A GIS PERSPECTIVE FOR LOCAL LEVEL PLANNING AND DECISION-MAKING: THE CASE OF SPATIAL DATA INTEGRATION, HEALTH AND SANITATION IN THE GA DISTRICT OF GHANA

BY

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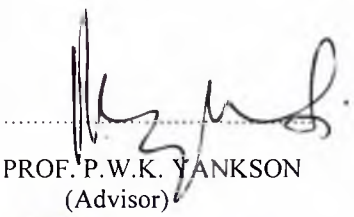
DECLARATION

I hereby declare that except for references cited which have been duly acknowledged, this work is the result of my own research. It has never been presented anywhere either in part or wholly for the award of any degree.



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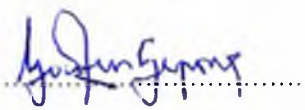

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ABSTRACT

The devolution of political administration, planning and the decision-making process from over burdened central governments to the local level has been borne out of one basic fact – that community participation in governance, planning and decision-making will make the process of development more self-sustaining. The assumption being that bringing policy decisions that reflect local conditions closer to the people will lead to a fuller participation in programmes that will bring about improvement in the well-being of the people. This has been the basic idea behind Ghana's decentralization policy and the District Assembly concept. The concept has led to the creation of basic units of government called the District Assemblies. Even though the framework for pursuing the decentralisation policy and the planning process have been laid down, the tools or techniques to enhance holistic planning have been inadequate, especially for the integration of sets of information held within the various functional agencies in the District Assemblies. The fact is that many of the questions facing planners, policy-makers, administrators and researchers, among others, are inherently geographical and spatial analysis and mapping are emerging as vital tools for providing answers to such questions.

The District Assemblies have not only been seen as the basic units of government, but understandably the ideal and most manageable units for data acquisition and processing. For holistic plan development and for a more informed decision-making, what is required for the integration of data and making it available in forms that are easily comprehensible is a GIS. This study considered the application of GIS as a tool for the integration of disparate data sets in the district departments and proposed the elements of a prototype GIS for planning at the district level. It is an attempt to use the integration concept to provide answers to some fundamental planning and policy issues in the health sector.

The study is a case type and centered on the Ga District, one of the five districts that make up the Greater Accra Region. Like all other District Assemblies in Ghana, it carries out its administrative, political, planning and decision-making functions within the framework of the laws that established the District Assemblies and the National

Development Planning Commission (NDPC). However, planning has been hampered by several factors, basic among which is the lack of a mechanism for integrating data held within the district departments. The study considered the use of GIS as a tool to facilitate the integration of spatial data held within 15 departments in the district. It also proposed the type of approach required for multidatabase design in the context of the district and for GIS interoperability. The study proposed a scheme, which shows, some of the basic elements for a prototype district GIS.

The study showed through the use of the overlay method of analysis that integrating diseases data with environmental data could help provide clues to the causes of major diseases in the Ga District. It has been shown that in many cases the high incidence of the diseases was associated with poor sanitation practices, solid waste disposal and household water supply sources. The technology offers a good way of studying the geographical aspects of diseases and thus contributing to both educational intervention and planning. It also showed the added value of GIS in ascertaining health care services coverage. Here the study was able to demonstrate the additional number of health care facilities and services required to bring coverage closer to the communities.

The study recommends GIS as an instrument that can be used to device quick, reliable and scientifically valid methods of rapid assessment and utilization for planning, monitoring and evaluation of programmes at the district level. It will be necessary for the district assemblies to be equipped with the basic facilities for prototype GISs that will enhance the execution of their holistic plans. The GIS facility will not only facilitate spatial data capture, storage, manipulation, analysis and update but also serve as a store of data to meet the needs of any particular department. While saving costs in data collection and avoiding the duplication of efforts, it will also pave the way for uniformity in modes of data representation, scales, standards, updates and data quality levels to allow for interoperability. The present study was based on one district out of the 110 in the whole country. Future studies may require that more districts are studied in terms of their departmental data acquisition and processing operations for plan development. This will set the pace for a national consensus and capacity building for spatial data acquisition,

processing standards setting and quality levels among others. It also views the inclusion of geodemographic data or household surveys in the investigation of explanatory causes of diseases as relevant in future studies.

LIST OF ACRONYMS

AMA	Accra Metropolitan Assembly
CDH	Communicable Disease Hospital
CDROM	Compact Disk Read Only Memory
CERSGIS	Centre for Remote Sensing and Geographic Information Services
CSIR	Council for Scientific and Industrial Research
DANIDA	Danish Agency for International Development
DB	Database
DBMS	Database Management Systems
DHMT	District Health Management Team
DHO	District Head Office
DPCU	District Planning Co-ordinating Unit
EIS	Environmental Information Systems
ENRECA	Danish International Development Agency's Enhancement of Research Capacity Project
ESRI	Environmental Systems Research Institute
FDB	Federated Database
FP	Family Planning
GAMA	Greater Accra Metropolitan Area
GERMP	Ghana Environmental Resources Management Project
GIS	Geographic Information Systems
GPS	Global Positioning System
INSTI	Institute of Scientific and Technological Information
KVIP	Kumasi Ventilated Improved Pit
LAM	Location-Allocation Modeling
LI	Legislative Instrument
MCH	Maternal and Child Health

MCLP	Maximal Covering Locational Problem
MLGRD	Ministry of Local Government and Rural Development
MOH	Ministry of Health
NAFGIM	National Framework for Geospatial Information Management
NDPC	National Development Planning Commission
NGOs	Non-Governmental Organisations
NICs	New Industrializing Countries
NLCD	National Liberation Council Decree
NTNU	Norwegian Technical University, Trondheim
NUFU	Norwegian Council of Universities Committee for Development Research and Education
OPD	Out Patients Department
PC	Personal Computer
PHC	Primary Health Care
PNDC	Provisional National Defence Council
UK	United Kingdom
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
URTI	Upper Respiratory Tract Infections
WHO	World Health Organisation

TABLE OF CONTENTS

LIST OF TABLES

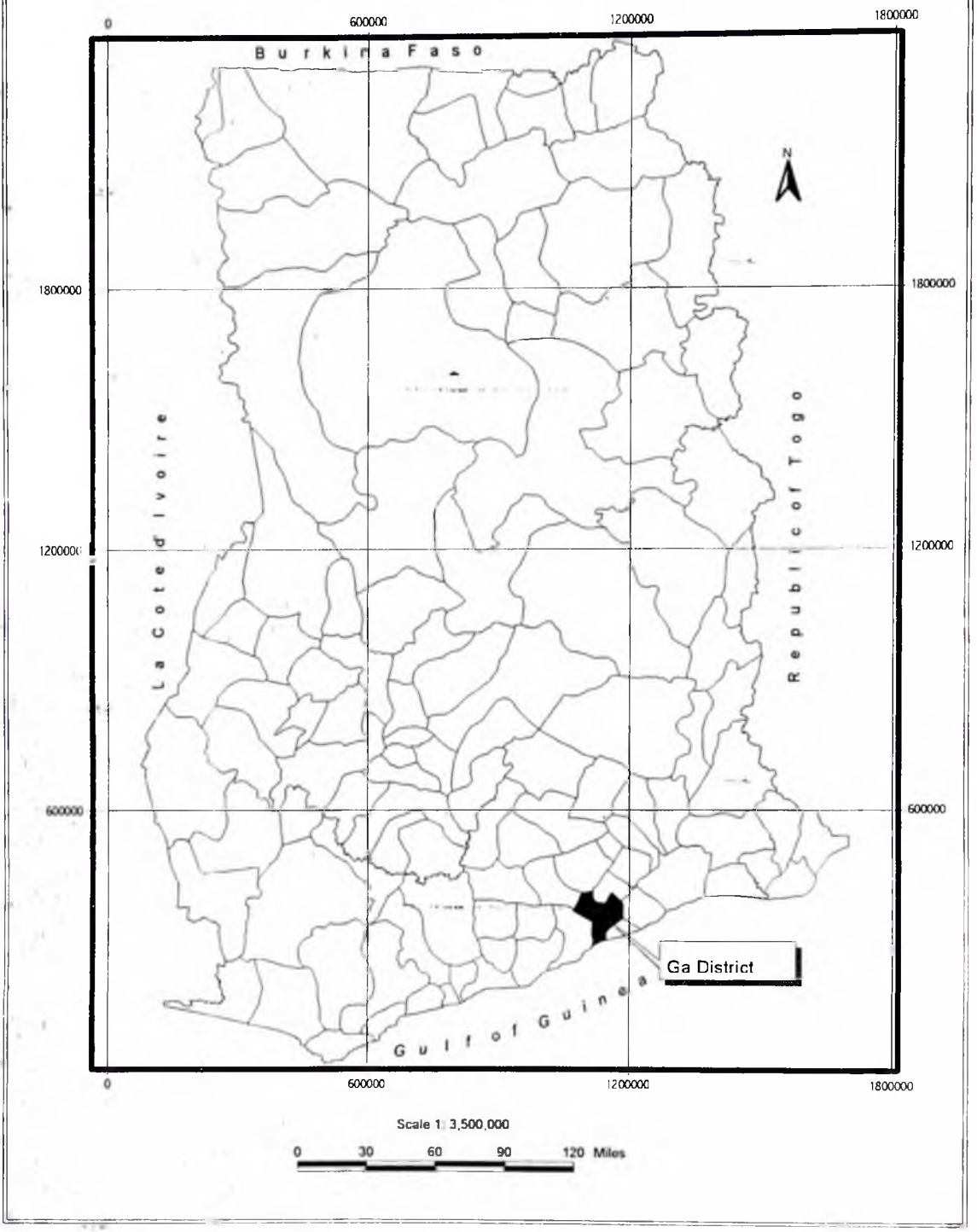
TABLE Page

LIST OF FIGURES

LIST OF MAPS

LIST OF APPENDICES

Location of Ga District in Ghana



CHAPTER ONE

BACKGROUND TO DECENTRALIZATION AND LOCAL LEVEL PLANNING IN GHANA

1.0 Introduction

1.1 The concept of decentralization

Decentralization is commonly associated with the process of democratisation in terms of economic, social and political affairs. It has been described as a process that attempts to improve the general welfare and well-being of people (Malo, 1997). The concept has gained popularity in recent times among developing countries as a scheme and an alternative mechanism in delivering public services and goods as well as carrying out governmental functions and duties. Many social planners have heralded it as a multifaceted remedy to overextended and deteriorating delivery systems of social goods and services.

Decentralization has its advantages. As a means of decentralising the delivery of social services, the concept is thought by some as a means to improve its efficiency and effectiveness as well as make such services available to people who need them most; thus, it promotes equity. Likewise, it mobilizes and augments existing resources – human, technical and financial. This is done by bringing decision-making, management and responsibility in the administration of resources closer to the local level, i.e., to a certain extent, the private sector. It has been argued that decentralization policy can also solve problems brought about by the lack of transportation and communication facilities as well as simplify the procedures in decision-making. Furthermore, decentralization may bring about policy decisions that reflect local conditions; and to achieve its goals, local customs and traditions must be taken into account in policy making, a valid concern not understood by national officials (Malo, 1997). Finally,

decentralization can cut down red tape practices which commonly beset developing countries.

Decentralization has also been associated with some disadvantages which include the following:

- the lack of control over the local or decentralized institutions leading to inefficiency in managing government's budget;
- widening the gap between regions/districts whereby wealthy and progressive ones could develop their economy better and faster while poorer or less endowed regions/districts are left behind; and
- intensifying regional-centred sentiments at the expense of national unity.

Decentralization has been applied in many regional contexts with different approaches in attempts to improve the general welfare and well-being of the people. For example, in the cases of the Asian Tigers, popularly known as the New Industrialising Countries (NICs) – Taiwan, South Korea, Singapore and Honkong – it has been shown that economic power and amelioration of the plight of the masses can be attained not through the dispersion of power but concentration of power in the hands of government. Some commentators have argued that the initial phase of economic development in the said countries can be characterised as a period of extreme political repression and centralisation of power.

On the other hand, experiences of Latin American countries reveal another dimension; here decentralised structures of administration served only as a more effective tool for centralising power. The local government experiment led to chaos in the bureaucracy. As was tacitly described,

> "*decisions are solely made by government officials of regional and district committees while the local representatives are silent;*

village councils as mechanisms of peoples participation in decision-making, do not have the power to decide on the allocation of resources. Too often, the word decentralization seems to convey only what the public relations departments want it to mean" (Malo, 1997).

In view of the different conceptions of decentralization, it has been argued that in order to minimise its negative effects and maximise positive outcomes, decentralization must be operationalized in various sectors. A comprehensive approach in the execution of decentralization and deep sense of commitment among implementers across sectors is needed if success is expected.

1.2 **The concept of planning**

Different authors have variously defined planning, but the common thread that appears to run through all the concepts is the goal of improving the well-being of communities. For example, Lichfield *et al.* (1975) stated that planning should be concerned with achieving objectives which thereby lead to some improvement in the well-being of persons within the community. Planning is concerned with the allocation of and use of resources (Eversley, 1973), the development of activities within a region (intra-regional) and the distribution of resources and activities between regions (inter-regional) (Conyers, 1984). It has also been indicated that the main objective of development planning perhaps is to link overall national development to the available resources to ensure orderly development as well as efficient or optimum allocation of the scarce national resources (Botchie, 1986).

Different types of planning can be distinguished. These include physical planning, which involves the allocation of land uses and the control of building elevation; economic planning, which involves the allocation of capital for housing, infrastructure or industrial purposes and social planning, which involves allocation of land, capital,

employment opportunities, educational and other social services, revenue and manpower to projects and areas with the intention of altering the distribution of real incomes; as well as other types like regional planning, which involves the preparation of strategies intended to optimise resources, usually on long term basis. Eversely (1973) indicated that 'regional planning is a continuous process, which does not imply an amorphous, incoherent set of guesses based on widely different and wildly imaginative scenarios'.

It is important to note that whatever decision the planner takes affects the distribution of wealth and real incomes in a very important way. The planning process itself may thus be defined as a course of activity that is intended to heighten understanding of the nature of problems requiring examination, of the alternative possible solutions that exist, and of the relative merits of these alternatives (Lichfield, 1975).

Another aspect of planning that has often been discussed within the context of broader coverage is what is often termed integrated planning. It is planning which attempts to incorporate all sectoral (or functional) components of a plan and which considers the inter-relationship between these sectors (and the agencies responsible for them) and regards the region as a whole rather than as a number of sectoral parts (Conyers, 1984). The current decentralized planning dispensation in Ghana takes on aspects of integrated planning. It starts at the district or local level and builds up to the national level via the regional level. The following sections provide a background to decentralisation in Ghana and the type of planning framework within which it currently operates.

1.3 **Decentralization in Ghana**

Decentralisation as a form of grassroots government and administrative technique in Ghana is not new. It has characterised the country's development thinking since colonial times (Ministry of Local

Government and Rural Development (MLGRD), 1994). For example, attempts at local administration during the colonial era were with native authorities that revolved around chiefs or some units of local royalty. These native authorities assisted the then colonial government to administer law and order with limited involvement in local administration. Since then several policy measures have been put in place followed by passage of legislation such as:

- Local Government Ordinance 1951 (cap 64);
- Local Government Act 1961 (Act 54);
- Local Administrative Act of 1971 (Act 389); and
- Local Administrative Act (Amendment Decree of 1974, NLCD258) (MLGRD, 1994).

The frequent changes in governments and the lack of commitment to grassroots development planning and decision-making led to the non-attainment of the desired results. Planning and implementation of development programs were not devolved from the overburdened central government (Akuoko-Frimpong, 1986). Present day decentralisation is conceived as a government administrative technique that promotes rapid economic and social changes from below, and these have been given meaning through the passage of the following legislation:

- Local Government Law of 1988 (PNDC Law 207);
- 1992 Constitution;
- Local Government Act 462 of 1993;
- Local Government (Urban, Zonal and Town Council and Unit Committees (Establishment) Instrument 1994 L.I.1589;
- NDPC Act 1994, Act 479;
- National Development Planning (system) Act 1994 and Act 480; and
- Civil Service Law 1993, PNDCL.327 (MLGRD, 1994).

These enactments have unique provisions geared towards effective attainment of the goals of decentralisation. One of these unique features is the devolution of the development planning process. For the purpose

of effective governance and spread of socio-economic development, the country has been divided into 110 basic units of government called the District Assemblies. These have been made into the district planning authorities to ensure participation, co-ordination and integration into the preparation of the District Plan (Government of Ghana, 1993). The unique feature of this system is the effective participation of the communities. It enjoins every individual in the community to have 'the right to be heard' (NDPC, 1995).

Some commentators have agreed that, so far, the decentralisation programme has produced some positive results. The local people have been enabled to show interest in their own affairs and participate, even if minimally, in policies and programmes of their areas (Ayee, 1997). People living in previously neglected rural areas have also gained an incremental access to central government resources and institutions. Contrary to this has been the view that the desired results have not been achieved owing to limited resources. This disillusioned elected and nominated representatives such that the less endowed districts resorted to taxation or self-help projects, mostly in collaboration with non-governmental organisations (NGOs) (Ayee, 1997). The fact was that expectations were high at the early stages of inception of the programme, but the District Assemblies never really accepted local responsibility for local development, although they were intended to do so.

1.4. **Decentralisation and the planning process**

Development planning in sub-Saharan Africa, according to Friedmann (1992), has always been a contested issue. Under colonialism and in the early independence period, planning failed to redress underdevelopment and became largely an ideological activity intended to legitimize the colonial and post-colonial state (Hyden, 1983; Rakodi, 1986). It is only in recent times that more neoliberal models which valorise the market

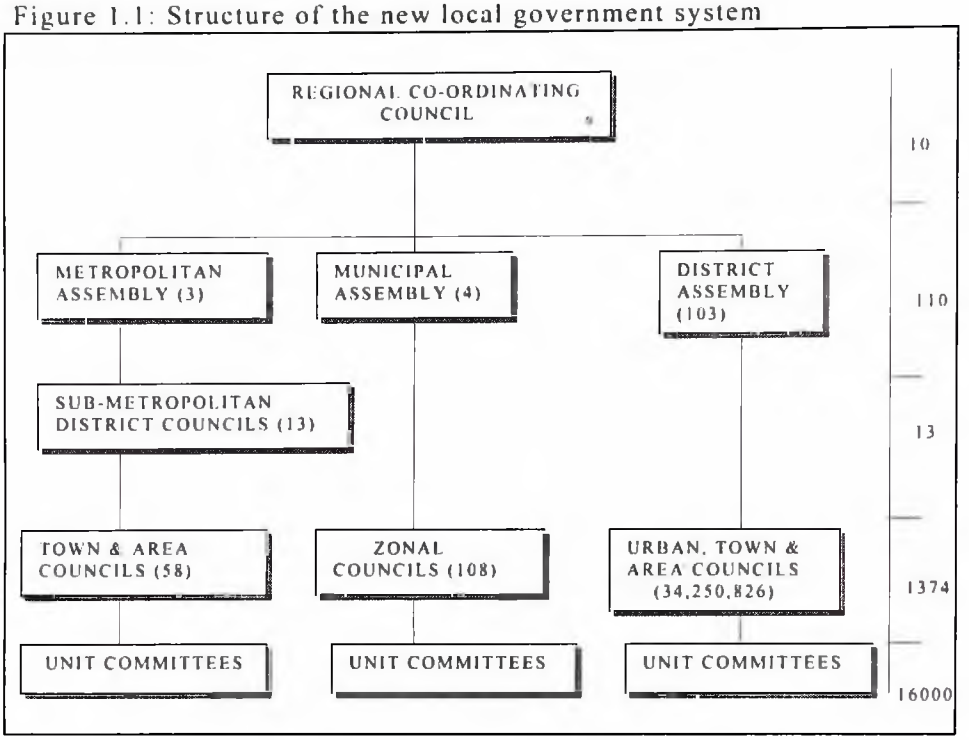
as the only genuine means to develop have been put into practice among some countries (Watts, 1994). With it has come the removal of the hitherto statist top-down planning system and its replacement with a market-driven model of development in which individual 'goal-orientation' is emphasised (Mohan, 1996).

Ghana is among the few sub-Sahara African countries to have embarked upon structural adjustment programmes (Herbst, 1993; Leechor, 1994) and while at it has worked towards an ambitious decentralization programme (Ayee, 1991; Mohan, 1993; Crook, 1994) with the neoliberal development model (as regards planning) involving the bottom-up approach. Ghana's example has been cited as instructive because it has been in the forefront of development planning, even under colonial rule with the adventurous Guggisberg Plan of 1919 (Botchie, 1986; Frimpong-Ansah, 1991).

The present planning system is more area-based, flexible and does not alienate the mass of society. It begins with the National Development Planning Commission (NDPC) prescribing the format and content of the development plans. Hitherto, planning was characterised by a long chain of activities between the client (specific project in the district or region) and the service deliverer (national government). Planning was therefore over-centralised with several stages of decision-making. The present framework prescribes the provision of the district profile based on current status (NDPC, 1995). Information is required on physical environmental conditions, social and economic conditions, population characteristics and the main development problems of the districts. The framework also requires the use of graphic information including maps to illustrate existing (or current) conditions and the outcome of plan proposals. The requirements of this framework indicate how integrated the planning would be and also allow for popular participation. The

basic planning units are the unit committees found in every community throughout the country (Figure.1.1).

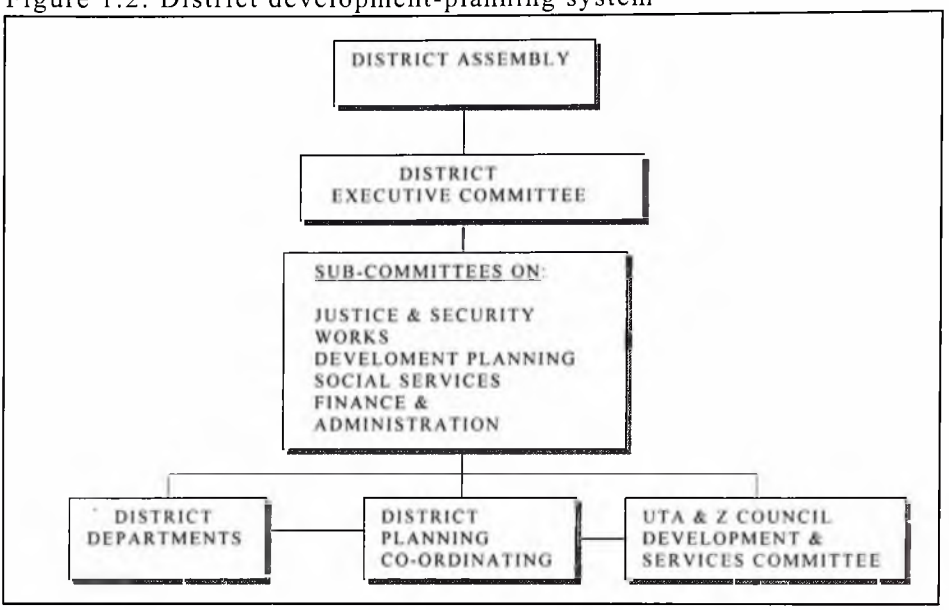
Figure 1.1: Structure of the new local government system



Source: Ministry of Local Government and Rural Development, 1994

The 16000 unit committees constitute the grassroots establishments from which the developmental needs and plans are synthesised. Thus, the national plan takes on aspects of integrated planning which considers inter-relationship between sectors (functional agencies at district level), regions, etc, rather than as a number of sectoral parts. The communities are the target beneficiaries of development and there is the need to equip them with knowledge and information about what affects their living conditions and opportunities that are available to improve them. Figure 1.1 shows that the planning process starts from below and moves upward to the 10 Regional Co-ordinating Councils (one for each region of the country).

Figure 1.2: District development-planning system



Source: Ministry of Local Government and Rural Development, 1994.

The planning system also involves collaboration among the various functional agencies in the District Assemblies. These functional agencies, also referred to as the District Departments (Figure 1.2), present their individual plans to the District Planning Co-ordinating Unit which in turn submit them to the Office of the District Assembly. These plans are then integrated and made into a holistic plan for the district. The inputs from the various communities and departments are very crucial in providing a thorough picture of the realities of the situations at the grassroots. Theoretically, planning requires active participation of the population (Ward, 1986). It should be open, democratic and participative.

The study looked at the aspects of spatial data integration for planning and decision-making and opined that holistic plan development and decision-making can be achieved by finding a technique for integrating

sets of data/information held by the various departments. This is a pre-requisite for GIS interoperability, especially where GIS is to be used as a planning and decision support tool in the District Assemblies. The study focused on the health and sanitation sectors of the district economy and proposed a scheme for data integration and the design of a prototype GIS.

1.5 The GIS technique

GIS is a computer-based technique that facilitates the capture or entry, storage, manipulation, retrieval, analysis and display of spatial data (Clarke, 1997). Because these data can be accessed, transformed, and manipulated interactively in a GIS, they can serve as a test bed for studying environmental processes or for analysing the results of trends or anticipating the possible results of planning decisions (Borrough 1987). According to Calkins & Tomlinson (1976), the general function of GIS is to acquire, store, manipulate and display geographic data for decision-making. By using the GIS, it is, in principle, possible for planners and decision-makers to explore a range of possible scenarios and to obtain an idea of the consequences of a course of action before the mistakes have been irrevocably made in the landscape (Borrough, 1987). Maps constitute the primary source material for such systems. Other source materials include satellite data, point observations, i.e., rainfall or tabular data associated with geographic areas, i.e. census records.

1.6 GIS application for district level planning and decision-making

It is noted that local government or in the Ghanaian context the District Assembly, is one of the most important groups of users of GIS. The range of application in the field is very considerable, extending from property registers and highways management to emergency and landuse planning (Department of Environment UK, 1987). Various studies on the level of GIS adoption in local government have shown a high level

of commitment to the technology in several countries including the US (Wiggins & French, 1991), Europe as a whole (Green, 1990), Italy (Craglia, 1992), and the UK (Biddick, 1991; Willis & Nutter, 1990; Campbell & Masser, 1992). Local government or the district assembly is a good environment in which to study the practical consequences of GIS. It is one of the few organisational contexts in which there is potentially significant interest in the full range of application field as well as being one of the most important users of GIS.

GIS has been defined both as a tool and a database system. As a tool, it is a powerful facility for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world (Borrough & McDonnell, 1998). As a database system, it facilitates spatial data indexing and enables the performance of sets of operations in order to answer queries about spatial entities in the database (Smith *et al.* 1987).

An important product of GIS is the map. It facilitates the production of customised maps at any scale showing features individually or in any number of combinations. The relevance of maps for taking inventory of earth resources dates back to antiquity (Borrough, 1987). Maps generally enable discussions of resources and development potential since it is only through their medium that geographical relationships can be compared and appreciated (Oxford University, 1963). They are instruments for recording, calculating, displaying, analysing and in general understanding the interrelation of things in their spatial relationships (Robinson *et al.*, 1995). These basic functions underlie the need for their application for spatial planning and decision-making at all levels.

Keeble (1969) wrote that planning surveys and analysis of surveys and planning proposals have to be presented graphically; though this graphic presentation must be supplemented by words and figures

(statistics), they are subordinated to it. Planning deals with land (space) and land and its use are, for the most part, best described and analysed by maps, plans and models. Even though written and spoken communications are important, they can only partially and imperfectly perform much work that is simply and efficiently done by graphical means.

GIS application at the district level will facilitate the study of diverse spatial processes and enhance analysis of the result of trends or for anticipating the possible results of planning decisions.

1.7 **The problem**

The study focuses on two fundamental problems of the District. These are the general problem of data/information integration among the district assembly departments and the problem of health and sanitation in the district. The problem of spatial data integration has emerged as an important requirement in the decentralized planning scheme. Information has been described as a valuable resource in planning (Dias & Poudyal, 1992) at both national and sub-national levels. The way data is acquired and processed and the advantages to be derived from inter-departmental data sharing are yet to be tackled in the business of decentralized planning.

The problem of health and sanitation are among the basic issues of district level development for which adequate data and basic analytical tools are required to support policy decision-making and planning. The occurrence and distribution of certain categories of diseases and their association with certain sanitation practices, solid waste disposal forms and types of household water supply sources need to be investigated. This could be attained through the use of tools that ascertain not only these relationships but also establish the type of spatial database that could be utilised for planning and policy decision-making.

1.7.1 The problem of district level planning

A peculiar feature of the planning system at the district level is the effective participation of the communities and the collaboration among the various functional agencies in the District Assembly. The framework for the plans outlined by the NDPC enjoins every District to provide a profile based on current status, information on physical environmental conditions, population characteristics and the main development problems of the district. The framework also requires the use of graphic information including maps to illustrate existing (or current) conditions and the outcome of plan proposals (NDPC, 1995). The format requires a synthesis of the district's problems, objectives and goals through sectoral inputs for the plans.

Among the functions of the Development Planning Sub-Committee of the District Assemblies is the development of an information base on the resources (MLGRD, 1996). This information base could be referred to as a database. The inadequacy of information necessary for planning for the optimum utilisation of resources in the districts has led to shortfalls in informed decision-making. In many cases the data are non-existent or are found in forms that are disorganised and require to be deciphered by the planner. This makes data gathering expensive and often lead to loss of time.

The format does not also prescribe or suggest the types of techniques or tools to be applied for the integration of the sectoral or departmental inputs to the district plan. It mentions collaboration among the district departments without specifying the nature of collaboration. It is obvious that mere collaboration among these functional agencies will not be enough to produce an integrated and holistic information/data base for planning for the Districts. Neither will it provide for informed

policy decisions that will lead to a more effective and less wasteful administration and dissipation of resources.

A study of the district, based on the data types acquired and processed by the various departments, showed that data integration for all aspects of planning and policy decision-making is yet to be a feature of the development process. Many of the departments collaborate with each other but not in the area of data exchange in order to save cost and time of operations, among others. So far the various departments use traditional and analogue methods of spatial data capture, manipulation, analysis, and display. Data is stored on paper or in traditional files or databases. Their reuse for new applications becomes a problem.

Generally, the present method is handicapped in several ways, notably:

(a) processes involved in information/data presentation often lead to loss of information;

(b) production of several sheets of maps where the volume of information is high;

(c) difficulty in retrieving data from maps to combine with other spatial data;

(d) problems of updating data; and

(e) in cases where maps are the medium of expressing spatial forms, the fact remains that the printed map is a static qualitative document.

Borrough (1987) has indicated that in such cases, it becomes extremely difficult to attempt quantitative spatial analysis within the unit delineated on a thematic map without resorting to collecting new information for the specific purpose on hand. The collection of data and the publication of a printed map are costly and time-consuming. Consequently, the extraction of single themes from a general-purpose map can be prohibitively expensive if the map must be redrawn by hand.

Planning is a dynamic process activity that involves change and how to address the change. This process is enhanced with the use of tools that allow for the projection of alternative outcomes or revision of plans so that more informed decisions can be made. For example, the prescription for the use of graphic information including maps to illustrate existing conditions and the outcome of plan proposals (NDPC, 1995) would be facilitated by the use of the GIS technique.

Geographical Information Systems techniques facilitate integrated and conjunctive analysis of large volumes of multidisciplinary data, both spatial and nonspatial within the same georeferencing scheme (Saraf & Choudhury, 1998). Geographical information technology is applied as a tool to facilitate the integration of data or information held by the various departments or sectors on separate locations within the districts. It also leads to standardisation and harmonisation of data. The technique facilitates a digital entry of existing or current conditions in the districts and is also capable of executing the type of scenarios required for predicting the outcome of plan proposals.

The thesis focuses on GIS and its use as a tool for integrating the type of information required for planning and for the health and sanitation sub-sectors of the Ga District Assembly and also demonstrates its capabilities as a decision support tool. It is aimed at the design of a scheme for integrating sets of spatial data or information held within the departments in the District Assembly and also provides the elements for a prototype GIS for the district.

1.7.2 The problem of health and sanitation in the Ga District

The Ga District is one of the five districts which make up the Greater Accra Region. It is located to the west and partly to the north of the region. The district does not have a district hospital or a polyclinic. Maternal and Child Health (MCH) and Family Planning (FP) services

are provided by three rural health centres in the district, the Communicable Disease Hospital (CDH) and the five purely MCH clinics. In addition, growth monitoring and immunisation services are offered on outreach basis (Ga District Assembly, 1996). Major health problems are catered for in hospitals and polyclinics in the Accra Metropolitan Assembly (AMA) or in the hospital at Nsawam in the Akwapim South District. The district has five Ministry of Health facilities and these form the basis upon which the district has been divided for health planning and administration. The delineation of the health sub-districts is illustrated in Figure 6.1 in page 111b.

Studies show that the district suffers from low patronage or usage of health facilities (Ga District Assembly, 1996). Even though several factors account for this phenomenon, it has been explained that distance and the nature of communication network pose problems of accessibility to healthcare facilities. King (1998) indicated that communities living along or close to the main Accra-Nsawam corridor appeared to patronise health care facilities than those farther away. Stock (1992) also found distance to be a major determinant of facility use. The thesis further focuses on the application of GIS to ascertain the locational efficiency of the health facilities.

Malaria, diarrhoea, acute eye infections, chicken pox, ear infections, upper respiratory infections, measles, intestinal worms infestation and buruli ulcer are endemic in the district. Substantial cases of buruli ulcer (*Mycobacterium ulcerans*) have been reported in the district. For example, in a surveillance mounted in 1993 by the Regional Health Management Team, 100 cases of the disease were identified. Out of these, 98% of the cases came from the Ga District (Mensah-Quainoo, 1997).

Table 1.1 indicates that 39.8% of outpatients' department (OPD) cases is related to malaria which is the dominant disease.

Table 1.1: Top ten diseases seen at OPDs in the Ga District

No.	Diseases	No. of cases	%
1	Malaria	3758	39.8
2	Skin diseases	1756	18.7
3	Upper respiratory infect.	989	10.6
4	Diarrhoeal diseases	796	8.5
5	Acute eye infection	240	2.5
6	Measles	159	1.6
7	Chicken pox	126	1.4
8	Ear infections	69	0.7
9	Intestinal worms	48	0.5
10	All other diseases	1490	15.7
	Total	9431	100

Source: MOH/Ghana Health Service, 1998.

The general causes of these diseases are well known, and the role of GIS is to further ascertain their spatial incidence, level of endemicity and their relationship with environmental factors such as types of sanitation practices, forms of solid waste disposal and sources of household water supply. This aspect of the study is aimed at helping to provide elements for policy decision-making and for planned control measures for these diseases.

In the area of sanitation, it is noted that the Ga District suffers from indiscriminate defecation (Ga District Assembly, 1996). Pan latrine and the Kumasi Ventilated Improved Pit (KVIP) facilities exist on a small scale in some individual homes and communities. Solid waste disposal is mostly by open or crude dumping, resulting in many unapproved dumps. Consequently high cases of communicable diseases were

reported in the various health institutions in the district. Nine of the diseases reported at the major sub-district health institutions in 1998 emerged as the major ones, with malaria and skin diseases as the dominant cases (Table 1.1). The communicable diseases could be caused by unsanitary and other environmental conditions.

Household water supply is yet another major problem in the district. A substantial proportion of the settlements depend on wells and boreholes while others living along the main rivers and streams depend on these sources. The various data sets can be integrated through the overlay method to show correlations that could help inform policy and decision-making on control measures and educational programmes which mitigate the effects of some of these diseases.

These problems can be analysed in a spatial context and thus form a good basis for GIS application. According to Clarke (1997), results of spatial analysis are generally easy to interpret and are thus powerful tools for use in resource management, planning and policy development.

1.8 **Literature Review**

The potential of geographic information technologies to enter, store, display, manipulate and analyse spatial data has long been recognised. However, very little is known about the actual impact this computer-based technology is having in practice (Campbell, 1994). The introduction of GIS into organisations certainly offers opportunities for a more rational decision-making; this leads to a more effective and less wasteful administration and dissipation of scarce resources.

Considerable progress has been made in the application of geographic information technology for the analysis of spatial data for decision making and planning in both the developed and developing countries. The use of GIS in developing countries for resource management is

exemplified by Tappan *et al.* (1991) who discussed the monitoring of grasshopper and locust habitats in Sahelian Africa. Fox (1991) and Pieter van Teeffelen *et al.* (1992) have discussed various institutional issues encountered when using GIS in a developing nation. Sets of problems related to the lack of sufficient and well-organised information, limited financial means and lack of human resources have been enumerated. In the former war torn Liberia in West Africa, GIS was used for humanitarian work. GIS facilitated a comprehensive view of the area's infrastructure, population displacement and the distribution of the relief materials (EIS, 1996). Schimdt *et al.* (1995) employed GIS technology in a study of land use dynamics and forest soil fertility status in a watershed in Nepal. The methods of resource evaluation described in the study were not overly sophisticated and could be applied in similar studies in developing countries.

In Ghana, GIS technology has been variedly applied for landuse and soil suitability mapping. The digitisation of 351 topographical maps has also been executed. These projects have been carried out within the framework of the Ghana Environmental Resource Management Project (GERMP). Digital formats of the topographical sheets are obtainable.

1.8.1 *Local government application*

Local government is a level of government that is best equipped to assess and understand local needs and mobilise local resources to deal with such needs (WHO & UNEP, 1988). While encouraging them to use their initiative to find solutions to their problems, it is important to equip them with the requisite information that will enhance the understanding of their problems and therefore plan effectively to mitigate their effects. Local government is one of the most important groups of users of GIS. The local authorities exist primarily to provide services for people and should be able to formulate relevant policies to meet the needs of certain client groups. The range of potential

application of GIS in this field is considerable, extending from property registers and highways management to emergency and landuse planning (Department of the Environment UK, 1987).

1.8.2 *Planning application*

Geographic information systems are being increasingly applied in planning, from site design to regional strategies. Gilfoyle (1991) noted the various advantages offered by a GIS in this direction including:

- rapid and easy access to large volumes of readily-updated data;
- selection of information by area or theme, and merging of data sets;
- ability to search for particular features; and
- simulation and modelling opportunities.

Other practitioners have reported favourably on the potential for integrating the different types of information held by local authorities, including maps, socio-economic surveys, inventories and registers (Campbell, 1990).

The successful use of the technology in planning is cited in a case study involving an evaluation of its application in rural environmental planning. Selman *et al.* (1991) showed that the technology provided information for policy formulation and decision-taking which was genuinely helpful and accessible to planners. They concluded that there was an evident need for planners to be able to compare, manipulate and display complex geographic data sets on rural resources, and to present results in a variety of ways and to different audiences. They argued that planners work against tight time limits and appropriate GIS techniques should enable more rapid interpretations of policy and determination of individual cases.

Conventional methods of landuse analysis and project visualisation can be costly and time consuming, especially in remote rural areas. Indeed, it has been claimed that these practicalities have often contributed to a

blanket restrictive attitude being adopted within countryside planning. A particular advantage was the ability to pinpoint the precise location and boundaries of a development in the landscape, for it is often difficult to locate these in the open countryside where there are a few reference points.

Favourable reports have been given about projects that involved GIS use. The advantages enumerated include the ability to store vast amounts of map data and related information used by planners and policy makers, the facility to update this information easily and rapidly, and freedom from inconvenience of map boundaries. GIS also provides the ability to produce various high quality maps highlighting different features or combining different data sets, plotted in any colours or at any scale appropriate to the task. Another key advantage is the ability to explore 'what if?' type questions (Selman *et al.* 1991). Using models and assumptions, various scenarios can be developed, displayed and evaluated before decisions are taken (Riezbos, 1991).

Notwithstanding the advantages inherent in GIS, it is noted that there are constraints to its use for planning in developing countries. The constraints comprise three categories: training, planning data and models. Even in the so-called developed countries the introduction and use of GIS requires thorough training in operating hardware and software. Although more attention has been paid to training skilled personnel to handle computers and GIS, personnel in this field are still insufficient in developing countries. Hence they are sought after and their skills are very much in demand, in and also outside the world of regional planning.

Regional planning requires the adoption of a system for planning which should be largely based on a geographical information system containing relevant geo-referenced data on socio-economic aspects and

natural resources, data management facilities, analytical tools and mathematical models. The use of a system has the advantage of providing the necessary information for comparing and deciding. Furthermore, it helps in identifying deficiencies in data types and quality (Reizbos, 1991).

1.8.3 *GIS, spatial data integration and the issue of interoperability.*

Database development and integration from different sources is a vital component of any GIS operation. In fact, it is this capability that differentiates GIS from other widely used computer programmes which do not permit spatial operations on data (ESRI, 1997). The process of unifying existing data sources into a single framework is called database integration (Devogele *et al.* 1998). It takes as input a set of databases (schemas and data instances), and produces as output a single unified description of the input schemas (called the integrated schema) and the associated mapping information supporting integrated access to existing data instances through the integrated schema (Batini *et al.* 1986, Parent *et al.* 1997).

A very important requirement for local or sub-national level planning is data and of particular interest is how these can be federated for effective use and for the design of information systems. Local level departments collect and use data as a mater of routine for their work. A large volume of data is therefore generated routinely which makes it unnecessary to collect various kinds of data from scratch whenever needed (Dias & Leelasena, 1983). Some data are still stored on paper, including maps and traditional files or databases. Very often their reuse for new applications becomes a nightmare, due to poor documentation, obscure semantics of data, diversity of data sets (what information is stored, how it is represented and structured, what quality it has, which date it refers to, which scale is used, etc.), and the heterogeneity of existing systems in terms of data modelling concepts, data encoding

techniques, storage structures, access functionalities, etc. (Devogele *et al.* 1998).

In the GIS domain it is quite common to find such data sources describing, at least partly, the same geographical space (Devogele *et al.* 1998). Usually data are collected for specific purposes, very different from one source to the next. As no concrete guidelines exist for data collection, the existing sources rarely describe the same space in the same way. Therefore, when the decision is taken to integrate various data sources into a single framework, the major problems encountered are: developing a correct understanding of the semantics of existing data, i.e., what they really mean; establishing an accurate correlation structure to avoid what Dias & Leelasena (1983) referred to as comparing apples and oranges; and choosing a well-suited integrated description, based on integration goals and on the available data conversion techniques.

The value of data is often limited by the way in which they are processed, the level at which they are aggregated and the accessibility to them (Dias & Leelasena, 1983). This problem can be overcome if there is national level agreement or consensus on the basic areal unit for data collection. This must be the same for all the agencies even if they are subsequently aggregated into different larger units. Laurini (1998) has advocated the top-down approach for designing a distributed database, which seemed to agree with Dias & Leelasena (1983). The basic areal unit he referred to as the global schema could be split into different local schemas due to some placement strategy.

Spatial data integration in Ghana is relevant to the current dispensation of decentralized planning. The problem has been the parochial manner in which each District department acquires and uses data. Each department has become an island onto itself in the generation and use of

data. Advances in information technology and the envisaged growing demand from information users to overcome the bottleneck and cost of data capture will compel users to share data by transferring them from one island to the other. It is already possible to obtain digital formats of some categories of data from some organisations such as the Survey Department, Lands Commission, Soil Research Institute of the Council for Scientific and Industrial Research and the Centre for Remote Sensing and Geographical Information Services of the University of Ghana. It is advocated that data interoperability become feasible at the District level to facilitate planning and policy decision-making. This will provide the means by which spatially distributed data sets can be connected together in a web in order to transparently exchange data and some remote access to other data services (Bishr, 1998). Interoperability is the ability of a system, or components of a system, to provide information portability and inter-application co-operative process control.

The thesis took a look at the decentralized departments of the District Assembly; the type of data acquired, processed and used to meet their operational mandates, and data types/files that could permit interoperability among the departments. A scheme was designed to show the spatial data types generated or required by the various departments and the type of approach to multidatabase design proposed. Details are discussed in Chapter Four.

1.8.4 *Spatial accessibility and the use of location-allocation models.*

A fundamental problem that has often confronted health planners in developing countries is the battle between improving healthcare delivery and the availability of resources to meet this objective. Health facilities are very often geographically inaccessible to the majority of the population, especially those in the rural areas (Freund, 1986; McEvers, 1980; Stock, 1985). The cost of healthcare makes it extremely

difficult to improve geographical accessibility to services, the main impediments being financial constraints and shortage of human resource (Philips, 1990).

