve. This has resulted in some committees serving for a long period, and was blamed for the inactivity in some groups. Dynamic leadership governed by set regulations would go a long way in enhancing effective management of water points.

An assessment of management in place revealed that more than half of the water points are good or fairly managed (table 24). The rating was based on aspects such as cleanliness, appropriate protection, and whether the water drawing system is operational. Nevertheless, there is the need to sensitize the community on appropriate protection, especially for the wells, in order to avoid pollution/contamination and possible accidents.

Table 24: Rating of the water point management status

Management status	Frequency	Percent
good	147	26.8
fair	205	37.3
average	138	25.1
poor	44	8.0
N/A	15	2.7
Total	549	100.0

Source: Author calculations

Table 25: cross tabulation between type of management and operational status

	Current Operational status					
	fully operational	partially operational	non-operational	dried up	not yet operational	**Total**
Private	381	54	12	17	4	**468**
Group	22	3	0	1	1	**27**
Institutional	22	1	1	0	0	**24**
other	11	0	0	1	0	**12**
none	6	3	5	0	4	**18**
Total	**442**	**61**	**18**	**19**	**9**	**549**

Source: Author calculations

5. Water Standards, Protection and Challenges

5.1 Water standards and protection of water points

Water quality plays a major role in the prevention of water borne diseases. Among the reasons for establishment of water service providers by the Water Act 2002 was to limit the activities of unscrupulous water vendors who supplied water even from polluted sources. An assessment to understand people's view about the water they use revealed that 80% of the water points are rated clean and non-saline (table 26), which illustrates the reliability of the available water for human consumption.

Table 26: Water standards for the mapped water points

Water standard	Frequency	Percent
Clean & non-saline	439	80.0
dirty & saline	14	2.6
Clean & saline	66	12.0
contaminated	4	0.7
dirty & non-saline	6	1.1
N/A	20	3.6
Total	549	100.0

Source: Author calculations

This could explain why many respondents do not treat their water before use. Only a few do treat their water by boiling or by chemical treatment using water guard and aquatab. This is despite the fact that some water points are improperly protected and are therefore prone to pollution or contamination through runoff and dust even if they have clean ground derived water. Sensitising the community on such matters is needed.

48.5% of the water points are protected and this came in different forms. For instance, shallow wells are covered using concrete or by wooden planks. The later is however ineffective in controlling dust and runoff water from entering the wells. Boreholes were covered during construction and the community only maintains the cleanliness of the surrounding areas. Springs are protected by conserving the vegetation in its catchment to maintain their ecological integrity. Similarly, some earth dams are fenced, and grass and trees planted around to control erosion and the subsequent siltation. Protection of the remaining water points is needed. Attention should also go to constructing livestock troughs where water can be piped to avoid incidences of livestock getting inside the earth dams.

5.2 Challenges and Threats

From this study it was evident that each type of water point had its own set of threats or challenges that need to be addressed. The piped water system though providing treated water safe for drinking is expensive. The quantities of water supplied are also low and mainly intended for domestic uses only. It does not therefore meet the expectations of many of availing clean and affordable water for multiple purposes including irrigation. Moreover, the proportion of the population and the area covered is small relative to the total location. This implies that majority of the population will continue relying on other water sources for some time.

Some of the group-owned water points lack effective committees and this challenges management. Others are improperly protected which exposes them to possible pollution or contamination through run off, damping of materials and siltation. Proper protection is required to maintain water quality. Similarly, some water points are seasonal and are therefore unreliable in supplying water especially during the dry season. In addition, the spatial distribution of the water points is skewed with the lower part of the location having just a few. Households are therefore forced to travel for long distances in search of water.

6. SYNTHESIS AND POLICY IMPLICATIONS

The study findings elicit policy oriented interventions in order to improve the water supply and sewerage situation in Mbeti South location. These are highlighted in the following sections.

6.1 Spatial distribution of water points

The findings show skewed distribution of water points with the north and north-eastern parts of the location being well served than the rest of the location. This is due to domestic and irrigation needs. However, the District water office only had records of boreholes but not for other types of water points. This implies that while private interventions are increasing in these zones thereby facilitating water access, the reliance on government statistics on available water sources may be misleading. Prioritising of water development needs based on government statistics and consideration on population might serve areas not in dire need of water. This calls for the District water office to improve its records of the various existing water points and their location in order to guide future interventions. Similarly, the District Water Office ought to be equipped with appropriate technologies, especially in GIS, and the personnel trained so that they can be collecting information on water points to aid prioritising areas in need of water development. Appropriate and recent statistics on human population in the area is required as a step towards assessing the correct number of people without appropriate access to water.

The study also found that majority of the water points (wells and boreholes) derive their water from below ground aquifers. Boreholes are fairly distributed in the region unlike wells which are concentrated in the upper and eastern parts of the location. The skewed distribution of wells could probably be attributed to the fact that there is no legal requirement on sinking a well and anyone can invest in it. However, their numbers, distances between them, and the sheer lack of regulation on the optimal depth raise the question of sustainable water supply from ground sources. This is especially so considering that more wells are likely to be sunk as need arises. Investment in unsustainable wells or in areas with low recharge rate is likely to continue. Hence, the District Water Office ought to monitor prospective investors for inventory and regulation purposes. Similarly, the ground water hydrologist needs to be facilitated to determine the aquifers recharge rate so that the regulation on spacing and depth can be established.

6.2 Characteristics of water points

Households in Mbeti South location derive water from a variety of sources. The available water varies in quantity, quality and reliability. The study mapped a total of 610 water points of which the majority are wells as households strive to seek reliance in water supply. The trend is likely to continue and sustainability may be affected. There is need for collective action in water management in order to develop common water sources that will supply water to most households. Collective action will also allow the development of effective water distribution systems. The Ministry of Water and Irrigation and other lead agencies should therefore be in the forefront in mobilising people and sensitising them on the best practices for water management and use. This should include the formation of water user associations.

The fact that most water points (61.9%) are not registered with the District Water office or any service provider, and only a few (22.1%) are metered raises the question of efficiency in water usage. As the water resources continue to decline, there is need to ensure that existing water abstractions are legal and metered to enhance efficiency in use, and to enhance revenue generation for subsequent investment in water resources management. For instance, most river abstractions are not metered and permits are based on pump horse power indicated during registration. However, there is no follow up by the Water Office to ensure that owners abide to stated pumps as a measure of controlling water use. Going by the average 8000 litres/day abstracted by the two abstractors the study managed to get in-depth information from, it is reasonable to argue that more water is used than is paid for. Similarly, since the user cost is minimal and there is no follow-up by the Water Office to ensure efficient use, gross water wastage could be occurring through irrigation. Consequently, potential revenue is lost.

Most water points derive their water from below ground aquifers and varied modes of abstraction are used. Most of these abstraction methods (63.4%) are manual in nature i.e. using rope and bucket (45.4%), hand pumped (6%) or using hand operated system (12%), and could have implications on water access considering who fetches the water. Since the study found that water collection is undertaken by all (gender and age) access by children and women may be limited owing to the fact that they might not be strong enough to operate the manual systems. This becomes critical when large quantities of water are required. To ensure that women and children are catered for and are able to access water without challenges, there is need to invest in more friendly drawing systems such as powered pumping. Exploration and funding of alternative power sources such as solar panels or wind mills is required since the greater part of the location is without electric power.

The study also found that most water points are privately owned (86%) while institutional based (5.7%) and group based water points (5.8%) are few. Amongst the few group owned water points, access is subject to meeting set requirements. This would mean that households without the financial capability to meet the requirements are unlikely to access water. This is likely to be worse for cases of women led households. This calls for active interventions by the government, NGOs and other donor organisations in developing more public water points to supply affordable water to all with minimal cost implications on the users.

Most water points (80%) were reported to provide clean and non-saline water that can be used for both agricultural and domestic purposes. However, based on location within agricultural fields (62.7%) and only a few (24.8%) are located within homesteads it is deducible that agriculture is the main driving factor behind water points development in the location (especially wells). Moreover, lack of appropriate protection for some wells implies that the available water would support agricultural and livestock needs while not being adequate enough for human consumption. As a result, an investigation on the quality of available water for human usage, especially from wells, is necessary. Additionally, efforts should be made to expand the distribution coverage of clean piped water as initiated by EWASCO.

The realisation of irrigation potential using shallow wells is likely to promote agricultural intensification and diversification as households try to make a living. However, the sustainability of agricultural development in an arid environment is questionable especially with the level of agricultural information available to farmers. A more active role by the agricultural departments and other agencies in training farmers on dry land farming, and especially on efficient water use, should be emphasised.

6.3 Water supply, costs and funding

Water supply in the location is surface and ground based. Ground water aquifers provide most water through wells and boreholes while surface water sources are limited to springs and the seasonal earth dams that collect flood flow during the rains. The river sources and rain water harvesting are not common. Each type of water source serves a certain proportion of the population. The main sources serving the population are boreholes (50.05%), springs (24.23%), and earth dams (14.65%) normally used by groups. GIS analysis however shows these water points are located distant apart. The earth dams are few, small and sometimes seasonal while tanks are owned by institutions where access is limited. River water is limited by the distance and accessibility, while lack of sufficient technologies lowers rain water harvesting. This is irrespective of the fact that Rupingazi River flows along the border of the location and only used by a few individuals and companies for irrigation.

There are various reasons for the low proportion of the population served by the water points. Most water points are privately funded and managed thereby limiting access to public. Those under group ownership have financial requirements to be met implying limited access by persons without economic capability to meet the set requirements or to invest in own water supply system. This is likely to affect the financially disadvantaged households such as those headed by single mothers', the old and the unemployed. We recommend additional funding for the development of water sources that could benefit many households at minimal cost.