The solution to this problem, according to some experts, has been found in a better spatial organisation of existing healthcare delivery systems. Rushton (1984) has advocated strongly for the role location-allocation model could play in using limited resources more efficiently to provide access for those currently without access. Oppong & Hodgson (1994) applied a simple location-allocation model using readily available local data to evaluate a public health policy, recommendation for improving accessibility to health facilities in rural Ghana. The result of that study was that simple applications of location-allocation models provide important information for general spatial decision-making. They contend that the models may be used to improve spatial accessibility without increasing the number of facilities and a minimum disruption to the existing system of facilities. Their analysis began by evaluating, using the *p*-median criterion, the accessibility provided by the system of facilities in place. It demonstrated how accessibility could be improved, and evaluated the potential for improving accessibility by providing additional facilities. They concluded their work with a discussion of how location-allocation modelling might be included in primary healthcare planning in Ghana.

Location-allocation modelling is not new. According to Møller-Jensen (1997), research into the theory of this concept has been carried out since the 1960s and early 1970s in relation to the growth of computer science in general. He maintained that what was missing back then was the detailed digital maps and the broad access to the necessary computing power which meant that the methods were seldom applied to realistic and complex situations.

GIS is a useful tool in location-allocation modelling. Several GIS software packages provide the tools for fast location-allocation modelling as a specific type of network analysis tool based on digital vector maps and databases (Møller-Jensen, 1997). This requires that a network of linear features links the area surrounding a centre. These linear features identify the fact that transportation resources on the ground normally occur along certain pre-defined corridors. Each linear feature in the network has an associated impedance value indicating the cost in terms of distance, time, and amount of fuel expended or other relevant unit, of transportation along this line. This impedance value will often be related to specific means of transportation.

Møller-Jensen (1997) applied location-allocation modelling assigning children from a residential location to the nearest school for a selected area of Copenhagen. The objective was to maximise accessibility while at the same time ensuring that no one has to travel an excessively great distance to attend school. This thesis used some aspects of the methodology to explore the possibility of maximising accessibility to health care facilities within the Ga District.

1.8.5 *Health and Sanitation application*

Works done in the area range from analysis of spatial accessibility to health care facilities, health facility placement, determination of the catchment population around health facilities, public health, epidemiological studies/disease mapping and the relationship between sanitation forms and disease incidence. With the availability of powerful personal computers and sophisticated user-friendly software, what used to be a tedious and approximate process of manually drawing maps and displaying data is less time consuming and more exact. Health specialists now attach great importance to map-based data presentation and analysis for several reasons (Yoon, 1995). First, map-based presentation of human disease data can be both informative and

intuitive, since human diseases tend to follow certain spatial and temporal patterns. Second, the information presented using maps may be easier for non-health specialists to comprehend. This is an important issue in the instances when politicians and non health-specialists make health resource allocation decisions. Finally, the tools for analysis of spatial information (GIS) are now used with ease by non-GIS specialists for their work.

GIS has had an impact on epidemiological mapping and modelling. This derives from the age-old practice within geography of using maps to examine the spatial incidence of diseases (Cliff & Hagget, 1996). For example, the distribution maps of yellow fever produced in 1798 are often given pride of place. But these were predated by maps of topics as diverse as hospital capacities and distribution of dressing stations on battlefields, through to maps of pestilential swamps and hostile medical environments. By the 1820s, the spread of cholera from India over Eurasia and North America saw the production of a spate of cholera maps with plates showing routes of spread, and dates and regions of occurrence.

The breakthrough in disease mapping occurred in the middle of the nineteenth century with the cholera map produced by Snow (1854) for the second edition of his prize-winning essay *On the mode of communication of cholera,* (Cliff & Hagget, 1996). What made Snow's work unique was not the cartography (dot maps, which were a well-established cartographic device, to show the geographical distribution of individual cholera deaths), but his inductive reasoning from the map. By showing what he termed the '*topography of the outbreak*', Snow was able to draw inference about the main source of infection.

The advent of GIS has made the mapping of disease distribution by chloropleth and point-pattern methods a relatively straightforward task.

But serious work in this field involves two approaches for which GIS may ultimately prove crucial:

- as an aid to spatial epidemiological modelling and forecasting, and
- as a vehicle to test hypothesis about mapped distributions.

A central issue raised by the growing number of disease maps (especially computer-produced maps) is the extent to which they are effective in enhancing our understanding of disease processes. While maps are often used to good visual effect, they can obscure evidence, suggest bogus concentrations, and start false trails. Cliff & Hagget (1996) contend however, that with careful use, GIS has the ability to rapidly sift the visual correlation between disease distributions and covers of explanatory variables. The technology also has the capability of combining such evidence with statistical and mathematical modelling in a manner that may both sharpen our appreciation of the value of disease maps and reduce errors of interpretation.

GIS is variedly used as a tool to control diseases. According to Yoon (1995) there are three obvious uses:

(i) as a surveillance and monitoring tool;

(ii) as an analytical tool; and

(iii) as a presentational tool.

By allowing the user to rapidly retrieve and display data associated with a geographical area, GIS can be considered an ideal tool for the surveillance and monitoring of tropical diseases. GIS can easily display, for example, prevalence levels of schistosomiasis for each town around a body of water using colours. Using longitudinal data, GIS can be used to identify the towns with increasing prevalence over a period of time.

GIS has been applied in many developing countries for diseases monitoring and control. An example of this was in Northern Botswana where a programme was carried out to control schistosomiasis

(Mokgweetsinyana, 1995). Environmental and health data were integrated into GIS to analyse the correlation between the distribution of the disease and other spatial information (e.g., population density, groundwater and sanitation). The programme involved the use of the information provided by the GIS for monitoring the disease and planning for environmental and community control. It also integrated other disease data (e.g. malaria and diarrhoea) into the system and explored the potential for planning of control measures. The methodology consisted of constructing base maps in ArcInfo formats. Schisto data (in a preliminary table) compiled and definitively analysed since 1985 were entered into Dbase III files. The data include locality or school, age, sex and quantitative faecal *s.mansoni* egg counts.

Clark et al (1997) described GIS application for the control of river blindness, as part of a regional public health initiative, in the inaccessible regions of six tropical Latin American countries including the Amazon Basin. The project used GIS to identify communities suspected to be infected by the river blindness disease, programmed the delivery of medication, measured performance of health workers and determined impact of treatment. The methodology involved digitising maps of the endemic zones, identifying suspect and endemic communities using buffer zones of known vector breeding sites, and locating communities with the help of GPS units. It also involved the production of maps to measure the performance of health brigades in the delivery of medication at the community level, and measuring the endemicity and trend of the disease.

The GIS tool used was Atlas GIS version 3.0 for windows. Data bases were in Xbase format and the application for gathering and keeping data were written in FoxPro and EpiInfo. The work aimed at showing that GIS is a powerful tool for managing and modelling public health problems in developing countries where digital maps are non existent,

access is difficult and funds are scarce. Maps were produced, for example, on the distribution of endemic onchocerciasis risk areas based on 5-km flight range (of the fly) buffer zone; and onchocerciasis prevalence based on skin snips.

A malaria field study in Western Kenya also ascertained the usefulness of GIS by using the Global Positioning System (GPS) in differential mode (DGPS) to obtain highly accurate longitudes and altitudes of a number of houses, health centres, mosquito breeding sites, and some water sources (Ombok *et al.*, 1997). Location data were entered into a geographic information system for map production and linked with various databases for spatial analyses.

Studies based on location-allocation of health facilities using GIS technology have also been done in a developing country. A project sponsored by WHO in Niger involved the use of GIS for health centre placement (Long, 1995) to assist in bringing health coverage to about 45% of the population. The methodology included the production of automated base maps showing location of existing health centres, administrative boundaries, roads, and village locations. Population figures were added from the 1988 census and proportionate circles used to depict populations for villages and towns. This was to allow for the visualisation of the population distribution around each health centre and search for best possible sites for new health centres using GIS technology.

The attributes considered were population within 5-km radius of a targeted village. This represented the catchment area of the health centre. By adding up the population of each village, it was possible to estimate the total population served by the health facility. Villages were listed in order of size of catchment population; so those with the highest catchment population were most desirable for selection. By

adding (one by one) new centres to the villages, beginning at the top of the list, and recalculating the total number of people served in the system and then calculating the resulting percentage of the population served, one could bring the expected total health coverage up to the desired 45% national goal.

Using this technique, it is possible to establish the minimum number of new health centres necessary to bring the health coverage up to 45% nation-wide (Long, 1995). The technique, even though valuable for analysis of potential sites for new health centre placement, could be enriched with the use of other factors such as distances from existing health centres, the population size of the settlements selected, locational efficiency and the central place function including existing and developed infrastructure base.

The project encountered database problems that most GIS applications face in developing countries. The census data could not be matched to all villages digitised from the original base map. This was due to village name inconsistencies. Spelling differences between names in the two databases caused many mismatches when combining or joining them. Many villages had multiple names, some had been relocated since the base maps were produced, and new villages had been established. It was noted that, for the whole of Niger, only 35% of the census villages could be matched to the digitised villages from the original base maps. In Ghana, the latest base maps produced by the land Survey Department are over 24 years old. This poses problems for settlements identification and location. The issue of inconsistencies in place names rendition has also posed problems to GIS researchers and other spatial database managers. The basic problem lies with joining data sets from different databases (mismatch).

A GIS approach to the determination of catchment populations around local health facilities was proposed for Kenya (Oranga, 1995). In the face of economic difficulties, the rational allocation of scarce resources on the basis of population size has become prime in most developing countries. In Kenya the fundamental issue has been the weaknesses in the health information system. Some highly desirable information such as population-based epidemiology, service quality data and socio-cultural information is not being collected. Problems exist in the flow of information from the field, including delays, non-reporting, non-response, and a generally unsatisfactory quality of generated data.

The Kenyan population is heterogeneous with ethnic, religious and socio-economic differences influencing illness concepts and demands for health care. However, the only available information on the local population is the Census of Population, normally conducted every ten years, which does not coincide with the actual catchment populations served by health facilities. The health information system should reflect these circumstances, but available data are almost exclusively about care-seeking clients and their service utilisation. A need exists for a more precise and complete description of the catchment population and health situation. It is important to generate this information at village, community and division or district level.

The methodology included the acquisition of data through field surveys, analyses of existing secondary data from maps, aerial photographs, reports and other documents. The main emphasis of data analysis would be on the production of maps of demographic data. This activity will rely on the collection of point data from known locations, and the use of the GPS to record precise locations where sample data are located.

It is concluded by the Kenyan study that a study to find the best location for health facility would start by identifying homesteads, road

networks and health facilities in the study area. For the allocation of health facilities, a number of variables such as road conditions/types and travel times will have to be incorporated into the database before running the allocation function. The various solutions generated will have to be evaluated against the criteria specified for siting the health facilities. Such criteria may be to locate a facility where travel costs are minimised.

1.8.6 *Problems of GIS use in developing countries*

Interest in GIS use is increasing among many third world country scientists, planners, policy makers and project managers (Teeffelen *et al*, 1992). It is noted however, that actual applications are still limited. It is only the national mapping agencies that have progressed most in using GIS. These agencies indeed were among the first organisations in the developing countries, which introduced computer techniques. Most of these through the largess of multi-lateral agencies notably, the World Bank, UNDP, and DANIDA. The reasons for this are obvious. The creation of topographic and other maps traditionally carried out in a painstaking way by professional draughtsmen often take many years; even minor updates meant that maps had to be completely redrawn. Consequently, planning agencies frequently had to cope with the lack of up-to-date maps, which were hardly ever available at suitable scales. Developments in computer-supported database and electronic cartography encouraged many organisations to resort to this new technology. National and regional planning agencies took advantage of this and thus introduced the use of computer-supported mapping procedures to display their physical and socio-economic data on different administrative levels. The technology was also prominently applied in the field of urban planning.

In spite of the transition towards a more thorough adoption of GIS systems it is noted that the process is fraught with problems. Teeffelen

et al, (1992) mentioned the problem of lack of well-organised spatial information. Where the data exists at all it is not easy to use without considerable processing. Borrough (1992) for instance discussed the problems that occur when spatial data sets, differing in spatial scale and quantitative detail, are to be combined. For this, he believes that it will take years before most developing countries possess fully operational GIS. He therefore cautioned against attempts to install super systems quickly. On the contrary, a modest start would provide some guarantee success in relatively short time. To this end, it has been advocated that a start with what is described as 'low-end' PC-based GIS systems to develop basic in-house expertise in the manipulation of geographic data is preferable. (Meijer & Kuipers, 1992).

Secondly, limited financial means often impose practical restrictions on the adoption and establishment of GIS. Lack of human resource seems to further compound the problem. While admitting the usefulness of GIS for regional planning, Riezbos (1991) indicated there are several obstacles impeding its implementation in planning practice. He mentioned the issue of thorough training in the use of GIS and the requirement of facilities, which are not always available. Secondly, there are often problems regarding the selection of data relevant for planning, data collection methods and data analysis. In addition, incompatibility of data may hamper the use of GIS in planning procedures. Clearly, according to him, geographical information systems cannot be blamed for these kinds of problems. In many cases such problems only become apparent when GIS is being implemented.

In Ghana the general lack of up-to-date base maps is a major set back to full GIS database development and utilisation. Available digital formats of base maps were derived from hard copy sheets published in the early 70s. Thus for example, newly developed transportation network, settlements and other spatial features cannot be represented except with

the aid of a GPS. At the District level, maps constructed so far have arbitrary boundary delineation, which pose problems for planning and research. Among various departments maps and data types used vary to the extent that they are virtually unusable in a GIS due to differences in scale. Also notable is the general organisation of spatial data sets. The various sectoral agencies demarcate different administrative units for their own purposes; many of them do not necessarily coincide. In many situations, the data collected by one department may not relate to the areal unit for which another agency collects data. It is therefore not possible to relate data sets for different data elements, which provides some of the most useful information.

1.9 **Objectives of the study**

The study focuses on the use of GIS as a decision support and planning tool and is applied in the integration of data and analysis of the problems of health and sanitation in the Ga District. Specifically, the study is based on the following objectives:

(a). To ascertain the spatial data needs of the Ga District departments and design a scheme for the integration of such data sets for planning and decision making purposes,
(b). To identify the elements of a prototype GIS for the Ga District,
(c). To apply this integrative format for the analysis of problems of health and sanitation in the Ga District using the overlay and other techniques involving data on major endemic diseases, and
(d). To ascertain geographical accessibility to healthcare services in the Ga District using network analysis.

1.10 **Propositions**

The Ga District Assembly, like all other districts in the country, is plagued with the problem of proper data documentation, lack of data integration, harmonisation and standardisation. For example, various

forms of data relating to the same problem are held in different forms within the district departments. A thorough understanding of the health and sanitation sectors and the relationship between these and disease types can only be achieved through the use of appropriate tools. The roles of GIS to integrate data, store such data, display and serve as a query and retrieval source for policy decision-making and planning is very immense. GIS serves also as a useful tool for the analysis of the inter-relationship between various phenomena through the overlay process. Based on the objectives outlined above and the potentials of GIS for District level development planning and decision-making the following propositions are made:

(a). That GIS constitutes a useful platform for the integration of various spatial data sets relevant for planning and decision making in the Ga District.

(b). The GIS tool is useful for investigating the association between endemic diseases incidence and environmental factors, and

(c). That GIS constitutes a useful platform for the analysis of spatial accessibility to health care services.

1.11 **Conceptual framework**

1.11.1 *Maps as Models and the Systems Approach*

The use of GIS as an approach to the analysis of problems of planning and as a decision support tool stems from the capacity of the technology to integrate different categories of information and modelling them to reveal real world situation in ways that are easily comprehensible. GIS is a modelling tool that offers among others, opportunities for reducing hitherto complex spatial phenomena to easily observable and assimilable form. The basic component of a GIS that facilitates the performance of this function is the map. Maps are regarded as iconic or representational models employed to communicate something of the nature of the real world (Board, 1967).

GIS also offers the tool for demonstrating the interrelationship between the various functional agencies or components of the district economy and integrating them to reveal its unified wholeness. According to Yoon (1995), GIS allows the display, analysis and understanding of data from diverse sources in what could be called a holistic approach to data management, analysis and presentation. This aspect of GIS's capabilities can best be explained away by the systems concept and approach. The study therefore lends itself to the use of maps as representational models and to the systems concept which explains the interrelationship between the various sectors and sub-sectors of the district economy and how these work together to explain the nature of the district as a unified entity.

1.11.2 *GIS/Maps as representational models*

In our attempt to explain the interrelationship between the large and complex phenomena that concern us, it becomes necessary to reduce them in order to be able to bring them into view (Robinson *et al.* 1995). The map offers the tool for doing this. Jack Estes and Jeffrey Star in defining GIS stated as follows: "An information system that is designed to work with data referenced by spatial or geographic co-ordinates. In other words, a GIS is both a database system with specific capabilities for spatially referenced data, as well as a set of operations for working with the data" (Star & Estes, 1990). The reference to geographic co-ordinates is an important one because the co-ordinates are literally how we are able to link data with the map. Maps therefore constitute the medium by which spatial data is represented to help explain the real world or significant aspects of the real world.

As representational tool the map is a conceptual model containing the essence of some generalisation about reality (Board, 1967). In that role

maps are useful analytical tools which help investigators to see the real world in a new light or even allow them an entirely new view of reality.

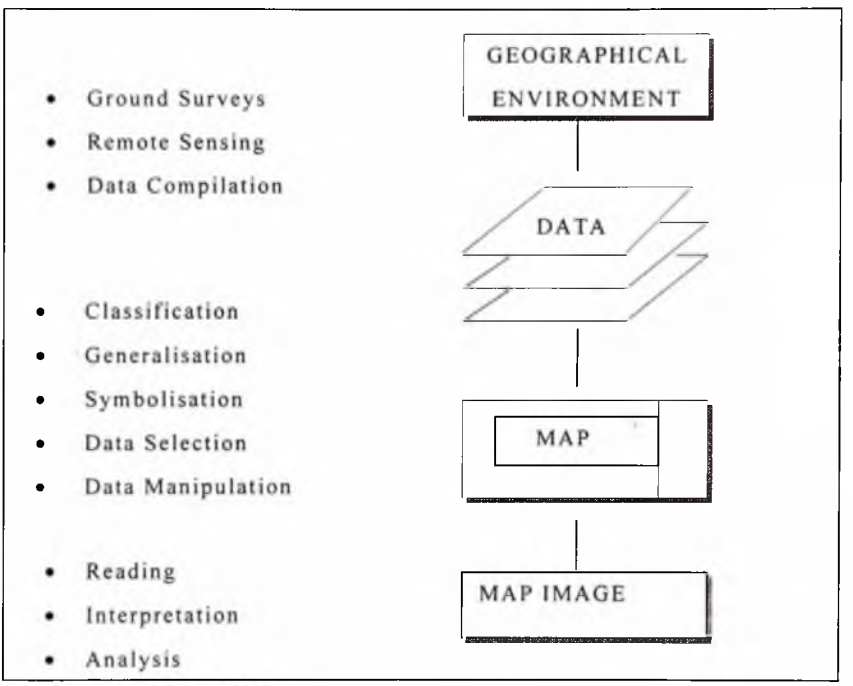
In his discussions about cycles of map making, Board (1967) indicated two major stages. The real world concentrated in model form and the model being tested against reality. In practice, the investigator who makes such maps has a new view of the real world. It is also obvious that the cycle may begin again with the revised view of the world. Board cites the example of an area with minimal map cover but with seemingly interesting variations in landuse pattern. These variations could be brought to view through the medium of maps, which records the significant elements of the landuse pattern. Once completed the map of landuse is taken into the field or is compared with reality in some other way. Speculations on the relationship between landuse and physical, economic and cultural factors may be tested. In many cases such tests will involve the design and construction of new maps of both trends and relationships in an attempt to unravel some of the complex patterns of the real world.

Sometimes the process of investigation starts with a map whose elements somehow give rise to some speculations in relation to the origin of, for example, a drainage pattern or some peculiarity in a maze of property boundaries. In this case the map, which is already a model of what it portrays, is dissected as is the landscape or the environment of the real world (Conzen, 1960). After such an investigation some of the results may well be presented in map form, thus entering yet another phase of the cycle.

As a representational tool, levels of information transformation takes place during the process of map construction. According to Tobler the mapping process is a series of information transformation, each of which has the power to alter the appearance of the final product

(Tobler, 1979). For example, the actual phenomena are altered through the processes of data collection, that is, ground surveys, remote sensing and data compilation. The data is further altered through the abstraction process of mapping, such as data selection by the map compiler, data manipulation and symbolisation (Figure 1.3). The acts of reading and interpreting the final map(s) further change the data.

Figure 1.3: The process of information transformation



Source: Tobler, 1979.

The importance of the map as a model and as an essential component of a GIS is seen in its ability to facilitate the depiction of different categories or layers of information hereby referred to as 'coverages'. As Board (1967) put it, speculations on relationship between several factors can be tested using maps in order to unravel some of the complex patterns of the real world. The fact is that each of these tests will involve the construction of new maps, which in the traditional and analogue setting is laborious and time consuming. The test here referred

to, consist of coverages put together through the overlay process to unravel existing patterns of relationship between the factors under investigation.

For a District GIS, this modelling capabilities, which are designed to enhance planning and a more informed decision making, is facilitated by the 'overlay' process which allows for the execution of planning scenarios. For every scenario, a new map of trends and relationships between the various phenomena is constructed. Besides, GIS has the advantage of database query and analysis. For each theme on the map an attribute data table is available to which additional data fields could be added, queried and new information generated.

Notwithstanding the immense advantages inherent in the map, the issue of information transformation at the various stages of modelling the District phenomena cannot be lost sight of. Without doubt there arises issues of digitising errors, data mismatch, settlement placement due to same names occurring for several communities, symbolisation, generalisation, etc.

1.11.3 *The Systems Approach*

The linkage or spatial relationship between the various components of the district economy (a system here denoted by the operations of the functional agencies or district departments) can be demonstrated in a GIS. A GIS does this by linking data sets or coverages to facilitate a more thorough understanding of the relationship among the various phenomena under study. This capability lends GIS technique to the systems approach; an approach that is implicit in most geographic work (Chorley & Haggett, 1967).

The word system implies an organisation of 'things' that are linked together. Very simply a system can be defined as a collection of

components, parts or events which are linked together in such a way as to form a working unit or unified whole (Tivy & O'Hare, 1990). As a result any change in one part of the system will impact on, and be reflected in changes in, all the other parts.

The systems concept has been applied in diverse studies including ecology, geomorphology and hydrology. For example, in adopting a general systematic approach to the study of landforms, it is held that the emphasis should lie in the organisation and operation of the system as a whole or as linked components, rather than in detailed study of individual system elements (Von Bertalanffy, 1962). Tansley (1946) in applying the ecosystem concept into ecology for both the biome and its habitat stated as follows:

> "All the parts of such an ecosystem organic and inorganic biome and habitat may be regarded as interacting factors which, in a mature ecosystem, are in approximate equilibrium: it is through their interactions that the whole system is maintained".

The thesis views the district as an integral system, that is to say, a unified entity and the components or inputs from the functional agencies (district departments) as the identifiable parts or significant elements. It is assumed that a change in the functioning of a part of the district system will impact on and be reflected in the smooth working of other parts. An analysis of the interactions between the components of the district is what is hoped to bring about the effective functioning of the district as a whole. For example, the planning system for the district involves among others an effective collaboration among the various functional agencies within the District Assembly. A synthesis of the District's problems, objectives and goals through sectoral inputs has been prescribed as a basic requirement for the District plans (NDPC, 1995).

The role of GIS in such a system is to provide the means of facilitating the integration of information applying the layered data or overlay concept with the view to helping explain the interrelationship between the various facets of the economy. It is also to facilitate the analysis of issues that are relevant to planning and decision-making. The study has considered as a major facet, the integration of sets of spatial data located within the district departments. The health and sanitation sub-sectors studied could be viewed as subsystems of the district whose components together provide typical example of how decision could be made through the integration of data as a form of analysis.

CHAPTER TWO

METHOD OF STUDY

2.0 Introduction

The study is in two parts. The first part is concerned with the design of a scheme for data integration at the district level and the identification of the elements of a district level prototype GIS. The second part deals with the application of GIS to the analysis of problems of health and sanitation in the district through the integration of various data categories such as on sanitation types, household water supply sources, forms of solid waste disposal, endemic diseases, healthcare facilities, major water bodies, settlements, population and road network. The purpose is to see how the superimposition of some of these data categories or layers of information or coverages helps to show the types of relationships among them in order to provide information that will support decision making and policies in the health and sanitation subsectors. It is also to show how disparate data sets from various sources but of the same scale could be combined within the context of a district to produce new information for decision-making and planning.

2.1 The scheme for data integration

Data integration is relevant within the context of local or sub-national level planning. It forms the basis for merging data sets acquired and processed by individual district departments and thus helps remove the bottlenecks of cost of data acquisition. The framework for plans outlined by the NDPC for the districts enjoined a holistic approach to plan development through sectoral or departmental inputs. The study takes this into view and sought to apply this concept to the integration of data sets from the district departments and also to see how the integration of different categories of data in different combinations (through the overlay process) could help support planning in health and sanitation subsectors of the Ga District.

An open-ended questionnaire on spatial data types acquired and processed was drawn and administered at all the decentralised and non-decentralised district departments. In all, 15 departments were identified as producing spatial data. The questionnaire ascertained the mandates and functions of the departments, the data types they generate and use, and the spatial scales at which they collect such data sets. It was also to help show in the final analysis a global conceptual schema. The study also considered the basic approaches to multidatabase development and integration. Following after Laurini (1998), the approach is discussed in Chapter Four.

2.2 **The elements of district level prototype GIS**

The elements of the prototype GIS for the district were conceptualised and based on the following:

main sources of data – encompassing all district departments acquiring and processing spatial data,

data categories generated or acquired consequent to the operations of the district departments – encompassing several aspects of environmental data and socio-economic and cultural data,

means of generating such data (using both GIS and Remote Sensing),

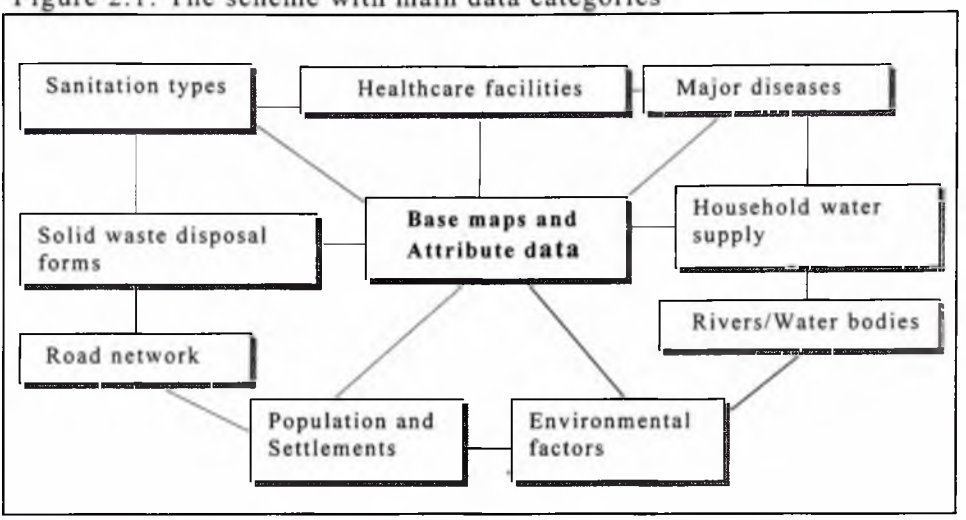
software components of the GIS showing the theoretical bases for modules for data input, data storage, data presentation, data transformation and analysis and query input.

These provided the basic ingredients for the design of a scheme shown and discussed in Chapter four. This was based on a general study of the structure of the district through discussions with officials of the District Co-ordinating Directorate and on general knowledge of the theoretical basis for GIS implementation. For example, Borroughs (1998) has discussed the basic software module for a GIS.

2.3 **Data categories for the GIS analysis**

The study was based on data categories that have health and sanitation as the main components. These data categories or layers of information were linked to base maps and attribute data tables. These are illustrated as a scheme and presented in Figure 2.1 below.

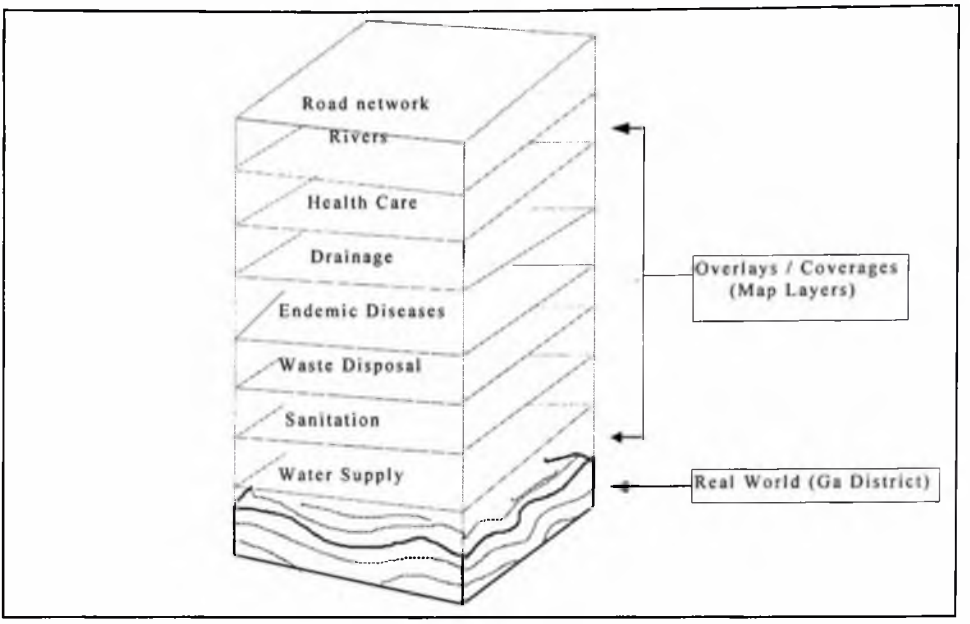
Figure 2.1: The scheme with main data categories



The other components of the scheme include major diseases, household water supply, population and settlements, road network, solid waste disposal forms, sanitation types, environmental factors and healthcare facilities location.

The purpose of these data categories is to facilitate GIS analysis by integrating them through the 'overlay' method. Here different geographical attributes are represented by separate sets of Cartesian arrays to create layered databases. Theoretically, the district (real world) situation is portrayed by a series of overlays or themes in each of which one aspect of reality (e.g. sanitation, health care, population etc.) has been recorded such as is shown in Figure 2.2. The objective is to allow for the display of different scenarios, which can lead to better information and therefore improved decisions.

Figure 2.2: The 'overlay' or layered database concept



After Borrough, 1987

2.4 **Sources of base data**

A digital format of base map data covering the study area was obtained from the Survey Department. This data was originally digitised from the 1:50,000 topo sheets series of 1974. From the Centre for Remote Sensing and Geographic Information Services (CERSGIS), University of Ghana was obtained a digital copy of both map and attribute database of the study area. This data was based on a feeder roads project executed by the Centre and includes road network, population and settlement listing for the Ga District. Supplementary base map information was obtained from the District Town and Country Planning Department. Field trips and the use of the GPS facilitated modifications to be made to the existing district boundary delineation. It also enabled the inclusion of areas hitherto not shown on the basic maps of the district. Some road network data was also captured through the use of a continuously logging GPS.

2.5 Map layers (coverages)

Details of map layers or coverages based on the categories of data outlined in Figures 2.1 and 2.2 are discussed below. These categories of data were entered as fields into an already established attribute database, which has 1984 population and settlements data as the common field.

The sets of data collected did not involve household surveys which are often the reliable way to get crucial data for a given population especially for primary health care (PHC) evaluations (El Bindari-Hammad and Smith, 1992). This is due to problems posed when mapping dynamic human populations/features rather than discrete physical objects in a GIS milieu (Martin, 1991). Thus at the scale of mapping, on which the thesis was based, data sets were aggregated at individual town/settlement (point) level. In this way the general sanitation types, solid waste disposal forms and household water supply system were depicted for each settlement. This means that on a map face the symbol for the environmental factor common in the settlement was used. These were the basic thematic information required to describe the situation for each settlement. The case for data on the major diseases obtained from patients' diagnostic records was no less different. Here the main emphasis was on the number of cases reported from the various communities. These were then aggregated as graduated symbols for each community.

2.5.1 *Sanitation types and solid waste disposal forms*

Data on sanitation types and forms of solid waste disposal were obtained through personal enquiries at the District Health Management and the Environmental Health Units. No samples were taken. The data sets were collected at individual town or village level based on data covering the entire district compiled by the Environmental Health Unit as part of the routine data acquisition for environmental health

monitoring. The predominant sanitation types or practices and solid waste disposal forms at each community were chosen as being the general. Specifically, the following categories were contained in the sanitation theme: flush toilets or water closets, KVIPs, pit latrines and open defecation. The solid waste disposal theme is a map layer containing the following categories: home collection, backyard dumping and sanitary landfill. The relevance of these data sets was to establish the spatial relationship between them and disease incidence in the district.

2.5.2 *Health care facilities*

This is a coverage or theme that shows the spatial distribution of the major health care facilities. In all, five Ministry of Health facilities were mapped. These are the main facilities providing primary health care and supporting outreach services in the district. On the basis of their location, the district has been divided into 5 sub-districts. An assessment of the locational efficiency of these facilities was done using network analyst functionality in ArcView. This is an aspect of location-allocation modelling, which determines spatial accessibility to the major facilities based on map data of population and linear features such as the road network. Data for this component of the study was obtained from the District Health Management Unit. Population and road network data were already established in the main attribute data table and was used as the linear feature for the analysis.

2.5.3 *Household water supply*

Closely related to health and sanitation is the issue of household water. Sources of household water supply were entered as coverages or themes. The categories are pipe borne systems, wells, boreholes and rivers or streams. Data for this was obtained from the District Co-ordinating Unit where through the scalogram methods of analysis matrices of communities and the infrastructure requirements were

compiled for all electoral areas in the district. This was supplemented with data obtained from the Environmental Health Unit. Direct field observations were also made of the household water sources to confirm the general situations. The data categories were entered as fields created in the main attribute database against every individual community and converted into shapefiles. Graduated colours were used to show the different categories.

2.5.4 *Endemic diseases*

Endemic in the district are malaria, buruli ulcer, skin infections, upper respiratory tract infections, diarrhoea, acute eye infections, measles, chicken pox, ear infections and intestinal worms infection (MOH/Ghana Health Services, 1998). Data covering a period of one-year (October 1997 and September 1998) was obtained from health diagnosis records of individual patients at the five main MOH facilities. The five facilities are supposed to serve five major geographical or catchment areas in the district. For community level data, cases reported by patients were aggregated. This was done for the prevalent diseases listed above on monthly basis. The aim was to ascertain the spatial incidence and levels of endemicity of the various diseases in the district with the view to providing indications of their causes. In this way policy makers are equipped with the relevant information to assist in control and mitigation measures. This was achieved by overlaying the diseases coverage on each of the environmental factor coverages, namely sanitation types, solid waste disposal forms and sources of household water supply.

Although buruli ulcer was not ranked among the top diseases in the district in terms of reported number of cases, it was given special attention. Notable is its debilitating effect on the affected communities and the social stigma attached to it. A case study of the disease in 1997 by the District Director of Medical Services provided some data on

distribution pattern of cases observed. Clinical records for the period between October 1997 and September 1998 from Amasaman and Obom Health Centres also supplied some data that was used to show endemic communities. Buffer zones of the endemic areas were constructed and environmental factors that could explain the cause of the disease were modelled using the overlay method of analysis.

2.5.5 *Population and settlements*

The population database was used as a source table for much of the attribute data sets used in the GIS. It helped to define the region being referred to as the Ga District (formerly Ga Rural) and this was principally obtained from the 1984 census. This also provided the list of settlements and the related attribute data. In the absence of any recent population census data on the district annual growth rate of 6.2% was computed to obtain the projections for 1996.

2.5.6 *Road network*

The road network theme was included as a layer from the base data obtained from Survey Department and the Feeder Roads Project of CERSGIS. Part of the network was also captured using the Garmin 12XL GPS. Attributes such as road length, road type, distance, travel time, and surface type were included as part of the data. As linear feature the road network layer was used not only to show the general communication network but also to facilitate location-allocation modelling (LAM). LAM is a specific type of network tool based on digital vector maps and databases. A background study of the major components of geographical accessibility to health care services in the district was done. This was through a questionnaire administered on a sample of 22 patients from different communities in each of the five sub-districts reporting at the MOH facilities. This was the average number of communities from which patients commuted to the health facilities daily.

2.5.7 *Major rivers*

A theme for the major rivers or streams in the district was digitised on screen from the original rivers and streams layer also obtained as part of the base data from Survey Department. It was basically required for a study of the association between some of the major diseases and water bodies.

2.6 **Summary of the study approach**

Generally, the study approach was divided into three phases, namely:

conceptual database design,
physical database design, and
the development of the user interface.

Conceptual database design or rather to say initial design framework included the following mutually related activities:

(a) Identification and design of a scheme for the integration of the various categories of data under healthcare, sanitation, household water sources, solid waste disposal forms, environmental conditions, endemic diseases and population in the district. Also considered was a general scheme of data integration to allow for inter-departmental data sharing.

(b) Collection and categorisation of data as well as evaluation of their usefulness for planning and decision making.

(c) Determination of the scope and contents of GIS database for the health and sanitation sectors along with the development of the database model and its component database documentation etc.

The second phase was the design of the physical database. It included:

(a) Acquisition and preparation of base data in digital and analogue formats. In this case the digital data was obtained from Survey Department and the CERSGIS. Data obtained from the field were fed into the attribute database, converted into shapefiles and used as layers of information or themes.

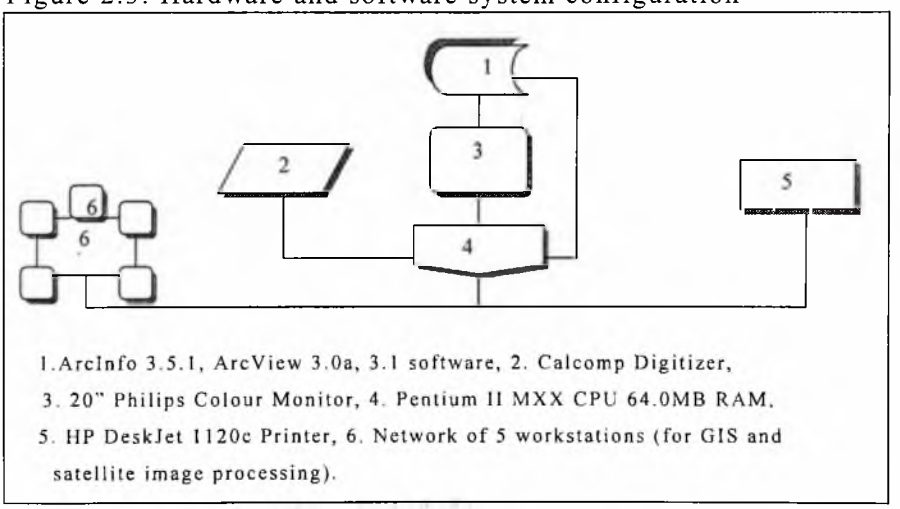
(b) Map preparation. Several thematic maps were prepared and edited in the view window and for map composition or better cartographic effect they were composed in the layout.

The third phase, which is basically an interactive one, involved the use of integrated set of computer-assisted procedures and extensions to facilitate the database query and analysis. The results were discussed and shown in Chapters five and six.

2.7 **Hardware and software systems configuration**

The software used were ESRI's PC ArcInfo Version 3.5.1 and ArcView GIS Version 3.0a and 3.1. Several extensions of ArcView were utilised. This included the network analyst, the geoprocessing tool, buffer wizard and legend tool. The software and hardware systems used and their configuration is shown in Figure 2.3.

Figure 2.3: Hardware and software system configuration

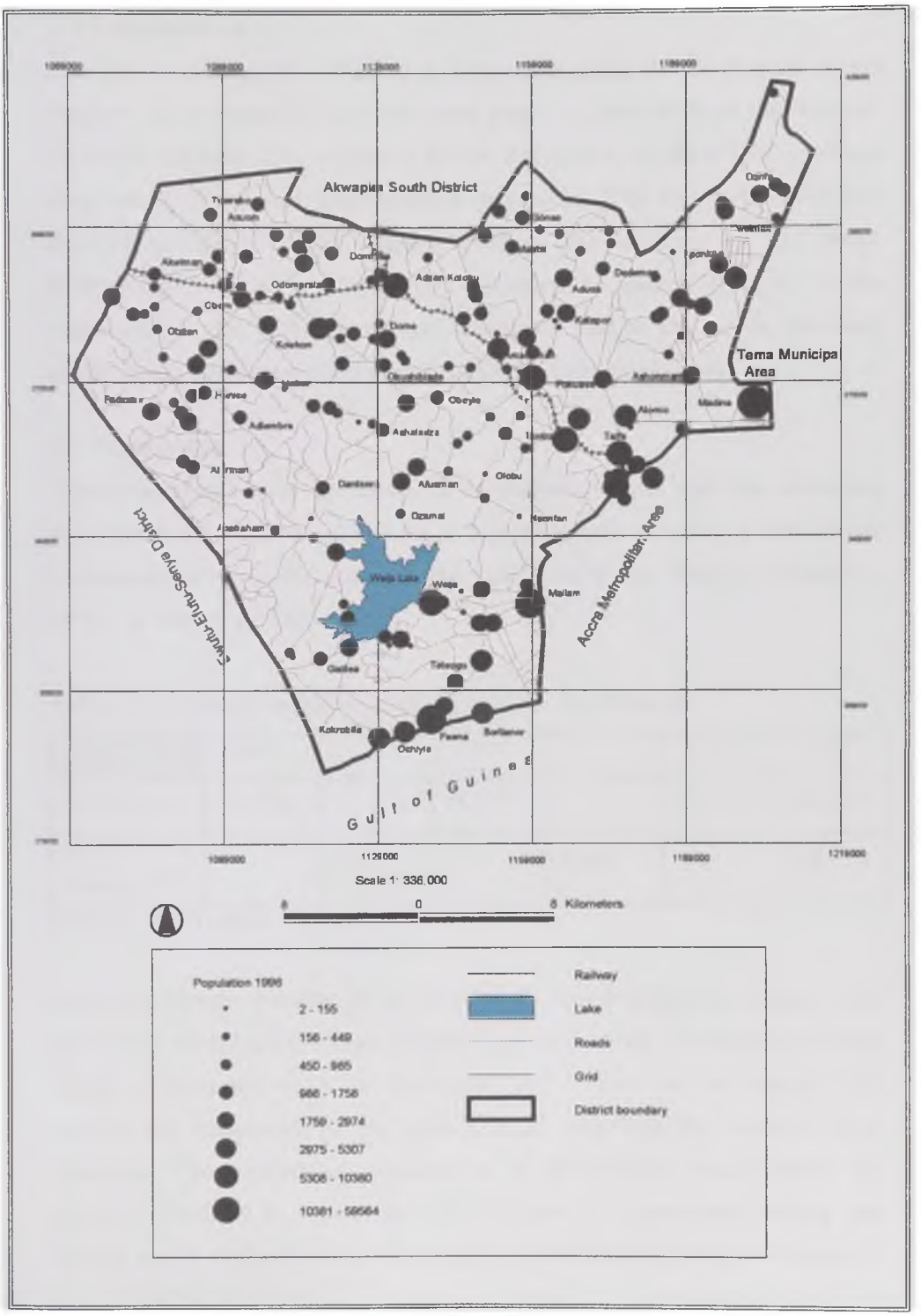


1.ArcInfo 3.5.1, ArcView 3.0a, 3.1 software, 2. Calcomp Digitizer, 3. 20" Philips Colour Monitor, 4. Pentium II MXX CPU 64.0MB RAM, 5. HP DeskJet 1120c Printer, 6. Network of 5 workstations (for GIS and satellite image processing).

It includes a 0.98GB disk capacity Pentium II MXX CPU 64.0MB RAM, a 20" Philips Colour Monitor, CalComp Digitising Board and a Hewlett-Packard DeskJet 1120c Printer. The GIS projects were executed in the Remote Sensing Applications Laboratory of the Department of Geography and Resource Development, University of Ghana and in the

GIS Laboratory in the Institute of Geography, University of Copenhagen, Denmark.

Figure 3.1: Population distribution - 1996



CHAPTER THREE

BACKGROUND OF THE GA DISTRICT

3.0 Introduction

The Ga District is one of the five districts making-up the Greater Accra Region. It is located to the west and partly to the north of the Region. Towards the east, it is bordered by the Ablekuma, Okaikoi and Ayawaso districts of the Accra Metropolitan Assembly. The Ewutu-Efutu-Senya district of the Central Region borders the district to the west. Northward is the Akwapim South District of the Eastern Region. To the north-east is the Tema Municipal Assembly and to the south, the Gulf of Guinea. It has a total land area of 859 square kilometres.

3.1 Population

The District has been divided into 42 electoral areas and the estimated population by 1996 was 280,656 at a growth rate of 6.2%; a rate which is considered twice the national average of 3.1% (Ga District Assembly, 1996) as shown in Table 3.1.

Table 3.1: Basic population statistics of the Ga District

	1960		1970		1984	1996
Population	31,308		58,674		133,358	280,656
Annual changes (%)		1.065		1.062		6.2

Source: Ga District Assembly, 1996.

High population density in the district is found along the border with the Accra Metropolitan area (Figure 3.1) and along its southern border where settlements such as Bortianor and Oshie can be found. This depicts the expansion of the metropolitan area into the hitherto rural districts. The remaining population is distributed evenly over the district. Table 3.2 shows the distribution of population among the eleven major settlements in the district. The relatively large settlements

are Madina, Mallam, Bortianor, Pokuase, Weija, Dome, Kwashiman, Ofankor and Adzen Kotoku. The District capital, Amasaman is the twelfth largest settlement with a population of 2799 according to 1996 estimates.

Table 3.2: Population by major settlements

	Settlement	Population			
		1960	1970	1984	1996
1	Madina		7,480	28,364	59,564
2	Mallam	2,407	2,536	4,943	10,380
3	Bortianor	1,840	2,088	3,298	6,926
4	Weija	1,551	1,909	2,464	5,174
5	Pokuase	1,207	1,990	2,527	5,307
6	Dome	420	772	1,931	4,055
7	Kwashiman			1,906	4,003
8	Mile 7			1,870	3,927
9	Ofankor	504	937	1,649	3,463
10	Adzen Kotoku	968	1,290	1,654	3,473
11	Oshie	701	715	1,416	2,974
	Total (10 largest settlements)	7,358	16,411	48,142	100,052
	Total (District)	31,308	58,674	133,358	280,656

Source: Ga District Assembly, 1996.

Less than 80% of the population live in the rural areas of the district and depends mainly on the subsistence or small scale agriculture-related income activities. The vagaries of the weather, the marginal soils, the high cost of agricultural produce, the lack of post harvest handling facilities etc. makes income levels quite low.

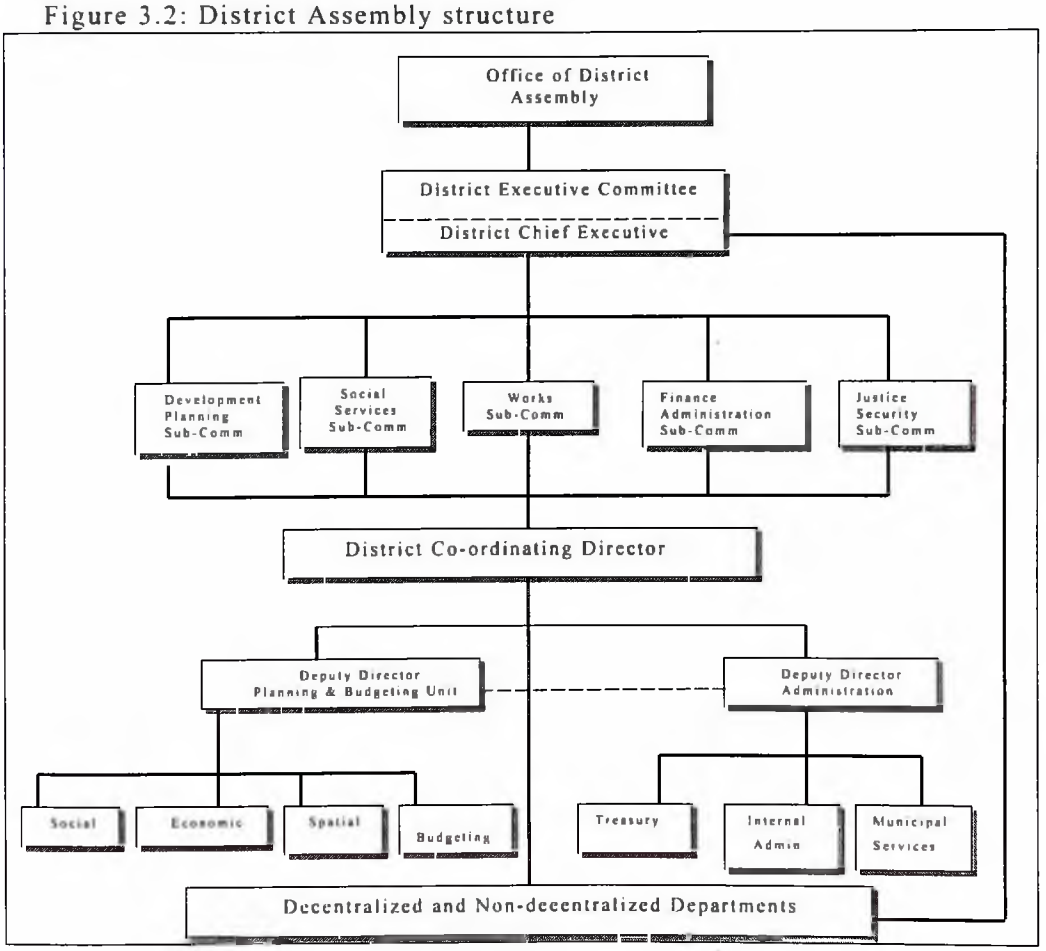
3.2 **The Ga District Assembly Structure and Planning**

The Ga District was created in 1988 and is the second largest of the five districts of the Greater Accra Region. Some of the decentralized and semi decentralized departments represented in the district include Education, Agriculture, Works, Physical Planning, Social Welfare and Community Development, Natural Resource Conservation, Disaster

Prevention, Central Administration, Health, Finance, Trade and Industry. The constituents of these departments are shown in Figure 3.2. The political head is the District Chief Executive.

The District Assembly consists principally of the Office of the District Assembly as the highest body. Its executive functions are performed by the Executive Committee, which is presided over by the Chief Executive. For the effective governance and socio-economic development, sub-committees on Development Planning, Social Services, Works, Finance and Administration, Justice and Security have been established as important organs of the Executive Committee.

Figure 3.2: District Assembly structure



Source: Ministry of Local Government and Rural Development, 1996.

The District Co-ordinating Director (who heads the DPCU) serves as the Chief Director of the district and co-ordinates planning activities of the various departments both decentralized and non-decentralised.

Nineteen departments constitute both the decentralized and non-decentralized establishments in the district. These serve as the functional agencies of the Assembly through which the various facets of development are carried out. The categories of spatial data sets acquired and processed by these departments have been illustrated in a scheme in Chapter four of the thesis.

According to the law that established the District Assemblies, the Assemblies are supposed to be the first line units of the national planning system. Their role is to provide the basic data to go into the over all national planning. This planning is supposed to be both short term and long term. The short term planning implies the annual budgeting where the Assembly is expected to provide a "composite budget" including income and expenses for all ministerial departments as well as for its own offices. In terms of long term planning the Assembly is expected to prepare plans for the development of infrastructure in its district and thereby submit its priorities for development projects to be included in the National Plan. It should be emphasised that the main role of the local authorities is to provide data and information (including priorities). This information is then supposed to be "harmonised" with that of other districts and adapted to regional and national frames at the regional and eventually at the national level where the National Development Planning Commission is responsible for working out the National Plan.

3.3 **The Health Sector Infrastructure**

The district is subdivided into five health catchment areas or sub-districts namely, Amasaman, Danfa, Madina, Obom and Weija. These sub-districts are supposed to be served by the five B-Level health

facilities. The various levels of facilities in Ghana are based on a three-level hierarchical structure designed by the Ministry of Health (1978). The number of government, quasi-government and non-governmental institutions providing health services in the district is shown in Table 3.3.

Table 3.3: Institutions providing Health Services by Sub-District in the Ga District

Sub-district	Ministry of Health institutions		Quasi-Govt. institution	NGO built clinics	Total health institutions
	Health centre	MCH/FP clinic			
AMASAMAN	1	0	0	2	3
DANFA	1	2	0	1	4
MADINA	0	1	1	0	2
OBOM	1	0	0	2	3
WEIJA	1	1	0	1	3
DISTRICT TOTAL	4	4	1	6	15

Source. Ga District Health Management Team, 1996.

Altogether there are 15 health institutions in the district but not all of these provide services covering the entire district. Basically, it is the Ministry of Health facilities that are patronised by the majority of the people in the district. The number therefore makes them inadequate to meet the goals of primary health care in the district. The only quasi-government institution located in the Madina sub-district is a specialised facility, which caters for mental health cases. According to the DHMT, information on private health facilities providing services in the district is incomplete. They include the private medical practitioners, maternity homes, traditional birth attendants, pharmacy shops, chemical sellers' stores, traditional medical healers and others (MOH/Ghana Health Service, 1998).

The main sub-district, number of communities that constitute the catchment area for the health facilities and projected population for

1998 are presented in Table 3.4. According to this projection the District's population was 236088. Based on estimates made by the District Health Management Team (DHMT) following the routine

Table 3.4: Ga District health sub-districts and population projection, 1998

Sub-district	Approx. no. of communities in catchment area	Health facilities	1998 projected population	No. of outreach points
Amasaman	151	Amasaman Health Centre, Oduman Health Centre	87482	46
Danfa	31	Danfa Health Centre, Abokobi Maternal and Child Health Clinic	22809	29
Madina	13	Madina Maternal and Child Health Clinic/FP	43222	14
Obom	101	Obom Rural Health Centre, Kwameanum Maternal and Child Health Clinic	43045	90
Weija	24	CDH, Communicable Diseases Hospital, Weija Public Health Nursing Demonstration Clinic, Malam, Amanfro Health Centre	39530	18

GA District Health Management Team, 1996.

immunisation exercises done, the total population has been put at 290,000. This estimate is based on increased infrastructural development in the District and the surge in migration from both the city centres and the adjoining hinterlands to the District (MOH/Ghana Health Service, 1998). The crowding of the city of Accra coupled with the high cost of rental accommodation has led a considerable number of workers to chose to live outside the city and commute to work instead. For example, communities such as Ofankor, Pokuase, Dome, Fise, Medie and Amasaman the district capital itself have large concentrations of residents who do business in the Accra metropolis and the nearby township of Nsawam in the Akwapim South District. There

is also the phenomenon of land acquisition in the district by many residents from the Accra metropolis as a way of getting away from the congested core area of Accra. Since it is likely that this rise in population will continue to be a feature of the district's development, it is important to see how this impinges on available health facilities or the health sector in general. Geographical accessibility to the MOH facilities was therefore investigated and results presented in Chapter five of the thesis.

3.4 **Sanitation facilities**

The Ga District is predominantly rural but has a substantial proportion of its population residing in the urban areas, especially along areas that fringe the Accra Metropolitan Area. It is therefore common to find different categories of sanitation facilities and practices in the district. The sanitation factor has become relevant since it contributes to determining the health status of the population. It has been shown that improvements in health cannot be achieved without a look at the environmental factors including where people live and the variety of life styles of the people (Scholtern & de Lepper, 1991). Health and environment have therefore become intricately linked. For example, a considerable number of communicable diseases were associated with the sanitation situation in some of the communities. The categories and distribution of the types of sanitation in the district are illustrated and discussed in Chapter five of the thesis.

3.5 **Household water supply**

Household water supply in the district varies from pipe-borne systems to wells, ponds, boreholes and rivers or streams. The majority of the populations however rely on streams or rivers as the main source of water supply. In some cases the incidence of skin diseases and diarrhoea was linked to poor water supply situation. Only a few areas in the district have piped or potable water. Amasaman, the district capital,

relies on water delivered by tankers, stored in concrete tanks and dispensed to poor households in buckets and other receptacles. Sometimes these concrete tanks are connected to rooftops to harvest rainwater to supplement household supplies. In some communities water sources include rivers or streams and wells. The range of drinking water facilities are illustrated and discussed in Chapter five of the thesis.

3.6 **Solid waste disposal**

Various forms of solid waste disposal are found in the district. The commonest is open or indiscriminate or crude dumping of garbage usually around households or designated spots within the communities. House to house collection of household refuse is done in the urban parts of the district. A characteristic of these practices is that much of these are not collected regularly and thus pose danger to the health of residents. A large sanitary landfill is found in Mallam very close to residential units. This is a major problem having implications for the health of residents. The categories of solid waste disposal forms in the district and the diseases associated with them are illustrated and discussed in Chapter five of the thesis.

CHAPTER FOUR

THE DESIGN OF A SCHEME FOR SPATIAL DATA INTEGRATION AND IDENTIFIABLE ELEMENTS OF A PROTOTYPE GIS FOR THE GA DISTRICT

4.0 **Introduction**

GIS practitioners contend that about 80 percent of all data contain a geographic or spatial component (ESRI, 1997). This means that such category of data has potentials for use in a GIS. Many agencies and departments collect and process data as part of their functions, or collect data as indirect consequence of their regular functions but do not process such data regularly or collect little data incidental to their regular work but rarely process them (Dias & Poudyal, 1992). The fact remains that substantial proportions of such data have spatial elements, which may be required by other agencies or private individuals for use. Planners and researchers are often confronted with the issue of how to integrate the maze of data that they collect and process from different sources. It is within this context that the issue of geographical interoperability becomes very relevant especially where computers must be required for information processing. There is an increasing need to share various types of resources such as data and services and this is especially true of spatial information.

In Ghana, the decentralization policy did not only involve the devolution of political administration from the central government to the local level but also the planning process. This also called for the creation of decentralized departments, which carry out the various facets of development in the districts. Armed with their operational mandates these departments acquire and process different categories of data either consequent to their functions or rather incidental to their regular work. As part of the policy, these departments must not only collaborate with each other but also seek to integrate development plans. Collaboration among the departments to achieve the goal of holistic plans for the district will certainly call for data integration.

This chapter attempts to look at the issue of data integration among the district department for GIS interoperability and proposes the basic elements for a scheme for a prototype GIS for the Ga district. The idea is to demonstrate that for holistic planning and decision making, data from the various decentralized departments need

to be integrated as a first step. A practical end to this idea is to integrate sets of data generated from different sources for health and sanitation sector planning particularly for diseases monitoring. In a similar vein the same principle of data integration is applied within the framework of layered data concept to analyze spatial accessibility to healthcare services within the district.

4.1 **The concept of spatial data integration and interoperability in GIS**

The process of unifying existing data sources into a single framework is called database integration (Devogele *et al.* 1998). It takes as input a set of databases, herein referred to as schemas and data instances, and produces as output a single unified description of the input schema called the integrated schema. It also unifies the associated mapping information supporting integrated access to existing data instances through the integrated schema (Batini *et al.* 1986, Parent *et al.* 1997).

Interoperability can be formally defined as the ability of different software applications to freely exchange data and processing resources in real time without the penalty of information loss (Raper, 1999). Interoperability is attained when compatibility exists among the database formats, software products, spatial conceptions, quality standards, etc. With the rapid advancement in information systems and distributed database paradigms, GIS users realized the need for interoperable geographical information systems, IGIS. IGIS provide the means by which spatially distributed GISs can be connected together in a web in order to transparently exchange data and some remote access to GIS services (Bishr, 1998). For example, spatially distributed databases found lodged within the various decentralized departments could be connected in a local web of cooperating systems to enable data exchange and flexibility of analysis. Even though interoperability has not yet been achieved in GIS circles, being thought of as a nightmare for systems developers but a dream for users, the fact that its basic ingredient is data integration from different sources makes it unique for planning applications. It holds great advantages for district level decision-making and planning where data from different departments require to be integrated for what has come to be termed holistic plan development.

It has been argued that database integration is the most sophisticated and most powerful approach to data interoperability (Devogele *et al.* 1998). Simpler alternatives have however been prescribed. The first basic approach, which does not attempt any integration, is to provide users with a global catalogue of accessible information sources, where each source is described by some associated meta-data, including representation mode, scale, last update, and data quality level (Stephan & Vckovski. 1993; Uitermark, 1996). The Alexandria Digital Library project (Frew *et al.* 1995) is one example of a major effort to build sophisticated tools for such catalogues. A variant to this solution is the use of dedicated Web browser services to explore GIS data available at different sites (GEO2DIS, 1997).

The concept of federated database (FDB) has been proposed (Sheth and Larson, 1990). It aims at scalable integration, combining data integration and site autonomy requirements. They allow each database administrator to define the subset of the local data, if any, which is to be made available to users of the federated system. These subsets are integrated into one (or more) virtual DB, called the FDB; virtual here being referred to the fact that only the schema of the FDB is created.

Some methodologies for the process of organizing database integration and general GIS database conversion have been discussed (Devogele *et al.* 1998; Parent & Spaccapietra; Piwowar *et al.* 1990; Bugayevsky & Snyder, 1995; Demirkesen & Schaffrin, 1996; Fagan & Soehngen 1987; Laurini, 1994; Flowerdew, 1992; Raus & Plazanet, 1996). However, what is most relevant to the present study and which focuses attention on an approach to spatial database GIS interoperability implementation, is the global framework proposed by Laurini (1998).

4.2 **Practical problems of data and planning in the Ga District**

A major ingredient of planning is information (Dias & Poudyal, 1992). The nature of this information need for planning has however changed drastically in recent times due to the fact that planning has become more decentralized and target group oriented. It is also adopting a bottom up approach to respond to the needs of the people. The value of the information however depends upon two factors, the reliability of the data from which it is derived and the ease with which it can be accessed. As Dias and Pouydal (1992) put it " *the faster we can collect and process the data to provide the*

information we need the more timely and valid will be the decisions we make". The advent of planning and policy decision-making at the district level has meant that data had to be produced on regular and timely basis.

The main data sets required for this has continued to come from the decentralized, semi decentralized and non-decentralized departments of the District Assembly. They cover virtually every facet of the district economy and include agriculture, population, health, education, infrastructural facilities, births and deaths, co-operatives and forestry. Some of these sets of data are compiled routinely or on ad hoc basis and stored in files or registers manually and summarized for annual report production. Inconsistencies or gaps in data sets are a common phenomenon, which makes it difficult to perform time series analysis. Another major shortcoming is the poor linkages among the departments themselves. No standards for data information sharing or data exchange exists and while some still rely on directives from their headquarters in Accra others have endeavoured to work within mandates laid down for them by their sector ministries. In the end the types of linkages required for holistic plan development become problematic. Notwithstanding these difficulties planning has continued to be conducted with available information and co-ordinated in the office of the District Planning Co-ordinating Unit. The advantage inherent in district level GIS to support planning and decision-making is that, at least the data requirement will not be unwieldy and overly sophisticated. It should be relatively easy to develop methodologies to facilitate the development of geographical databases and harmonisation to facilitate inter-departmental data communication.

4.2.1 *Data types acquired and processed and present levels of inter-departmental collaboration within the District.*

A survey of spatial data types acquired and processed by the departments was undertaken for the study. These include data on population, socio-economic activities, health facilities and incidence of diseases, infrastructural facilities including road network, vegetation, agricultural production including livestock, and crop area estimates, environmental degradation and renewable and non-renewable resources. As has been noted all the fifteen departments have their plans co-ordinated by the District Planning Co-ordinating Unit (DPCU). To date, the traditional way of storing data in files still prevails. In many cases the data are heterogeneous in character and are of

different spatial scales. A system that will facilitate easy access to stored and reliable information was very much advocated for by the heads of the departments surveyed. A review of the channels of communication of plans and the structure of the organograms of these departments also showed that plans are co-ordinated via the Planning Office to the District Chief Executive for presentation to the Assembly. This could be seen as holding an advantage for the process of putting together the various islands of information or disparate data sets, which form the basis for a federated database. Federated databases are said to be in place when already existing databases must co-operate or interoperate together (Laurini, 1998).

The need for data integration to ensure homogeneity of information types, avoid duplication of efforts and dissipation of scarce resources was noted to be vital to facilitating the work of the Planning Co-ordinating Unit. Even though, by their mandates, these departments are supposed to have working links with each other, little collaboration was found to exist among them. Each department was found to be an island onto itself seeking ways of collaborating but lack the necessary technologies to accomplish this. It is in the light of this that this thesis proposes that as a first step to planning, issues of inter-departmental collaboration and data integration need be ascertained. The following sessions show the feasibility of seeking levels of inter-departmental data sharing that will lead to a multidatabase development for the district and for that matter GIS interoperability. Interoperability is feasible when uniformity exists among the database formats, spatial conceptions, quality standards, etc. This will call for the design of a framework by the district planners, which prescribes among others the basic areal unit and scale for data collection.

4.3 **The scheme for spatial data integration**

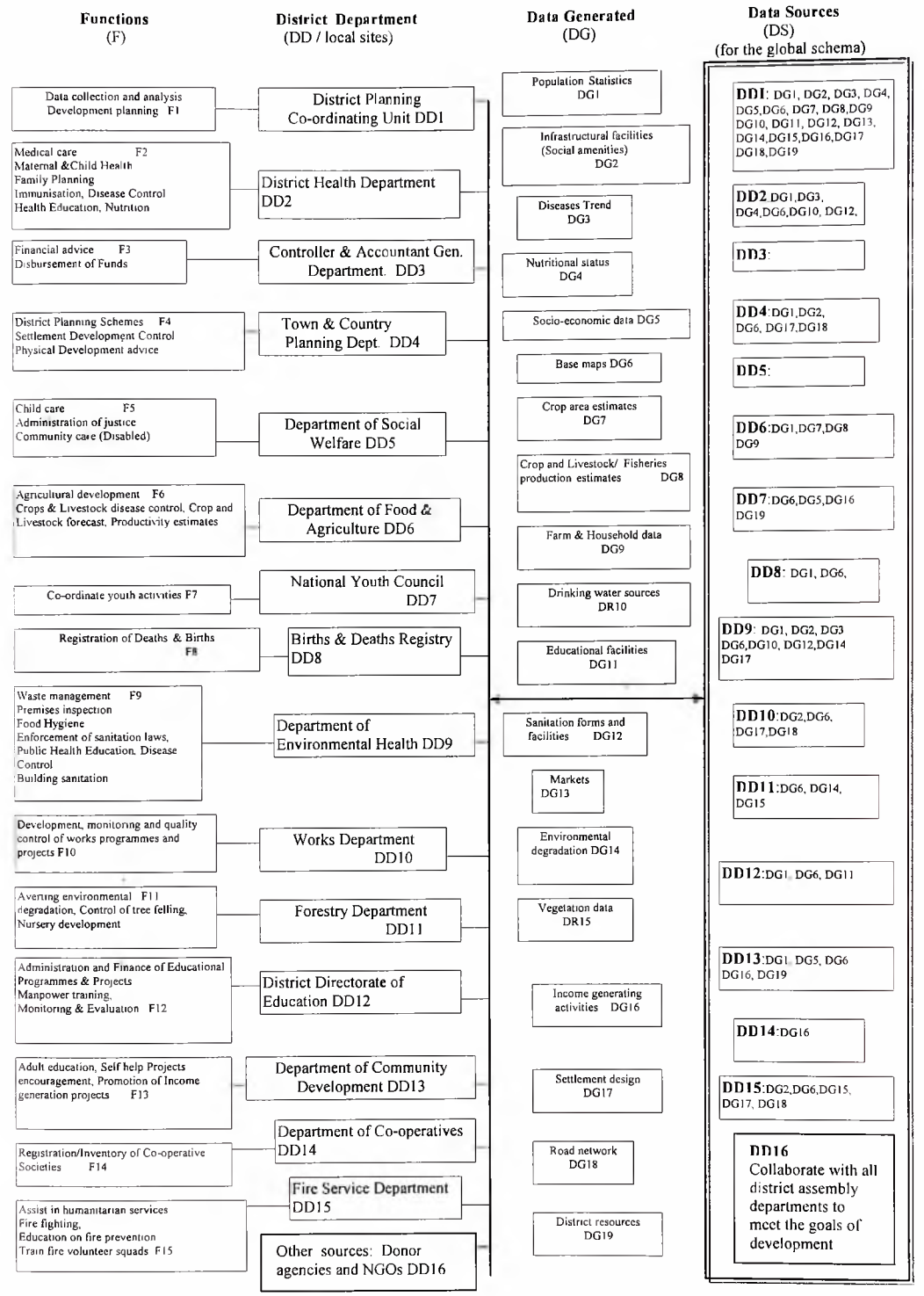
An investigation of the spatial data types acquired and processed by both the decentralized and non-decentralized departments of the District Assembly was made through a questionnaire administered among the departments and interviews with heads of departments. The study was not concerned with the type of algorithms required to accomplish database integration and interoperability but was concerned about proposing the type of approach needed as a first step to data integration and GIS interoperability in the district. The major components of the investigation include the following:

- The identification of the department;
- Operational activities carried out by the department;
- Data type acquired and processed (data specification);
- Scales at which the data are compiled;
- Existing levels of inter-departmental linkages and data harmonization; and
- Common data sources to be shared based on inter-departmental needs.

A proposed scheme for spatial data integration based on fieldwork is presented in Figure 4.1. A first step to the development of the scheme for spatial data integration was to identify the departments, which generate spatial data, and therefore has potential for GIS implementation. Such departments *DD1, DD2...DD15* as shown in the figure could be referred to as *local sites* where sets of databases or schema and data instances, *DGs* are found lodged. It was found that not all departments produce spatial data as a consequence of their operational mandates. As shown in the scheme, the section *F* illustrates the summary of the different categories of functions carried out by the departments listed *F1, F2...F15.* From this listing, it was possible to obtain information on the spatial data types acquired and processed by the departments. It also constituted the bases for data harmonization to achieve the objective of data integration and exchange among the departments.

A second step was to look at the existing systems of inter-departmental collaboration in terms of common data sharing. It was common to find departments professing inter-departmental linkages, but this could not be found in much practice. Virtually every department indicated not less than two departments with which they interact by way of data sharing or have common sets of objectives and mandates. However, it is encouraging to see this as a major step towards federated database development. It is possible that as the District Assemblies concept matures, issues about interdepartmental collaboration and information sharing for holistic plan development will become a permanent feature.

Figure 4.1: Proposed scheme for district level spatial data integration



Source: Based on field work, 1998.

The last step, which would lead to a global conceptual schema or a federated database development, was to seek the data sets or categories of data that the various departments or local sites could use. It shows at the first instance what individual departments would require to accomplish their operational mandates. For example, *DD1* as a department will require data from sources such as *DG1, DG2, DG5, DG6, DG10, DG13, DG16* and *DG19*. It was noted however, that not all departments had clearly defined spatial data types and their sources to meet their operational needs (e.g. *DD3* and *DD5*). These sources therefore could not be shown in the scheme. Other sources of data included in the scheme are from donor agencies, both bilateral and multilateral and NGOs.

4.4 **The approach to multidatabase design for the district**

Even though the various departments and their data requirements have been identified, it is important to develop a basic approach to the design of the multi-database for the district. Multidatabase refers to any kind of structure that links several databases together. They are relevant in several ways, for instead of centralizing geographic information into a unique database, they serve a more useful purpose when they are federated and stored into different databases or sites. Another aspect is that it can be very interesting also from any computer system to use geographic data stored in other computers. The multidatabase design process involves starting from the local schemata in order to synthesize them to build the global schemata. The main difficulties with this process is that the databases can have different structures; that is to say the same data name can refer to different things and so on. For example, the settlement of Obom in the Ga district is referred to in other records as Obon and Oboum. This creates problems when executing spatial joins.

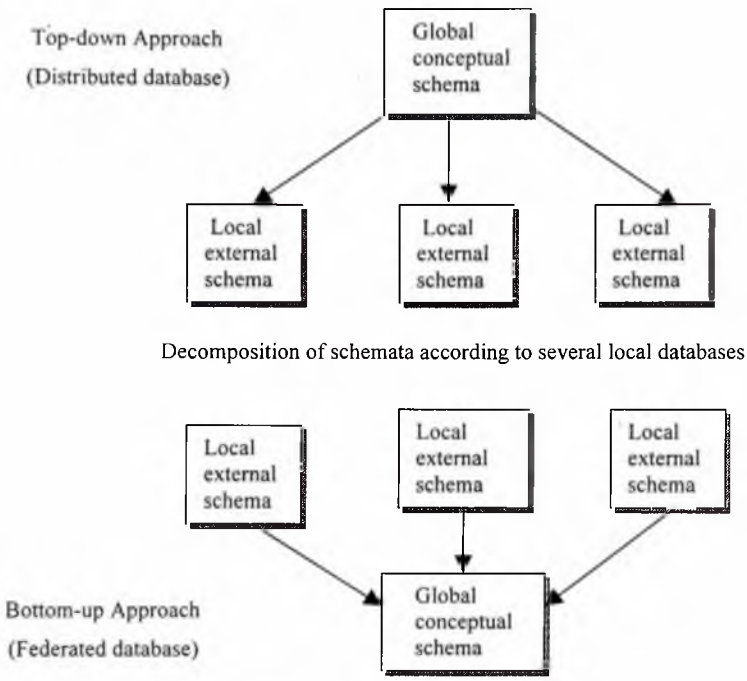
The need for a multidatabase development and interoperability therefore calls for agreements or consensus among departments on issues such as:

- Who are the potential users;
- What are the output products requirements;
- A definition of spatial data categories,
- Establishment of required levels of accuracy; and
- An evaluation of data sources/quality (ASPRS, 1988).

This consensus can be sought at the district level or at national level to allow for homogeneity.

In designing a multidatabase, two main cases have been cited (Laurini, 1998); either one has to build a distributed system from scratch (top-down), or one has to federate different existing databases (bottom-up).

Figure 4.2: The top-down and bottom-up schema designs



After Laurini, 1998

4.4.1 *The top-down approach*

In this approach, one is starting from a global schema encompassing all data aspects of the systems. The global schema is then split into different local schemata due to some placement strategy. By placement strategy, we mean that rules have been designed and must be followed in order to place adequately data fragments. In this approach, generally speaking, same network, DBMS, operating systems and hardware are used, so giving a homogeneous distributed system. The study favours this top-down approach for several reasons. In the first place the global schema could be brought about by the present efforts at plan synthesis or integration by the District

Planning Co-ordinating Unit (DPCU). As shown in the scheme, (illustrated in Figure 4.1), the DPCU, *(DDI),* has the responsibility of synthesizing all the data sources *DG1, DG2....DG19*, or building what is referred to as the distributed database. The use scalograms have already formed a substantial base for spatial data and resource inventory by the DPCU. As it were, the district has been divided into areal units called electoral areas, which form the basis for representation at the assembly, and also as basic units for development planning and allocation of resources. It will be relatively easier therefore for the district departments or local sites to use these areal units as the bases for spatial data inventory. By so doing a global schema design could be brought about much more easily under a general consensus.

4.4.2 *The bottom-up approach*

The bottom-up approach or local-to-global approach is much more complex. The problem here is starting from different existing databases, to create a federation taking the maximum in common. Due to the variety of hardware operating systems, data representation capabilities, it is often difficult to federate different databases (Laurini 1998).

It must be noted that this scheme has not involved a prescription for the type of hardware and software configuration needed to achieve multidatabase design. The study is concerned with a first step approach to data integration and interoperability which some authors have often referred to as a dream of spatial data users but a nightmare for system developers (Laurini, 1998). It is sufficient to state however that given the decentralized system of government and planning, the districts constitute homogeneous and manageable units for which the same network, DBMS, operating systems and hardware could be prescribed.

4.5 **Proposed elements for prototype GIS in the district**

The preceding sections have been an attempt to underline the basic requirements for database integration and GIS interoperability in the district. It shows the relevance of multidatabase development and the type of approach needed to attain this in order to enhance the planning and decision-making process. The proceeding sections describe the elements for a prototype GIS that could be implemented in the district and which could be replicated in other districts. The main components of the scheme are based on spatial data types acquired and used by the decentralized departments. The objective is to show data sources, methods and tools for obtaining the various

categories of data – environmental or socio-economic and cultural and the software components of the prototype.

Figure 4.3: The elements of a prototype district GIS showing the main data sources, data categories and software components

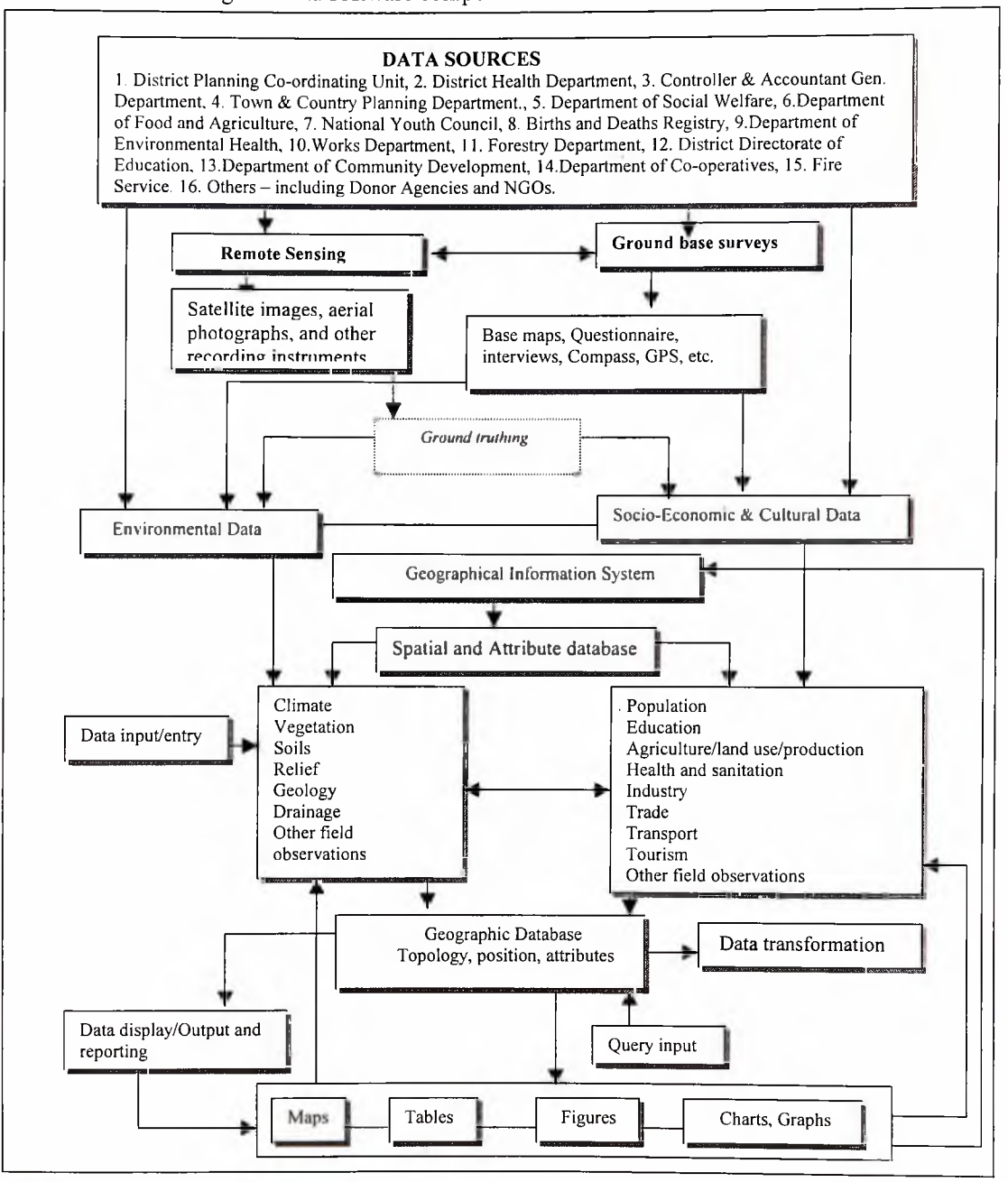


Figure 4.3, is a model of the basic elements of the proposed prototype district GIS. The salient elements of the model are:

- the data sources,
- the categories of data available in the district for planning,
- the means by which the data sets are captured,
- the software components of the GIS and
- the GIS and its products.

4.5.1 *Sources and categories of data*

The study identified fifteen district departments whose activities generate spatial data – environmental, socio-economic and cultural. These departments use very diverse data sets, especially diverse in content and in the scale of coverage. Much of the data are collected and based on individual community level. The advantage inherent in this scale of coverage is that it lends itself more easily to data harmonization for the purpose of generating any new information. Chapter five of the thesis uses this community level data gathering to generate various data sets for the analysis of health and sanitation issues in the district. So far the geo-coding scheme used was based on population census of 1984. All other attribute data used in the thesis were related to the population and settlements data, which was the common key field.

Even though the study did not come across instances where remote sensing methods have been employed in data gathering in any of the departments, the technology is here mentioned as an important source of data for any meaningful district level primary data generation. Meijer & Kuipers. (1992) mentioned that remote sensing data is relevant when there is the need for environmental information system.

Ground base survey methods including questionnaires, interviews, the use of the GPS, and radiometers have also been mentioned as other means of obtaining data. These could be applied to both environmental data and socio-economic and cultural data. As shown in Figure 4.3 a large array of data is available for use in any planning and decision making venture within the district. These range from climatic data to tourism data, which can be constituted into a spatial and attribute database.

4.5.2 *Software components of the prototype system*

The software components of the scheme as shown in Figure 4.3 consist of five basic technical modules (after Borrough, 1986). These basic modules are sub-systems for:

(a) Data input and verification;
(b) Data storage and database management;
(c) Data output and presentation;
(d) Data transformation; and
(e) Interaction with the user (Query Input).

A few of these modules are mentioned here to establish how they function within the context of the scheme employed for the prototype outlined.

4.5.2.1 Data input and verification

Data input covers all aspects of transforming the district data captured in the form of existing maps, field observations, and remotely sensed data into compatible digital form. This involves a range of computer tools including the interactive computer screen and mouse, the digitizer, scanners and lists of data text files or spreadsheet programmes and devices that facilitate the reading of data sets already written on magnetic media such as tapes or CDROMs.

In the context of this study, digital copies of base map information on the district were obtained. Coverages or layers of information required for the study such as drainage (rivers and streams network), road network and other socio-economic and cultural features were obtained from Survey Department. Other coverages such as lakes, settlement location, population, and road classification were obtained from the CERSGIS, Legon. The spatial and attribute database established by these data sources served as base or common key fields for all other data sets that were joined to form various themes for the GIS analysis.

Verification and editing were simultaneous processes employed for checking data for errors such as possible inaccuracies, omissions and other problems prior to linking the spatial and attribute data.

4.5.2.2 Data storage and database management

Organizing data in a GIS is enabled by the Database Management System (DBMS). Theoretically data storage and database management concerns the way in which the data about the position, linkages (topology) and attributes of such geographical elements as points, lines, and areas representing the various spatial objects are structured and organized, both with respect to the way they must be handled in the computer and how they are perceived by the users of the system. The creation of digital data sets by manual input already creates the data needed. But this must be stored in forms that will facilitate its management and organization.

The DBMS is basically designed to store and manage large amounts of data. Its aim is to make data quickly available for multiple uses and multitude of users whilst still maintaining its integrity to protect the data against deletion and corruption, and to facilitate the addition, removal and updating of data as necessary (Borrough & McDonnel, 1998).

An inherent problem of planning in the districts is the lack of properly organized databases. A few departments such as the DHMT maintained some categories of data for health monitoring. For example, it was possible to find data with such details us sex, age, disease type, community of patients etc. These are however all found in analogue forms and held in files and books. Respondents to a questionnaire on GIS use and relevance admitted the advantages inherent in the application of the technology especially for DBM in the departments. Several advantages are there to be gained. Frank (1998), for example, has indicated that a well functioning DBMS could provide the following:

(a) Allow storage and retrieval of data and data selection based on one or more attributes or relations.
(b) Standardize access to data, and separate data storage and retrieval from the use of data in application programmes to maintain independence in those programmes.
(c) Provide an interface between database and application programme based on a logical description of the data without requiring details of the physical storage.
(d) Make access functions in applications independent of the physical storage structure so that programmes are not affected by changes in storage media.
(e) Allow several users to access the data simultaneously.

(f) Protect the database from indiscriminate and illegal changes.

(g) Provide sound rules for data consistency which will be enforced automatically. These rules are an excellent way of removing errors and inconsistencies from the database.

A major advancement in GIS software development is the concept of relational database (Scholten & de Lepper, 1994). It is a standard tool, which facilitates data manipulation and analysis. This involves the linking together of different datasets by the use of common key fields – in what is known as spatial join (ESRI, 1996). What this means for any district GIS is the advantages it offers for joining different datasets from the various departments as long as there is a common field or address to match. For example, the data sets on diseases, sanitation practices, household water supply sources and forms of solid waste disposal were all joined as attributes to a common key field - settlements and population data.

4.5.2.3 Data output and presentation

Data output is the operation of presenting the results of data manipulation in a form that is comprehensible to the user or in a form that allows data transfer to another computer system. The output of the data, the way it is displayed and results of analysis reported is an essential component of the GIS. Data may be presented as maps, tables, charts and figures in a variety of ways ranging from the image on the computer monitor through hard-copy output from the printer or plotter to information recorded on diskettes, CDROMS or magnetic media in digital form.

In recent times, capabilities for producing aesthetically pleasing graphical output have increased. In ArcView layout, details such as map legend, title, orientation indicator, a scale or scale bar, neatline, as well as colour, symbology, shaded patterns and texts among others are features that can be added readily as part of the process of map composition.

4.5.2.4 Data transformation

Data transformation embraces two classes of operation. These are:

(a) the transformations needed to remove errors from the data or to bring them up to date or to match them to other data sets, and

(b) the large array of analysis methods that can be applied to the data in order to achieve answers to the questions asked of the GIS.

Borrough & McDonnel (1998) have listed some basic requirements for a typical GIS. These do not only provide new insights to existing problems that the GIS is set to solve but also lead to the creation of new sets of information or data which could be added to existing databases thereby increasing the size and value of the database. In this way the district GIS should be able to provide answers to such requests as,

(a) the locations of settlements with population within a given range,

(b) the distribution of settlements with certain categories of facilities, e.g. types of household water supply or communities with certain categories of sanitation practices,

(c) the number of occurrences of disease *M* within distance *D* of settlement *B*,

(d) the size of regions most vulnerable to the strain of disease *Q*,

(e) the attributes of entities located at points Y1, Y2, etc.

4.5.2.5 Interaction with the user (Query Input)

One of the most important aspects of GIS application is the interaction with the user or user interface that is, query input. This is absolutely essential for the type of analysis of data required for spatial planning and decision-making at the district level. This module enables direct interaction between the user and the computer especially where commands are menu driven, or initiated by a response to requests in English-like command language, e.g., the query builder in ArcView. The module allows features in a view or records in a table to be selected by a logical expression based on attribute values.

4.6 **The choice of software**

Even though it is not the intention of this thesis to prescribe the appropriate software required for the prototype GIS being proposed, it is important to suggest the types that can be handled within the constraints faced by most developing countries. These constraints principally are in the area of expertise and capital. Again the choice of software and data relies on the clear and concise definition of project objectives and goals (Kolars, 1995). Meijer & Kuipers, (1992), proposed what is described as the

low-end GIS tools. According to them, several standard PC packages available for socioeconomic fields of interest, have proven to be very useful in western organizations. These packages can also be used in developing countries for prototype purposes in the early phase of the introduction of larger systems. Others have emphasized the choice of appropriate software taking into consideration issues such as the price of software and hardware, hardware capacity requirements, technical agent training as well as project goals and objectives (OSS/UNITAR, 1995).