Similarly, in 91.4% of the sources, water is collected at source due to lack of distribution systems. Households spend time and energy travelling for the commodity. Distances to water points increase during the dry season when water declines or dries out. Alleviating the situation requires the construction of adequate storage facilities (dams and tanks) to collect water during the wet season for use during dry season; putting in place effective distribution systems to supply water at strategic locations for easier access; and facilitating the development of water supply systems from River Rupingazi to feed the location. The government and other development agencies should therefore be in the forefront in providing the financial support. Additionally, there is need to sensitise and fund rain water harvesting by use of water pans (for agriculture and livestock purposes) and water tanks (domestic uses) especially in the lower part of the location where water supply is currently low.

The optimal depth and suitable location for wells needs to be established. This is because all boreholes had water by time of spot check while 31 shallow wells were dry and many more had little amounts of water. The average depth of boreholes was 172 feet compared to 42 feet for wells. While investigation for the siting of boreholes might have been made, many households investing in wells had limited capability for the same. Even where undertaken, cost became an overriding factor such that many households sunk their wells up to initial struck level. This suggests that the optimal depth might not have been exploited for optimal yield. The study therefore recommends an investigation on the optimal well depth while farmers are encouraged to seek services of a ground water hydrologist in order to identify the best location for optimal yield.

6.4 Management & protection

In several privately and group managed water points, the quality of management is not up to standard. This is because they are poorly maintained and lack adequate protection, which is likely to affect the quality of the water provided. Effective protection is necessary in order to maintain water quality and check possible accidents such as slippage into open or partially covered wells during water collection. Therefore, the community needs to be sensitised on water sources management and protection to avoid contamination, possible disease outbreaks and accidents.

The fact that most households (74%) use pit latrines, the contamination of water sources through overland flow of waste is minimised. However, the situation of pit latrines relative to water sources needs to be considered. Some wells are located in the same compound with or at lower elevation than pit latrines and this may compromise water quality through underground seepage. Thus, sensitising the community on the need to have latrines for sewage disposal (for households without) and the best location of latrines vs. wells is needed. Moreover, an investigation on the influence of latrines location on water quality would better inform the awareness creation process.

7. CONCLUSIONS AND RECOMMENDATIONS

The study shows the existence of varied types of water points in the location: piped systems, wells, boreholes, springs, and undeveloped water holes but with skewed spatial distribution. Most of them are concentrated in the upper part of the location where population density is high and soils are conducive for agricultural purposes. While most of the water points are neither legal nor metered to enhance efficient use, they supply clean and non-saline water to a fair proportion of the population for multiple uses: domestic, livestock watering and irrigation.

The water points derive their water from ground and surface sources. While surface sources are relatively easier for all to collect, the ground sources use manual drawing systems that may be challenging to women, the aged and children. In addition, one has to travel to the water point to collect water as there lacks distribution systems.

Private intervention in water development has taken place as evidenced by the prevalence of privately owned water points. Funding and management seem to influence access and the most disadvantaged groups in such a situation would be the financially challenged such as single mothers, the unemployed and the old.

The role of gender in water matters in the location was not pronounced as all ages and sexes are involved in collection. Moreover, women are involved in management of group owned water points or own water points.

There are numerous options to be considered in ensuring that the entire population in the location has access to adequate supply of water. They include seeking for more water projects that will ease the cost burden; enhancing water distribution systems in order to reach every corner of the location, enhancing management, ensuring effective protection of water points, and taking advantage of the major rivers in the location (such as Rupingazi River) to develop new water supply systems.

The study recommends:

- Equipping and building capacity in the District Water Office for assessing the water situation, and storing such information for development purposes;

- The District Water Office be facilitated to receive information about prospective water investments for inventory and regulation purposes;
- A study be undertaken to determine the potential of ground aquifers recharge rate in order to guide the regulation on spacing and depth of boreholes;
- Mobilising people and sensitising them on the best practices for water management and use. This should include the formation of water user associations;
- Ensuring water sources are legal and metered to facilitate efficient use, minimise wastage and raise revenue for enhancing water resources development;
- Investing in more friendly water drawing systems that are solar or wind powered to ensure that women and children can also access water with ease;
- Investing in more public water points to supply affordable water to all with minimal cost especially to take care of the financially disadvantaged groups;
- Enhancing water storage and distribution to reduce distances travelled in search of water;
- Investing in water supply systems to take advantage of the perennially flowing Rupingazi River for domestic and other uses;
- Sensitising the community on water sources management, protection and effective waste disposal to avoid contamination, possible disease outbreaks and accidents. The management of springs and earth dams should take into consideration planting grass and trees around them as a remedial measure of countering erosion and the subsequent siltation, and constructing water collection and livestock watering points.

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Appendix 1: Questionnaire used to collect attribute information

IEA Mapping Project – Mbeere 2008

Part 1: Water Points Attributes Information

Date………..**Location**………………**Point No**…………… **Photo No**………………
X Coord…………… **Y Coord** ………………………**Interviewer**…………………

A) Water Point Characteristics

Type of water point: *Surface Earth dam / sub-surface dam /concrete dam/ rock catchment / water pan / borehole / well / spring / water tank / river abstraction/ piped water system*.......................................Name:………………………………
Status of water point: newly constructed or installed/ rehabilitated/ non-rehabilitated/ conserved……………...
Year of installation/construction/rehabilitation: ………………………………………
Registration status: *legal / illegal*………………………………………………………
Permitted abstraction amount:…………………………………………………………
Amount abstracted:……………………………………………………………
Abstraction type: weir / pump /canal/ traditional …………………………………
Mode of Abstraction: gravity flow / pumping/ hand pumping/ ……………………
Metered: yes / no ………………………………………………
Current operational status: fully operational / partially-functional/ non-operational / dried up /……………….

B) Location of water point and its Influence on water access

Location of water point:…………………………………………………

Condition of the area: *arid / semiarid / medium potential / high potential*…………

Land use where located……………………………………………

Does location of water point influence public access to water? *Yes / No…………*

If YES, explain how………………………………………………………

C) Ownership & influence on access to water

Ownership of water point: *Group / private /* institution (provide name) ………………

If owned by group, how many members: ………………………………………

Are non-members allowed to get water? *Yes / No*………………

If YES, which category is allowed? *Men / women / boys / girls* /………

Any condition to comply with………………………………………

If privately owned, is the public allowed to fetch water? *Yes / No* ……………………

If YES, which category is allowed? *Men / women / boys / girls* ……

How many households / people get water from it? …………

Any condition to comply with…………………………

D) Management, Roles & Funding

All parties involved:…………………………………………………

Management: Who manages the water point? ………………………………

Composition of management team: *Males ………… .Females* ……

Mode of selecting the management team:……………………………

Gender roles in management: Men…………………………………………

Gender roles in management: Women…………………………

Management status: *good / fair / average / poor*………………………

Source of funding: *Donor / government / church /NGO / community /* ………………

Community contribution: ………………………………

Does source of funding influence access to water? *Yes / No*,

If YES, explain how……………..

E) Source, Capacity & Coverage

Source of water: *below ground / river/ spring/ surface runoff / stream inflow / pumped / roof harvesting* …………………………………………

Point of water collection: *at water point* / *piped to another location*/ *storage place where it has been pumped to / …………………………………………………………*

Water availability during the year: *all year round / seasonally /*……………………

Water availability per day: *throughout the day* / *some hours (state)*………………

Is water available currently? *Yes / No* ………………………………

Total storage capacity (m^3): ………………………………………

Depth (ft) (for wells & boreholes): ……………………………………

Purpose/uses: Initially - *Domestic / commercial / irrigation / livestock watering/*……

Currently - *Domestic / commercial / irrigation / livestock watering/…*

If Domestic, beneficiaries: *Households…., total population…..*

Also categorize as: *No of females*……… *males*…………………

If commercial, total population served ………………………………………

If for livestock production: *No of livestock units*……………………………

If for irrigation: *total irrigated area (ha)….. irrigated area actively farmed (ha)*……

F) Water cost and its influence on access

Is water sold or provided free: ……………………………………

If sold, how is costing done: *per unit / per month*…………Give figures…………

How affordable is the cost to:

Men – *affordable by most/ affordable by a few / non-affordable*

Women - *affordable by most/ affordable by a few / non-affordable*

Explain

………………………………………………………………………………………

F) Sanitary Conditions

Water standards: *clean / dirty / saline / contaminated*…………………………………

Water treatment undertaken: …………………………………………

Is water point protected: *Yes / No*; if Yes, explain nature of protection done

…………………………………...

Who is/are responsible for water point protection? ………………………………

Are there proposed protection measures (if any): ……………………………………

What are the possible threats to the water point…………………

Any form of rehabilitation required…………………………………………

G) General information

Challenges / problems: ………………………………………………

Remarks …………………………………………

Recommendations …………………………………………

<u>Part 2: Sewerage Systems Attribute information</u>

Date………..**Location**………………**Point No**…………… **Photo No**…………………

X Coord………….. **Y Coord** ………………………**Interviewer**…………………

Name …………………………………

YoC/I…………………………………….........