4.7 **Conclusion**

Even though the application of computers and for that matter GIS technology in many agencies and departments in developing countries is still limited, the use of GIS to meet the needs of planning and decision support is gaining currency. Where information is the key to planning and decision-making then the use of appropriate technologies that will enhance the integration of different data sets held within the various departments should be advocated. The study has indicated the desire of most departments to integrate their data sets and allow for GIS interoperability. However, when the decision is taken to adopt GIS, issues such as what data to use, their sources, formats, scale and the type of approach to integrating them for the purpose of interoperability should be resolved. This chapter has been an attempt at proposing a scheme for spatial data source identification and an approach to the type of multidatabase development to achieve holistic plan development in the district. It has also been an attempt to show the design of the basic elements for a prototype GIS that takes into consideration data types, their sources, tools for acquiring them, the databases that could be established and the software modules for the prototype.

District level planning and decision making for holistic plans development requires a technology that will facilitate data integration, multidatabase development and data interoperability. The only medium for achieving this is through a GIS. The study has demonstrated that it is possible to integrate data sets held by the various departments within the district. It favoured an approach, which involves a split of the global schema into different local schemata. In the district context these schema refer to the global database supposed to be maintained by the District Coordinating and Planning Unit (global schema) and the local database supposed to be maintained by the district

departments (local schema). To allow for homogeneity requires the use of the same network, DBMS, operating systems and hardware.

The proceeding chapters are an attempt at using the data integration concept based on disparate data sets held by district departments and others acquired through direct investigations among health institutions, to conduct some health and sanitation sector analysis such as will be required to aid decision-making and planning. These data sets include population distribution, types of sanitation facilities and practices, household water sources, solid waste disposal forms, vector data (road network) and major diseases. The objective is to see through the GIS medium how data federated from various sources using the same spatial scale could be employed to generate new sets of information for a more informed and reliable decision-making. The choice of the health and sanitation sector was relevant because of the challenging problem it poses for the study area as outlined in Chapter 1 of the thesis. The sector is therefore a test bed for studying the various socio-economic and environmental processes or for analysing the result of trends or anticipating the possible results of planning decisions in the district.

CHAPTER FIVE

AN ANALYSIS OF THE SPATIAL DISTRIBUTION OF ENDEMIC DISEASES, SANITATION FACILITIES, HOUSEHOLD WATER SUPPLY SOURCES AND SOLID WASTE DISPOSAL FORMS IN THE GA DISTRICT USING THE INTEGRATED DATA CONCEPT

5.0 Introduction

An increasing recognition is being given to planning in the health sector as a result of the fact that it is the key to achieving the most efficient utilization of available resources for the improvement of the state of health of any given population (Popov, 1971). The WHO Expert Committee on Public Health Administration in its fourth report defined health planning in the following terms: "The careful, intelligent interpretation and orderly development of services, in accordance with modern knowledge and experience to meet the health needs of a nation within its resources" (WHO, 1961). During the past 30 years, governments have shown increased interest in health planning as part of the general economic and social development towards the systematic organisation and rational deployment of national economic and manpower resources. Without doubt ill health and disability are serious handicap to the development of any economy, and those loses that they can cause can be reduced by measures to safeguard the health of the labour force. Among the important ingredients that have often been cited for the successful accomplishment of any health planning programme is information. A report by the Institute of Medicine on health planning in the United States indicated that the availability of solid information and good research are essential ingredients in the effectiveness of any health planning activity (Institute of Medicine, 1980). Information and particularly how it is packaged is essential for planning and decision-making. The proceeding sections are an attempt at data integration to generate the relevant information for primary health care planning and decision making on major diseases in a district context.

The study of diseases and their geographical aspects has become relevant because it contributes to both educational intervention and the planning of health care delivery systems. One of the important instruments for achieving this is through the use of maps (Kabel, 1990). The explanation of the spatial dynamics of diseases and associated environmental factors has for a long time been done using maps (Scholten

& de Lepper, 1991). A classic example often cited is the work of John Snow (1813-1858) on cholera. Snow used maps to show the geographical distribution of cholera deaths in an area in London. He was able to demonstrate the association between cholera deaths and contaminated water supplies (Gilbert, 1958). The geographical distributions shown were very striking.

One of the most important issues in public and environmental health concerns the type of instruments that can be used to device quick, reliable and scientifically valid methods of rapid assessment which in turn, can be utilized in health research and in the planning, monitoring and evaluation of health programmes. As the application of GIS relate to the collection, storage, integration, management, retrieval, analysis and display of spatial data, it is not suprising that the potential usefulness of this technology in the area of health research and policy is fast been realized.

This chapter demonstrates the relationship between health and some environmental factors in the context of the Ga district, with the aim of understanding the relationships between the distribution and diffusion of some endemic diseases and the environment. The concern is not an attempt to link causes and effect but to show the spatial distribution of the diseases and some environmental factors that could help explain the pattern of such distribution. The chapter is aimed at showing the use of layered databases, which integrates different themes with the view to providing indications of those areas on the maps shown in which further research may be useful. The various data layers and their sources demonstrates the multisectoral approach to solving spatial problems. This multisectoral approach lends itself to the systems concept where linked components, here signified by data layers or themes are integrated at different levels to help explain interrelationships between the various phenomena. It is also to strengthen the fact that, it is possible to integrate data from different sources within a given region for planning and decision-making. The study also employed the point in polygon technique of analysis to identify cases of diseases within areas zoned as endemic. Through this, communities that are at risk were noted.

Figure 5.1: Household water supply sources

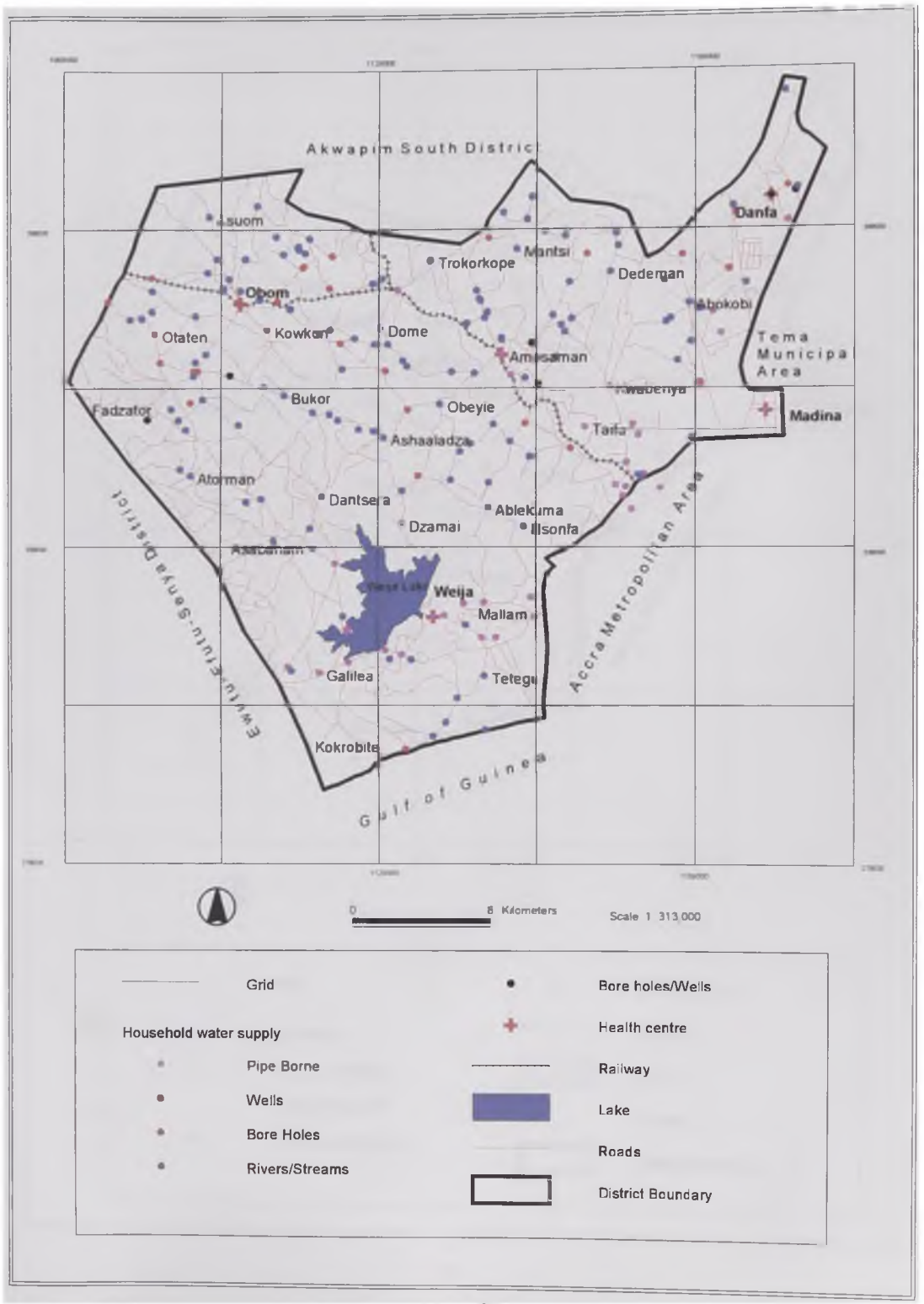
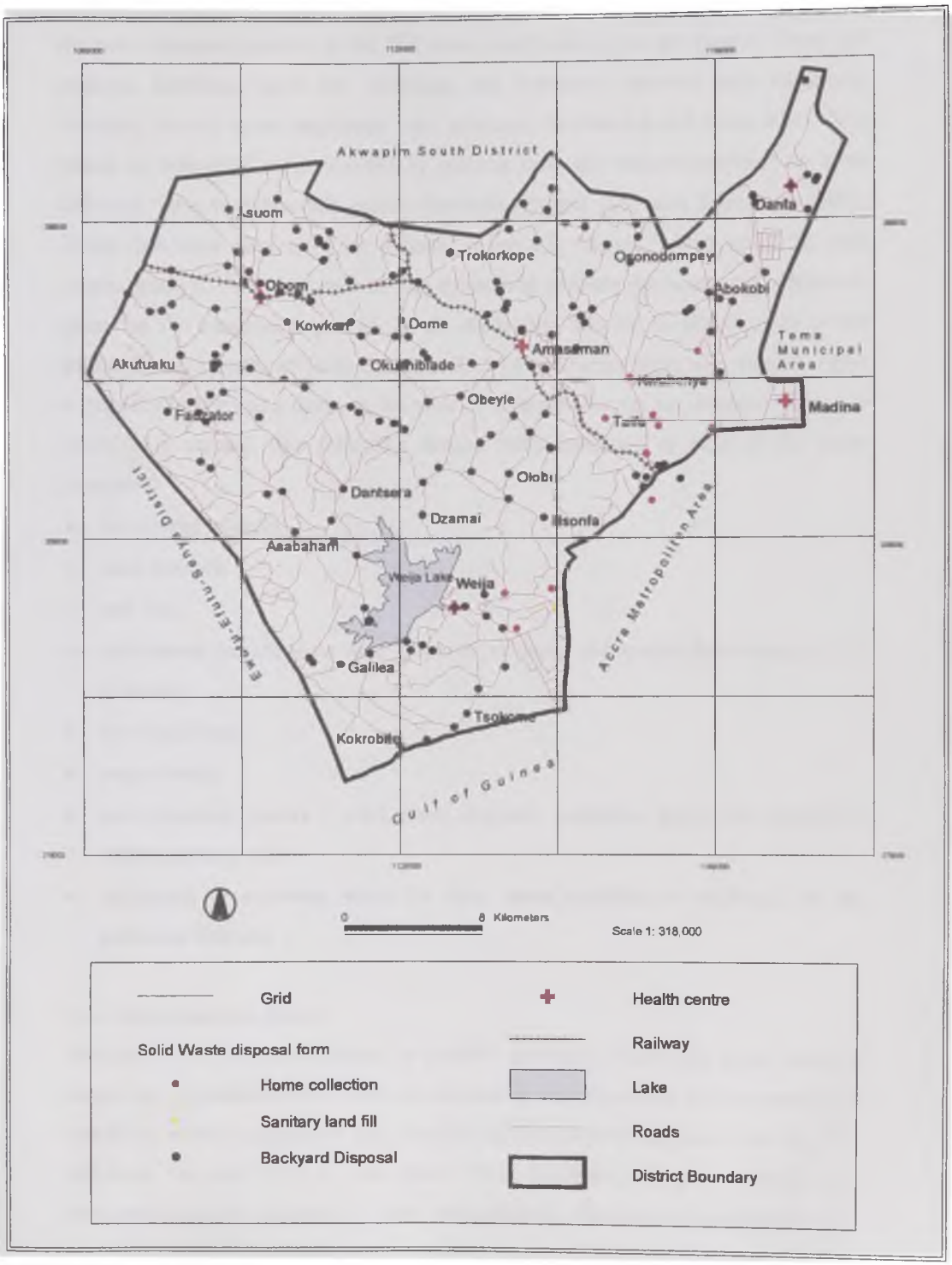


Figure 5.2: Distribution of solid waste disposal forms



5.1 Data types utilized and their sources

5.1.1 Endemic diseases

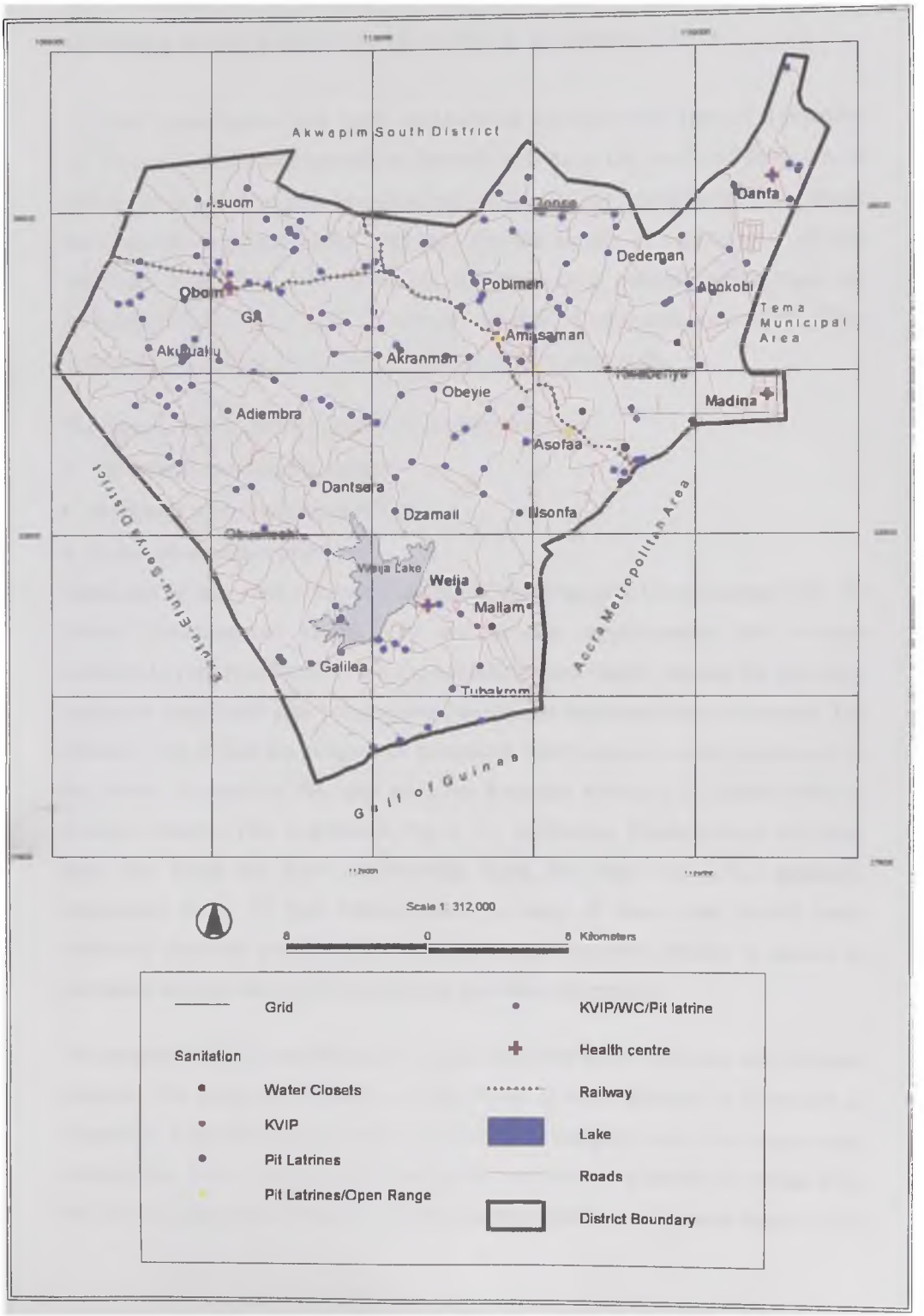
The main focus of the study was on the spatial distribution of the ten most common endemic diseases reported at the five main health centers in the district. These are malaria, diarrhoea, acute eye infections, ear infections, measles, skin infections, intestinal worms, upper respiratory tract infection, chicken pox and buruli ulcer. Data based on individual cases reported by patients from the various communities were collected for a twelve-month period (between October 1997 and September 1998). These data were obtained from patients' diagnostic records, which make the data source primary. They were entered into an existing attribute database using settlement names as the common key field. In all, these data sets led to the creation of ten additional fields in the attribute database. Each of the disease types was converted into a shapefile to become a theme in the table of contents. For the ten diseases listed, ten views were created. The following themes were contained in most of the maps generated:

- the district boundary,
- road network,
- rail line,
- settlements (which were used as points to depict the spatial distribution of the diseases),
- the Weija lake,
- major rivers,
- environmental factors (solid waste disposal, sanitation forms and household water sources) and,
- delineated or exposure zones (to show areas described as endemic for the particular disease).

5.1.2 Environmental factors

Despite vast improvements in health globally over the past several decades, environmental factors remain a major cause of sickness and death in many regions of the world. In the poorest regions, one in five children do not live to see their fifth birthday, largely because of environmentally related – and preventable–diseases. Even though little

Figure 5.3: Types of sanitation practices



research has been conducted on how much environmental factors add to the worlds burden of ill-health it is becoming increasingly clear that health and ill-health are affected by a variety of life style and environmental factors including where people live (Scholten & de Lepper, 1991).

A good association has been established between the spatial dynamics of diseases and environmental factors and here the work of John Snow cited earlier is worth mentioning. This thesis considered the basic environmental factors that account for the levels of endemicity of the diseases indicated. The issue of lifestyle as a causal factor was not considered for reasons of time and scope of research involved. This could be a factor to be considered for future research.

The environmental data constituted the following themes:

- Household water supply sources
- Refuse or solid waste disposal types
- Types of sanitation practices

These sets of data were obtained from the District Planning Co-ordinating Unit, the District Environmental Health Unit and through supplementary field surveys conducted by the researcher. Under the household water supply sources the following categories were listed: pipe borne system, wells, bore holes and rivers or streams. The objective was to find the category of household water sources in each community in the district. In many of the rural areas the dominant source of household water is rivers or streams. This is shown in Figure 5.1. In Madina, Dome, Gbawe and those areas that fringe the Accra Metropolitan Area, the water source was generally categorized under the pipe borne system. In many of these areas treated water obviously from the piped system is either found connected directly to homes or purchased in tanks and stored in reservoirs and other receptacles.

The categories of solid waste disposal types listed were home collection and backyard disposal. The spatial distribution of these forms of waste disposal is illustrated in Figure 5.2. A sanitary landfill was also included as a category since it is a major waste disposal site. Even though sited in the district, it serves as a landfill for refuse from the Accra Metropolitan Area. For the purpose of the study the dominant form of solid

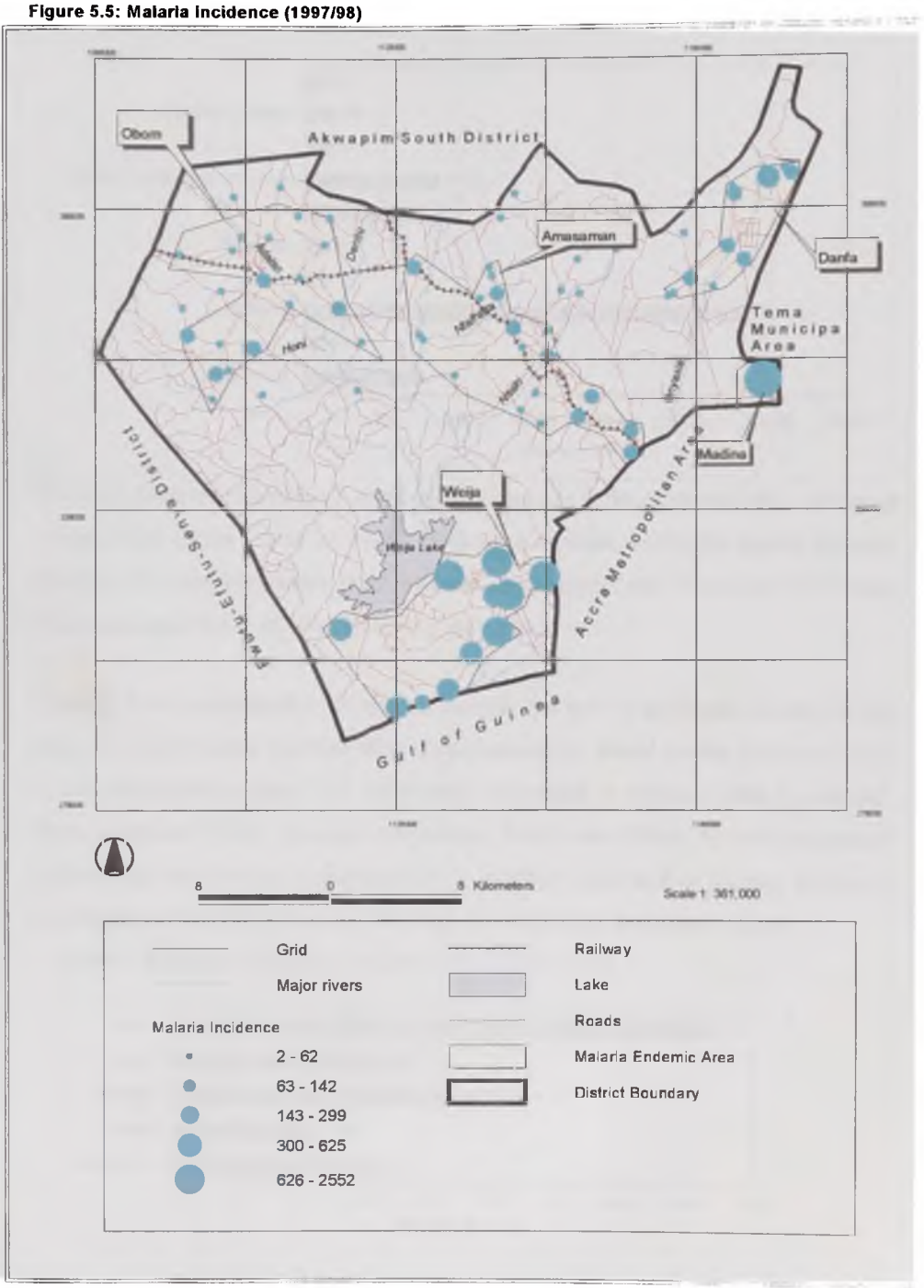
waste disposal in each community was chosen to be the general. In the rural areas the waste disposal type was not difficult to ascertain. It was either individual household backyard disposal or a system where a few households created a dump for common use. It was concluded in the study that whichever form the backyard waste disposal system took, insofar as it was akin to the unorganized system of open range disposal, it would be accepted as backyard disposal.

In the more urban areas of the district, the situation varied. The local authorities regulate refuse disposal through the designation of collection points either at the frontage of homes or identified spots for household refuse dumping which are collected periodically. Whichever form it took, the general situation was that of organized collection more akin to the home collection.

Sanitation is the term broadly used to include such categories as flush toilets or water closets systems, Kumasi Ventilated Improved Pit (KVIPs), pit latrines or pan latrines and open defecation. In some of the communities listed, at least, more than one of these categories of sanitation is found. Figure 5.3 shows the spatial distribution of the various types of sanitation in the district.

Each of the environmental factors and their categories were coded and added as fields to the attribute database for settlements and population. These became themes with their own attribute data tables. Thus as coverages, they were employed as themes for the overlay method of analysis. The proceeding sections are attempts at modeling the spatial incidence of endemic diseases in the district and the association between their patterns of distribution and the three major environmental factors mentioned under 5.1.2 above.

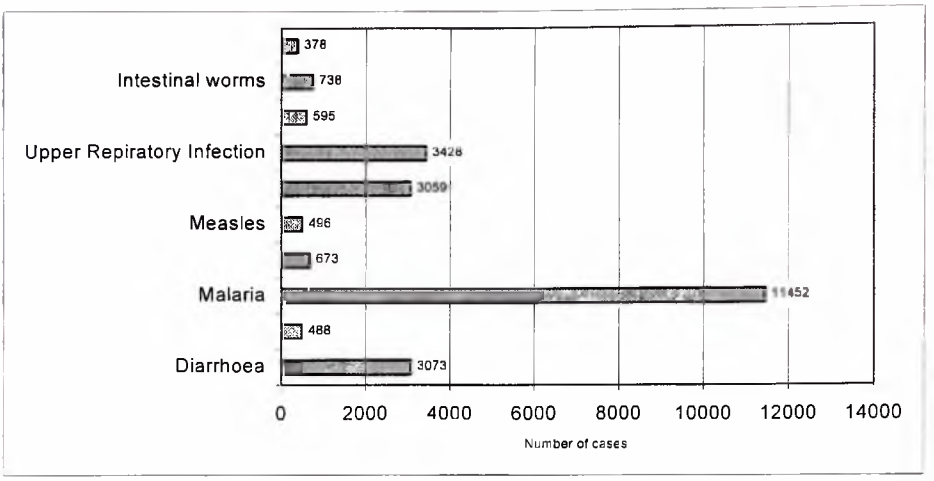
Figure 5.5: Malaria Incidence (1997/98)



5.2 Monitoring endemic diseases in the Ga District

5.2.1 The spatial incidence of malaria

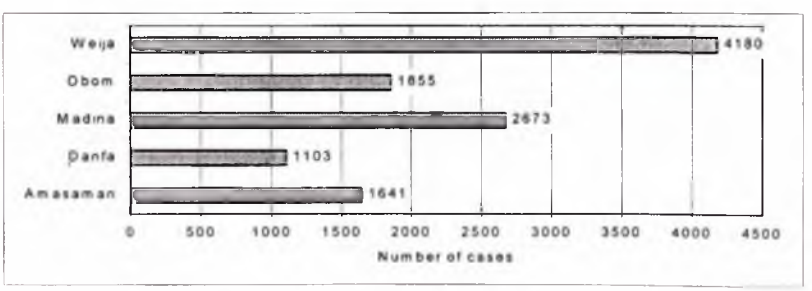
Figure 5.4: Reported cases of major diseases in the Ga District (1997/98)



Of all the diseases investigated in the district, malaria is the most endemic. As shown in Figure 5.4 above a total of 11452 cases were reported within the period between October 1997 and September 1998. Malaria alone constituted 53 percent of all cases of diseases reported in the district during the period.

Figure 5.5 is a cartographic depiction, through the use of graduated circles, of the range of malaria cases reported from each community. Based on the clusters created by the distribution pattern, five zones were delineated as endemic with the disease. These zones are Weija, Madina, Amasaman, Danfa and Obom. For the purpose of analysis, the *identify* tool, a functionality in ArcView was used as a query builder to investigate individual locations on the map. By activating the malaria theme

Figure 5.6: Malaria distribution in the Ga District (1997/98)



in the view, the identify tool selects the communities that are found within each zone. In this way all the attribute data on each community shown on the map, including the total number of reported cases for malaria were obtained. As shown in Figure 5.5, the largest concentration of malaria is in the Weija and Madina zones. In the case of Madina, the distribution is concentrated in the Madina township while in the Weija zone it is scattered over eleven communities. A comparative analysis of the distribution among the five zones is also illustrated in the chart shown in Figure 5.6 where the total number of cases for the two sub-districts is shown. These two zones alone contribute 60 percent of the cases of malaria in the district. They incidentally are the most urban parts of the district.

Through out the district the dominant sanitation form is pit latrine system (Figure 5.3). Backyard disposal method also dominates the forms of solid waste disposal (Figure 5.2) while the population is mainly reliant on rivers or streams as sources of household water supply (Figure 5.1). The effects of these environmentally related factors are not well known for the spread of malaria in the district. What is known generally is the association of the disease with insanitary conditions, especially stagnant water bodies. It is observed that zones of high incidence in the district are those that are located near the Accra Metropolitan Area where insanitary conditions mostly attributed to unwise development are well known. An overlay with the major rivers theme showed no visible relationship between the incidence of malaria and rivers shown on the map. It is however possible to suggest that the Weija Lake could account for the high incidence of malaria around Weija and its surrounding areas. As shown in Figure. 5.5, the townships of Weija, MacCarthy Hill and Mallam are situated nearest to the Weija Lake and this may account for the high cases of malaria. The Weija Lake side is a hub of small-scale irrigation activities and this type of activity has been known to bring about the proliferation of diseases usually associated with water impoundment projects, malaria being no exception (Kofi, 1990). Pools of water in the irrigated plots can be favourable vector habitats. The case of Madina

Figure 5.7: Malaria distribution in the Weija sub-district (1997/98)

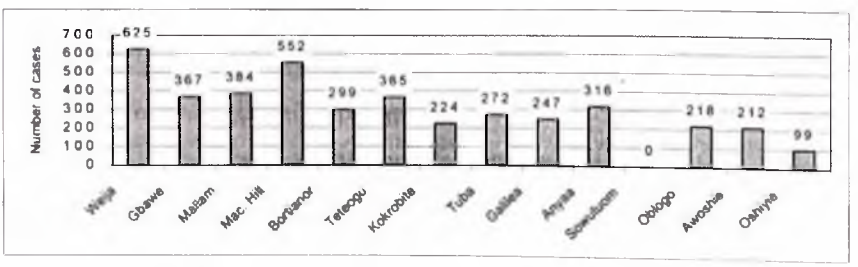
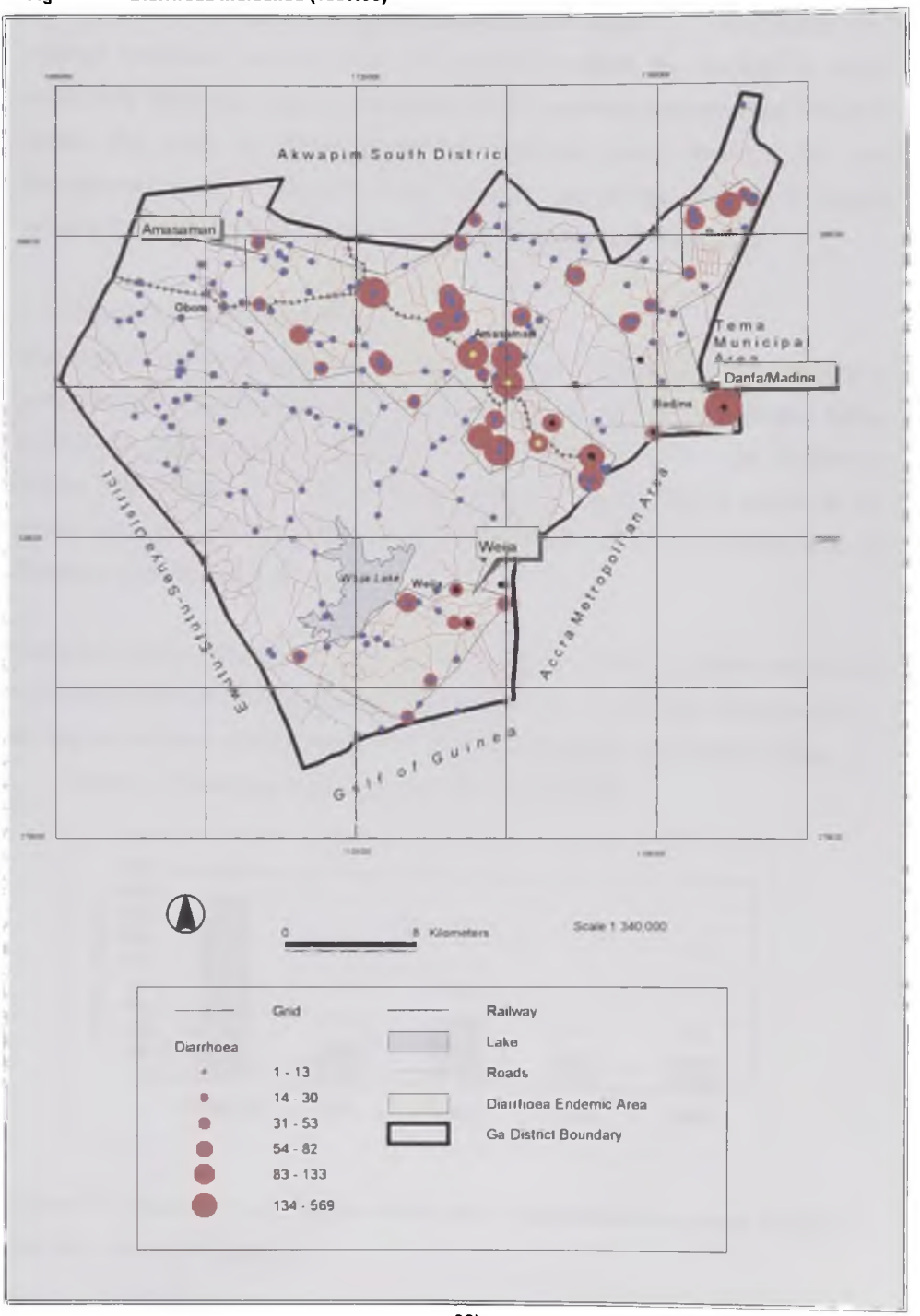


Figure 5.8: Diarrhoea incidence (1997/98)



could be explained away by the usual insanitary conditions associated with urban areas, where choked gutters and stagnant water bodies among others are a common site.

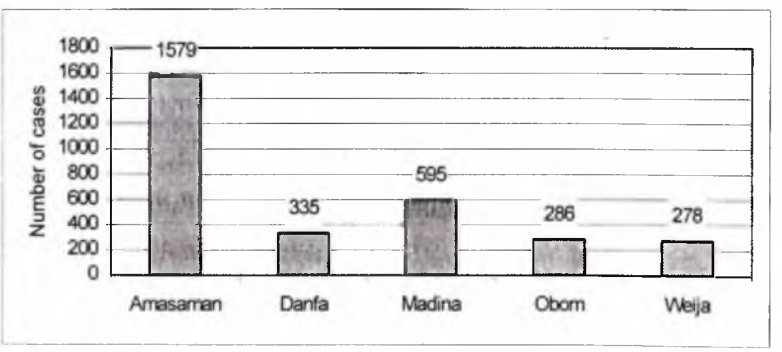
The pattern of distribution of malaria illustrated in Figure 5.7 raises question of primary healthcare and the need for policies to tackle the diseases at source particularly those that address preventive actions to reduce environmental threats to health. The value of GIS as a tool for supporting policy decisions has been demonstrated to be worthwhile in this direction. As shown, any plan to control malaria in the district could be emphasized in the Madina and Weija areas.

5.2.2 Spatial incidence of Diarrhoea

Diarrhoea is associated with poor sanitation and contaminated food and drink and is widely recognized as a major cause of morbidity and mortality in Sub-Saharan Africa (Kirkwood, 1991). It ranks third among the commonest diseases in the Ga District (Figure 5.4). A total of 3073 cases were reported at the five health centres in the district between 0ctober 1997 and September 1998. The spatial distribution of diarrhoea is shown in Figure 5.8.

Three zones were delineated as endemic with the disease. These, as shown on the map are Danfa/Madina, Amasaman (which extends to Obom) and Weija. As is observed the largest incidence of the disease is found in the Amasaman sub-district. This is

Figure 5.9: Diarrhoea cases in the Ga District (1997/98)



followed by Madina. A bar chart representation of the distribution pattern in the sub-districts is shown in Figure 5.9.

Figure 5.11: Diarrhhoea and types of sanitation practices (1997/98)

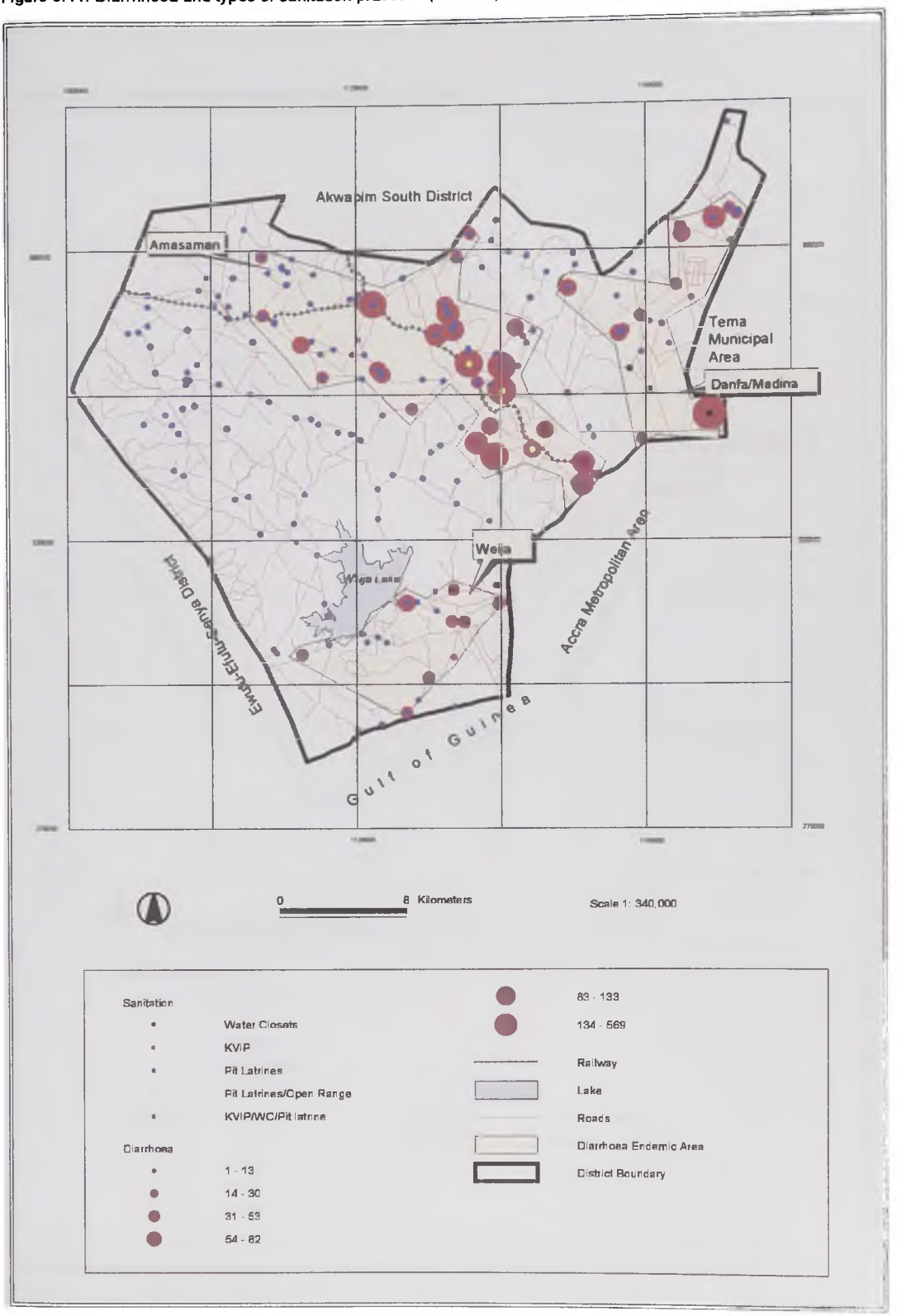
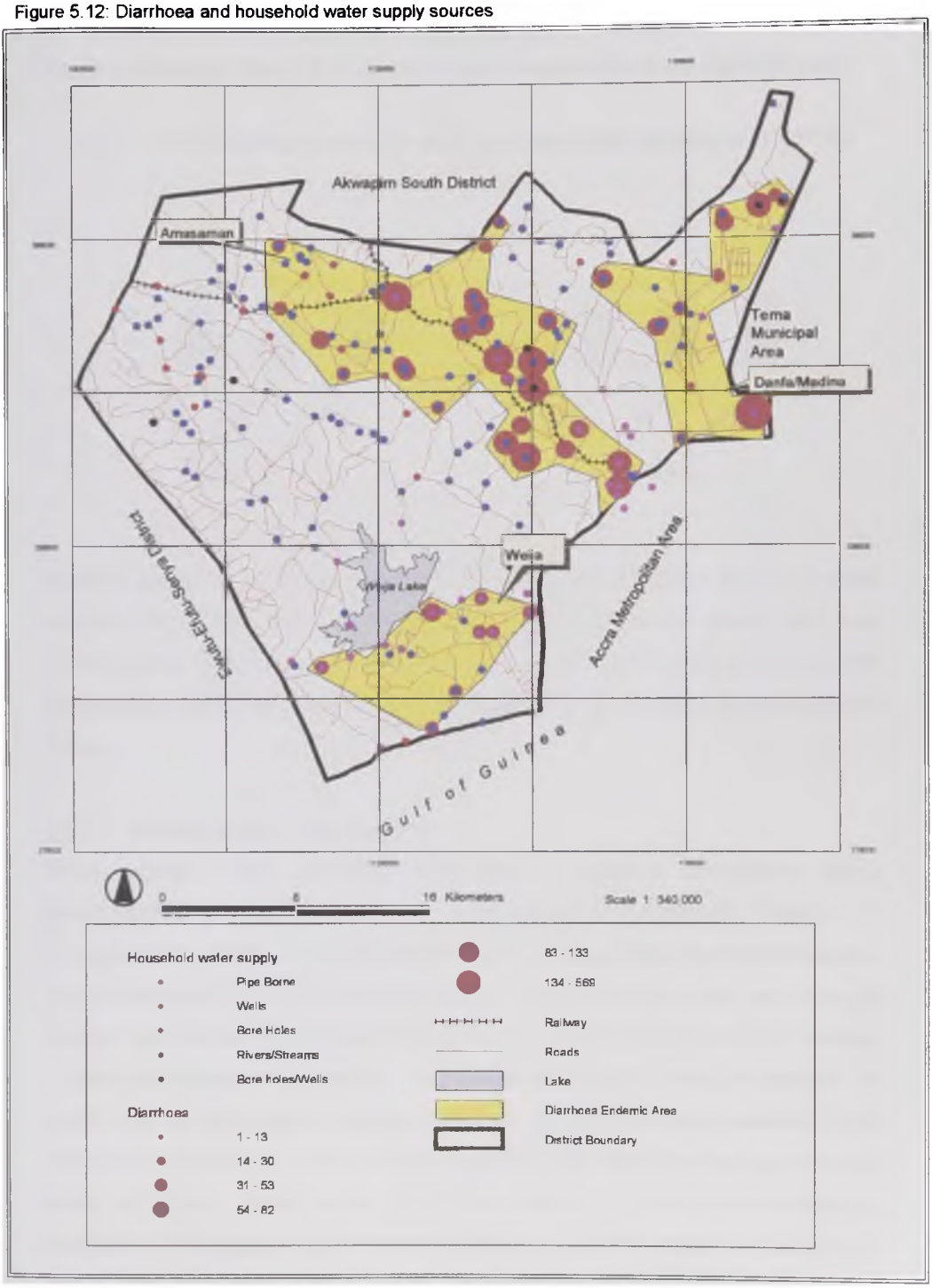
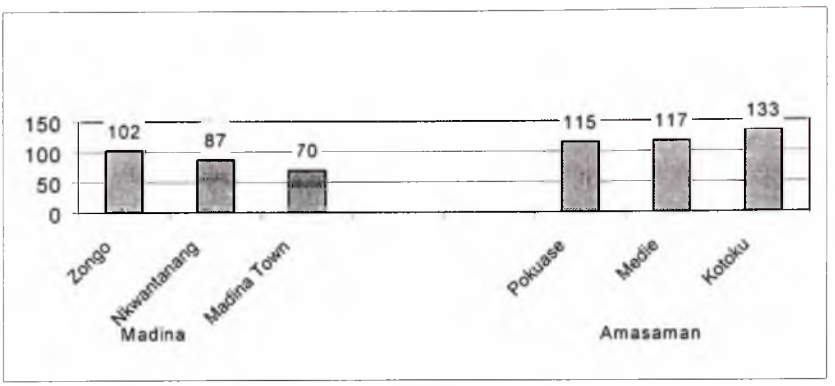


Figure 5.12: Diarrhoea and household water supply sources



Within the Madina and Amasaman subdistricts the following areas have the highest concentration of the disease: Zongo, Nkwantanang and Madina Town, Pokuase, Medie and Kotoku. Figure 5.10 shows the top six communities and diarrhoea cases

Figure 5.10: Top diarrhoea cases in the Madina and Amasaman sub-districts (1997/98)

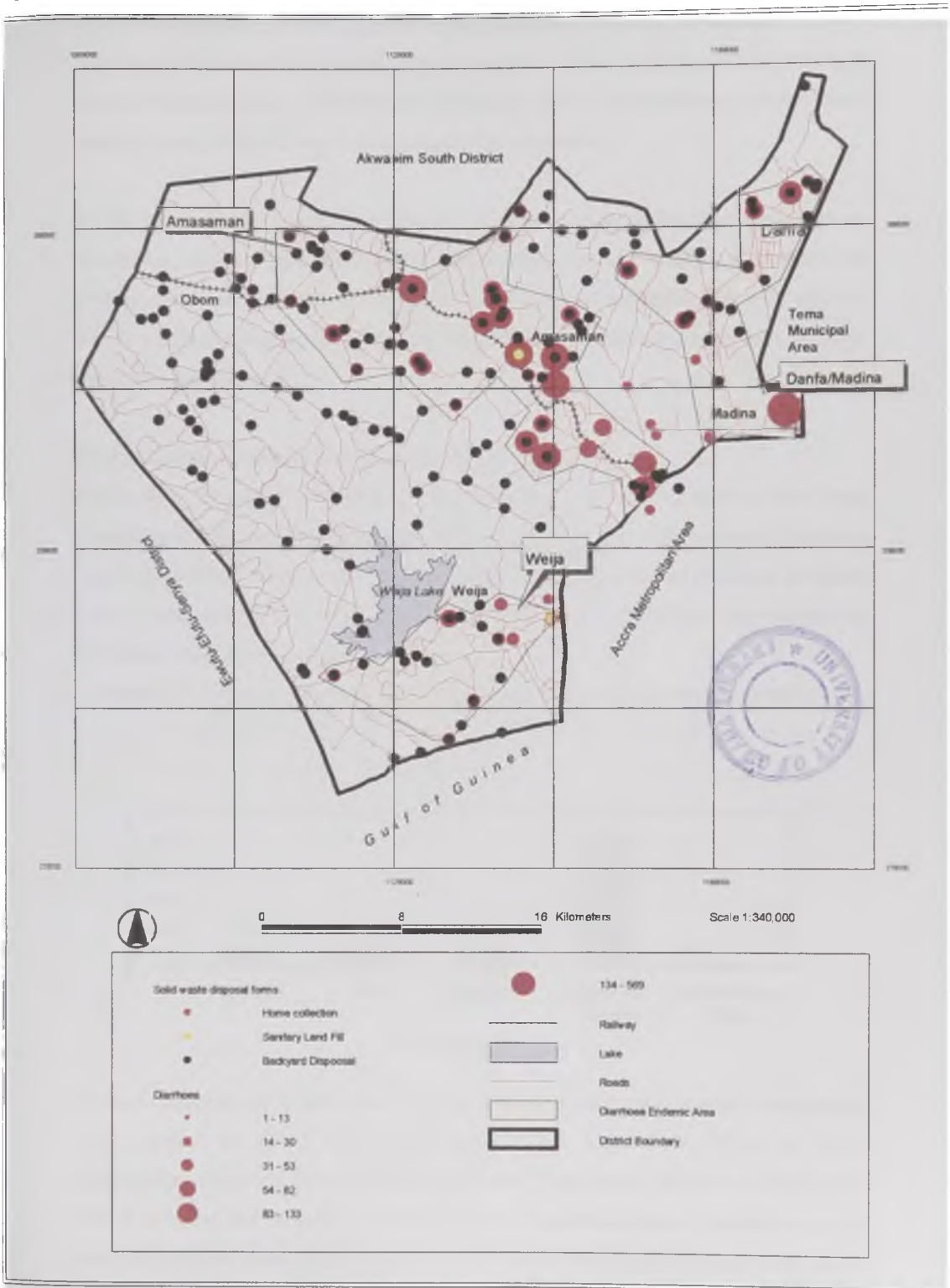


reported. Kotoku in the Amasaman sub-district recorded the highest number of cases. An analysis of the link between diarrhoea incidence in the district and such environmental factors as types of sanitation, household water supply and solid waste disposal form was done using the overlay method and illustrated in the sections that follow.