Ownership ……………………………………………………

Current operational status: *fully functional / partially functional / non-functional*……

Households / persons connected ……………………………………

Households / persons currently being served: ……………………………………

Challenges/ problems: ………………………………………

Rehabilitation required: ………………………………………

Remarks &/ recommendation …………………………………………………………

Latrines

Existence of Latrine: Yes / No………………………………………

If yes, nature of latrine: Permanent / semi-permanent…………………………

Appendix 2: Photographs showing the water points and their conditions

1. Categories of water points

Plate 1: A communally used water spring

Plate 2: Water supply tank

Plate 3: Roof water harvesting to a storage tank beneath the building

Plate 4: An Earth dam


Plate 5: Silted Kigondore concrete dam


Plate 6: Piped water supply

Plate 7: Water well using manual hand operated system

Plate 8: Shallow well that uses bucket and rope abstraction method

Plate 9: Borehole constructed by Plan International

Plate 10: Water abstraction along Rupingazi River using a portable pump

Plate 11: Water abstraction along Rupingazi using installed pump

2. Protection of water sources for sanitation

Plate 12: Concrete wall to protect the borehole

Plate 13: Fenced earth dam to keep livestock away

Plate 14: Improperly covered water well

Plate 15: Unprotected earth dam with livestock watering inside

Plate 16: Concrete covered well to keep water clean


Plate 17: Uncovered well with objects dumped into it


Plate 18: Spring with well conserved catchment

3. Gender and water resources

Plate 19: Young men on trail to collect water from a group managed borehole

Plate 20: Men and women participate in water collection


Plate 21: Women fetch water from Kamukororo spring


Plate 22: Women fetch water from a group owned borehole

4 Water uses

Plate 23: Water for irrigation


Plate 24: Water use in irrigated Khat production

Appendix 3: Attributes information for the water points[12]

A. River abstractions

LAT	LONG	X_PROJ	Y_PROJ	Owner	River	Division	Registration status	Ownership	Commonly used for
-0.731944	37.496944	332646.123304	9919372.233008	Moses Kathenya	Rupingazi	Gachoka	unknown	individual	irrigating
-0.730556	37.496389	332584.236947	9919525.778500	Fanuel J. Njiru	Rupingazi	Gachoka	unauthorized	individual	irrigating
-0.728889	37.494444	332367.749666	9919709.987372	Juma Magara	Rupingazi	Gachoka	authorized	individual	irrigating
-0.728056	37.494444	332367.718989	9919802.127363	Alfred Ngari	Rupingazi	Gachoka	authorized	individual	irrigating
-0.725556	37.493611	332274.873720	9920078.517674	David Nduhiu	Rupingazi	Gachoka	authorized	individual	not in use
-0.719444	37.485000	331316.191094	9920753.898652	Aqua farm	Rupingazi	Gachoka	authorized	individual	irrigating
-0.715278	37.479167	330666.757692	9921214.387719	Halai farm	Rupingazi	Gachoka	authorized	individual	irrigating
-0.711944	37.477222	330450.207847	9921582.881304	Peter Ngiri	Rupingazi	Gachoka	authorized	individual	irrigating
-0.709444	37.478611	330604.708562	9921859.355239	Njeru Kithaka	Rupingazi	Gachoka	unknown	individual	irrigating
-0.709444	37.478611	330604.708562	9921859.355239	Patrick Mureithi	Rupingazi	Gachoka	unknown	individual	irrigating
-0.704167	37.479722	330728.191151	9922442.954416	Joram Ngunguru	Rupingazi	Gachoka	authorized	individual	irrigating
-0.695556	37.480278	330789.720846	9923395.097555	Beram farm	Rupingazi	Gachoka	authorized	individual	irrigating
-0.678889	37.477222	330449.033116	9925237.810258	Fides kenya ltd	Rupingazi	Gachoka	authorized	company	irrigating
-0.676944	37.477778	330510.803245	9925452.826053	Beram farm II	Rupingazi	Gachoka	authorized	individual	irrigating
-0.670000	37.487500	331592.710391	9926221.001488	Karinga farm	Rupingazi	Gachoka	authorized	individual	irrigating
-0.666667	37.488056	331654.434650	9926589.582554	Highland canners	Rupingazi	Gachoka	authorized	individual	irrigating
0.665278	37.476944	330417.833440	10073861.159500	Waki farm	Rupingazi	Gachoka	authorized	individual	irrigating
-0.662778	37.476389	330355.725466	9927019.175757	Muthua farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.660556	37.480000	330757.591816	9927265.007727	Kanyue farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.658056	37.475278	330231.891614	9927541.270783	Gitonga farm	Rupingazi	Gachoka	authorized	individual	irrigating
-0.657778	37.474444	330139.125564	9927571.956509	Wanjira farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.656667	37.473889	330077.251465	9927694.792498	Muthui farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.656389	37.473611	330046.323202	9927725.497081	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating

[12] Detailed attributes information are provided in the database

-0.658889	37.472778	329953.651762	9927449.045103	Gachihi farm	Rupingazi	Gachoka	unknown	individual	not in use
-0.654722	37.473056	329984.430478	9927909.761134	Mwangi's farm	Rupingazi	Gachoka	unknown	individual	not in use
-0.651667	37.473889	330077.083990	9928247.639743	Munene's farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.649167	37.473889	330077.000734	9928524.063361	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating
-0.650278	37.473611	330046.118734	9928401.199231	Henry Mitaru	Rupingazi	Gachoka	unknown	individual	irrigating
-0.643056	37.477778	330509.660892	9929199.894129	Ngari kibuti farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.634722	37.814167	367949.271885	9930131.067298	Kinondo farm	Rupingazi	Gachoka	applied for permit	individual	irrigating
-0.634167	37.480278	330787.639625	9930182.813376	Kinondo farm II	Rupingazi	Gachoka	applied for a permit	individual	not in use
-0.639167	37.480278	330787.801919	9929629.967824	Rurima farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.639444	37.480000	330756.892037	9929599.245925	Wainaina Munderu	Rupingazi	Gachoka	unknown	individual	irrigating
-0.633333	37.482500	331034.962101	9930275.027215	Simon Ngangu	Rupingazi	Gachoka	unknown	individual	irrigating
-0.630833	37.480833	330849.368988	9930551.395790	Antony Kuria	Rupingazi	Gachoka	unknown	individual	irrigating
-0.630833	37.480833	330849.368988	9930551.395790	Mukami's farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.630000	37.481944	330973.016994	9930643.572218	Daniel Mbai	Rupingazi	Gachoka	unknown	individual	irrigating
-0.627222	37.482778	331065.685001	9930950.735420	Naomi Mugo	Rupingazi	Gachoka	unknown	individual	irrigating
-0.626111	37.482778	331065.649563	9931073.589715	Njeru's farm	Rupingazi	Gachoka	unknown	individual	irrigating
-0.626389	37.483611	331158.414208	9931042.902602	Mathew Kiura	Rupingazi	Gachoka	unknown	individual	irrigating
-0.613611	37.488333	331683.629833	9932455.876204	Abel Nguru	Rupingazi	Gachoka	unknown	individual	not in use
-0.619444	37.488333	331683.812188	9931810.892568	Ngari Nguru	Rupingazi	Gachoka	unknown	individual	irrigating
-0.613611	37.488333	331683.629833	9932455.876204	Godfrey Kiringa	Rupingazi	Gachoka	authorized	individual	irrigating
-0.613056	37.488056	331652.694696	9932517.293945	Mariko Njeru	Rupingazi	Gachoka	unknown	individual	irrigating
-0.611389	37.487778	331621.723964	9932701.566807	David Nyaga Ngari	Rupingazi	Gachoka	authorized	individual	irrigating
-0.611389	37.487778	331621.723964	9932701.566807	Rwika Technical Inst	Rupingazi	Gachoka	applied for a permit	Technical Institute	Domestic
-0.606944	37.484167	331219.642460	9933192.871875	Casper Wanjau	Rupingazi	Gachoka	authorized	individual	irrigating
-0.606389	37.483889	331188.706254	9933254.289804	Joseph Wanjau	Rupingazi	Gachoka	authorized	individual	irrigating
-0.605278	37.484444	331250.509062	9933377.161235	Joseph Njeru	Rupingazi	Gachoka	unknown	individual	irrigating
-0.605278	37.483611	331157.752943	9933377.135417	Johnstone Ndirica	Rupingazi	Gachoka	unknown	individual	irrigating
-0.604444	37.482500	331034.052036	9933469.242526	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating
-0.604167	37.482500	331034.043492	9933499.955272	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating

-0.603611	37.482500	331034.026417	9933561.382974	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating
-0.603611	37.482222	331003.107306	9933561.374383	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating
-0.603056	37.481944	330972.171126	9933622.792402	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating
-0.603889	37.480833	330848.521350	9933530.617526	owner not traced	Rupingazi	Gachoka	unknown	individual	irrigating
-0.600833	37.478333	330570.157300	9933868.390832	Tabitha Ngunguru	Rupingazi	Gachoka	authorized	individual	irrigating
-0.599167	37.479167	330662.863829	9934052.697729	Ngina Mutua	Rupingazi	Gachoka	unknown	individual	not in use
-0.599167	37.479167	330662.863829	9934052.697729	Mutua	Rupingazi	Gachoka	unknown	individual	irrigating
-0.599167	37.479167	330662.863829	9934052.697729	Francis M. Ngunguru	Rupingazi	Gachoka	unknown	individual	irrigating
-0.598611	37.479444	330693.764928	9934114.134062	M. Wachira	Rupingazi	Gachoka	unknown	individual	irrigating
-0.598333	37.480278	330786.513980	9934144.873547	Njoroge Kagwe	Rupingazi	Gachoka	unknown	individual	irrigating
-0.597500	37.479722	330724.650226	9934236.997053	Nalea Ngunguru	Rupingazi	Gachoka	unknown	individual	irrigating
-0.596944	37.478889	330631.876846	9934298.399294	Joel Kiamati	Rupingazi	Gachoka	unknown	individual	irrigating

B. Earth and Concrete dams

Lat	Long	X	Y	Water Point	Name	Ownership
-0.589769	37.561549	339832.276172	9935094.256850	Earth dam	John Kinyita E. dam	Private
-0.673678	37.549189	338459.101134	9925816.396220	Earth dam	J. Wachira E. dam	Private
-0.624490	37.566571	340392.241931	9931255.412310	Earth dam	Kiamuringa E. dam	Group
-0.639182	37.531172	336452.669632	9929629.861340	Earth dam	Ivinge E. dam	Group
-0.720751	37.505512	333599.269589	9920610.188670	Earth dam	Ciarugaga E. dam	Group
-0.627760	37.511636	334277.799370	9930892.152060	Earth dam	Gachoka E. dam	Group
-0.670077	37.521115	335334.284977	9926213.616820	Earth dam	Kwigaca-Kathuriri E. d	Group
-0.733420	37.525590	335834.554856	9919210.152930	Earth dam	Muige E. dam	Private
-0.570917	37.541435	337592.888524	9937177.981770	Earth dam	Kabathi quarry dam	Private
-0.584693	37.557673	339400.739992	9935655.280680	Earth dam	Grace Kariuki E. dam	Private
-0.589769	37.561549	339832.276172	9935094.256850	concrete dam	Kigondore C. dam	Group

C. Boreholes

LAT	LONG	X	Y	Water Point	NAME
-0.655618	37.561192	339794.466021	9927813.557210	borehole	Carlo Liviero BH
-0.660346	37.554185	339014.714527	9927290.666440	borehole	Kangungi BH
-0.622164	37.533212	336679.164005	9931511.650460	borehole	Gachoka BH
-0.626832	37.541306	337672.988448	9930699.977228	borehole	Itabua BH
-0.592545	37.544577	338036.098361	9934490.718927	borehole	muteme cBH
-0.564764	37.539108	337426.499306	9937561.906927	borehole	KwaThatia BH
-0.570316	37.569987	340863.745973	9936948.981095	borehole	Ciakarangu BH
-0.592470	37.553564	339036.401392	9934499.245837	borehole	Kamuga BH
-0.601785	37.543814	337951.384980	9933469.183697	borehole	Kavorori BH
-0.680894	37.541497	337696.071371	9924723.110289	borehole	Kangami BH
-0.582886	37.557065	339332.930092	9935855.135420	borehole	Kanyariri BH
-0.609691	37.552116	338782.941741	9932891.288210	borehole	Mumbu wa Nguru H
-0.619409	37.556947	339320.903231	9931816.942280	borehole	Irianthage BH
-0.632594	37.553450	338932.062846	9930359.023740	borehole	Muraru BH
-0.641963	37.555103	339116.318276	9929323.221190	borehole	Mutuathiti BH
-0.627460	37.528054	336105.255943	9930925.862660	borehole	Ngenge BH
-0.663120	37.501067	333102.525368	9926982.123400	borehole	Joseph Njeru BH
-0.665658	37.527631	336059.333696	9926702.458630	borehole	Kiamakumi BH
-0.658068	37.508622	333943.264620	9927541.059380	borehole	Kangeta BH
-0.645591	37.519821	335189.411349	9928920.906450	borehole	Kaninwanthiga pry BH
-0.646546	37.520175	335228.849545	9928815.350640	borehole	Kaninwanthiga pry BH
-0.644265	37.519626	335167.705552	9929067.550860	borehole	Gachoka catholic BH
-0.617866	37.504724	333508.211659	9931985.909530	borehole	Rwika Dispensary BH
-0.630239	37.500686	333059.042769	9930617.730290	borehole	Kwa Muturi BH
-0.603651	37.510258	334123.717002	9933557.813090	borehole	Daniel ng'ang'a BH
-0.604571	37.500924	333084.761316	9933455.862580	borehole	Muthoni Githima BH
-0.585802	37.494780	332400.314408	9935530.867360	borehole	St Lukes School BH
-0.587502	37.502930	333307.517665	9935343.188050	borehole	Kamutungi farm BH
-0.564706	37.539123	337335.378324	9937864.660500	borehole	Kiamuringa BH

D. Water Springs

LAT	LONG	X	Y	Water point	Name/ location
-0.616824	37.550472	338600.111178	9932102.500910	water spring	Kaunvari
-0.645192	37.550462	338599.870742	9928965.970870	water spring	Gatata ishoni
-0.646431	37.550064	338555.614147	9928829.049340	water spring	Gatata
-0.664310	37.555060	339112.211965	9926852.332820	water spring	Kiama
-0.619120	37.545958	338097.781691	9931848.555140	water spring	Kathuri Spring
-0.651647	37.567609	340508.600579	9928252.888990	water spring	Karuri spring
-0.613614	37.530235	336347.557469	9932456.843090	water spring	Kathuri Spring
-0.615974	37.533169	336674.142621	9932196.013260	water spring	Gakanae
-0.600971	37.520346	335246.470678	9933854.404880	water spring	Gitithini spring
-0.644378	37.544788	337968.340034	9929055.825110	water spring	Mwanya Kathima
-0.623624	37.557050	339425.349360	9931055.125172	water spring	ka mwaniki spring
-0.636466	37.541173	337658.527988	9929634.849396	water spring	ceasar mutimu
-0.627303	37.542571	337813.824538	9930647.946564	water spring	Katheru
-0.597891	37.543786	337948.172197	9933899.657289	water spring	muteme spring
-0.639883	37.528622	336168.842401	9929552.294190	water spring	Ivinge spring
-0.650038	37.506163	333669.366925	9928428.812900	water spring	Kamukororo spring
-0.605995	37.516939	334867.373756	9933298.818240	water spring	Murigi spring
-0.635351	37.512579	334382.986654	9930052.911750	water spring	Githima kia Mukuu
-0.610336	37.510287	334127.073067	9932818.625550	water spring	Ngugi's spring
-0.600921	37.520272	335238.184666	9933859.981860	water spring	Gitituri spring
-0.615928	37.533207	336678.460986	9932201.065120	water spring	Gakanai spring
-0.568917	37.523020	335543.183035	9937398.678770	water spring	Kisima ya Mukuuri
-0.576814	37.531065	336438.812822	9936525.706210	water spring	kamavidi spring

E. Water holes

LAT	LONG	X	Y	Water Point	Location
-0.653154	37.485462	331365.277354	9928083.627700	undeveloped water ho	Duncan Nkonge farm
-0.625341	37.510666	334169.799186	9931159.613120	undeveloped water ho	Mr Mwaura farm

F. Piped Installations

LAT	LONG	X	Y	Water Point	Owner/ Location
-0.601565	37.557655	339399.171572	9933789.831780	piped water	Stephen Kagai Wega
-0.602582	37.559355	339588.420333	9933677.531910	piped water	Gitundu Justus Njeru
-0.639378	37.526574	335940.860763	9929608.057500	piped water	Agnes Njagi
-0.605254	37.556673	339289.957454	9933382.016220	piped water	Gaya Academy tank
-0.629130	37.528377	336141.272616	9930741.290530	piped water	ACK Ngenge church
-0.628315	37.525658	335838.570860	9930831.324010	piped water	Ngenge school
-0.637187	37.524911	335755.666946	9929850.259830	piped water	Andrea Muturi
-0.638086	37.526438	335925.706976	9929750.949680	piped water	Moses Ngari
-0.638816	37.526559	335939.154506	9929670.223180	piped water	Elikana Njeru
-0.635965	37.523268	335572.743036	9929985.329280	piped water	Dedan Kimwea
-0.634775	37.524242	335681.189142	9930116.932550	piped water	Johnson Kamau Kimani
-0.633135	37.524005	335654.753886	9930298.291240	piped water	Mary Charles Kithetu
-0.632401	37.523206	335565.745724	9930379.404430	piped water	Benjamin Ngari
-0.631499	37.523322	335578.638904	9930479.164890	piped water	Gabriel Njeru
-0.630842	37.524202	335676.624846	9930551.822880	piped water	Ayub Njagi
-0.629119	37.525070	335773.112811	9930742.345740	piped water	Chrispin Mugo
-0.611801	37.517334	334911.548839	9932656.916820	piped water	James Kariuki
-0.610984	37.516846	334857.159926	9932747.261820	piped water	Regina Musyoka
-0.619331	37.526906	335977.200556	9931824.644850	piped water	David Kariuki
-0.620565	37.525176	335784.677909	9931688.154280	piped water	Ernest Enimalinka
-0.619481	37.523543	335602.887328	9931807.980420	piped water	Mwangangi Ndaru
-0.623415	37.519379	335139.507806	9931372.893880	piped water	Jacob kabunga
-0.621903	37.527512	336044.722610	9931540.297000	piped water	Margaret Wambui Njoka
-0.682363	37.486291	331458.594666	9924854.040890	piped water	Yoda Karwigi pry school
-0.627425	37.521611	335388.087312	9930929.581970	piped water	Elijah Njeru
-0.609098	37.516124	334776.803185	9932955.714340	piped water	Danson Nyaga
-0.609788	37.516698	334840.703767	9932879.422760	piped water	Quinto Nyaga Barnabas
-0.610367	37.517599	334940.957947	9932815.438480	piped water	Michael Ndwiga Ngari

-0.611775	37.518371	335026.926655	9932659.831040	piped water	Barnabas Ngari
-0.600886	37.511900	334306.354525	9933863.612950	piped water	Leonard Macharia Ngugi
-0.600505	37.511816	334297.050130	9933905.722270	piped water	Harun Muchemi Ngugi
-0.625071	37.523141	335558.249192	9931189.818160	piped water	Mary Mwangi
-0.626375	37.522793	335519.554228	9931045.649020	piped water	Mathiew Nyaga
-0.635991	37.518369	335027.452658	9929982.346450	piped water	Andriano Kithaka
-0.639069	37.521476	335373.404554	9929642.045860	piped water	Stephen Kathanje
-0.640770	37.522214	335455.660683	9929454.084550	piped water	Musau Wambua
-0.641086	37.522717	335511.582618	9929419.106170	piped water	Titus Karoki
-0.642275	37.521505	335376.762090	9929287.625330	piped water	John Karoki
-0.613446	37.505688	333615.281161	9932474.717800	piped water	Christopher Waboyo Justus
-0.612693	37.502868	333301.419076	9932557.826190	piped water	Rwika Technical Institute
-0.613002	37.503726	333396.870672	9932523.748070	piped water	Rwika Family Life Centre
-0.612669	37.506261	333679.100497	9932560.563790	piped water	Elias Ngari
-0.611720	37.507622	333830.518329	9932665.524610	piped water	Benson Kumbu Nderi
-0.609820	37.508008	333873.432306	9932875.709090	piped water	Cyrus Njiru
-0.608317	37.505830	333631.013168	9933041.737080	piped water	Hosea Mugo
-0.608965	37.503900	333416.189963	9932970.038660	piped water	Nicholas Kithumbu Mugo
-0.608202	37.507709	333840.141333	9933054.509990	piped water	Julius Mainge
-0.607406	37.508810	333962.652216	9933142.568820	piped water	Dr. Wanjala
-0.607994	37.509448	334033.696945	9933077.612170	piped water	Harun Utuku
-0.608669	37.495458	332476.472292	9933002.539610	piped water	Ismael Nyaga
-0.616748	37.505880	333636.738230	9932109.566980	piped water	Njiru
-0.599246	37.509946	334088.831366	9934044.903550	piped water	Gerald Njuki
-0.603071	37.506544	333710.295752	9933621.786360	piped water	Mr. Warurii
-0.602144	37.506433	333697.942758	9933724.366650	piped water	Nicholas Mugo
-0.602112	37.505866	333634.808643	9933727.815720	piped water	Maria Wamugoiri
-0.602929	37.505370	333579.657432	9933637.543050	piped water	Jackson
-0.601263	37.505547	333599.208292	9933821.679180	piped water	Stephen Nyaga
-0.600676	37.505635	333609.071299	9933886.638250	piped water	Alfam Nyaga Njeru
-0.607225	37.499367	332911.562917	9933162.278680	piped water	Mrs Wawira