5.2.2.1. Diarrhoea and sanitation forms

When overlaid with sanitation types theme, diarrhoea distribution shows predominantly in areas where the use of pit latrines is commonest (Figure 5.11). Throughout the district, about five hundred and nineteen communities use pit latrines. These constitute about 60% of the population. In the Amasaman zone, apart from pit latrines, open defecation is found to occur in a few communities notably, Pokuase, Kotoku and Amasaman Township. The implication of these sanitation practices on health and for that matter diarrhoea incidence are quite obvious especially when diarrhoea is generally known to be associated with poor sanitation and contaminated foods and drinks. Benneh *et al.* (1993) have shown in a study of environmental problems in the Greater Accra Metropolitan Area (GAMA) that most households obtain food from open markets where very often the food is displayed openly on

Figure 5.14: Diarrhoea and solid waste disposal forms



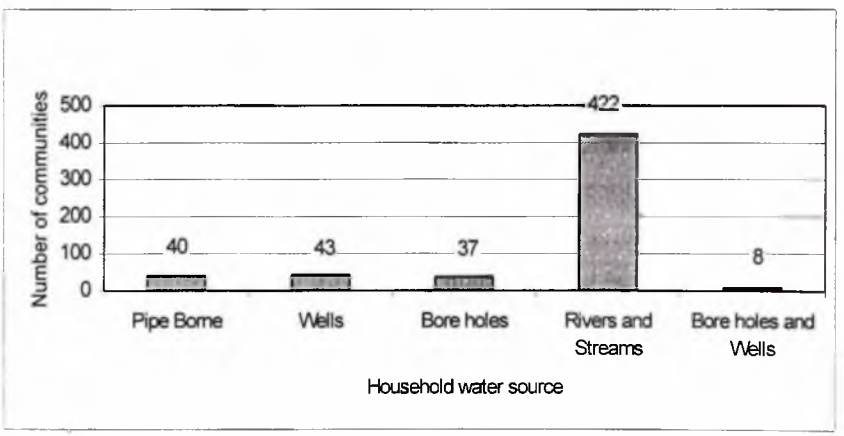
tables and on bare ground in very poor sanitary environments. The prevalence of disease vectors such as houseflies at these markets, as well as the presence of pests such as cockroaches and rodents in the storage locations, suggest a potentially high level of contamination. According to the study such contamination poses particular risks for meat, fish and for fruit and vegetables eaten raw.

In the Madina and Weija zones, water closets are used in few locations such as Kwabenya, Haatso, Madina, Mallam MacCarthy Hill and Gbawe. This does not prevent diarrhoea however, for there are other forms of sanitation that may account for its incidence especially when one considers the high cases in Zongo, Madina Town and Nkwantanang.

5.2.2.2 *Diarrhoea and household water supply sources*

Of the five categories of household water supply sources in the district, rivers and streams constitute the most dominant. Figure 5.12 shows the distribution of diarrhoea cases vis a vis household water supply sources in the district and as is shown in Figure 5.13, over seventy-five percent of the communities in the district have this category as their main form of water supply.

Figure 5.13: Communities and sources of household water supply in the Ga District



In the Amasaman and Obom zone, rivers or streams are the main source of household water supply for about 102 communities. Piped systems are found in forty communities including Madina, Pantang, Dome, Amasaman, Weija and MacCarthy Hill. It is noted that in some of the communities mentioned above, potable or piped water is supplied to households in tanks by vendors because piped water is not found

running on regular basis. Many households are also not connected and have had to rely on vendors.

In Madina, Fise and Amasaman for example it is common to find water being dispensed from concrete tanks erected in some homes for sale to members of poor households or those who have no supplies or connections to their residences. Others harvest rainwater into these concrete tanks or other receptacles for sale. The probability that these systems could be contaminated is high and likely to be a source of diarrhoeal diseases. The GAMA study had it that some of these household water are faecaly contaminated (Benneh *et al.* 1993). The study indicated that samples of tap water and those from household storage containers had positive counts of faecal coliform with the latter considerably higher. Faecal contamination, according to the study is likely to be a greater health risk when water supply originates outside of the immediate household. In both the Amasaman and Madina zones water vending is a common phenomenon. Contaminated water sources for homes are likely to be a source of spread of diarrhoea in the district.

5.2.2.3 *Diarrhoea and solid waste disposal forms*

A cartographic depiction of the diarrhoeal diseases distribution vis a vis forms of solid waste disposal in the district show backyard disposal as the commonest in the district. In Figure 5.14 backyard waste disposal is found in more than 95 percent of the communities and as is further illustrated in Figure 5.15, 531 communities dispose of their solid waste through the backyard method. The largest concentration of this form of waste disposal is found in the Amasaman zone, which also has the highest incidence of diarrhoea. Home collection system is found in only 3.2 percent of the

Figure 5.15: Forms of solid waste disposal in the Ga District

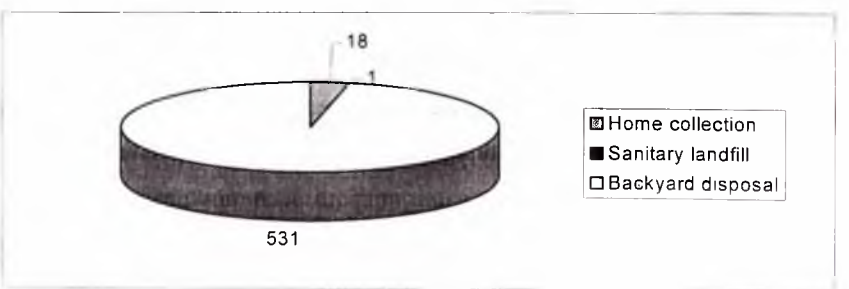
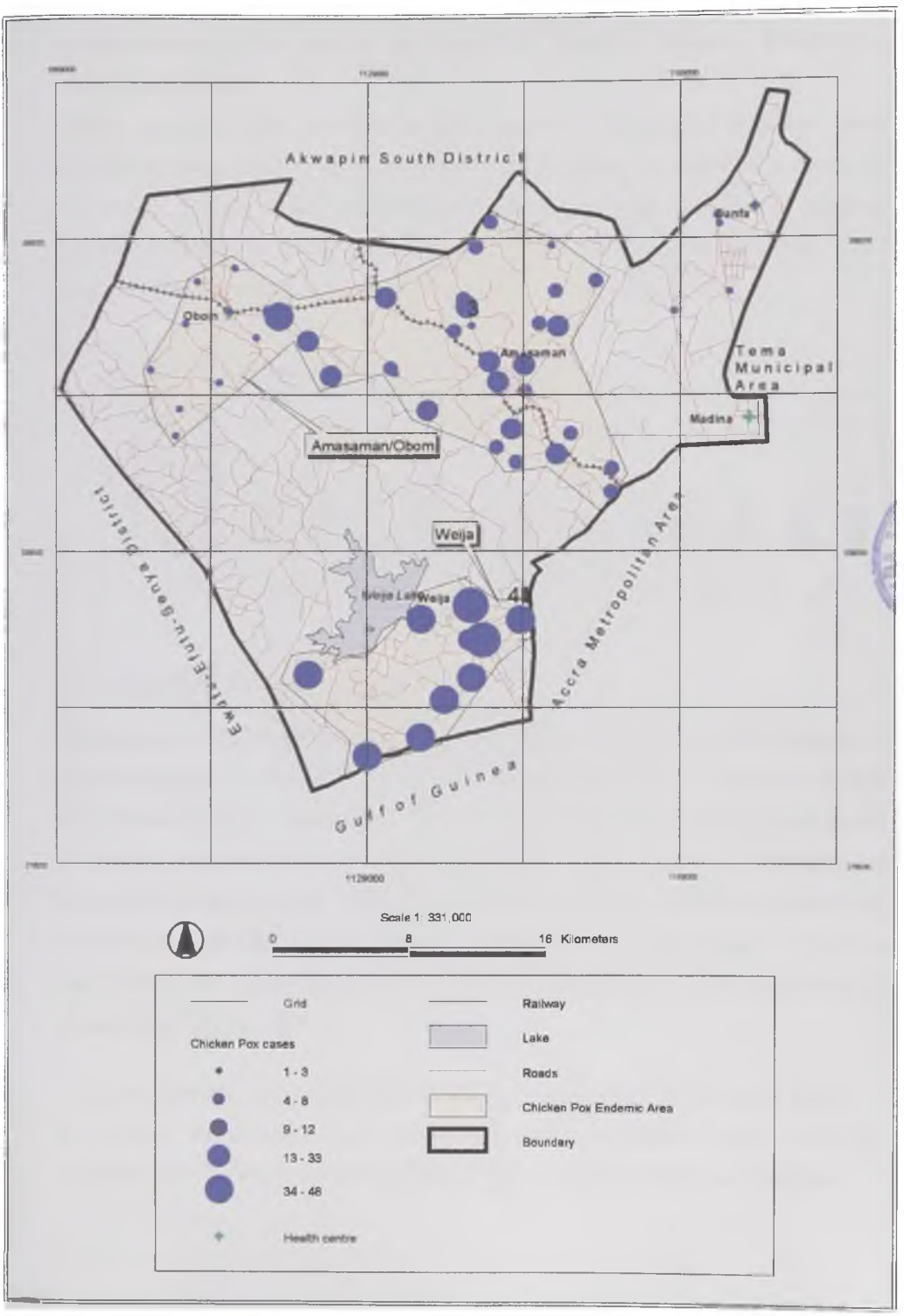


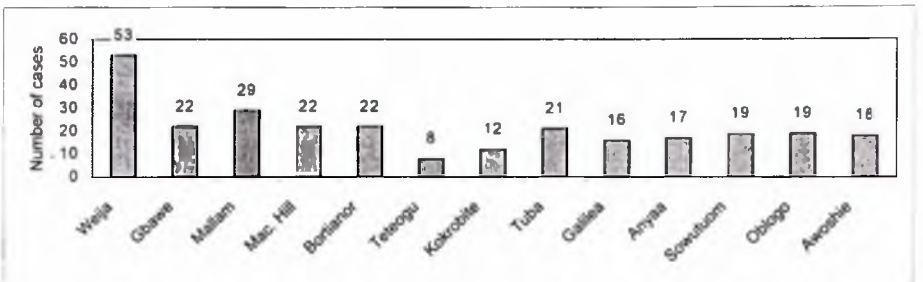
Figure 5.17: Chicken pox incidence (1997/98)



communities in the district. As noted elsewhere in this thesis, home collection method of solid waste disposal includes the system where solid waste or garbage is collected from designated spots either at the frontage of homes or collection points within the communities. This system is found in Madina, Haatso, Kwabenya, Taifa and Dome.

There is a sanitary landfill at Mallam near Weija and this has been known to be a habitat of flies, pests and rodents. In the Weija zone, as shown in Figure 5.16, the Mallam community had the second highest reported cases of diarrhoea during the period between October 1997 and September 1998 – coming after Weija Township itself.

Figure 5.16: Diarrhoea in Weija sub-district (1997/98)

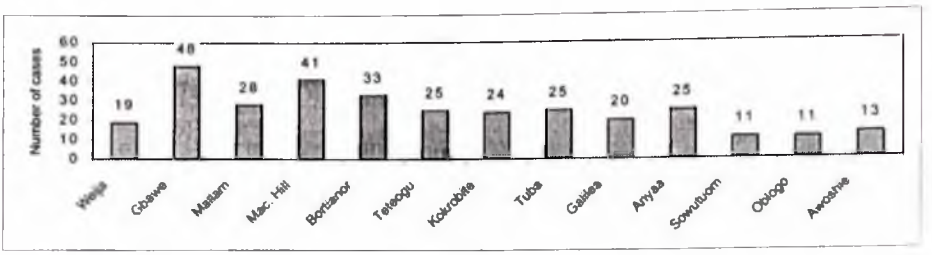


5.2.3 *Spatial incidence of chicken pox*

Chicken pox is a viral infection. It is known to be very contagious and 90 percent of people who are not immune will catch it when they are exposed to someone who has it (American Medical Association, 1997). A total of 595 cases were reported during the period between October 1997 and September 1998. In Figure 5.17 chicken pox shows predominantly in the Amasaman – Obom and Weija areas than anywhere else in the district. Weija has about thirteen communities with a population of 34,620 at risk while in the Amasaman zone, over 180 communities with a total population of about 58,947 was at risk.

It is noted however that the area with the greatest incidence of the disease is Weija. As shown in Figure 5.18, top cases of the disease were found in communities such as Gbawe, MacCarthy Hill, Bortianor and Mallam.

Figure 5.18: Chicken pox in Weija (1997/98)



It is difficult to explain the reason for this pattern of incidence by looking at the map alone. However, it is important to see whether the disease has any association with some environmental factors particularly those listed and discussed with other diseases earlier on mentioned. The association of chicken pox with the environmental factors is discussed in the preceding sections. Another view is the association of the Weija health facility with communicable diseases in general. It is noted however that the survey dealt basically with cases from communities within the sub-district only and so the high cases were all based in the district and not from outside.

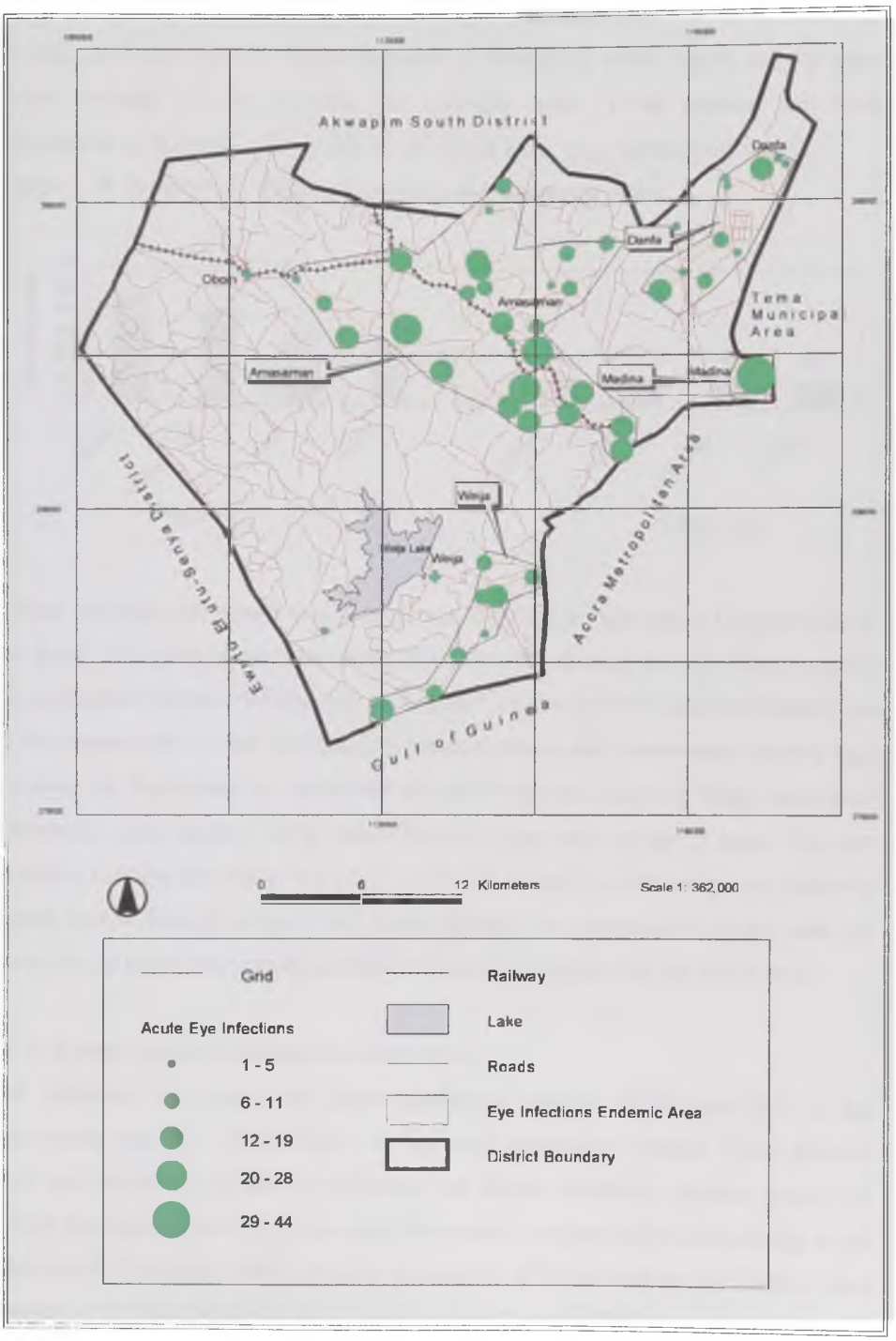
5.2.3.1 *Chicken pox and sanitation*

In all the zones delineated, the commonest form of sanitation is the pit latrine system. In Ofankor, Pokuase and Amasaman townships, an average of nine cases of chicken pox was reported during the period surveyed. Kojo Ashong, near Obom had thirty-three cases of the disease. In the Weija area, even though flush toilet system is found in communities such as Mallam, MacCarthy Hill and Gbawe, cases of small pox incidence were as high as those in other areas in the subdistrict where pit latrines are commonly used. Even though it is possible to suggest that in such communities flush toilets may be in use in only a few homes and therefore not likely to be a source of the disease, cognisance should be given to the fact that chicken pox, as a viral and contagious disease, is spread more among the populace by direct contact with infested persons rather than the sanitation system used. Of course the disease is also known to be spread indirectly by articles soiled with discharges from the vesicles and mucous secretions (Bradley, 1990).

5.2.3.2 *Chicken pox and solid waste disposal*

Backyard method dominates the form of solid waste disposal in the two areas delineated. In the Weija zone, a sanitary landfill and backyard dumping system can be

Figure 5.20: Incidence of acute eye infections (1997/98)

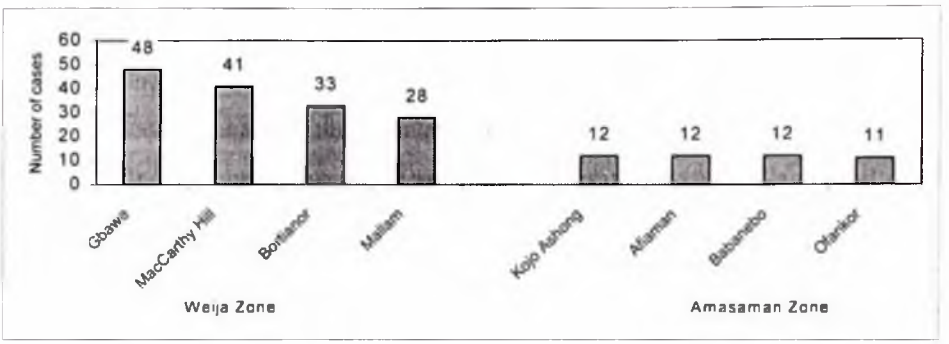


found but apart from these, home collection of waste is done. Yet chicken pox incidence is as high as anywhere else in the district.

5.2.3.3 *Chicken pox and household water supply sources*

Piped, well and river or stream systems of household water supply are the types found through out the chicken pox endemic areas. These systems are found intermixed. It is noted however that in the Weija zone, pipe borne water supply

Figure 5.19: Top cases of chicken pox in Weija and Amasaman zones



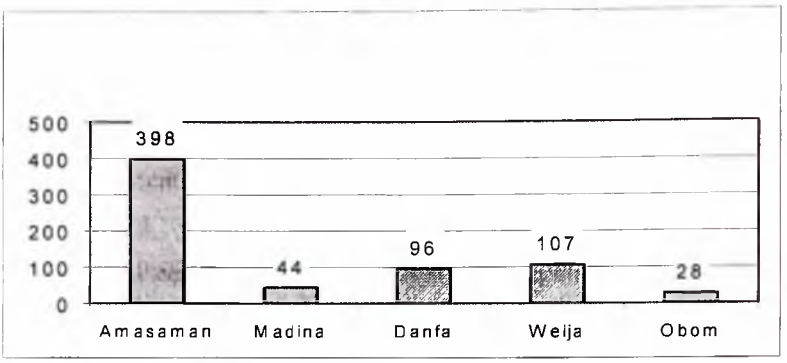
system predominate. Again, this does not account for the high cases of chicken pox in the zone. This also means that other causes of the disease may be found outside environmental factors. For example, in Figure 5.19 the top four cases of chicken pox in the communities in the two zones delineated, Weija and Amasaman, show a high incidence in Weija than in Amasaman and yet Weija has relatively better sources of household water supply, solid waste disposal form and sanitation type. The fact therefore remains that chicken pox is a viral and contagious disease spread rather by human agents through contacts with those infected. For policy-decision this calls for mounting up more educational and immunization programmes in the Weija area.

5.2.4 ***Spatial incidence of acute eye infections***

Eye infections are caused by factors including bacteria in the tear duct or the membranes that line the eyelids or by polluted atmosphere (smog). Some sources have also attributed certain eye infections to highly contagious disease caused by minute parasites especially in districts where poor hygiene and overcrowding occur (Shryock & Hardinge, 1985). A total number of 673 cases of eye infections were reported in the district during the period between October 1997 and September 1998.

The disease as illustrated in Figure 5.20 occurs predominantly in the Amasaman zone. The chart in Figure 5.21 shows that a total of 398 cases or 59 percent of the district total were reported in Amasaman zone alone.

Figure 5.21: Acute eye infection in the Ga District (1997/98)

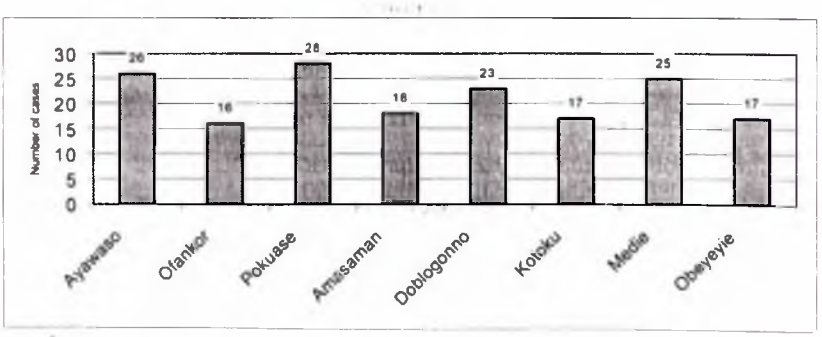


5.2.4.1 *Acute eye infections and sanitation*

In the three delineated zones, pit latrine system is the main type of sanitation. In the Amasaman zone, pit latrines are coupled with open defecation. Acute eye infections show highly in Pokuase, Ayawaso, Ofankor, Amasaman, Doblogonno, Kotoku and Obeyie, all of which can be described as poor hygiene communities. In each of these communities as shown in Figure 5.22 not less than sixteen cases were reported during the period.

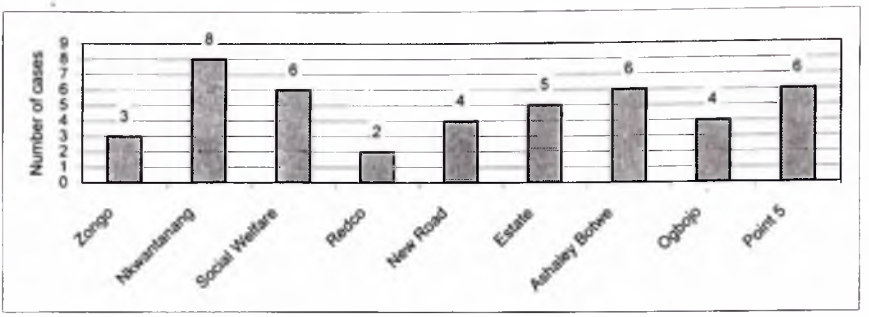
Madina as a zone had a total of forty-four cases of the infection but the disease presented itself more in communities such as Nkwantanang, Social Welfare, Ashaley Botwe and Point 5 as shown in Figure 5.23. It is noted that the entire Madina

Figure 5.22: Top cases of acute eye infections in the Amasaman sub-district (1997/98)



Township has been categorized under the flush toilet systems of sanitation. Communities without adequate water supply however rely on pan latrines and KVIPs.

Figure 5.23: Acute eye infections in Madina (1997/98)



Field investigations took note of reported cases of the practice whereby people defecate into containers and polythene sheets and dump them into public refuse containers. MacCarthy Hill Township in Weija reported eighteen cases of the disease during the period. Here the sanitation type is generally known to be that of flush toilet system.

5.2.4.2 *Acute eye infection and solid waste disposal*

Backyard method is the commonest among the forms of solid waste disposal in the three zones shown for acute eye infection. In Madina, as has been shown, the home collection system or methods akin to it is the commonest. The incidence of eye infection could be accounted for by the manner these are disposed of and the health threat they pose. It is common to find sites where refuse has been allowed to pile up for long periods and at the mercy of flies and rodents.

In Weija, the disease show highly in the MacCarthy Hill and Gbawe communities where home collection system is found, Mallam, the site for a sanitary landfill and Kokrobite where backyard dumping is common.

5.2.4.3 *Acute eye infections and household water supply*

Nineteen communities have access to potable or pipe borne water in the three zones delineated. The rest of the systems are either rivers or streams and wells. Eight communities rely on wells while twenty-three rely on rivers or streams for their water

Figure 5.24: Incidence of ear infections (1997/98)

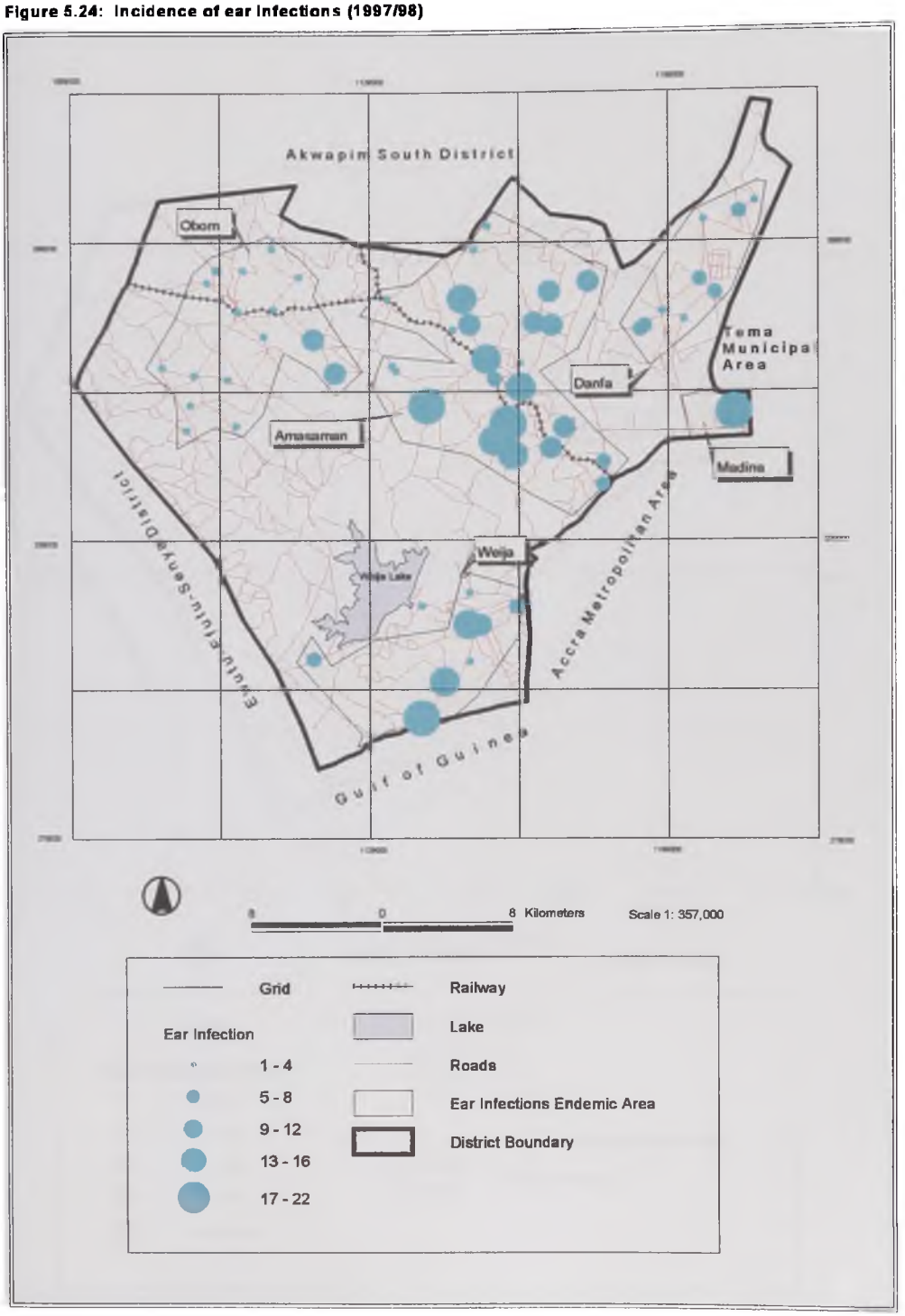
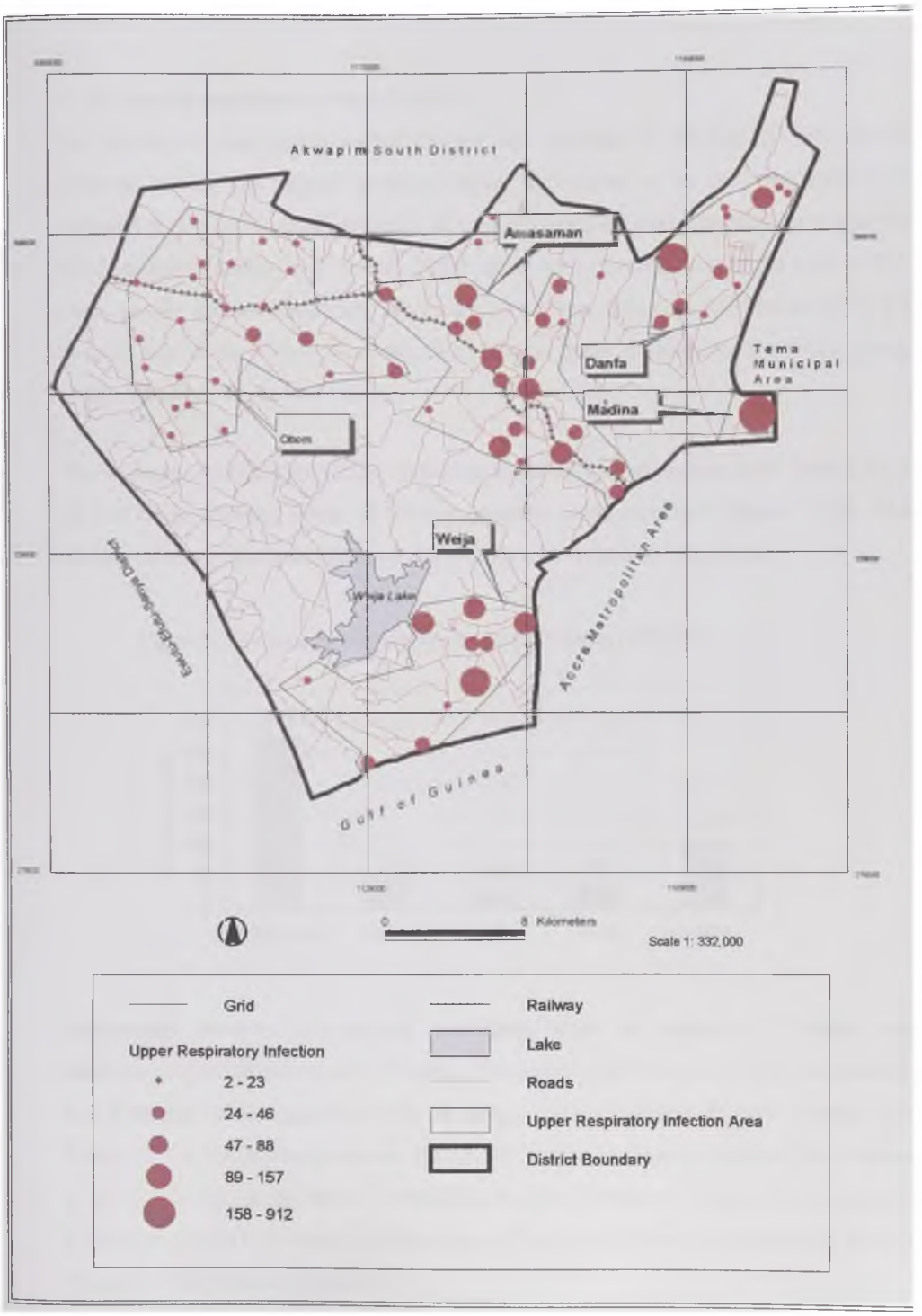


Figure 5.26: Incidence of upper respiratory tract infections (1997/98)



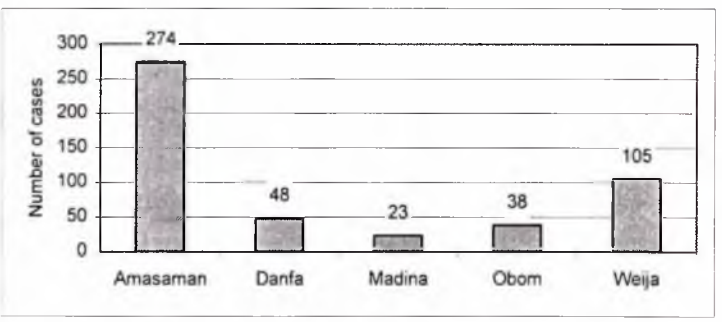
supply. The health implication of these systems of household water supply on the incidence of eye infections are not well known but it is possible to suggest that polluted water sources could be a source of bacteria that could result in some of the categories of eye infections.

5.2.5 *Spatial incidence of ear infections*

Ear infections rank ninth among the top ten diseases in the Ga District. Health officials explain the disease as being caused by injuries to the ear, which becomes infected or due to a complication of an upper respiratory tract infection. It is also the result of measles (Royle & Walsh, 1993). Sixty-four communities with a total of 439 cases in the entire district had reported cases of ear infection. On the basis of the clusters shown in Figure 5.24, the five endemic areas delineated were Amasaman, Danfa, Madina, Weija and Obom.

The highest concentration of the disease is found in the Amasaman area. Here a total of 274 cases coming from of 24 communities were reported (Figure 5.25). The disease however showed more in communities like Ayawaso, Obeyeyie,

Figure 5.25: Cases of ear infection in the Ga District (1997/98)



Amamorley, Pokuase, Asofan and Amasaman where an average of 17 cases was recorded. In the Madina zone, 23 cases of ear infections were recorded. The disease was common in communities such as Zongo, Social Welfare, Estate, Ogbojo, and Point 5. The Weija zone recorded the second highest number of cases of the disease in the district during the period. Settlements such as Bortianor, Oblogo, Kokrobite and Tuba all recorded an average of fifteen cases. Danfa and Obom zones recorded 48 and 38cases of the disease respectively.

5.2.5.1 *Ear infections and environmental factors*

The incidence of ear infection in the Ga District has not been linked to any of the environmental factors discussed so far. Infections as noted earlier are the result of injuries to the ear and developments due to measles. It is also due to complications of upper respiratory tract infection.

5.2.6 ***Spatial distribution of upper respiratory tract infections (URTI)***

Upper respiratory infections have been linked with air filled with smoky fumes and generally dusty environments. It is considered among the top killers of children in developing countries (World Bank *et al*, 1998). The disease is second to malaria as the most endemic in the district. A total of 2512 cases were reported during the study period. On the basis of the pattern of distribution shown in Figure 5.26, five zones were delineated as pockets of concentration of the disease.

The largest spatial concentration is found in the Amasaman and Madina zones where 941 and 929 cases respectively were reported. These two zones account for about 54 percent of the total number of upper respiratory infections in the district. As shown in

Figure 5.27: Upper respiratory tract infections in the Ga District (1997/98)

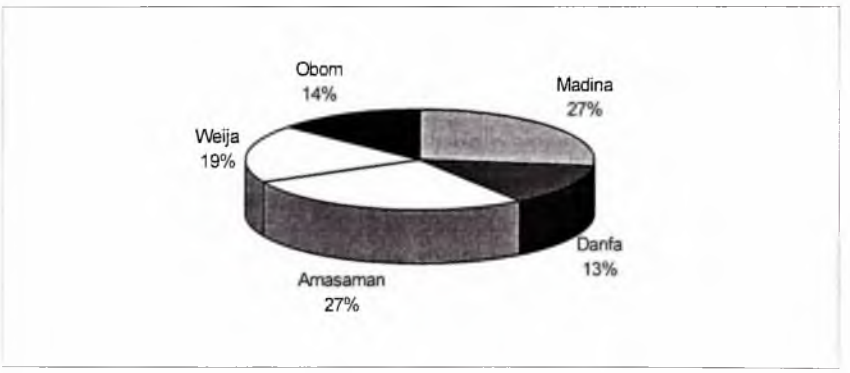


Figure 5.27 the rest of the district, namely Weija, Obom and Danfa had 19, 14 and 13 percents of cases respectively.

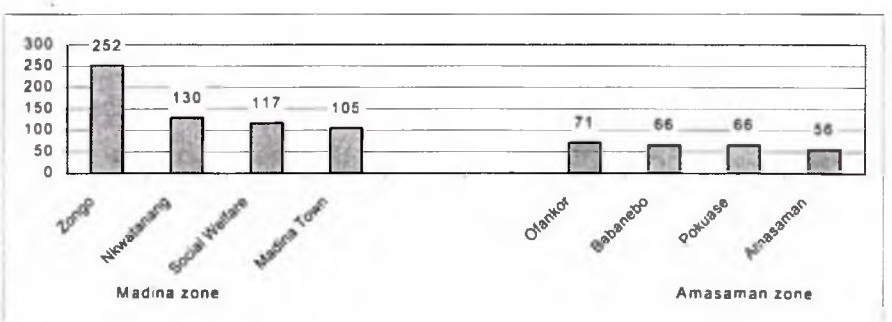
5.2.6.1 *Upper respiratory tract infections and environmental factors*

The environmental factor that accounts for the cause of URTI has been mentioned as mainly air pollution - caused by smoke fumes or dust. In the most endemic areas of

Amasaman and Madina therefore, factors such as refuse disposal forms, general sanitation types and drinking water supply system would not be described as having direct association with the disease. In the two zones for example the sanitation forms are basically flush toilets, KVIPs, pit latrines and open defecation. These are not known to be the direct cause of URTI. A study of the communities with the top case of the disease shown in Figure 5.28 below indicated sand-winning activities, dust from unpaved roads and other surfaces and uncontrolled use of unclean household fuels are common and observable phenomena which are potential causes of the disease. In the Amasaman zone, where sand-winning activities are very prevalent, tipper trucks are a common nuisance as the cruise along dirt roads spreading along much of the sand and dust they carry. Communities such as Ofankor, Amasaman, Pokuasse, Babanebo and many more lie within the sand-winning routes and this may account for the high incident rate of the disease.