-0.606613	37.499216	332894.750207	9933230.011390	piped water	J.T. Mwangi
-0.605817	37.499415	332916.874913	9933317.967810	piped water	Sophia Nyaga
-0.606251	37.502884	333303.050693	9933270.114220	piped water	Nichaus Njeru
-0.603753	37.503499	333371.407361	9933546.338330	piped water	Nathaniel Mbiti Murichu
-0.602393	37.503638	333386.807808	9933696.664040	piped water	Anthony Kamau
-0.603672	37.505748	333621.738281	9933555.313120	piped water	Hannah Njeri Muiruri
-0.604886	37.505359	333578.466722	9933421.086320	piped water	Simon Muiruri
-0.601913	37.502551	333265.768212	9933749.744470	piped water	Peter Kamau
-0.600096	37.502725	333285.100821	9933950.617450	piped water	Sammy Njeru
-0.600443	37.500556	333043.697546	9933912.276260	piped water	Felicio Ngiri
-0.600790	37.499931	332974.136672	9933873.889020	piped water	Daminion Munyiri
-0.600075	37.499824	332962.257547	9933952.883370	piped water	Jacob Ngari
-0.596830	37.498348	332797.808108	9934311.628850	piped water	John N. Nyaga
-0.596505	37.495930	332528.628356	9934347.561080	piped water	Nicholas Njue
-0.596663	37.495868	332521.813322	9934330.042990	piped water	Patrick Munyi
-0.597753	37.494346	332352.418523	9934209.517130	piped water	Kiboi
-0.597703	37.494652	332386.405866	9934214.966370	piped water	Monica Mairu
-0.600495	37.495802	332514.502625	9933906.283550	piped water	James Gatumu
-0.602555	37.494269	332343.972265	9933678.472570	piped water	Emaculate Njoki
-0.605657	37.492912	332192.972799	9933335.533890	piped water	Martha Mwaura
-0.605196	37.493563	332265.430909	9933386.434220	piped water	Gasper Njoroge
-0.605691	37.493875	332300.161652	9933331.810870	piped water	Ignatius Mwangi
-0.603521	37.499404	332915.563971	9933571.819700	piped water	Simon Muthari
-0.602944	37.499511	332927.422915	9933635.621860	piped water	Marion Nyawira
-0.599700	37.505145	333554.463773	9933994.499980	piped water	Peter Njuguna
-0.588366	37.489128	331771.335941	9935247.169880	piped water	Edwad Njeru
-0.587652	37.489693	331834.159080	9935326.167080	piped water	Njagi Njeru
-0.587156	37.490766	331953.583188	9935381.054490	piped water	Joseph Thimba
-0.590864	37.489524	331815.520714	9934971.067620	piped water	Rosemary
-0.590592	37.489583	331821.987354	9935001.125240	piped water	Mwangi Gachie
-0.585557	37.491171	331998.635437	9935557.876740	piped water	Stanley Githee Gacheru

-0.583817	37.493735	332283.942622	9935750.295710	piped water	Simon Ngugi
-0.585802	37.494780	332400.314408	9935530.867360	piped water	St Lukes School for the deaf
-0.591791	37.497592	332713.494475	9934868.753610	piped water	Jaco Thiri
-0.596214	37.512050	334322.877549	9934380.205280	piped water	Karumba
-0.594540	37.511113	334218.615917	9934565.225240	piped water	Simon Nyaga
-0.595577	37.510458	334145.679690	9934450.508400	piped water	Alfaxad Karuiki
-0.596452	37.510957	334201.328990	9934353.769040	piped water	John Kiamati
-0.601902	37.518364	335025.844240	9933751.399560	piped water	James Mugo
-0.598816	37.514862	334635.981058	9934092.520260	piped water	Elshadai Njoroge
-0.600303	37.517037	334878.118780	9933928.224030	piped water	Paul Papuu
-0.597355	37.509163	334001.618398	9934253.940080	piped water	Selesten Muriithi
-0.603690	37.518597	335051.834308	9933553.812030	piped water	Tiras Ndwiga
-0.608269	37.521852	335414.359630	9933047.583110	piped water	Peter Muguna
-0.616196	37.528332	336135.790656	9932171.342880	piped water	Alice Ngari
-0.619709	37.535225	336903.163675	9931783.076480	piped water	Edward Chege
-0.569516	37.524406	335697.482947	9937332.408920	piped water	Eunice Wanjira Gichovi
-0.568797	37.528717	336177.329906	9937412.083720	piped water	Charles Muriithi Njeru
-0.568574	37.536504	337044.068215	9937436.973730	piped water	Kiamuringa sec school
-0.568574	37.536504	337044.068215	9937436.973730	piped water	Kiamuringa sec school
-0.570758	37.538699	337288.405317	9937195.522420	piped water	Kiamuringa CPK church
-0.570725	37.537460	337150.466552	9937199.129570	piped water	Kiamuringa boarding pry school
-0.573330	37.538889	337309.608778	9936911.162770	piped water	James Mwangi
-0.574640	37.540079	337442.068097	9936766.316160	piped water	Lawrence Karanja
-0.569512	37.542062	337662.726955	9937333.434150	piped water	Mrs Murekio
-0.572813	37.544178	337898.342542	9936968.455810	piped water	Michael Karanja
-0.572516	37.548868	338420.273568	9937001.486390	piped water	Alex Ngari Njeru
-0.570641	37.534755	336849.418674	9937208.367400	piped water	Alsaviour Ruguru
-0.571847	37.533576	336718.167225	9937074.945710	piped water	Ndwiga Njeru
-0.572426	37.533271	336684.298633	9937010.991020	piped water	Francis Njuguna
-0.573369	37.533204	336676.843217	9936906.729420	piped water	Peter Kiguru Kariuki
-0.570059	37.532169	336561.567371	9937272.610860	piped water	Lawrence Mugo Mungai

G. Shallow Wells

LAT	LONG	X	Y	Water point	Name / location
-0.617409	37.561237	339798.376538	9932038.165170	shallow well	Peterson Mbaka
-0.617039	37.562125	339897.116308	9932079.163840	shallow well	David thungi kiura
-0.617340	37.563025	339997.369735	9932045.874280	shallow well	David Kiura
-0.633047	37.545814	338082.104594	9930308.734000	shallow well	Joseph Chege
-0.636281	37.549386	338479.823505	9929951.276780	shallow well	Justin Nyaga Nathan
-0.634292	37.547771	338300.058523	9930171.088550	shallow well	Samuel Ndii
-0.645119	37.557306	339361.582313	9928974.258880	shallow well	Ruturi
-0.634278	37.546239	338129.554829	9930172.635230	shallow well	Andrew Njue
-0.634682	37.546441	338151.976165	9930127.980670	shallow well	Francis N Kabaara
-0.634831	37.545113	338004.146756	9930111.434000	shallow well	Maina Gituko
-0.635679	37.546279	338133.945753	9930017.710570	shallow well	Felix Mureithi Njuguna
-0.635276	37.543752	337852.754693	9930062.190830	shallow well	Mrs Njeru
-0.630750	37.559819	339640.906705	9930563.076760	shallow well	Peter Nyaga
-0.635253	37.554473	339046.047206	9930065.063110	shallow well	Mr Njeru
-0.633207	37.553869	338978.682306	9930291.235750	shallow well	Benson Nyaga
-0.633631	37.553460	338933.233341	9930244.366600	shallow well	Benson njagi
-0.634388	37.554848	339087.694875	9930160.724820	shallow well	Muriithi James
-0.633272	37.554732	339074.813921	9930284.107770	shallow well	Eston thiga thitima
-0.639015	37.553576	338946.282983	9929649.046140	shallow well	Njoka Gituuro
-0.645587	37.553776	338968.766298	9928922.416460	shallow well	Ephantus njiru raini
-0.647044	37.549348	338475.951217	9928761.170330	shallow well	Ignatius Njuki
-0.647475	37.550729	338629.693915	9928713.615620	shallow well	Joshua Mungai Kuria
-0.647413	37.558880	339536.895321	9928720.703900	shallow well	Kiura Ngiri
-0.650921	37.558588	339504.492684	9928332.832030	shallow well	Peter Nthiga
-0.649275	37.557039	339332.072449	9928514.777770	shallow well	Peter Nthiga
-0.650542	37.556246	339243.773195	9928374.730550	shallow well	Jane Muthoni
-0.648406	37.556234	339242.464994	9928610.819170	shallow well	Tabitha Muthoni
-0.648216	37.555233	339130.955417	9928631.805960	shallow well	Leornard Njeru

-0.647463	37.556476	339269.360757	9928715.131900	shallow well	Muchiri wa gitundu
-0.647272	37.556913	339317.941972	9928736.257010	shallow well	James Njeru Njiru
-0.649063	37.561089	339782.793159	9928538.389740	shallow well	Enos Mwenje
-0.650977	37.559702	339628.500490	9928326.695570	shallow well	Mbungu Macuke
-0.651773	37.565130	340232.671878	9928238.854170	shallow well	Josephat Mugo Njeru
-0.651559	37.565050	340223.765412	9928262.464990	shallow well	Catherine Njiru
-0.651615	37.567088	340450.551915	9928256.440480	shallow well	John maceki rubuchi
-0.653194	37.566240	340356.320328	9928081.834130	shallow well	John maceki rubuchi
-0.655969	37.564376	340148.877315	9927774.855780	shallow well	David Miti Njuki
-0.655859	37.566123	340343.333986	9927787.116570	shallow well	David Miti Njuki
-0.660059	37.558852	339534.207464	9927322.547800	shallow well	Bernard njeru Mbugi
-0.659425	37.557562	339390.563098	9927392.605790	shallow well	Bernard njeru
-0.659282	37.554577	339058.313530	9927408.245470	shallow well	Celestino Njagi Mbugi
-0.658850	37.554450	339044.222108	9927456.006750	shallow well	Vincent mureithi njagi
-0.661884	37.553710	338961.940546	9927120.565020	shallow well	Joseph Nyaga
-0.656977	37.552298	338804.650105	9927663.121740	shallow well	gerald Njiru Muturi
-0.658643	37.544703	337959.269509	9927478.620190	shallow well	John nyaga raini
-0.658665	37.551537	338719.956672	9927476.394100	shallow well	Timina wa Misheck Maingi
-0.658403	37.551685	338736.386652	9927505.405730	shallow well	Nyambura
-0.658696	37.552085	338780.934011	9927473.028450	shallow well	Kwa Nyambura
-0.655115	37.547975	338323.401766	9927868.785250	shallow well	Cyrus Mbui Marioki
-0.654917	37.544906	337981.763576	9927890.641600	shallow well	Charles Mwangi Theuri
-0.654745	37.546173	338122.799809	9927909.680890	shallow well	Eston Ngari Karani
-0.653370	37.546081	338112.568324	9928061.702610	shallow well	James Mbugi
-0.647851	37.542281	337689.436360	9928671.783160	shallow well	Mwangi Jason
-0.648288	37.541593	337612.827466	9928623.430580	shallow well	Kariuki Benjamin njuki
-0.653179	37.550389	338592.025559	9928082.896710	shallow well	James Mbiti Mwithi
-0.628380	37.543747	337851.982006	9930824.611150	shallow well	Abija Kaoge
-0.624281	37.548041	338329.726962	9931277.980030	shallow well	Jason Maringa kiondo
-0.623698	37.548507	338381.628169	9931342.496100	shallow well	Jason Maringa kiondo
-0.623160	37.546792	338190.676190	9931401.848400	shallow well	Felista Ndwiga

-0.620944	37.547235	338239.999150	9931646.904360	shallow well	Ephantus mugo
-0.619954	37.549096	338447.007350	9931756.401060	shallow well	Francis Kariuki Murage
-0.619011	37.548674	338400.107586	9931860.703650	shallow well	John Ngari Machango
-0.618566	37.548819	338416.187666	9931909.890960	shallow well	Charles Namu
-0.618695	37.548889	338423.999532	9931895.666600	shallow well	Charles Namu
-0.618527	37.549789	338524.183866	9931914.192610	shallow well	Bernard Mbogo Mugo
-0.618642	37.551025	338661.758124	9931901.597920	shallow well	Celefine Mureithi Mugo
-0.619050	37.550993	338658.197552	9931856.417650	shallow well	Celefine Mureithi Mugo
-0.619421	37.550657	338620.788268	9931815.408650	shallow well	Celefine Mureithi Mugo
-0.619751	37.551060	338665.663793	9931778.887810	shallow well	Joseph Njagi
-0.622325	37.551175	338678.550349	9931494.305560	shallow well	Samuel Njue James
-0.635110	37.566849	340423.490183	9930081.209550	shallow well	Agatha Njuki Jonah
-0.633369	37.565084	340226.962666	9930273.695120	shallow well	Dickson Njiri Jonah
-0.631941	37.564418	340152.779039	9930431.518220	shallow well	Murage
-0.628404	37.563064	340001.974830	9930822.581460	shallow well	James Njiru Meti
-0.623891	37.567111	340452.277601	9931321.708870	shallow well	Titus Njeru Mbeceni
-0.624661	37.563271	340024.886004	9931236.489850	shallow well	Stephen Njagi Ngungi
-0.624233	37.562741	339965.883450	9931283.710460	shallow well	Stephen Njagi Ngungi
-0.623678	37.563758	340079.115734	9931345.184410	shallow well	Benjamin Kariuki Ngungi
-0.624273	37.562420	339930.200762	9931279.316850	shallow well	Alikumbi Ngarano
-0.624082	37.561099	339783.126386	9931300.388080	shallow well	Fred njiru Njagi
-0.626266	37.558911	339539.669072	9931058.894930	shallow well	Eston Ngungi Njoka
-0.628203	37.559758	339633.990771	9930844.666540	shallow well	Dickson Kiregene
-0.621463	37.564319	340141.462710	9931590.056170	shallow well	Danson Muriuki Njuuri
-0.620781	37.567558	340501.947156	9931665.599690	shallow well	Edward Njuri Kombo
-0.617192	37.560414	339706.680344	9932062.106540	shallow well	James mbiti mbaka
-0.616910	37.559826	339641.292131	9932093.310290	shallow well	Nicholas Mugo Nthiga
-0.617343	37.559660	339622.851990	9932045.448310	shallow well	Nicholas Mugo Nthiga
-0.619180	37.560600	339727.451041	9931842.399420	shallow well	Josephat Kanyi Mbaka
-0.615383	37.560072	339668.581776	9932262.133970	shallow well	Eston Nthiga Kithumbu
-0.613125	37.554459	339043.809245	9932511.622330	shallow well	Peter Nthiga nguru

-0.612733	37.556418	339261.854421	9932555.053460	shallow well	Jonas Nguru
-0.612733	37.556418	339261.854421	9932555.053460	shallow well	Godfrey Njeru Gikunju
-0.612229	37.555082	339113.072739	9932610.757250	shallow well	Jonah Nguru
-0.612916	37.557264	339355.927287	9932534.801030	shallow well	Joseph Ireri Sylvano
-0.612354	37.557376	339368.431194	9932596.989590	shallow well	Ezekiel Nyaga Sylvano
-0.613174	37.558403	339482.750154	9932506.300370	shallow well	Manasehh njeru
-0.613223	37.559089	339559.168375	9932500.927490	shallow well	Josephat Njiru Sylvano
-0.611070	37.559019	339551.295595	9932738.997590	shallow well	Edwin Wachira
-0.612596	37.561860	339867.513589	9932570.348700	shallow well	Lincoln Mbugi
-0.614267	37.559589	339614.764413	9932385.562150	shallow well	Michael Kithu Ngari
-0.614180	37.559310	339583.742570	9932395.191790	shallow well	Peter Kinyua Mureru
-0.610552	37.554147	339008.971519	9932796.134200	shallow well	Mutua George Mwania
-0.637015	37.554493	339048.265290	9929870.279580	shallow well	Josephat Kariuki Ngari
-0.637570	37.554963	339100.620701	9929808.943700	shallow well	Isaac Macharia Wahome
-0.636305	37.555880	339202.644779	9929948.763260	shallow well	Eunice N Njoka
-0.636019	37.554986	339103.100539	9929980.392570	shallow well	Maurice Ndie Njoka
-0.636814	37.556480	339269.402496	9929892.509660	shallow well	Josephant Njeru Njoka
-0.625875	37.555721	339184.674265	9931101.956790	shallow well	Nelson nduma njogu
-0.628966	37.561966	339879.860943	9930760.362910	shallow well	Godfrey Njeru Gikunju
-0.642471	37.553052	338888.081837	9929267.005140	shallow well	Alfred munyi
-0.647706	37.553222	338907.109467	9928688.181550	shallow well	Benson mugo
-0.651059	37.553173	338901.860345	9928317.461820	shallow well	Moses mugo mati
-0.654592	37.556366	339257.354429	9927926.884130	shallow well	Francis Kituko
-0.653172	37.555168	339123.928196	9928083.910580	shallow well	Boniface naggari nguru
-0.652306	37.564140	340122.546755	9928179.909500	shallow well	John Njeru
-0.652306	37.564140	340122.546755	9928179.909500	shallow well	jonathan njeru
-0.669283	37.554516	339051.816164	9926302.549770	shallow well	joseph Nthiga ireri
-0.668815	37.555154	339122.815535	9926354.319630	shallow well	Simon Njagi Ireri
-0.669076	37.553425	338930.415846	9926325.376840	shallow well	Salome Mutuku
-0.670942	37.555072	339113.853507	9926119.117910	shallow well	Peter njaga
-0.671365	37.552278	338802.865971	9926072.216200	shallow well	Henry Njeru muraaru