In the Madina zone, the situation for the communities listed in Figure 5.28 is not different. Unpaved roads have always left dust in most of the communities especially in the Zongo area. Burning garbage points, which result in huge piles of smoke, are also a common phenomenon. Overcrowding and smoky indoor air – from burning biomas fuels for cooking or heating is found in most of these communities too.

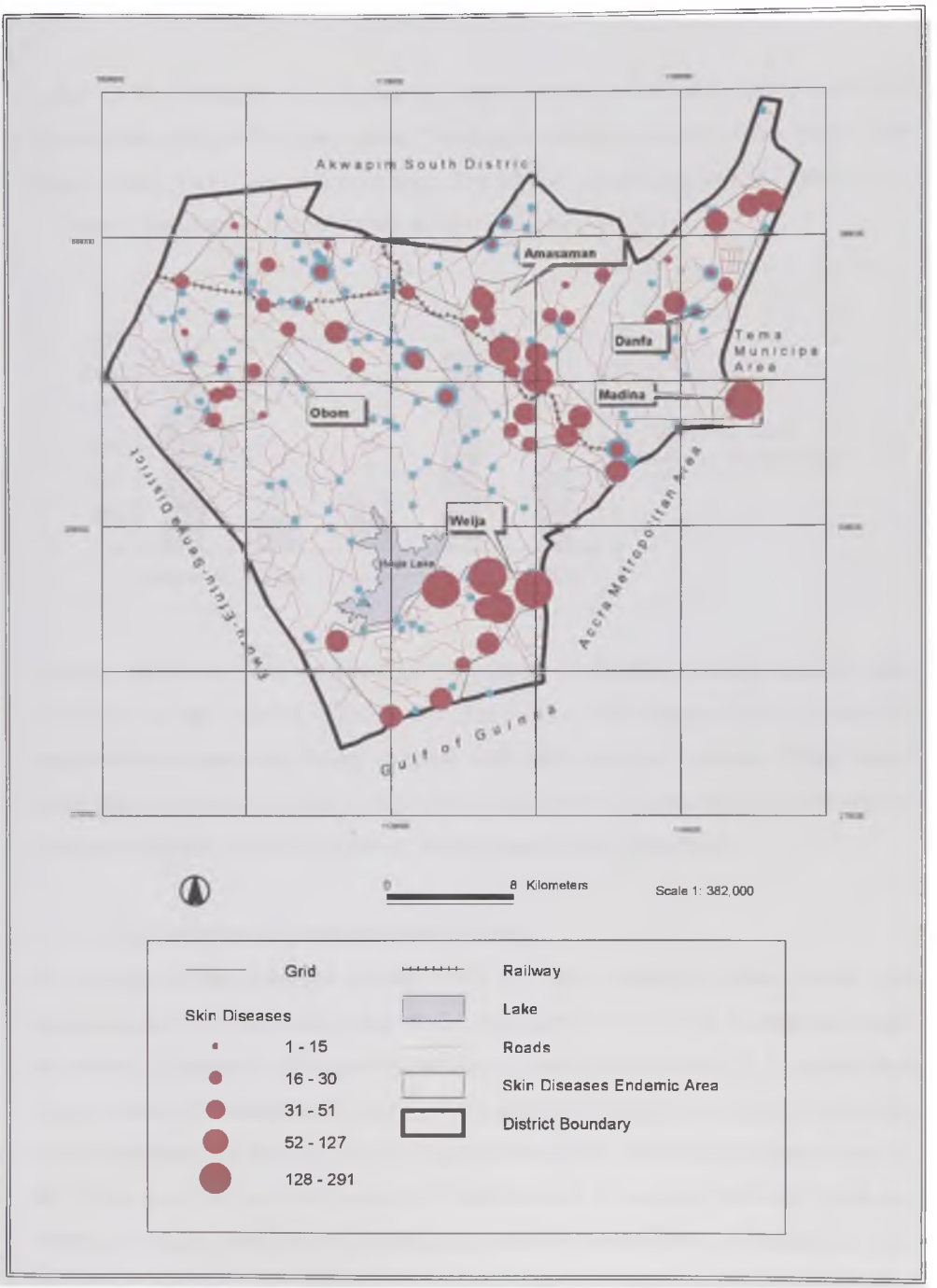
Figure 5.28: Communities with top cases of respiratory tract infections (1997/98)



5.2.7 ***Spatial incidence of skin infections***

Viruses, bacteria, fungi or mites may cause the many forms of skin infections. Health officials in the district contend that many cases of skin infection are the result of poor hygiene and bad environmental sanitation. Dr. Mensah-Quainoo (1997), the director of health services in the Ga District described some of the skin conditions as water-washed diseases. Skin infections are among the four most endemic diseases in the

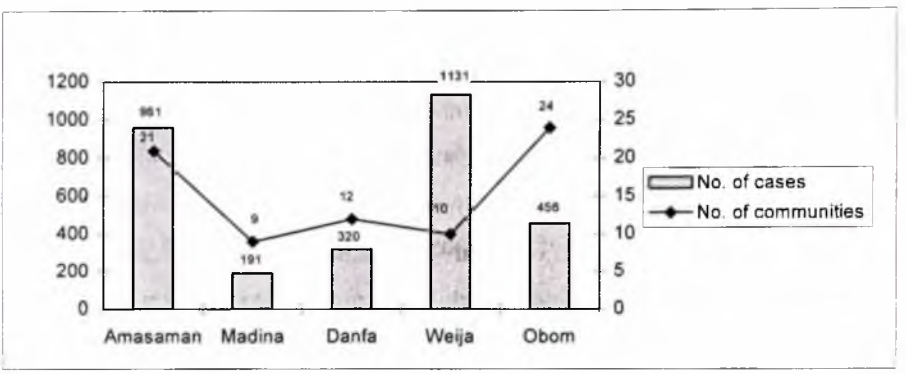
Figure 5.29: Incidence of skin infections (1997/98)



district. A total of 3059 cases were recorded during the period. Figure 5.29 shows the spatial incidence of skin infections in the district. Five main areas were delineated on the basis of clusters of concentration of the diseases. These zones incidentally coincide with the five health sub-districts.

Figure 5.30 illustrates the number of cases of skin infections reported and the communities from which they came. The largest cases are found in the Weija zone where a total of 1131 patients were seen. The second Amasaman, had 961 cases.

Figure 5.30: Cases of skin infections in the Ga District (1997/98)

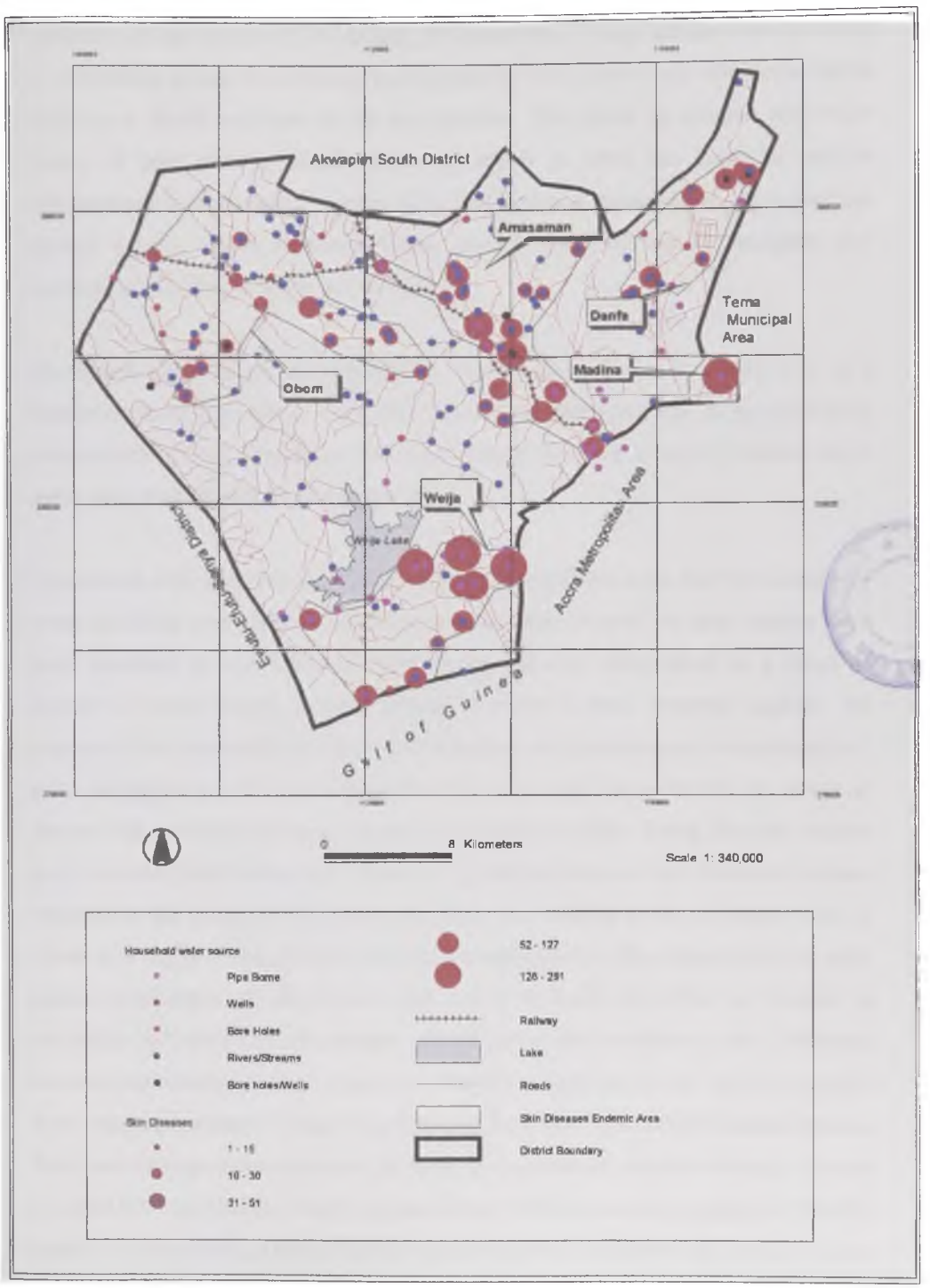


Together these two zones account for 68 percent of the total number cases of skin infections in the district. Obom and Amasaman sub-districts had 24 and 21 communities respectively being endemic with skin infection diseases. Weija zone, which had the highest number of cases, had much of the diseases concentrated in only three communities. These are Gbawe, Mallam and Weija Townships.

5.2.7.1 *Skin infections and environmental factors*

An overlay of the sanitation theme with the skin infections theme shows the predominance of pit latrines system in the delineated zones. In the Amasamam zone, the system is coupled with open defecation in some communities. It is argued that these systems of sanitation are likely to be a source of viruses and bacteria that could lead to the spread of skin infections. The situation in the three most endemic areas in the Weija zone and for that matter the entire district is however different. Here the system is that of flush toilets, which is a relatively better form of sanitation. This suggests that some other environmental factor may account for the high incidence rate.

Figure 5.31: Skin infections and sources of household water supply

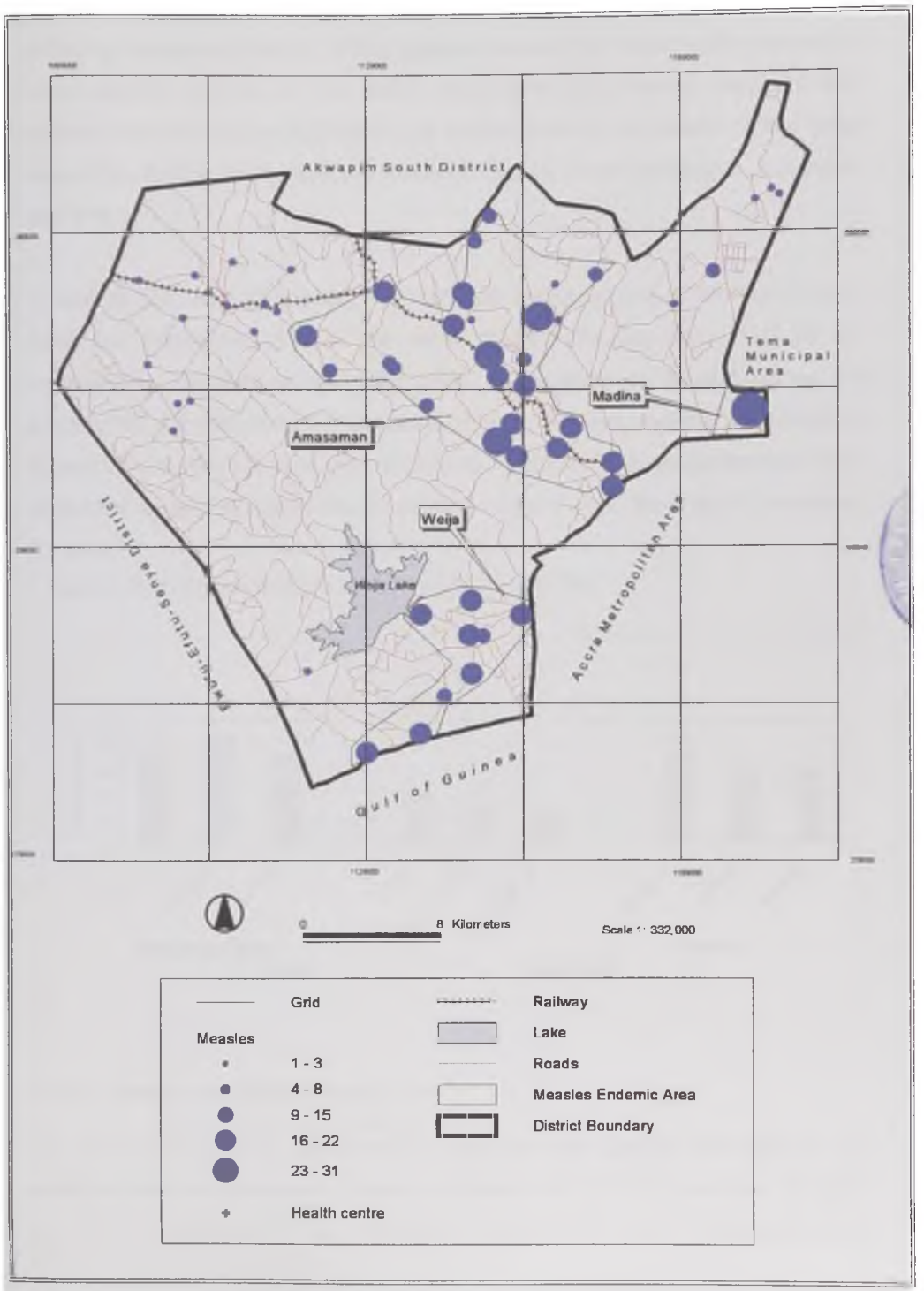


An overlay analysis done with the solid waste disposal theme showed a preponderance of the backyard disposal system in the district. In the areas of highest incidence of skin infections however the system is more of home collection or methods that are akin to it. In Mallam, the presence of a large sanitary landfill could be a breeding ground for flies and rodents and for that matter many a bacteria, which could pose health problems to the communities. This could be coupled with other forms of poor environmental sanitation, which is often the result of unwise development. In some of the communities bad drainage systems have led to garbage choked gutters, which constitute health hazard. They are usually unsightly and unpleasant and often a health risk to children.

Household water supply systems in the five zones as shown in Figure 5.31 is a balance between pipe borne, wells, rivers or streams and boreholes. In the more rural communities in the Amasaman and Obom zones however, rivers or streams are a major source of household water supply.

Discussions with some health officials in the district pointed to the fact that scarcity of water is a likely cause of skin infections. As indicated, some of the skin diseases have been described as water-washed. This means that they come about as a result of scarcity of water supply causing people to maintain poor personal hygiene. An analysis of the relationship between skin infections and the adequacy or inadequacy of water supply in the sub-districts, particularly areas that basically rely on rivers or streams did not show any trend towards high incidence either during the rainy season or dry season. In the Amasaman subdistrict the highest cases of skin infection diseases occurred in the month of November. In Danfa and Madina it was in March. And in Obom and Weija it was in July and October respectively. This disparity in the peak period of incidence of the disease does not demonstrate the effect of seasons or availability of rainfall on the disease. An interview with residents in the Taifa area however showed that in some years past, when residents had to rely on water supply from rivers and streams during the dry season, they developed series of skin diseases. This was often the case whenever the water was not boiled even for bathing. It must be noted however that this study was carried out with data covering a period of twelve months. Data covering a longer period may be required to ascertain the veracity of the health official's statement.

Figure 5.32: Incidence of measles (1997/98)

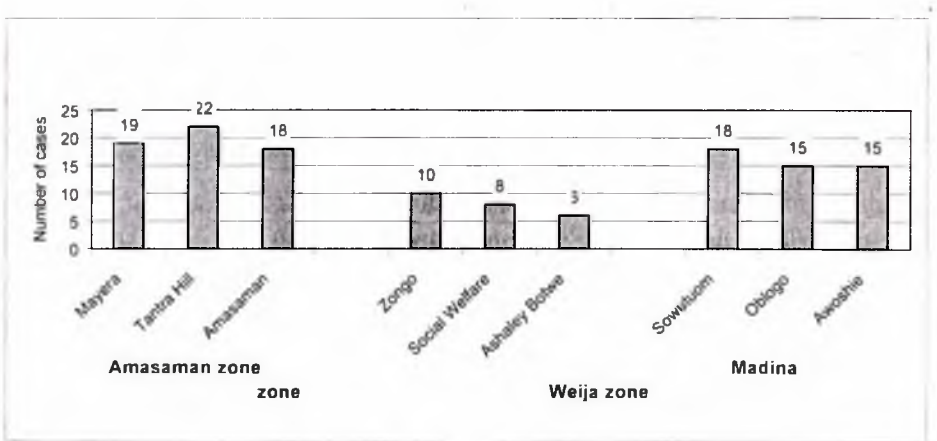


5.2.8 *Spatial incidence of measles*

Measles is an acute, highly contagious viral disease capable of producing epidemics. It is spread by direct contact with nasal or throat secretions of infected people or, less frequently, by airborne transmission. It is also spread by indirect contact with articles soiled by secretions (Bradley, 1990). Measles is one of the most readily transmitted communicable diseases. In the district, it however ranks among the three least endemic diseases. Figure 5.32 shows the spatial incidence of measles. Three zones were delineated on the basis of the clusters produced. These are Madina. Amasaman and Weija.

A total of 438 cases of measles were reported during the period between October 1997 and September 1998 in the entire district affecting about 11% of the communities. An assessment of the levels of incidence of measles among the communities showed that the Amasaman zone is the most endemic. As shown in Figure 5.33, the three communities of Mayera, Tantra Hill and Amasaman, had about 45 percent of top cases while the second most endemic zone, Weija had 37 percent of the cases.

Figure 5.33: Top cases of measles in the Ga District (1997/98)



5.2.8.1 *Measles and environmental factors*

An over view of the relationship between the spatial distribution of measles and environmental factors through the overlay process showed no direct association. As indicated, measles is very contagious and

spread by direct contact or less frequently by airborne transmission. The sanitation forms predominant in the most endemic zones shown in the map (Figure 5.32) are pit latrines and flush toilet systems. In parts of Amasaman zone, open defecation is also common but not associated with settlements such as Mayera and Tantra Hill from where the top two cases were recorded. These have little to explain about the cause and spread of measles.

The solid waste disposal types found in the endemic zones are predominantly backyard dumping, home collection and a sanitary landfill. If measles are to be associated with these waste disposal forms, it may bee seen more in the area of environmental sanitation where infested objects may be manhandled and exposed due to bad disposal. Thus since measles could be airborne it is likely to be transmitted from poor sanitary sites to communities within the vicinity or beyond.

Contaminated water sources by infected persons washing down in rivers and streams could pose health hazards to communities that rely on rivers or streams as sources of household water supply. This could be so in the Amasaman and parts of Weija zones. Judging from the mode of spread of measles, one would describe the disease to be attributed more to direct contact with infected persons. In communities with poor environmental sanitation, indiscriminate spitting and emission of nasal and throat secretions, the risk of contracting measles could certainly be high.

5.2.9 *Spatial incidence of intestinal worms infection*

Intestinal worms, particularly the roundworm (*Ascaris lumbricoides*) is an all-but-universal worm found wherever soil polluted with faeces contaminated with eggs from adult worms in the human intestine is ingested from soiled fingers or food (Learmonth, 1988). The hookworm (*Ancylostoma duodenale*) on the other hand is transmitted when a fairly short-lived free-living larval stage of the worm is able to penetrate the skin of bare feet on damp ground polluted with infected faeces, especially in warm, humid climates.

Figure 5.34: Incidence of intestinal worms infection (1997/98)

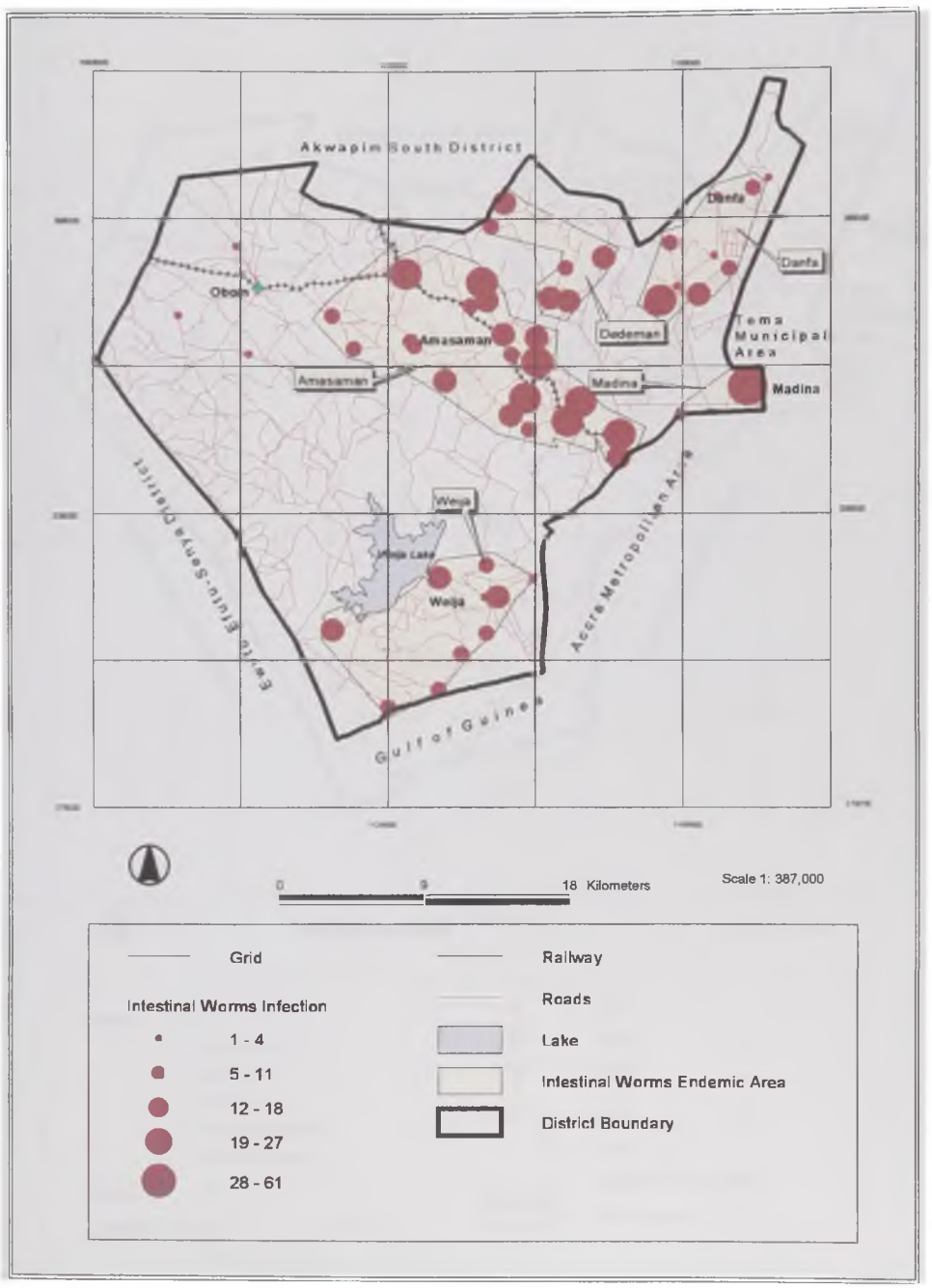
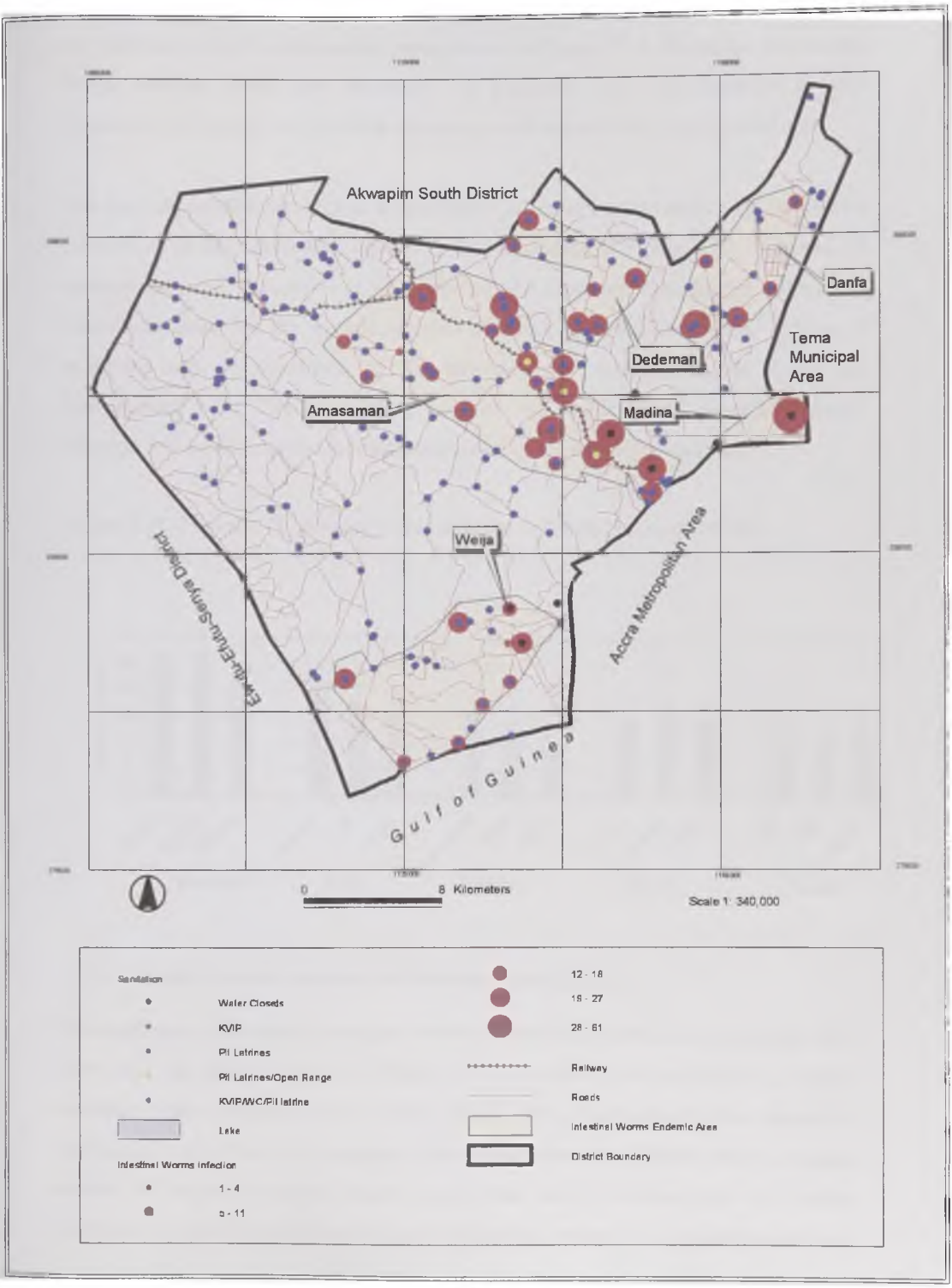


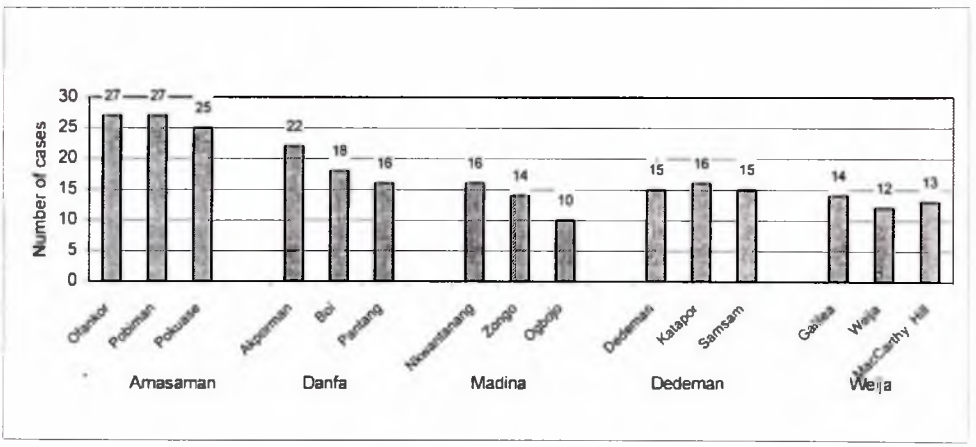
Figure 5.36: Intestinal worms endemiic areas and sanitation forms



Intestinal worms infection ranks fifth among the 10 most endemic diseases in the district. A total of 738 cases in 54 communities were recorded between October 1997 and September 1998. Like all the diseases aforementioned, intestinal worms infection are endemic in the five delineated zones shown in Figure 5.34. These are Amasaman, Weija, Madina, Danfa and Dedeman. The Dedeman zone was classified as such because of the unique nature of the clusters created around that geographical area.

The map shows that the largest concentration of communities with intestinal worm infection is in the Amasaman zone as further illustrated in Figure 5.35. It depicts 15 communities, and the number of cases which make them top in the district. Here again Amasaman zone has the highest number of cases. The reason for this pattern of incidence may be explained by the environmental factors that the zones are characterized with. The relationship between the incidence of intestinal worms' infection and environmental factors is discussed in the preceding sections.

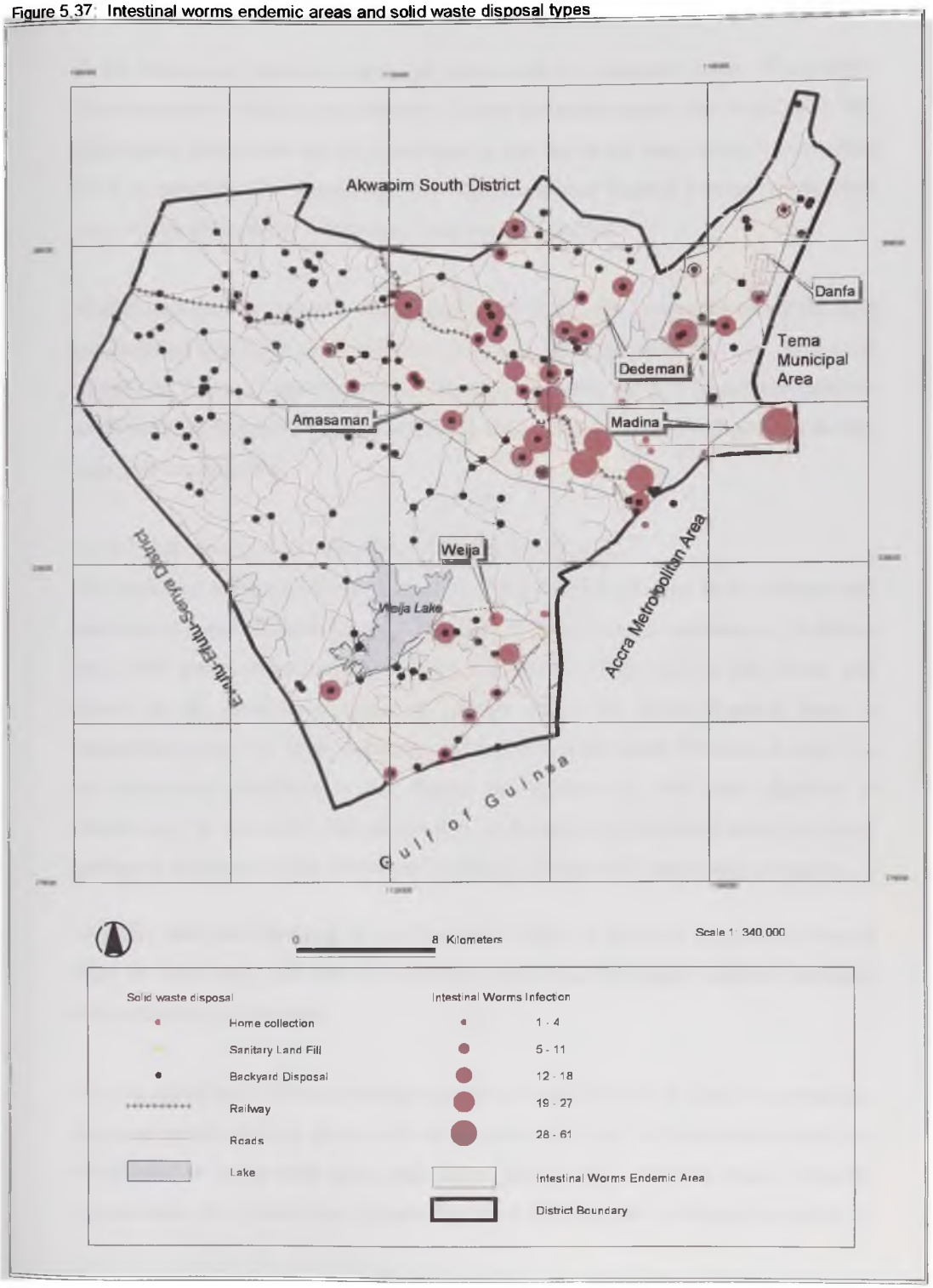
Figure 5.35: Top cases of intestinal worms infection in the Ga District (1997/98)



5.2.9.1 *Intestinal worms infection and environmental factors*

The sanitation types mostly associated with the zones delineated are pit latrines, flush toilets and the open defecation. Figure 5.36 is a view with the following themes, sanitation types, intestinal worms and endemic zones. Using the overlay method of analysis it is observed for example in the Amasaman zone (which has the highest number of communities and cases of intestinal worm infection) that pit latrines dominate the form of sanitation. In the communities where this form is coupled with

Figure 5.37: Intestinal worms endemic areas and solid waste disposal types



open defecation the incidence of intestinal worm infection is high. This is the case in Ofankor and Pokuase, the highest in the district.

In the Danfa and Dedeman zones, pit latrines are the dominant forms of sanitation. The situation in Weija is not different. Except for communities like MacCarthy Hill and Gbawe, which have water closets system, the rest of the zone use pit latrines. And yet a community like MacCarthy Hill had the second highest number of reported cases of intestinal worm infestation – coming after Galilea.

Madina as a zone is generally categorized under flush toilet system. However the high incidence of intestinal worm infection is due to an aggregation of cases from such suburbs as Zongo, Nkwantanang and Ogbojo. In many parts of these communities other methods of sanitation especially solid waste disposal form could account for the high cases of infection.

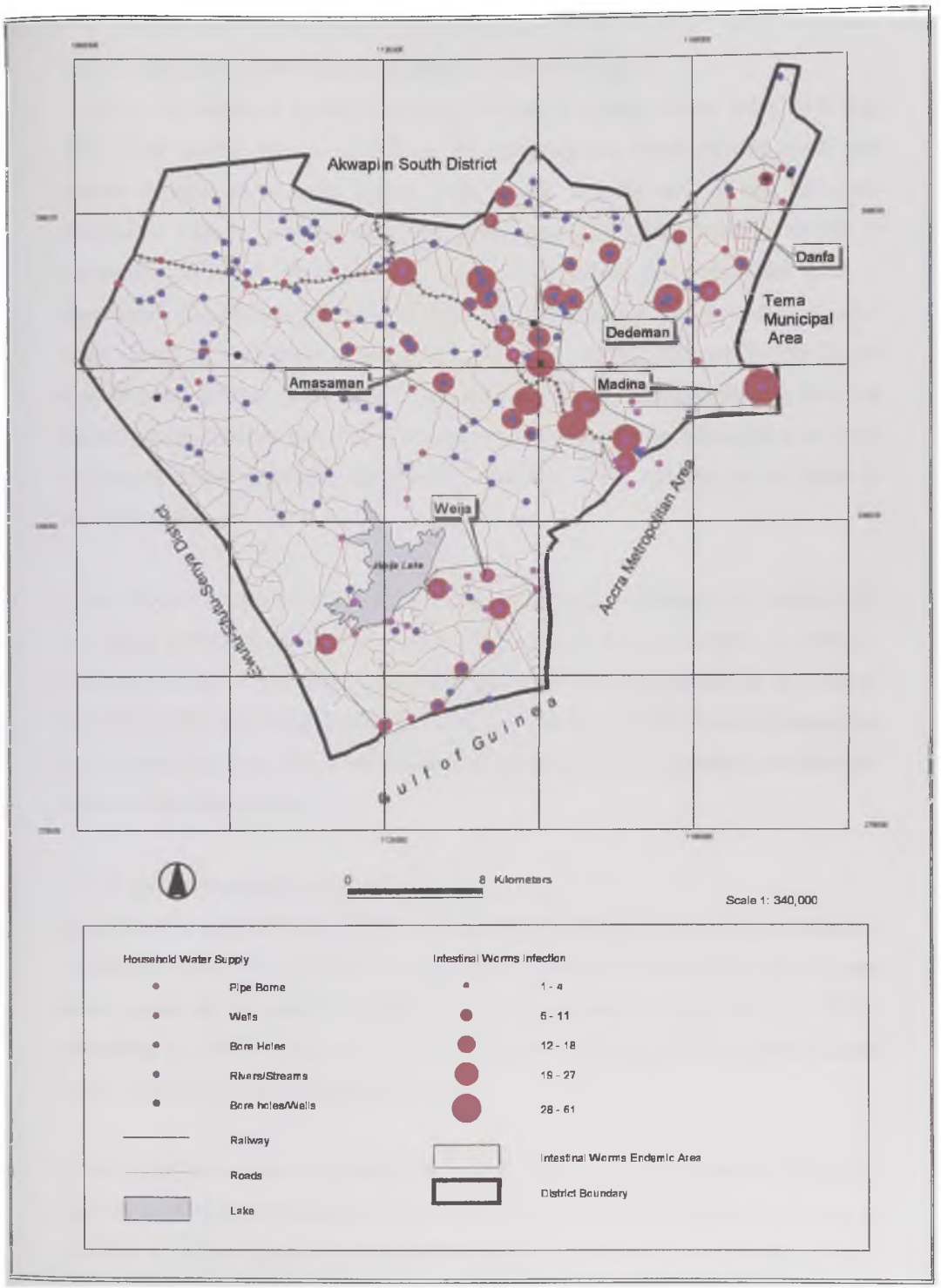
5.2.9.2 *Intestinal worms infection and solid waste disposal*

The backyard method is the dominant solid waste disposal form in the district and particularly in the delineated zones. This form is commonest in Amasaman, Dedeman and Danfa zones. Home collection form is however found in areas like Dome and Haatso in the Amasaman zone. In Madina where the waste disposal form is categorized under the home collection system, intestinal worm infection is high. As was mentioned elsewhere in this chapter the systems of solid waste disposal in Madina may be varied but they all involve the dumping of household waste and other garbage at approved points for onward collection by the local sanitation companies.

In Weija, backyard dumping is most common. There is however home collection of waste in MacCarthy Hill and Gbawe which have relatively higher cases of intestinal worm infection in the zone.

The fact about the backyard dumping system of waste disposal is that, it is a potential source of spread of many diseases. In situations where much of the domestic livestock are allowed to forage such open range refuse dumps and let loose to roam within the communities, the possibilities of these livestock infesting the communities cannot be

Figure 5.38: Intestinal worms endemic areas and household water supply sources



underestimated. There is also the element of flies and rodents infestation emanating from such dumps.

5.2.9.3 *Intestinal worms infection and household water supply*

If one of the modes of spread of intestinal worms is through faeces laden with eggs from adult worms, then it is possible for communities, which rely on rivers and streams for household water supply to be at risk. It is in view of this and other unhygienic ways of handling household water that much of the district is at risk of contracting intestinal worm diseases. Figure 5.38 shows that substantial parts of Amasaman, Danfa and the whole of Dedeman zones have rivers or streams as their main source of household water supply. Here too, worms infection is among the highest in the district. In Madina, water supply is mainly through piped system but most often the water does not flow causing the population to purchase and store water in concrete tanks, polytanks and other receptacles. These systems are all liable to contamination.

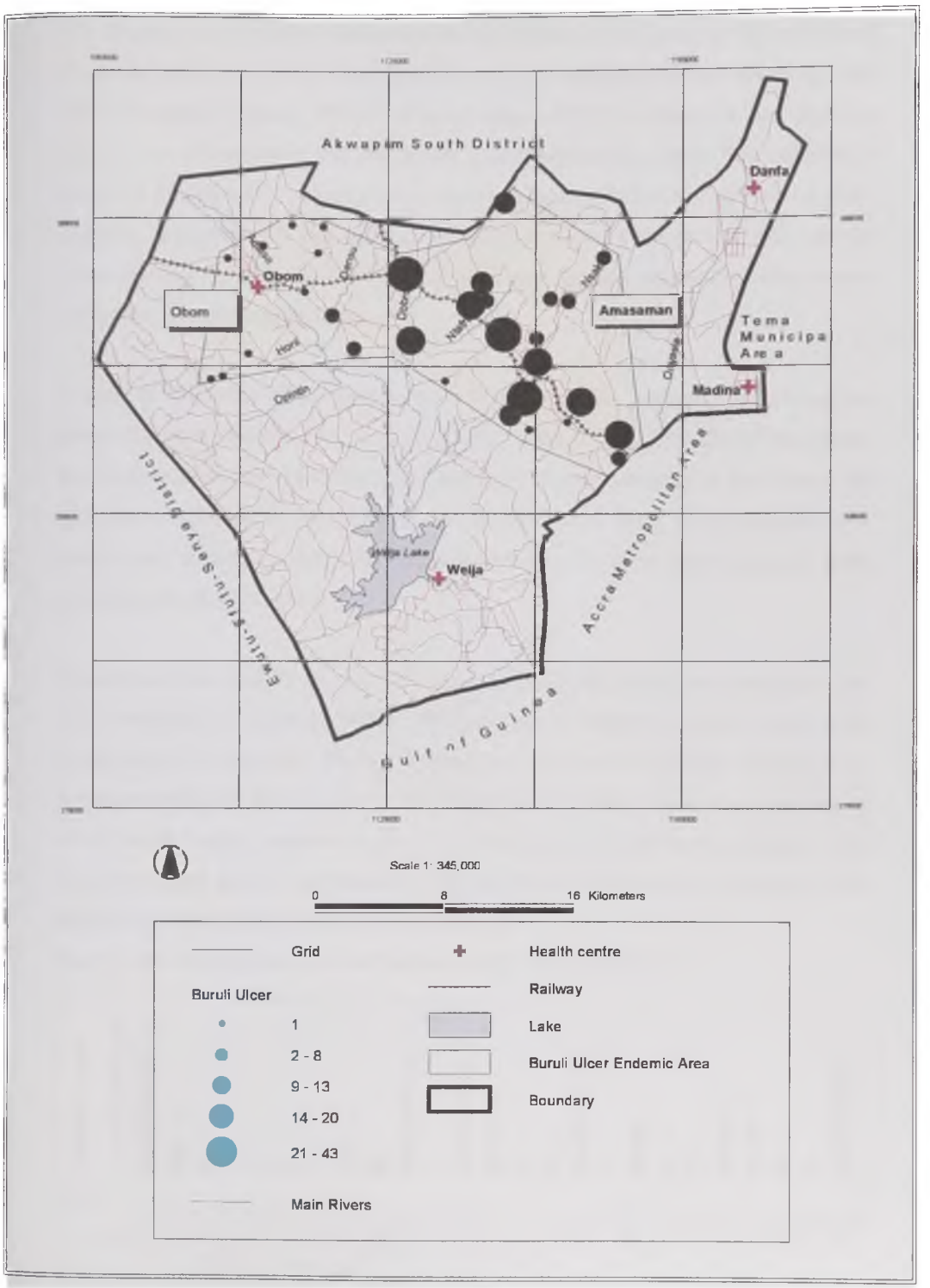
In the Weija zone, pipe borne system of water supply is commonest and interestingly it is those communities with this system that have the highest number of intestinal worms infection. A reference to Figure 5.35 shows the communities to be Galilea, MacCarthy Hill and Weija Township. This suggests the fact that other environmental factors including those discussed earlier could contribute to the incidence of intestinal worms in the communities.

5.2.10 ***Spatial incidence of buruli ulcer***

Buruli ulcer is a mycobacterial infection associated with tropical humid environments. It destroys tissues and causes horrifying lesions to the limbs of affected persons and seems to be on its way to replacing leprosy as a social scourge (WHO, 1997). According to WHO, buruli ulcer is the third most widespread mycobacterial disease in the world after tuberculosis and leprosy.

Buruli ulcer has assumed alarming proportions in the Ga District and even though it has not been recorded among the most endemic diseases in the district in terms of numbers of cases reported at the various health institutions, its study has become relevant for several reasons. For example, surveillance mounted in 1993 by the

Figure 5.39: Incidence of buruli ulcer (1997/98)

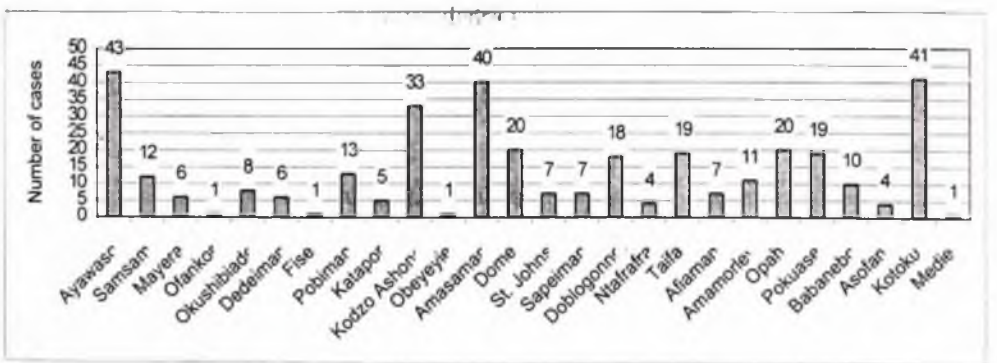


Regional Health Management Team (RHMT) in the Greater Accra Region showed that of 100 cases of buruli ulcer cases identified 98 percent came from the Ga District. The disease causes marked debilitation in sufferers and often leads to deformities and disability and may result in complications such as septicaemia (blood poisoning) and death (Mensah-Quainoo, 1997). Mensah-Quainoo (1997) indicated in her work on buruli ulcer in the district that the disease causes high dropout ratio from schools. It leaves in its trail social stigma such as severe deformity including total loss of arms, crippling, impaired grip and limping. The economic losses due to inactivity and the corresponding stress that this brings to already poor families and communities makes the disease worth researching into.

A total of 378 cases of the disease from 33 communities were reported during the period between October 1997 and September 1998. Figure 5.39 shows the spatial distribution of the disease in the entire district. The cases were all in the Amasaman and Obom sub-districts but the majority of them were from the Amasaman sub-district and especially along the railway corridor. No cases were reported from anywhere else in the district.

Amasaman alone had 94 percent (357) of cases of buruli ulcer, thus making it the most endemic sub-district. Within the sub-district itself the cases varied from community to community. The top 4 communities are Ayawaso (43), Kotoku (41), Amasaman (40) and Kodzo Ashong (33) (Figure 5.39 shows). The average number of cases for the entire community is 13. The factors that account for buruli ulcer incidence in the district and especially the pattern of concentration in the two sub-districts are discussed in the subsequent sections.

Figure 5.40: Buruli ulcer cases in Amasaman sub-district (1997/98)



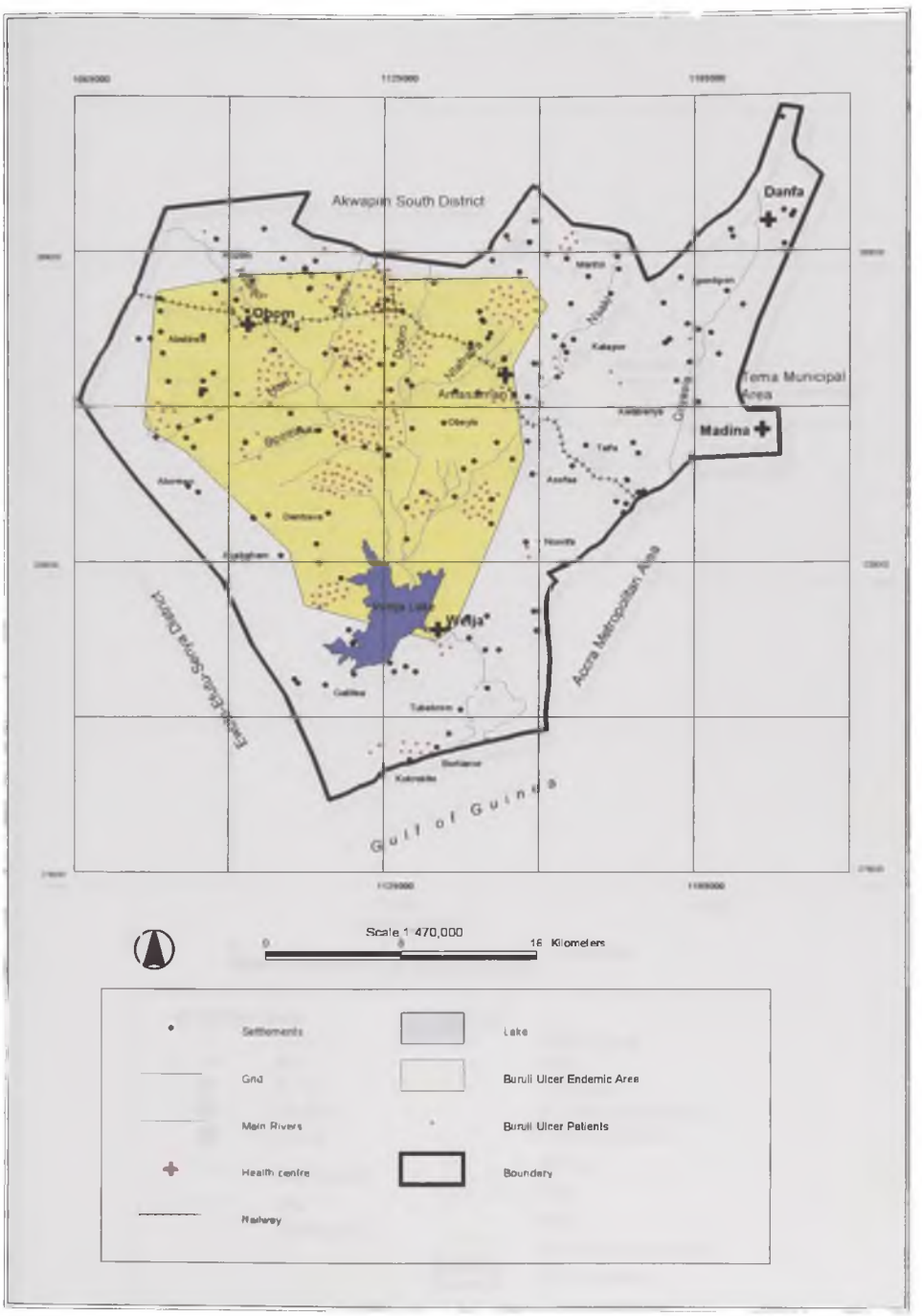
5.2.10.1 *Buruli ulcer and environmental factors*

A peculiar feature of buruli ulcer is that its causative agent is known, but the exact mode of infection and spread has not yet been established (Mensah-Quainoo, 1997). Since not much has been done to suggest human-to-human spread, much effort has so far been expended on environmental sampling. Some researchers have associated the bacteria with the tall siliceous spear grass (*Imperata cylindrica*) (Johnson, 1997) and the antelope grass (*Echinocloa pyramidalis*) which has a cutting edge (Barker, 1973). Johnson also indicated other environmental factors that were discovered to cause the mycobacterium ulcerans. In a study in southeastern Australia, he observed the bacteria to be associated with some swamps and golf course irrigation systems that used a mixture of ground water and effluence. Dr Kelvin Palmer, a WHO malarialogist on the same observation indicated that there could be an obvious connection between the use of sewage effluence for irrigation and the occurrence of the ulcers (Palmer, 1995). He noted that all the ulcers occur on the legs and arms, consistent with transmission by contact with infected grass or vegetation. According to him further investigation might reveal that it is only those golfers who spend much of their time off the fairways looking for lost balls that are infected.

An earlier study by Dr. Mensah-Quainoo (1997) in the Ga District also showed some correlation between the incidence of buruli ulcer and riparian environments. Her works involved a study of 751 patients who suffered the disease during the period between 1987 and 1997. By the use of the overlay process of analysis, which involved basically two themes, number of patients and major rivers, she discovered that many of the cases were found along the valleys of the Densu, Onyasia, Nsaki, Honi, Adaiso, Dobro and Ntafrafra. Figure 5.41 presents a cartographic view of the number of buruli ulcer patients from her study sites and the major river valleys along which they were found. This provides a clue that could call for further investigation into the disease and to facilitate decision making for control measures.

The distribution of the disease in Uganda, Zaire and elsewhere correspond to that of swamps and riparian areas in which the grass *Echinocloa pyramidalis* (antelope grass) which has a cutting edge is commonly found. Mycobacteria species have been isolated from this vegetation (Barker, 1973).

Figure 5.41: Buruli ulcer cases and riparian environments



(After Quainoo-Mensah, 1997)

Figure 5.42: Buruli ulcer and sanitation forms

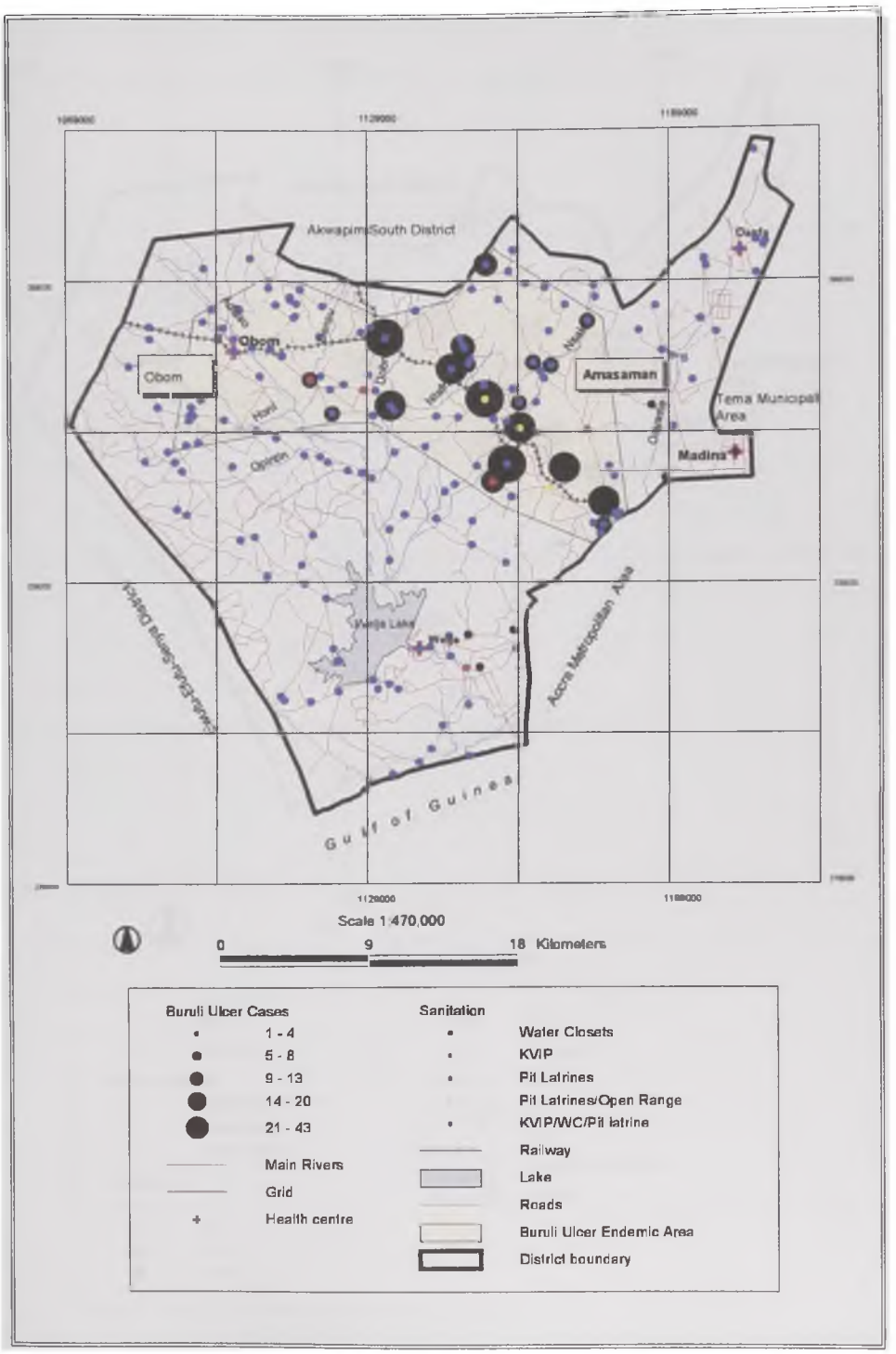
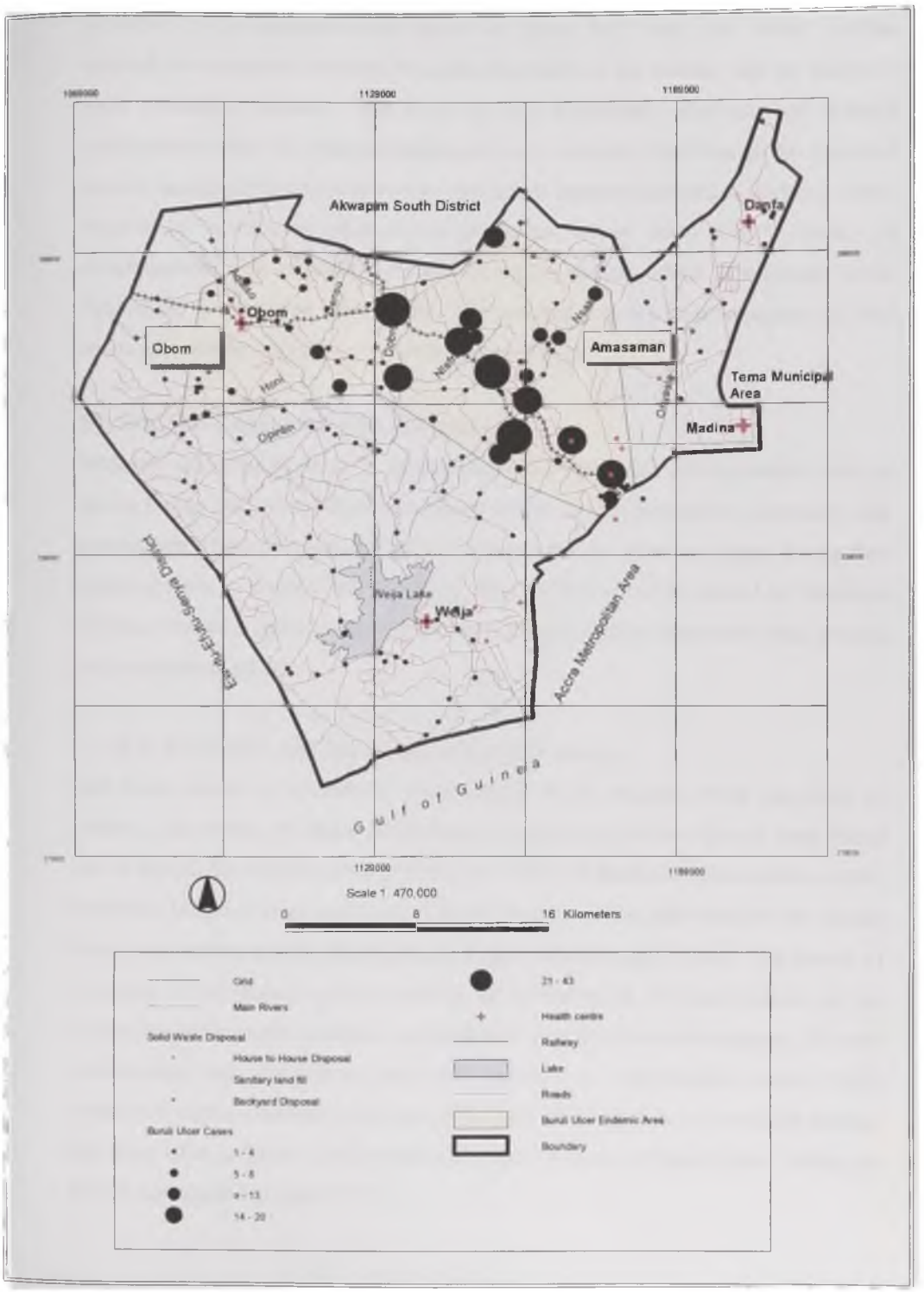


Figure 5.43: Buruli ulcer and solid waste disposal forms



5.2.10.2 *Buruli ulcer and sanitation*

An analysis of the relationship between buruli ulcer incidence and the forms of sanitation in the endemic areas shown in Figure 5.42 using the overlay process showed an association between the preponderance of the disease and pit latrine or open defecation systems. This is so in the Amasaman, Ayawaso and Kotoku communities where the highest incidences were recorded. Even though the literature has not associated the mycobacterium ulcerans to forms of sanitation, the issue of bad disposal of sewage or fecal matter could be visited since it is a source of contamination. For example the open defecation system which is common in the Amasaman and Pokuase communities is a potential source of contamination of food and water sources thus posing varied health problems.

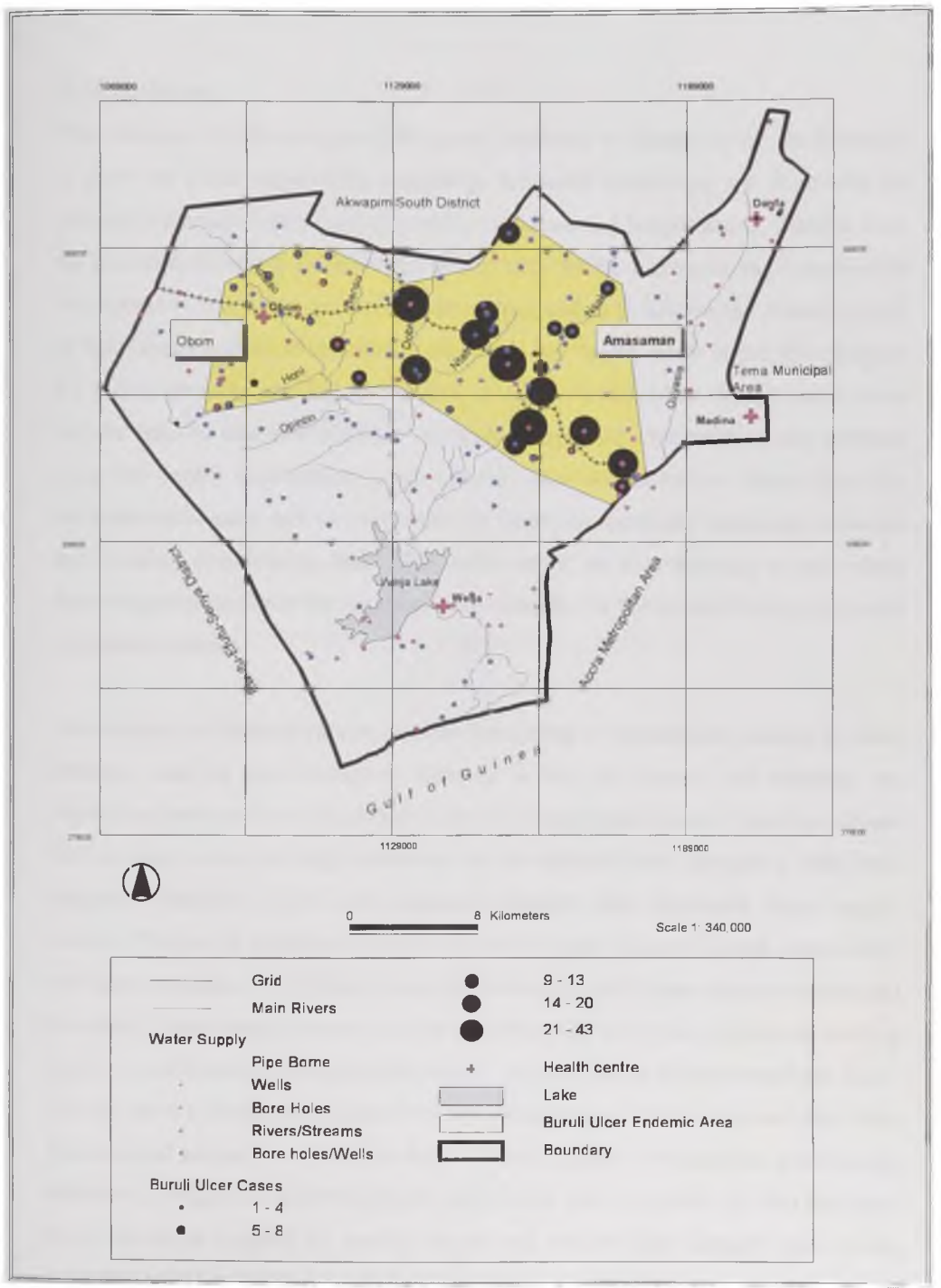
5.2.10.3 *Buruli ulcer and solid waste disposal*

Backyard dumping of waste is commonest in all the buruli ulcer endemic areas as shown Figure 5.43. This form is a potential source of filth propagation especially near homesteads where livestock are made to forage and live close to human beings thus exposing them to several health hazards. One of these could be caused by rainwater flowing over such garbage dumps and emptying into nearby household water sources such as rivers or streams.

5.2.10.4 *Buruli ulcer and household water supply sources*

The main sources of household water supply in the endemic areas are rivers or streams. An overlay of major rivers theme on the buruli ulcer endemic zone theme shows that all the endemic communities are within the basins of rivers Densu, Nsaki, Ntafrafra, Dobro, Adaiso and Honi. Figure 5.44 shows the major cases of the disease from communities around such rivers as Nsaki, Ntafrafra and Dobro. This pattern of incidence of the disease goes to confirm the works of Dr. Mensah-Quainoo on the correlation between the incidence of buruli ulcer and riparian environments. This also corroborates with discussions held with members of communities around Taifa, mentioned earlier about skin diseases associated with water from unreliable sources that they often suffered. Taifa community had 19 cases of buruli ulcer during the period investigated (Figure 5.39).

Figure 5.44: Buruli ulcer endemic areas and riparian environments,



So far the cause of spread of buruli ulcer is not known. What most researchers believe is its transmission by unknown means from the local environment to individuals. This means that in the absence of proven ways to avoid it the best remedy is to keep away from endemic areas.

5.3 **Conclusion**

The relevance of GIS analysis of the spatial incidence of diseases in the Ga District is to show the added value of the technology for health monitoring and to provide the relevant information for supporting policy decisions and programming. Starting from the district level where the data requirement may not be overwhelming, it is possible to integrate relevant data from the different departments to achieve the planning goals of the various sectors of the district economy. The health sector is one that requires for policy decision making varied data sources. As has been demonstrated these include data on diseases incidence as reported from the communities and obtained from the health institutions, environmental data on sanitation forms from the environmental health unit and water sources from the community water and sanitation and planning coordinating units. The health sector has thus emerged as one where data integration has been demonstrated to be feasible for health monitoring and health education purposes.

This chapter has been an attempt at using the overlay or layered data concept to show endemic areas of the commonest diseases in the Ga District and establish the correlation between these diseases and some environmental factors. It has been shown that in many cases the high incidence of the diseases was associated with poor sanitation practices, solid waste disposal methods and household water supply sources. The use of graduated circles to show the range of cases in each community, the superimposition of themes on sanitation forms, solid waste disposal types and household water supply sources on the disease types, were the methods of overlay analyses employed to accomplish the study. In cases where an environmental factor did not show a strong association with the disease type, it was proposed that other factors could account for the cause of some of the diseases. For example, even though Madina is categorized under the piped borne water supply system, the fact that such water has to be supplied by vendors shows that treated water already poses health hazards due to contamination. The case of diarrhoea incidence in some communities

in the Madina zone is worth mentioning. In the case of buruli ulcer the study has confirmed findings that show its association with riverine areas even though the mode of spread of the bacteria is still not yet known. An investigation into the vegetation and environmental sanitation types associated with the disease could be noted for further studies.

CHAPTER SIX

SPATIAL ACCESSIBILITY TO HEALTH CARE FACILITIES IN THE GA DISTRICT: THE ROLE OF LOCATION-ALLOCATION MODELS USING NETWORK ANALYSIS

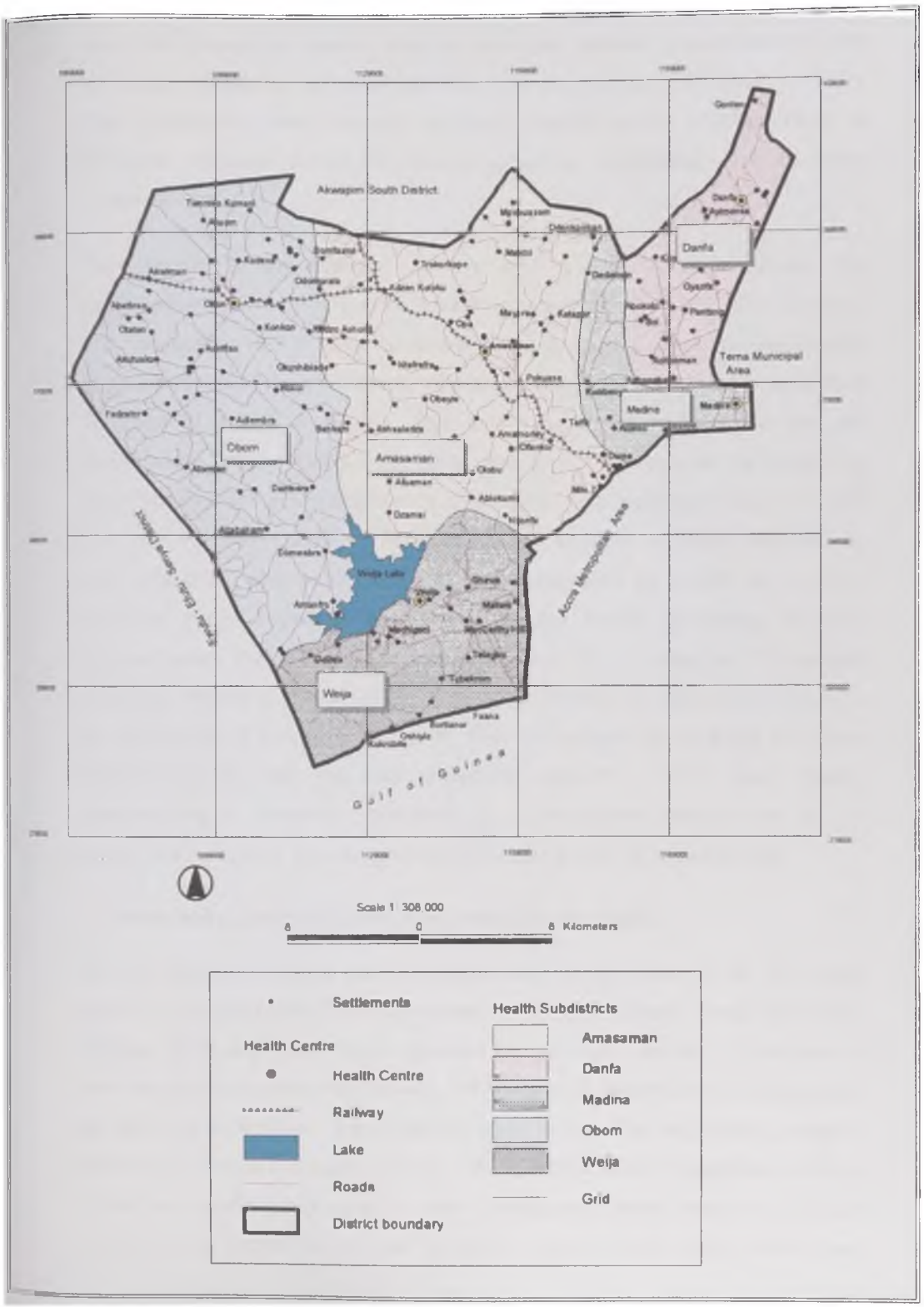
6.0 Introduction

Problems of health care delivery in many developing countries are not only found in the inadequacy of the available facilities and personnel but also in how geographically accessible they are to the populations. Freund (1986), Lasker (1981), McEvers (1980) and Stock (1985) have discussed that health facilities are often geographically inaccessible to the majority of the populace, especially those who live in the rural areas. This is coupled with high cost of the health care itself. Any attempts to extend care are often obstructed among other factors by the shortage of both financial and human resources (Philip, 1990). In view of this, it has been suggested that better spatial organization of existing health care delivery system is a logical strategy to follow (Oppong & Hodgson 1994).

Location-allocation models (LAMs) have strongly been advocated for as tools for providing important information on how limited resources can be used more efficiently to provide access for those currently without access to facilities (Rushton, 1984, 1988). Ayeni *et al.* (1987), in their work in Ogun State, Nigeria, showed that accessibility to maternal and child health clinics could be improved substantially through careful location of new facilities. In this, location-allocation models were proposed. Oppong & Hodgson (1994) have also demonstrated that location-allocation models may be used to improve spatial accessibility without increasing the number of facilities and with minimum disruption to the existing system of facilities.

Location-allocation models locate systems of facilities and allocate users to them. They may operate in continuous space, in which they solve for facility locations, or in discrete space, in which they select locations from predetermined potential ones. Some health care-related applications focus on locating health personnel and facilities to maximise access for users. Examples include those of Bennett, Eaton & Church (1982) who applied a maximal covering approach to find locations of health centres in Columbia. Eaton *et al.* (1982) used maximal covering in Columbia to find new

Figure 6.1: Health sub-districts and location of major healthcare facilities



health facility locations that, if added to the existing facilities, would most improve population coverage. Mehretu, Wittick & Pigozzi (1983) used the *p*-median model with a maximal distant constraint to find locations of health services sites in the eastern part of Burkina Faso. The procedure used assigns primary health posts (PHPs) first to villagers who are worse off, before granting additional units to other communities.

This thesis is an attempt to use GIS based LAM to study the geographical accessibility to health care services in the Ga District. The objective is to use network analysis as a tool to determine populations that have current access to services within the specified distance of 8-km (5 miles), find areas currently without access and recommend sites that could have the services located in order to improve overall accessibility or coverage. The analysis demonstrates how the various layers of information or themes, namely population, site locations, and road networks are integrated in a GIS to provide facts to support policy decisions and for health planning. It also demonstrates the role of systems approach to the analysis of spatial problems where a combination of several factors is required to explain the operation of the whole system. This is summed up in what has been referred to as the "layered database concept" where each layer, representing a thematic approach to a particular purpose or set of needs, may contain one or several different kinds of information.

6.1 **Status and capacity of health care facilities in the district**

The Ga District is divided into five sub-districts on the basis of the five major Ministry of Health (MOH) facilities located in Amasaman, Weija, Danfa, Obom and Madina. The facilities are widely dispersed geographically and are not adequate to serve the population (Mensah-Quainoo, 1997). Figure 6.1 shows the sub-districts and the major MOH facilities. These facilities could be described as providing levels A and B type services (Ministry of Health, 1978). These levels of healthcare delivery system are usually staffed with at least a community health nurse and a trained midwife in the former and at least one doctor, and providing mostly curative and

preventive services in the latter. As part of the general policy on Primary Health Care (PHC) the district has a District Health Management Team (DHMT), which is responsible for identifying locations to host PHC facilities and overall healthcare programming in the district.

The district as a whole has 15 institutions providing health care services. These include quasi-government institutions and facilities established by NGOs (MOH/Ghana Health Service, 1998). In spite of the policy to deliver healthcare to the vast majority of the people, a peculiar feature of the delivery system is the spatial imbalance in the distribution of healthcare facilities. The health sub-districts were delineated on the basis of the five main Ministry of Health (MOH) facilities (Figure 6.1). Geographically these are relatively far apart from each other and more especially from many communities, which have to travel beyond the specified distances to receive healthcare services. In many cases travels are along bush paths and unmotorable and dirt surfaced roads. This situation is exacerbated by the high health-manpower and population ratio.

Details about the staff cadre position by sub-districts are illustrated in Table 6.1. By March 1998 there were three doctors and a pharmacist working in the five MOH facilities in the entire district with a population of about 300,000. Out of this, one doctor and the only pharmacist were based in the District head office (DHO#) handling major administrative and local health policy, planning, monitoring and evaluation issues. Except in Weija, all the other health institutions in the district have Medical Assistants as the most qualified personnel providing health care services. Staff and population ratio ranged from 1:96,667 for Medical Officers to 1:14,500 for Orderlies (MOH/Ghana Health Service, 1998). Again, there are only four Environmental Officers in the entire district, which makes the staff and population ratio 1:72,500. This coupled with the poor logistics for proper environmental monitoring makes health care delivery a difficult task.

Table 6.1: Staff cadre position by sub-district, Ga District

Category	DHA	Amasaman	Danfa	Madina	Obom	Weija	District total	Staff/Popn. ratio
Medical Officers	1	0	1	0	0	1	3	1:96,667
Medical Assistants	0	1	1	2	1	3	8	1:43,333
Professional Nurses	4	23	7	18	4	19	75	1:3,867
Enrolled Nurses	0	2	1	0	2	7	12	1:24,167
Comm.Health Nurses	0	14	12	18	3	15	62	1:24,167
Technical Officers (CDC)	1	1	1	0	0	0	3	1:96,667
Field Technicians	0	1	0	0	1	1	3	1:96,667
Technical Officers (NUT)	2	1	0	1	1	1	3	1:48,333
Pharmacists	1	0	0	0	0	0	1	1:290,000
Dispensary Assistants	0	1	1	1	0	1	4	1:72,500
Dispensary Attendants	0	0	0	1	1	1	3	1:96,667
Environmental Officers	0	1	1	0	1	1	4	1:72,500
Records Officers	0	1	1	1	0	1	4	1:72,500
Orderlies	0	8	0	1	5	6	20	1:14,500
Total	9	54	26	43	19	57	205	1:1,415

MOH/Ghana Health Service, 1998.

6.2 **Problems of geographical accessibility to health care services**

Apart from the overview of the staff and population ratio and how this impact on health care delivery and meeting the goal of the PHC strategy, a survey of some of the major components of geographical accessibility to healthcare services in the district was done. This involved interviews with 22 patients from different communities at each sub-district facility on mode of transportation, road type traveled and cost of transportation.

The main mode of transportation from the various communities to the MOH facilities are walking and by trotro or busses (Table 6.2). Walking dominates the means of transport in areas such as Obom and Danfa. These are communities sited in typical rural parts of the district. Amasaman and Weija are sited on major roads thus enabling easy access by trotro or buses. Generally, travels are done over earth/dirt and partially tarred roads, some of which are in various stages of disrepair and therefore very difficult to convey very sick persons on. The condition of most of the roads goes from bad to worse during the rainy season making a sizable part of the district inaccessible for close to half of the year (Mensah-Quainoo, 1997).

Table 6.2: Mode of transportation to health care facilities in the sub-districts

Centre	Trotro/Bus	Taxi	Walking	Bicycle
Obom	1	0	20	1
Amasaman	18	0	3	1
Danfa	5	3	14	0
Weija	16	3	3	0
Madina	9	3	9	1
Total	49	9	49	3

Source: Fieldwork, 1998.

Throughout the district the main road types include asphalt, bitumen/gravel, earth/dirt surfaced and footpaths (Table 6.3). The survey showed that tarred or bituminous roads, are the major arteries through which most of the health facilities are reached by patients and except at Obom the rest of the centers are located in relatively well developed areas linked by major routes. This does not in anyway create the impression that patients do not have difficulties travelling along some of them. For example, the road to the Danfa facility is in a serious state of disrepair and could pass for an earth or dirt surfaced road. Vehicular movement on that route is sparse. It is for this reason that one finds nearly 63% of patients attending the health centre walking as their main means of transport.

Table 6.3: Road type travelled to health care facilities in the sub-districts

Centre	Tarred roads (bitumen)	Asphalt	Earth/Dirt	Footpath
Obom	0	0	14	8
Amasaman	14	1	6	1
Danfa	14	0	3	5
Weija	8	5	6	3
Madina	12	3	7	0
Total	48	9	36	17

Source: Fieldwork, 1998.

Cost of transportation to and from the health centres range from less than 500 to over 1000 cedis. However, in majority of cases, walking is the dominant means of transport (Table 6.4). This is exemplified by the fact that about 40% of patients walk

Table 6.4: Cost of transportation to health care facilities in the sub-districts

Centre	< 500 cedis	500 – 1000 cedis	>1000 cedis	No cost
Obom	0	4	2	16
Amasaman	12	4	3	3
Danfa	1	4	3	14
Weija	3	15	1	3
Madina	10	4	0	8
Total	26	31	9	44

Source: Fieldwork, 1998.

to receive treatment. At Obom and Danfa, patients mainly walk and thus incur no cost by way of transport fees. Reasons for this may range from nature of access roads, nearness to health facilities and the problem of lack of finances.

6.3 **Accessibility and the goals of Ghana's PHC strategy**

Traditional concepts of location-allocation modelling conceptualise geographical accessibility in two ways – proximity and coverage (Oppong & Hodgson, 1994). When defined in terms of proximity, accessibility has a distance minimisation connotation and may be measured using the average travel distance. As a locational goal, proximity translates into the simple *p*-median problem. This selects facility locations to minimize average travel distance for users. Earlier

works done in this area has shown that distance is a major determinant of facility use (Stock, 1982 & King, 1998).

Accessibility may also be expressed using a coverage distance. Simply put this means that if a facility is within the specified coverage distance from a person, it is considered accessible to the person and the person is said to be covered. Those people beyond this distance are not covered. The measure of accessibility in this context is the proportion of people covered. As a locational goal, this approach translates into the maximal covering locational problem (MCLP).

Improving accessibility, by reducing travel distance to healthcare facilities by its users has been found to be very fundamental to the goal of the government's PHC strategy. The goal can also be viewed in coverage terms, i.e., improving the proportion of people who are within a specified distance of a health care facility. The present policy specifies a distance of 8-km as that which at least a B-level facility must be within reach of every community. Location-allocation models effectively address the problems of identifying specific areas or communities that surround or are served by the particular centre or facility and the optimum locations for new centres or facilities given a set of objectives related to accessibility.

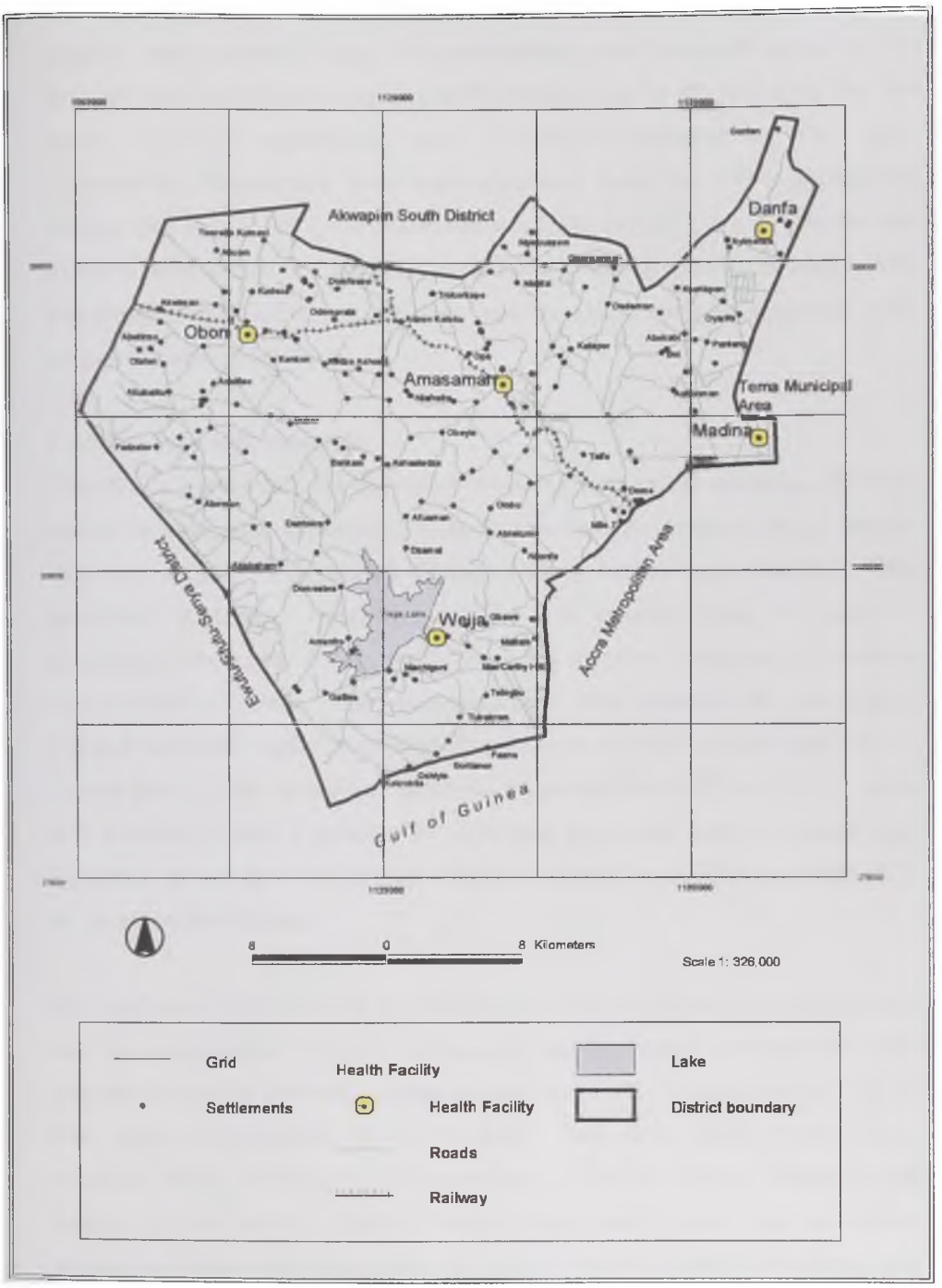
6.4 **Network analysis and location-allocation modelling**

Any system of interconnected linear features: sets of roads, railways, rivers, pipelines, telephone and electric lines, is a network (ESRI, 1996). A simple way of evaluating accessibility is by straight-line distance such as we obtain when generating buffers. For example, we can find out how many clients live within 8-km radius of a site using a simple circle. However, considering the fact that people travel by road most of which are not straight lines but include curves, this method will not reflect the actual accessibility to the site. Some researchers and students of LAMs have often used Euclidean distances instead of using the actual shape and geometry of the road network to reflect

actual accessibility. Oppong & Hodgson (1994) for example, in their work in the Suhum district did an analysis involving 150 population centres or communities as demand points for 30 healthcare facilities. They employed Euclidean distances because according to them, walking is the main mode of travel in Suhum district. The fact is that no matter the mode of transportation (except by air) travels are done along winding paths or roads. These are not found to be straight lines. Service networks computed by a Network Analyst, for example, can overcome this limitation by identifying the accessible roads within 8-km of the site via the road network.