-0.671516	37.551437	338709.288501	9926055.488770	shallow well	Peter kithumbi muria
-0.671543	37.550742	338631.930465	9926052.519360	shallow well	Anthony Ngare muria
-0.673465	37.554246	339021.911743	9925840.074590	shallow well	Muria fulana
-0.673772	37.552707	338850.626747	9925806.114620	shallow well	Silas Nyaki Muria
-0.654140	37.556498	339271.996503	9927976.839510	shallow well	John murage
-0.654209	37.556260	339245.447310	9927969.288040	shallow well	John murage
-0.654541	37.555688	339181.850341	9927932.524520	shallow well	John murage
-0.654917	37.555150	339121.958926	9927890.933660	shallow well	Samuel njiru kiura
-0.658055	37.556215	339240.606541	9927544.039180	shallow well	David nutegi njagi
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-0.676975	37.545989	338103.006463	9925451.725100	shallow well	John njue mwaniki
-0.676195	37.546672	338179.089764	9925538.037790	shallow well	Jenesio Kariuki
-0.678412	37.544884	337980.065153	9925292.842780	shallow well	Julius kazungu
-0.683844	37.546651	338176.899216	9924692.282870	shallow well	Simon Mureithi Nyaga
-0.690768	37.547837	338309.149689	9923926.762230	shallow well	Jonstone ndege muvunjia
-0.673678	37.549189	338459.101134	9925816.396220	shallow well	Elias ngare
-0.665814	37.558175	339458.983234	9926686.165740	shallow well	Boniface nyaga Ndia
-0.667204	37.556461	339268.262885	9926532.492920	shallow well	Celestial Njagi Kiende
-0.666661	37.555819	339196.801183	9926592.460360	shallow well	Peter Mureithi njagi Kiende
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-0.647616	37.561252	339800.903615	9928698.398000	shallow well	Chrispin njuki Gitabari
-0.651304	37.573838	341201.902877	9928291.007430	shallow well	Margaret Ruri
-0.646229	37.566577	340393.559396	9928851.913090	shallow well	Joseph Njue
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-0.646871	37.567348	340479.371517	9928780.920350	shallow well	Peterson Mbaka
-0.647104	37.570475	340827.501146	9928755.236680	shallow well	Kamau
-0.646653	37.567105	340452.319282	9928805.045720	shallow well	Nicasio njiru njoka
-0.642990	37.565494	340272.877936	9929209.944550	shallow well	Njue njiru
-0.643138	37.565048	340223.288169	9929193.564860	shallow well	Joseph Njagi Njeru
-0.639282	37.565516	340275.217763	9929619.927410	shallow well	Thiongo Githinji

-0.637797	37.565940	340322.433608	9929784.141480	shallow well	Ngare mboco
-0.639473	37.566756	340413.306067	9929598.845730	shallow well	David Njeru
-0.609679	37.558223	339462.644381	9932892.794410	shallow well	David njeru
-0.609012	37.557910	339427.769905	9932966.471290	shallow well	Peter Kariuki Njeru
-0.607317	37.549656	338509.025012	9933153.707510	shallow well	Peter Njue Njagi
-0.600503	37.556649	339287.197592	9933907.323230	shallow well	Stephen Ngungi Mwanganja
-0.599673	37.556431	339262.879134	9933998.980970	shallow well	James njue
-0.599056	37.556730	339296.083302	9934067.291380	shallow well	Faith Muturi Nyaga
-0.591358	37.557942	339430.783597	9934918.376870	shallow well	Joseph Mugo
-0.588704	37.558863	339533.267050	9935211.857650	shallow well	Patrick Thambiri Mugo
-0.603417	37.556270	339245.084883	9933585.054160	shallow well	Danson Mwaniki Migwi
-0.600445	37.559280	339580.036037	9933913.748790	shallow well	Franic Mwangi Muga
-0.602582	37.559355	339588.420333	9933677.531910	shallow well	Gitundu Justus Njeru
-0.603402	37.558358	339477.508611	9933586.756320	shallow well	Justus Nyaga Njoka
-0.594178	37.557419	339372.733541	9934606.566820	shallow well	Njeru Runji
-0.591165	37.558859	339532.926485	9934939.810910	shallow well	Gilbert Ndaro Kathuri
-0.592416	37.560887	339758.631586	9934801.488180	shallow well	Peninah Kagendo
-0.588046	37.550356	338586.421578	9935284.372070	shallow well	Gerald Njeru Mugiire
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-0.620231	37.534915	336868.632758	9931725.375660	shallow well	Samuel Njiru
-0.640480	37.545572	338055.457812	9929486.873080	shallow well	Celestino Njeru Ngare
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-0.644953	37.544824	337972.286041	9928992.260800	shallow well	Alexander njeru nguo
-0.633891	37.556882	339314.112247	9930215.669030	shallow well	JohnMurage
-0.624204	37.560024	339663.480986	9931286.862110	shallow well	Ngarano Ngari
-0.625933	37.560761	339745.603927	9931095.771650	shallow well	Joseph maina ngoco

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-0.624191	37.551285	338783.679468	9930992.240781	shallow well	david ireri mbaka
-0.625318	37.558211	339554.624291	9930867.880998	shallow well	stephen mwangi jesengo
-0.624745	37.557617	339488.423182	9930931.210468	shallow well	dictator mureithi mwaniki
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-0.651087	37.550794	338729.855077	9928018.730452	shallow well	njeru fredrick mtetu
-0.653170	37.548099	338429.939684	9927788.413355	shallow well	jeremiah muriuki
-0.650914	37.545935	338188.996848	9928037.756534	shallow well	justus mureithi njagi
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-0.618410	37.560640	339824.748724	9931631.683602	shallow well	dominic mugo mbaka
-0.619197	37.561060	339871.485377	9931544.700402	shallow well	samuel kithu mbaka
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-0.620617	37.567234	340558.731869	9931387.891757	shallow well	edward njuri kombo
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-0.617448	37.563557	340149.425934	9931738.105274	shallow well	jacob kinyua njeru
-0.614591	37.562861	340071.812025	9932053.993221	shallow well	ephantus kithuo mbaka
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-0.615721	37.562606	340043.483707	9931929.042514	shallow well	augustine mbaka
-0.616356	37.563874	340184.640824	9931858.858324	shallow well	jacob kinyua njeru
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-0.617172	37.563711	340166.527531	9931768.587742	shallow well	agostino nyaga
-0.616727	37.563282	340118.747330	9931817.835614	shallow well	silas mwangangi njeru
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-0.615398	37.563843	340181.235257	9931964.784626	shallow well	michael mugo mbaka
-0.658801	37.562647	340049.449946	9927166.328617	shallow well	geodfrey nyaga machaki
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-0.658375	37.544596	338040.197112	9927212.792859	shallow well	chalres njue raini

-0.659539	37.544016	337975.654781	9927084.106338	shallow well	chalres njue raini
-0.658762	37.544511	338030.805189	9927170.015816	shallow well	joseph nyaga raini
-0.657119	37.545295	338117.983688	9927351.658364	shallow well	njeru wanjuki
-0.658112	37.544841	338067.468472	9927241.954339	shallow well	ephatus njue nguru
-0.654254	37.544986	338083.493833	9927668.485922	shallow well	john nyaga raini
-0.653804	37.552159	338881.834907	9927718.423625	shallow well	peter mwai mburati
-0.637295	37.549312	338564.445761	9929543.448095	shallow well	jacob kibugi
-0.638963	37.545923	338187.267661	9929359.026946	shallow well	festus nduma nderi
-0.638117	37.545959	338191.252418	9929452.465050	shallow well	ethan njiru
-0.635281	37.547564	338369.871613	9929766.053841	shallow well	ezekiel njiru
-0.651647	37.567609	340601.472031	9927957.400905	shallow well	mrs njagi nyaga
-0.663556	37.551944	338858.293494	9926640.259419	shallow well	bernard ireri ngari
-0.663932	37.551203	338775.822272	9926598.655004	shallow well	samuel njiru kagio
-0.681837	37.548446	338469.480474	9924619.111826	shallow well	geodfrey ndicho
-0.605226	37.556246	339242.395276	9933385.061850	shallow well	Gaya Academy tank
-0.628315	37.525658	335838.570860	9930831.324010	shallow well	Ngenge school
-0.642657	37.527349	336027.196941	9929245.561500	shallow well	James Watuna
-0.639994	37.524854	335749.421269	9929539.941110	shallow well	Eranest Muturi
-0.637187	37.524911	335755.666946	9929850.259830	shallow well	Andrea Muturi
-0.638086	37.526438	335925.706976	9929750.949680	shallow well	Moses Ngari
-0.634631	37.523889	335641.907251	9930132.879510	shallow well	Johnson Kamau Kimani
-0.632375	37.523886	335641.397944	9930382.308340	shallow well	Benjamin Kariuki
-0.630842	37.524202	335676.624846	9930551.822880	shallow well	Ayub Njagi
-0.629119	37.525070	335773.112811	9930742.345740	shallow well	Chrispin Mugo
-0.626472	37.503929	333419.960528	9931034.361750	shallow well	Esther Njura
-0.626144	37.503896	333416.293801	9931070.643560	shallow well	Michael Mungai
-0.624572	37.510523	334153.830595	9931244.611850	shallow well	Julius Ngugi
-0.624763	37.510508	334152.139140	9931223.490760	shallow well	Njoroge Kihiu
-0.624646	37.508071	333880.952646	9931236.416900	shallow well	James Mbuthia
-0.621348	37.506774	333736.474488	9931600.994220	shallow well	David Mwaniki
-0.620428	37.508038	333877.126982	9931702.792560	shallow well	Rosemary Muthanje

-0.619601	37.516269	334793.236945	9931794.502620	shallow well	Nicasio Nyaga
-0.618544	37.516386	334806.190461	9931911.278540	shallow well	Mary Walter (Muthungu)
-0.618268	37.516866	334859.594299	9931941.839820	shallow well	Jane Njoki Kariuki
-0.614623	37.521021	335321.965964	9932344.960790	shallow well	James Mathenge
-0.615865	37.517429	334922.186839	9932207.606640	shallow well	Mr Ndereva
-0.621469	37.525073	335773.267949	9931588.172150	shallow well	Ernest Eliamachuka
-0.620834	37.524157	335671.230357	9931658.373640	shallow well	Justus Maringa
-0.623309	37.518987	335095.936178	9931384.558670	shallow well	Jacob Kabunga
-0.640992	37.482180	330999.613391	9929428.199730	shallow well	Kabuki Wainaina
-0.639653	37.482294	331012.266530	9929576.294070	shallow well	Gitau Wainaina
-0.650715	37.502658	333279.283383	9928353.805710	shallow well	Joseph Muriithi
-0.657379	37.500068	332991.172472	9927616.918860	shallow well	Njeru Njuki
-0.664779	37.499178	332892.404456	9926798.624070	shallow well	Mr Thauri
-0.663622	37.501375	333136.911063	9926926.676150	shallow well	Joseph Njeru
-0.662382	37.502530	333265.347608	9927063.830260	shallow well	Emilio Njiru
-0.685086	37.487413	331583.508806	9924552.980240	shallow well	Yoda market community
-0.719100	37.503323	333355.609592	9920792.617990	shallow well	Jonathan Njeru
-0.628378	37.512216	334342.341646	9930823.867290	shallow well	Andu a Muvake well
-0.650025	37.519309	335132.513498	9928430.633050	shallow well	Kanyinanthiga well
-0.654844	37.512988	334429.123520	9927897.656770	shallow well	Felix Njue
-0.657444	37.508414	333920.172701	9927610.022420	shallow well	Bishop Ngugi
-0.658068	37.508622	333943.264620	9927541.059380	shallow well	Bishop Ngugi
-0.606878	37.517189	334895.240239	9933201.284540	shallow well	John Murigi
-0.611775	37.518371	335026.926655	9932659.831040	shallow well	Barnabas Ngari
-0.607384	37.515422	334698.634433	9933145.226290	shallow well	Stephen Njeru
-0.608320	37.513461	334480.398052	9933041.646710	shallow well	Sammy Nduati
-0.607824	37.512454	334368.250870	9933096.452970	shallow well	Faith Mumbura
-0.601080	37.512251	334345.487889	9933842.196690	shallow well	Leonard Macharia Ngugi
-0.625619	37.522260	335460.231716	9931129.207730	shallow well	Mary Mwangi
-0.626375	37.522793	335519.554228	9931045.649020	shallow well	Mathiew Nyaga
-0.639069	37.521476	335373.404554	9929642.045860	shallow well	Stephen Kathanje

-0.613446	37.505688	333615.281161	9932474.717800	shallow well	Christopher Waboyo Justus
-0.613002	37.503726	333396.870672	9932523.748070	shallow well	Rwika Family Life Centre
-0.612783	37.503905	333416.847931	9932547.951420	shallow well	Elias Ngari
-0.611720	37.507622	333830.518329	9932665.524610	shallow well	Benson Kumbu Nderi
-0.609820	37.508008	333873.432306	9932875.709090	shallow well	Cyrus Njiru
-0.609720	37.505312	333573.333492	9932886.636530	shallow well	Hosea Mugo
-0.609293	37.504289	333459.527206	9932933.850710	shallow well	Nicholas Kithumbu Mugo
-0.608202	37.507709	333840.141333	9933054.509990	shallow well	Julius Mainge
-0.607406	37.508810	333962.652216	9933142.568820	shallow well	Dr. Wanjala
-0.607994	37.509448	334033.696945	9933077.612170	shallow well	Harun Utuku
-0.629360	37.502455	333255.991618	9930714.959390	shallow well	Ferdnard Njiru
-0.621156	37.496199	332559.380454	9931621.903010	shallow well	Francis Ndngu Gitong'i
-0.628561	37.491045	331985.953019	9930802.999940	shallow well	Benson Kariuki Musundi
-0.628156	37.492050	332097.821429	9930847.739400	shallow well	Ismael Nyaga
-0.620478	37.499536	332930.734246	9931696.937930	shallow well	Sophia Kabura
-0.621666	37.499952	332977.167325	9931565.609400	shallow well	Grace Wambugu Daniel
-0.618507	37.500349	333021.254188	9931914.875490	shallow well	Kariuki Ndwiga
-0.617091	37.502766	333290.229419	9932071.583900	shallow well	Sandrack Mwaniki
-0.618314	37.502726	333285.770571	9931936.366880	shallow well	Major Amasha
-0.616420	37.501124	333107.459849	9932145.665200	shallow well	Amasha Ndwiga
-0.619199	37.499452	332921.392440	9931838.369620	shallow well	Titus Ngari
-0.613088	37.496086	332546.533823	9932513.927920	shallow well	Karwika well
-0.610138	37.493462	332254.349512	9932840.032940	shallow well	Joseph Kinyuru
-0.608403	37.495912	332526.974182	9933031.969230	shallow well	Mugo Nyaga
-0.601014	37.508902	333972.684778	9933849.398450	shallow well	Tereza Njoki Mutegi
-0.599308	37.510286	334126.684139	9934038.046450	shallow well	Gerald Njuki
-0.600316	37.505865	333634.633198	9933926.440760	shallow well	Alfam Nyaga Njeru
-0.606610	37.503151	333332.683687	9933230.474930	shallow well	Nichaus Njeru
-0.602319	37.502885	333302.978136	9933704.870690	shallow well	Peter Muriuki
-0.601913	37.502551	333265.768212	9933749.744470	shallow well	Peter Kamau
-0.596663	37.495868	332521.813322	9934330.042990	shallow well	Patrick Munyi

-0.597753	37.494346	332352.418523	9934209.517130	shallow well	Kiboi
-0.600495	37.495802	332514.502625	9933906.283550	shallow well	James Gatumu
-0.605318	37.493658	332276.071151	9933372.998680	shallow well	Gasper Njoroge
-0.593459	37.495607	332492.608043	9934684.248370	shallow well	Mrs Mwatha
-0.594169	37.489576	331821.395686	9934605.576900	shallow well	Ali Mohammed
-0.594472	37.489596	331823.643189	9934572.139350	shallow well	Robert Gaoke
-0.598351	37.493049	332208.097559	9934143.361100	shallow well	Charles Njiru
-0.590094	37.490881	331966.498941	9935056.177710	shallow well	Edward Njeru
-0.589069	37.491480	332033.110516	9935169.577080	shallow well	Dr. Thiong'o
-0.588869	37.491394	332023.569930	9935191.714750	shallow well	Njogoro Kimata
-0.587722	37.490507	331924.771281	9935318.518010	shallow well	Stanley Mugo
-0.587156	37.490766	331953.583188	9935381.054490	shallow well	Joseph Thimba
-0.590864	37.489524	331815.520714	9934971.067620	shallow well	Rosemary
-0.590592	37.489583	331821.987354	9935001.125240	shallow well	Mwangi Gachie
-0.591291	37.488698	331723.496409	9934923.842050	shallow well	Mr Maina
-0.591822	37.489440	331806.191767	9934865.134830	shallow well	Mrs Sachi
-0.585557	37.491171	331998.635437	9935557.876740	shallow well	Stanley Githee Gacheru
-0.586824	37.492335	332128.282006	9935417.783620	shallow well	Joshua Irungu
-0.583817	37.493735	332283.942622	9935750.295710	shallow well	Simon Ngugi
-0.591791	37.497592	332713.494475	9934868.753610	shallow well	Jaco Thiri
-0.593100	37.492841	332184.689548	9934723.923120	shallow well	Jacob Wambugu
-0.575525	37.512252	334344.784590	9936667.691670	shallow well	Nyaga Silvanos
-0.579572	37.521687	335395.108025	9936220.523280	shallow well	Joseph M. Njiru
-0.580047	37.523566	335604.300754	9936168.058330	shallow well	Jacob Nyaga
-0.587663	37.514410	334585.309777	9935325.715200	shallow well	Zachariah Silvanos
-0.596128	37.512735	334399.191202	9934389.698120	shallow well	Karumba
-0.600548	37.515612	334719.570371	9933901.091100	shallow well	Macharia
-0.598816	37.514862	334635.981058	9934092.520260	shallow well	Elshadai Njoroge
-0.600303	37.517037	334878.118780	9933928.224030	shallow well	Paul Papuu
-0.600010	37.513305	334462.766123	9933960.511300	shallow well	Peter Mburu Njoroge
-0.601128	37.514857	334635.528124	9933836.880710	shallow well	Stephen Kibe

-0.603690	37.518597	335051.834308	9933553.812030	shallow well	Tiras Ndwiga
-0.603704	37.519510	335153.536182	9933552.208750	shallow well	Simon Ireri
-0.608269	37.521852	335414.359630	9933047.583110	shallow well	Peter Muguna
-0.616196	37.528332	336135.790656	9932171.342880	shallow well	Alice Ngari
-0.568144	37.535895	336976.239781	9937484.516700	shallow well	Josiah Munyi
-0.574640	37.540079	337442.068097	9936766.316160	shallow well	Lawrence Karanja
-0.579753	37.542141	337671.756568	9936201.073990	shallow well	Nelson Njagi
-0.570842	37.542017	337657.735254	9937186.329290	shallow well	Mrs Murekio
-0.573369	37.533204	336676.843217	9936906.729420	shallow well	Peter Kiguru Kariuki
-0.570124	37.532279	336573.827312	9937265.487960	shallow well	Lawrence Mugo Mungai

H. Water Tanks

LAT	LONG	X	Y	Water point	Name /location
-0.653950	37.561431	339821.085911	9927998.014990	water tank	Carlo Liviero Tank
-0.584270	37.561785	339951.158720	9935406.111603	water tank	Kanyariri MoW tank
-0.570895	37.538186	337324.146210	9936884.039785	water tank	kiamuringa EWASCO tank
-0.713197	37.527234	336016.834671	9921446.215870	water tank	St Joseph Gachuriri tank
-0.605254	37.556673	339289.957454	9933382.016220	water tank	Gaya Academy tank
-0.629068	37.528548	336160.228183	9930748.080220	water tank	ACK Ngenge church
-0.627009	37.525692	335842.355881	9930975.723110	water tank	Ngenge school
-0.673101	37.494342	332354.417220	9925878.313890	water tank	Minoori water project
-0.702813	37.516173	334785.302987	9922593.981650	water tank	Gachuiri Dispensary
-0.650242	37.519414	335144.284336	9928406.642310	water tank	Kanyinanthiga tank