The thesis employed the Network Analyst functionality in ArcView. It is a network analysis extension product developed by the Environmental Systems Research Institute (ESRI, 1996). Like all network analysis tools, it is based on digital vector maps and databases. This requires that the area surrounding a centre be represented as a network of linear features. With the Network Analyst the area surrounding a centre or the specified location on a network is the service area. The Network Analyst determines the extent of the area and displays it in a view. To do this, you need to specify a site location and travel time or distance (ESRI, 1996). Once the service area is established, the ArcView theme on theme selection capabilities can be used to evaluate accessibility of the site. It does this first by connecting points of equal travel time (referred to as isochrones if the objective is time) or equal distances (equi-distances if the objective is distance) from the reference point or centre. It also facilitates the computation of the total population that is covered and that not covered. Once several sites and travel times or distances are specified, the Network Analyst generates service areas for all the sites. By so doing it is possible to select optimum locations for new centres or sites subjectively or by a set of objectives related to accessibility, e.g. the geographical location, population, infrastructure base, etc.

Figure 6.2: Selected sites for service areas and network analysis



6.5 **Data requirements and approach to network analysis**

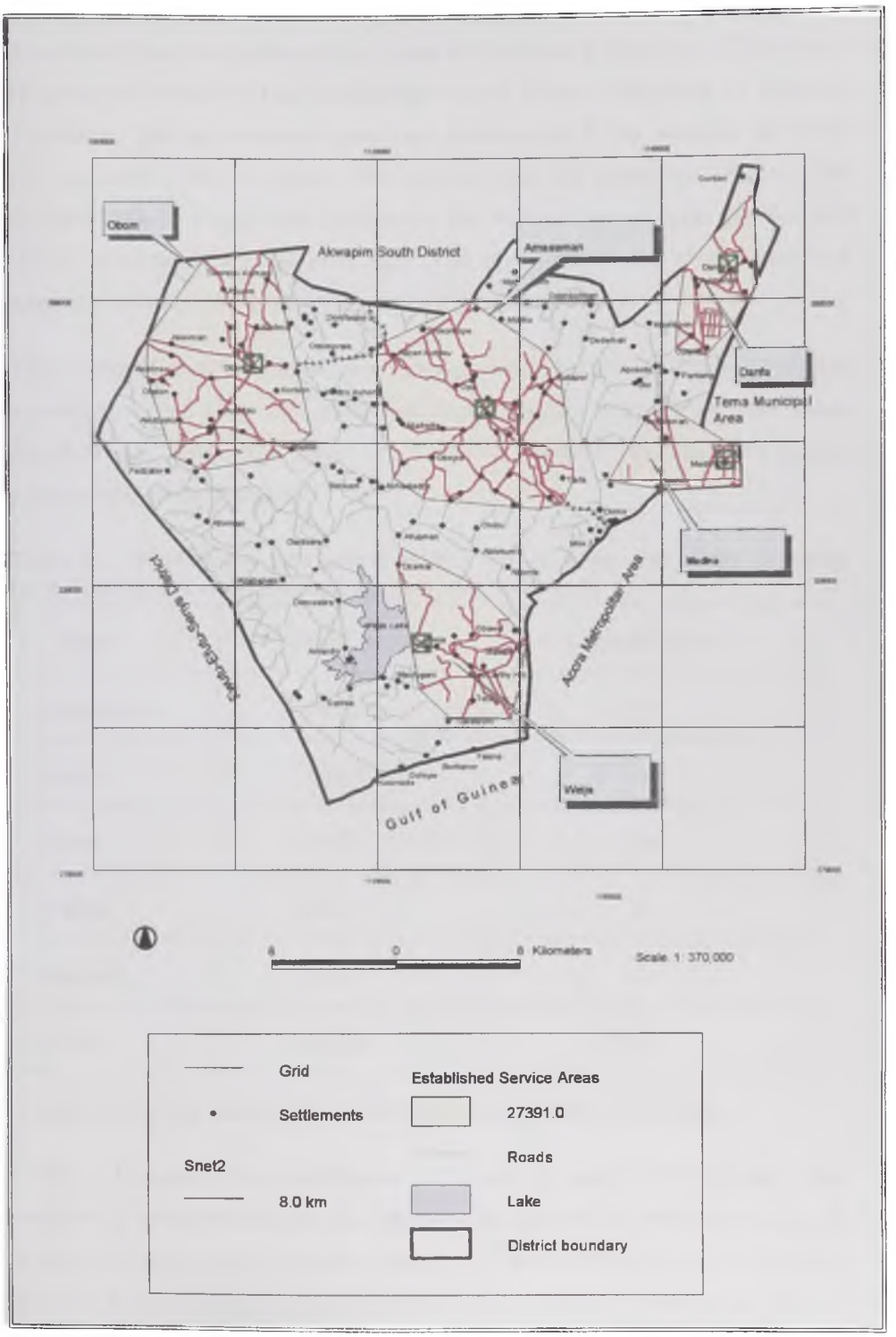
The current analysis is carried out using digital maps procured from Survey Department and the CERSGIS, Legon. These provided the digital road network base. Supplementary road network data on the district was captured using the GPS. Other sets of digital data for the study include population and locational information for each community. Population data were obtained from the 1984 population census and projected for 1996 based on 6.2% annual growth rate for the district were made and included as a field in the attribute database. The population data of some smaller communities were aggregated with larger centres close by.

6.6 **The network analysis**

The thesis employed the maximal covering locational problem (MCLP) which is basically concerned with improving the proportion of people who are within a specified distance of a health care facility. This specified distance, otherwise called the service area is used to determine coverage. It is usually built by forming a region that covers the accessible roads. The assumption is that patients do not travel beyond conventionally approved distances to receive health care. As is shown later in the analysis, substantial proportions of the district were left uncovered and a process of selecting proposed sites to locate new facilities given specific spatial objectives was done. This is referred to as location modelling.

The analysis involved 550 communities in the district as demand points and the population in each community as the proxy for demand. The population range between communities with two persons (as in Alhaji Farl farms) and 59564 (as in Madina). The sites selected were five existing MOH facilities at Amasaman, Weija, Obom, Madina and Danfa. A view with a line or linear theme was chosen and activated. Figure 6.2 shows the view with the selected sites of MOH facilities and the accessible roads network.

Figure 6.3: General areas around established healthcare facilities



In building the service areas, a travel distance from the facilities or sites to the surrounding areas was set. An alternative is to set the travel direction from the surrounding areas to the health facilities. Either way is adequate since in the Ga district travel is not restricted to any one direction. The government specified distance of 8-km was set to create two themes service areas (Sarea) and service networks (Snet). The service area is a tool that facilitates the evaluation of accessibility and this is used to determine coverage. The service network shows the road network selected by prompting specified distances.

The network analyst generated general areas or approximate polygons around the five sites or health facilities (Figure 6.3). Given the 8-km distance set from the sites the network analyst reveals a coverage pattern shown in Table 6.5.

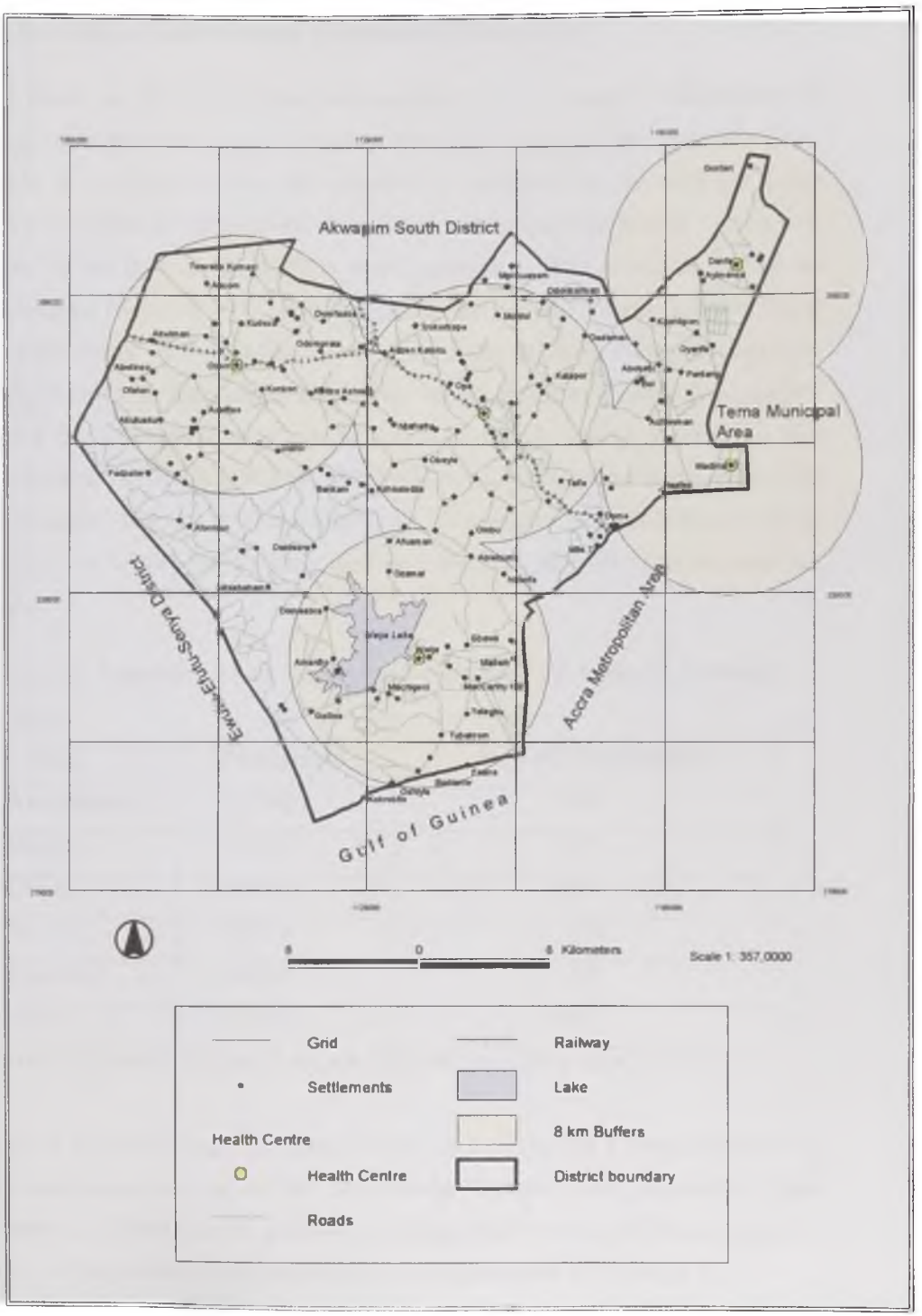
Table 6.5. Population and communities within 8-km travelling distance from healthcare facilities along main road network

Site	Population	Communities
Amasaman	40123	113
Danfa	9968	38
Obom	27421	119
Weija	24934	14
Madina	62088	12
Total	164534	296

Source. Network analysis and settlements attribute data table.

Table 6.5 shows that healthcare coverage is only 54% of the total number of communities in the district (296 out of 550 communities). In terms of population, present coverage is 64% (164534 out of 258173 for the district). The population thus not covered constitutes 34% of the district. This means that a way has to be found to ensure that health

Figure 6.4: Eight-Kilometres buffers around healthcare facilities



care services reach all. This can be done through the selection of optimum locations for new sites.

6.7 **Euclidean buffer zones (Alternative Scenario)**

The above is the result when accessibility or coverage is considered in terms of accessible road network. The next stage of the analysis is to create a scenario where the network is assumed to be straight lines (crow's flight) or Euclidean distances connecting the health centres or sites. To do this, 8-km buffers were generated. The result is shown on the map in Figure 6.4. It must be noted that around points, buffers form circular areas. It means therefore that if the method of travel were by straight lines or Euclidean distances, larger areas or population centres would be covered or would be considered as having access to the healthcare facilities. Wider area coverage or service area does not necessarily imply real accessibility especially in situations where methods of travel are by long distance walking and difficult to traverse roads.

Table 6.6. Population and communities covered by 8-km (Euclidean) buffers

Site	Population	No. of Communities
Amasaman	47500	140
Danfa	13831	49
Obom	46481	199
Weija	45619	43
Madina	66464	29
Total	219895	460

Source: Network analysis and settlements attribute data table.

Table 6.6 shows that the five health centres cover a total number of 460 communities out of the 550 in the district. The population thus covered is 219895 or 85 percent. A comparative analysis of coverage in terms of population and communities is presented in Table 6.7.

Table 6.7. Population and communities covered by network and buffer analysis

Type of analysis	Population covered	Communities covered
Network	164534 (64%)	296 (54%)
Buffer	219895 (85%)	460 (83%)
Difference	55361 (21%)	164 (29%)

The table shows that when the network analysis was used 64% of the district population was covered. On the other hand a coverage rate of 85% was attained when straight-line buffers were generated. In this way an additional population of 55361 and 164 communities were covered. The impression is that of a high coverage and as is shown this does not give a true picture of coverage since travels are not necessarily done by straight-line movements in the Ga district.

A statistical approach to determining whether significant differences exists between the two methods of analysis of healthcare coverage the network and the buffer, in terms of population and communities covered as shown in Table 6.7 was made using the chi-square. For the population, the calculated chi-square (χ^2) value was 0.000518042. At 1% level of significance the difference between the proportion of population covered by network and buffer was not statistically significant. However at 5 percent level of significance the difference between the proportion of population between the network and buffer was significant. What this means is that the network coverage by virtue of the linear features or reachable distance it employs has smaller coverage as compared to the euclidean buffer coverage. In terms of communities coverage the calculated chi-square (χ^2) was 1.01239E-05. The results were both found to be non-significant at both 5 and 1% levels.

It is for this reason that one sees the network analysis functionality, which takes into account linear features as very vital for estimating the

coverage of facilities even though it may have its shortcomings. It generates service areas either from sites or to sites. Different scenarios can be created using different distances.

The two types of analysis outlined above, namely estimating health services coverage employing existing systems of road network and estimating the coverage using straight line (Euclidean distance) travels or buffers all show that the specified distance of 8-km does not provide total coverage in the district. Portions of the district remain to be covered by the existing system of health facilities. The next stage of the analysis discusses the optimum sites for new facilities or at least outreach points rendering healthcare services to achieve the objective of total coverage.

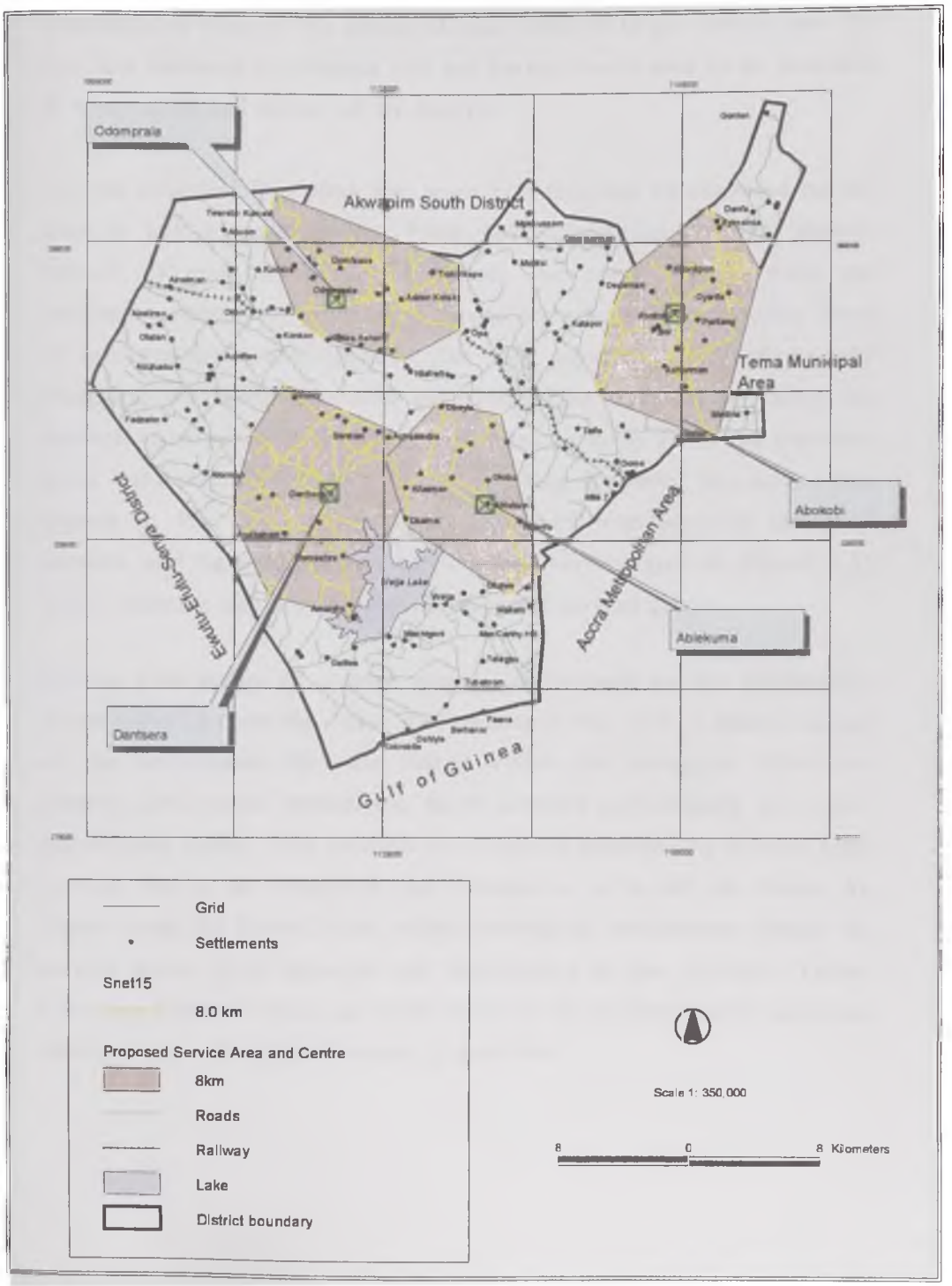
6.8 **Optimum locations for new health care facilities**

To improve overall accessibility to health services in the district requires providing additional facilities to the existing stock and increasing the specified distance to the facilities. The latter alternative may not be popular since it goes to increase the travelling distance instead of minimising the total travel distance or time, a fact that defeats the PHC strategy. The first alternative will be favoured since it maintains the specified travelling distance and is a way of improving the proportion of people without access. Even though some have criticised this strategy, calling it the add more strategy because of the relative cost of relocation (Oppong & Hodgson, 1994), it is argued that in a district with already few facilities and largely threatened by endemic diseases, a strategy that improves the proportion of people without current access is necessary. It is also argued that different levels of facilities may be required to answer to specific needs in specific areas.

6.9 **Selecting sites to locate additional facilities**

As shown in the Network Analysis, a 64% coverage rate was achieved at the specified 8-km distance. The ideal situation is for the remaining

Figure 6.5: Proposed sites for additional healthcare facilities



46% of the district population to be provided with facilities to enable the district achieve total coverage. However 100% coverage is not attainable in view of the nature of road network in the district and the fact that resource constraints will not permit health care to be provided at every nook and corner of the district.

For the analysis, four sites that were proposed can be observed on the map as not covered by the 8-km coverage distance. Even though several of such sites can be found, the basic criteria used are proximity, centrality, population around the site, and the existing level of infrastructural development. The four locations selected, namely Dantsera, Abokobi, Ablekuma and Odumprala were set by using the Network Analyst Add Location tool. Service areas from the Network menu were established using 8-km travelling distance. This added two themes to the Table of Contents – Snet15 that contains the road network and Sarea15 (shown as proposed service area in Figure 6.5) which contains the polygon representing the service areas.

Service area polygons created were superimposed on the settlements theme selected from the Table of Contents in the view to enable us see all the settlements that are found within the polygons. With the identify tool these settlements were selected individually and their populations noted. This process is to enable populations around each service area to be computed. An alternative is to use the *Select By* Theme from the Theme menu which enables all settlements within the service areas to be selected and highlighted in the Attribute Table. Choosing *Statistics* from the Field menu in the attribute table statistics about all the selected settlements is provided.

Figure 6.6: Service areas for existing and proposed healthcare facilities

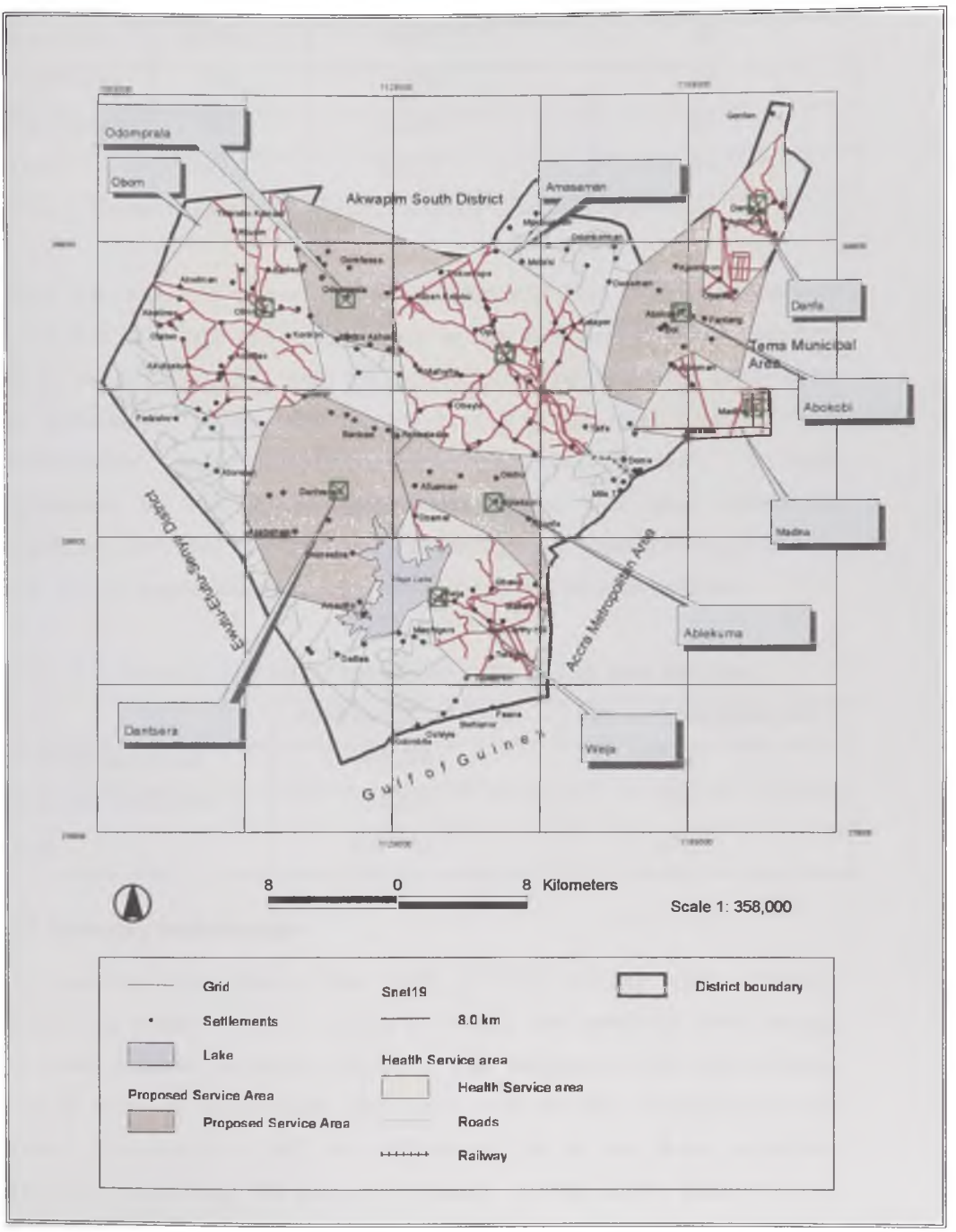


Table 6.8: Population and communities covered by proposed sites

Site	Population	Service area covered	No. of communities
Dantsera	628	7700	35
Abokobi	1028	14311	62
Ablekuma	365	6954	16
Odumprala	580	23286	81
Total	2601	52251	194

Source. Network analysis and settlements attribute data table.

Table 6.8 indicates that a total population of 52251 in the new service areas was covered. Also significant is the fact that 194 communities were covered. Together with the population of service areas covered by the Amasaman, Danfa, Madina, Obom and Weija sites (Table 6.5), a considerable improvement in coverage was observed. A total population of 216785 and 490 communities will have access to healthcare services (Table 6.9). This brings the total coverage rate to 84% for the population and 89% for the number of communities.

Table 6.9: Improved level of accessibility to health care services

	Population covered	No. of communities
Original facilities	164534	296
Proposed facilities	52251	194
Total	216785	490

6.10 **Achieving total coverage**

The analysis has shown that 16% (41178) of the entire district population remain without access to health care services even though the total number of health facilities was increased from the existing five to nine. It also shows that only 11% of the communities will remain uncovered or will be without access at the 8-km specified distance. Achieving 100 percent coverage for the entire district is the ideal but under the present circumstances this has not been feasible. Principally, this is explained by the geographical shape of the district

and the nature of road network. Also evident is the fact that population centres are unevenly distributed in the district. It is therefore necessary that as a matter of policy, emphasis be laid on the promotion of outreach points for the delivery of health care services.

The concept of outreach centres is not new to the district. They have been used by the DHMT for the promotion of primary health care. For example, there are 197 outreach points for immunisation (MOH/Ghana Health Service, 1998) in the district. In addition to these there are five NGO clinics. Some of the proposed centres for additional health facilities mentioned earlier are already outreach points of the main B-level facilities in the district. For example there already exists a facility at Abokobi under the supervision of Danfa. Ablekuma, which falls within the Amasaman subdistrict, could rightly serve as an outreach point for Amasaman while the proposed site of Odumprala could serve as the outreach point for the Obom Health Centre.

The proposed site of Dantsera was selected for geographical and its relatively higher population reasons. It is located not less than 12 km away from the nearest health care facilities. This distance far exceeds the specified 8-km. Although there is an NGO clinic at Ngleshi Amanfro, about 8-km south and near the shores of the Weija Lake, it is considered too far away for the population that could be served by the Dantsera facility. Dantsera has a population of 971 within its immediate environs and would serve at large, a population of 7700. This justifies its selection for the location of at least an A-level facility.

6.11 **Strategy of relocating health care points**

Trying to ascertain coverage of existing health care facilities based on existing structure of road network and coverage from Euclidean distances are just two of the several ways of ascertaining coverage using the network analyst. An alternative strategy could be to attempt modelling the coverage from different point locations on the map and

recalculating the coverage. This is so if we want to arrive at the optimum locations that will maximize coverage. It is noted however that in arriving at the location that will provide maximum coverage, sets of objectives related to accessibility such as geographical location, population, present infrastructure base, etc. need to be considered. When this has been done several scenarios could be tried out before the actual relocation is done. This method of scenario creation is more 'human guided' and allows for the planner a more careful choice of centres or locations.

6.12. **Alternative algorithms**

A number of algorithms exist that enable the choice of one or more new sites from a number of possible (candidate) sites in such a way that the maximum impact in terms of coverage or accessibility is reached. An example is the *p*-median problem, which selects facility locations to minimize average travel distance (Tietz & Bart, 1968). This can be executed in ArcInfo using the location functionality. It is argued however that the more 'human guided' process of trying out scenarios in ArcView using the network analyst functionality will work just as well or better, for in many cases other factors other than travelling distances can be taken into account by the planner.

6.13 **Conclusion**

An evaluation of proximity to health facilities in the Ga district using the maximal coverage approach involving the Network Analyst functionality shows that accessibility could be ascertained when the physical distances or linear features between the facility and its service area are used. The analysis showed that from both predetermined and proposed centres, specific areas or communities that surround or are served by the particular centre could be identified.

The results show that increasing the number of facilities from five to nine increased accessibility or coverage from 64 to 84 percent in the district. The selection of new centres or potential sites for new

facilities in order to improve coverage was determined by the service areas created when the specified 8-km distances were generated. This showed populations that did not have access and out of the communities, centres were selected given a set of objectives related to accessibility.

The analysis has proved location-allocation models using the Network Analyst functionality useful tools for evaluating accessibility to health care facilities in the Ga district. Given the present situation where NGOs and other private healthcare facilities have been haphazardly sited without due consideration to accessibility, these tools could be useful for plans for health facility locations and in general for strategic decision-making. It also emphasises the need for multisectoral approach to the solution of problems and takes cognisance of the integrative nature of sets of data to achieve the goals of spatial planning. The methods and tools used however are mere means to an end. They are not to provide the final prescription or answer to problems of accessibility to healthcare facilities instead they are mere tools to provide additional information to the planner. It has been said that several considerations come into play when taking planning decisions. Some of these may be political, physical conditions, population, social and economic considerations. Thus these will sometimes override models of accessibility to healthcare facilities.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

The aim of this study has been to ascertain the practical application of GIS for supporting district level planning and decision-making. The decision to devolve the planning process from overburdened central government is borne out of the fact that grassroots participation in governance, decision-making and planning will make the process of development more self-sustaining. It was not only seen as the basic unit of government but it is also suggested to be the best area and manageable unit in terms of data acquisition and processing for local level type of planning. To this end structures that will facilitate governance, planning and decision-making at the local level were established. Unfortunately the framework for planning failed to emphasize the types of tools to be employed to enhance the planning and decision-making process. Even though the framework indicated holistic plan development through interdepartmental or sectoral collaboration, it failed to prescribe or suggest the types of techniques or tools to be applied for the integration of the sets of information held within the departments or functional agencies. This thesis opines that a way to integrate data is a first step to any meaningful holistic plan development and decision-making process.

The district as a geographical entity comprises of such components as the population, settlements, functional agencies, socio-economic activities, etc., all of which generate, acquire or process data. A tool that will integrate the diverse sets of data pertaining to these sectoral activities will certainly be required to support planning. This tool has been found to be GIS. As Saraf and Choudhury (1998) put it "GIS technique facilitates integrated and conjunctive analysis of large volumes of multidisciplinary (multisectoral) data, both spatial and nonspatial within the same georeferencing scheme". The study has been an attempt to extend the capability of GIS as a tool for health and sanitation sector analysis through the integration of data on endemic diseases and environmental factors, which account for their causes. Another important aspect of the health sector that warranted GIS analysis was geographical accessibility to the existing health care facilities. In a similar vein layered data concept was employed with network analysis functionality to ascertain the health care services coverage in the Ga District. The advantages offered by GIS technology as the study

showed in each of two areas of application mentioned are twofold. These are the simulation and modeling opportunities offered in the form of maps and the access to permanent attribute databases that have been established and which could be readily-updated whenever necessary for new sets of information. This is useful for planning since as Selman (1991) put it, it offers the key advantage of exploring 'what if' type questions. Thus in the analysis of diseases in Chapter Five of the thesis models and assumptions made through the creation of scenarios involving environmental factors provided useful hints for decision-making and planning in the health sector.

The study has demonstrated that as a major step to holistic planning at the district level, sets of data held by the various departments need to be integrated. A survey of data types acquired, processed and used by 15 departments in the district showed that substantial proportions are spatial in character, which therefore lend them to GIS application. With the framework for plan integration already established it was possible to develop another framework for data integration. Thus the co-ordinating role of the District Planning Co-ordinating Unit (DPCU) was seen as useful for the attainment of this objective. The district as a spatial entity will thus have one database to which all departments have contributed. This will lead to homogeneity of information types, avoidance of duplication of efforts and the dissipation of scarce resources. Interoperability will thus be facilitated when uniformity among database formats, the spatial conceptions and quality standards are established in such distributed system.

The study showed that data integration for GIS interoperability could be achieved at the district level. Steps towards achieving this were outlined based on a questionnaire administered among the district departments. These steps include the identification of the departments which generate spatial data, operational activities or mandates that lead to the generation of the data types, their specification and scales, levels of inter-departmental collaboration that could lead to data harmonization and common data sources that could be assessed. The scheme developed showed all the 15 departments, their functions, the types of data acquired and processed and other sources of data (collaborating departments) required to accomplish their objectives and plans. It was the belief of this study that achieving a distributed database will be a first step to GIS interoperability among the district departments.

In view of the possibility of achieving data integration at the district level, the study also found it necessary to show the approach required to accomplish the type of multidatabase designed and which will allow for interoperability. Here the top-down approach proposed by Laurini (1998) was adopted. In the approach, a global schema encompassing all data aspects of the entire system was the type required to start with. The study indicated that the global schema in the district context conforms to the present framework in which the District Planning Co-ordinating Unit (DPCU) has been in charge of co-ordinating the district plans and therefore forms the fulcrum for data integration. The functional agencies or the decentralized departments constitute the local sites or local schemata. It has been shown that the district comprises of electoral areas that constitute the basic units for data inventory. With this basic structure homogeneity in data structure, spatial scales, etc., could be achieved.

In proposing a prototype GIS for the district, the study was concerned about the basic elements that could be considered. After considering the basic requirements for database integration and the possibility of interoperability, it becomes necessary to think of the elements for the prototype GIS that could be implemented at the district level. The study identified fifteen decentralized and semi decentralized departments in the district as spatial data sources. Such data sets will include data on physical environment and socio-economic and cultural data. Remote sensing, either by satellite imagery, air photos and other recording instruments (radiometers, GPSs, etc.,) and ground base survey methods including interviews and questionnaire are required as the main techniques for obtaining the spatial data sets. These data sets will constitute the geographic databases consisting of both spatial and attribute elements. This is usually the hob of the GIS.

The other elements of the prototype are the traditional software modules needed to execute the tasks in the GIS. What the study failed to emphasize however is the set of institutional arrangements and human or personnel elements required for running a GIS. In providing an operational definition of a GIS some authors have included what they call the orgware (ESRI, 1996) and the liveware (Robinson *et al.* 1995). The organizational (institutional) and human elements (expertise) have been found to be crucial for running a GIS. As Ozemoy, Smith and Sicherman (1981) put it GIS is 'an automated set of functions that provides professionals with advanced capabilities for

the storage, retrieval, manipulation and display of geographically located data'. Carter (1989) saw it as 'an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time'. Simply put an environment is required to place GIS and this is offered by the institutional set up and the expertise to be involved.

The study of diseases and their geographical aspects using the overlay and point in polygon techniques of analysis was discussed in the study. It was an attempt at extending the data integration concept to the health sector and to see how data from various sectors can be overlaid for new results. It showed the relationship between health and environmental factors in the district and cases of diseases within specified endemic zones. The distribution of ten most common diseases in the district and the environmental factors that account for their endemicity were discussed. The aim was to indicate areas shown on the maps, which will require both educational intervention and planning of health care delivery systems.

Malaria was the most endemic in the entire district accounting for about 53 percent of all diseases reported during the period specified. It was commonest in all the five sub-districts but most concentrated in the Weija zone. The study did not find any relationship between malaria incidence and any of the environmental factors, mainly household water supply sources, solid waste disposal forms and sanitation and hygiene types. It showed instead that the general unsanitary conditions especially associated with the Accra Metropolitan Area and regions that border it account for malaria spread. It was also concluded that the high cases of malaria in the Weija, MacCarthy Hill and Mallam communities could be the result of small scale irrigation activities usually associated with water impoundment projects. It is the view of this study that any programme aimed at malaria control should emphasize environmental sanitation and control of vector habitats.

Diarrhoea was found to be the third commonest disease reported in the district. The largest cases were from the Amasaman sub-district. All three environmental factors sanitation, household water supply sources and solid waste disposal types were found to be the most likely causes of diarrhoea in the district. Spread by contaminated foods and drinks, the disease could be found to be associated with bad sanitation like the

open defecation found in Amasaman, Pokuase and Kotoku. The prevalence of disease vectors such as houseflies around such unsanitary sites in those communities as well as the presence of pests like cockroaches and rodents is enough to cause the spread of diarrhoea. Open dumping of solid waste could also account for the spread of the disease since the dumpsites serve as habitat for pests including houseflies. This is exemplified by the high cases of diarrhoea in Mallam where a sanitary landfill is sited.

An important factor for the spread of diarrhoea is household water supply sources. The majority of the communities in the district rely on rivers or streams as sources of household water supply. Faecal contamination of rivers and piped water or generally water supplied from outside the immediate household are sources of diarrhoea.

Chicken pox has been described as a viral infection and the study shows that it was more endemic in Weija than anywhere else in the district. Since the disease is known to spread more by direct contact with infested persons or through contact with articles soiled with discharges from the vesicles and mucous secretions, environmental factors were not found to account for its cause and spread. The study concluded that, by way of policy the control of chicken pox should emphasize education and immunization programmes.

Eye infection diseases are caused by factors including bacteria in the tear duct or the membranes that line the eyelids or by polluted atmosphere. It is also attributed to diseases associated with poor hygiene and overcrowded areas. In the light of these causal factors Amasaman and Madina areas, both identified as having poor sanitation systems have undoubtedly the highest cases of eye infections.

Ear infection was found to rank ninth among the diseases reported in the district. Even though it is not a common disease it must be stated that any policy to control it must emphasis education.

Smoky and dusty environments was emphasised as the main cause of upper respiratory tract infection and it is considered among the top killers of children in developing countries. The top cases of the disease were found in the Madina and

Amasaman zones where sand winning activities, dust from unpaved roads, and uncontrolled use of household fuels is common. None of the traditional environmental factors that the study has employed was found to be associated with upper respiratory tract infection. Many of the communities are poor and the burning of garbage openly is a common sight. They are often overcrowded and characterised by smoky indoor air usually from burning fuels for cooking or heating.

Skin infection was found in the study to be among the top four diseases in the district. The study did not show any association with any of the environmental factors used. A review of the seasons of the year associated with adequacy or inadequacy of household water supply also did not show any trends towards high incidence of skin infections. The study proposed a study that would involve data covering a longer period to be able to ascertain the relationship between skin infections and water availability and its non-availability.

A study of the incidence of measles in the district showed Amasaman, Madina and Weija zones as the most endemic. It was concluded in the study that judging from the mode of transmission of measles, none of the environmental factors discussed so far account for the incidence of the disease. Direct contact with infested persons, poor environmental sanitation, indiscriminate spitting and emission of nasal and throat secretions are more likely to be the cause of measles in the district. Good environmental and personal hygiene could therefore be emphasised in any policy to mitigate measles.

Intestinal worms infection is among the top five diseases in the district and it is associated with poor environmental sanitation especially where the soils are polluted with faeces contaminated with eggs from adult worms. Foods and drinks exposed in very poor sanitary environments are likely source of contamination with eggs. This is the case for Amasaman zone, where the highest number of cases occurred and is characterised by the use of pit latrines and open defecation systems. It was also indicated in the study that the methods of solid waste disposal especially the backyard dumping form is also a source of worm infection.

Communities that rely on rivers or streams for household water supply were also liable to worm infection. For example, it was found that substantial parts of Amasaman, Danfa and the whole of Dedeman zones mostly rely on rivers and stream water and these are among communities with the highest recorded cases of worm infection in the district.

Although not ranked among the most endemic diseases in the district buruli ulcer (*Mycobacterium ulcerans*) was given special attention due to its increasing importance as a social scourge. No where else in the district was the disease found than in the Amasaman and Obom sub-districts with Amasaman alone reporting 94 percent cases. Inconclusive studies of the causes of the disease have been done. These have pointed to the association of the bacteria with some vegetation types, sewage effluence, and riverine environments.

Analysis carried out to establish the correlation of buruli ulcer with environmental factors showed few evidences and would therefore require further investigation. For example, a preponderance of the disease was found in areas with pit latrines and open defecation systems. This was shown in Amasaman, Ayawaso and Kotoku where contamination of food and water sources were likely to occur more often. Solid waste disposal by open dumping method in these areas could also be a good source of pollution whenever rain water flowing over such garbage dumps empty their loads into nearby water bodies.

The association of the disease with riparian environments was also established. This showed the disease to be endemic along the major rivers and streams like Nsaki, Ntafrafra and Dobro. Further studies would be required to make conclusive the association of buruli ulcer with the environmental factors discussed.

The issue of geographical accessibility to existing health care facilities in the district was considered as an important factor in the business of planning and policy decision-making for the health sector. The analysis showed how location-allocation models can be used to achieve health care coverage given specified distances at which services should be within reach of a given population or group of communities. The analysis also showed the advantages inherent in the overlay concept where different sets of

data themes namely road network, population centres and site locations are integrated to achieve the goals of health care coverage. It also showed the multisectoral approach to planning within the framework of systems thinking.

The study showed the inadequacy of the existing five MOH facilities in the district to provide total coverage when the network analysis functionality, which uses accessible road network is employed. On the other hand coverage was increased when Euclidean distance or straight-line buffers which does not base coverage on accessible road network were used. The coverage rate achieved by both methods did not however bring about total coverage for the entire district, which meant that additional sites were proposed for new health facilities. The choice of these additional sites was based on several factors. Notably these included the relative locations based on the service areas created by the existing system of health facilities, proximity, centrality, population around the site and the existing level of infrastructural development. The study showed that in spite of the additional sites proposed, 100 percent coverage was not attainable. It was indicated that this was the result of the nature of the road network and the geographical shape of the district.

The study took note of the existence of several other algorithms which are available to enable the choice of one or more new sites from a number of possible (candidate) sites in such ways that the maximum impact in terms of coverage or accessibility is reached. It was argued that the more 'human guided' process of trying different scenarios using the network analyst in ArcView appeared to work just well or better since in many cases the final decision for the choice of any new sites by the planner depends on several other factors apart from travelling distances.

Policy implications and suggestions for future research

The study has demonstrated that to start with any national plans the district level, understandably is the ideal and most manageable unit for data acquisition and processing. The use of local areas for planning and programming has been given much credence. Rondinelli *et al.*, (1989), for example, have stated the advantages inherent in localism. This include the fact that it leads to the improvement in the understanding of local perceptions and needs, reduction in resistance to change, encourages community participation and allows for easier crossing of professional

boundaries. The decentralization policy is therefore in the right direction when one views the fact that for holistic plan development the decentralized departments are already acquiring and processing data. What is left to be done is how to integrate such data sets based on representation mode, scales, standards, updates and data quality levels to allow for interoperability. The present study was based on one district out of the 110 in the whole country. Future studies may require that more districts are studied in terms of their departmental data acquisition and processing operations for plan development. This will set the pace for a national consensus and capacity building for spatial data acquisition, processing standards setting, quality levels, etc. By way of policy it will be important for the district assemblies to be equipped with the basic facilities for prototype GISs that will enhance the execution of their holistic plans and for more informed decision-making.

Questions have often been raised about the level at which GIS should be implemented. It is here argued that the district level will be most ideal since the data requirement will not be overly sophisticated and therefore wieldy. Data sets acquired and aggregated at the regional or national levels have the tendency of loosing their values due to problems associated with data transformation (Tobler, 1979). Such data will not be suitable for district level planning as is the case. The districts are required to produce their own plans and it will be misplaced if data sets required for the plans are rather obtained from the regional or national level. A GIS set up is without doubt an expensive undertaking. What is therefore recommended for a district is a PC with the relevant GIS software for data storage, analysis, manipulation, display and output. The districts would then be required to acquire the relevant digital base data sets (base maps) from institutions, departments or agencies that have GIS facilities. In this way costs would be minimised. At the national level institutions such as the MLGRD and the NDPC could implement GISs based on the disparate data sets provided from the districts and the regions. A national framework such as the National Framework for Geospatial Information Management (NAFGIM) is a first step towards the production and exchange of compatible geographically referenced datasets within the information in Ghana.

Programmes of disease control and monitoring in the districts should emphasise knowledge of the spatial incidence of the diseases and the environmental factors with

which they are associated. Here GIS has been demonstrated to play a very useful role as it will facilitate the implementation of the right type of policies on environmental education, control of vector habitats and immunisation exercises. The Ministry of Health and in particular the DHMTs will find GIS as a useful tool in this direction.

Further and more extensive research will be required to study the factors of spread of some of the more dangerous disease like buruli ulcer that this study could not accomplish. For example the association of the disease with some vegetation types.

It is also recommended for the inclusion of household and other socio-economic or geodemographic data (Beaumont, 1989) for the investigation of the causes of disease even though the representation of such category of data in GIS environments is still under development (Martin, 1991) and proposal for types of expert systems required have been made (Rod, 1997). The reason for the non-use of this category of data was explained in Chapter two of the thesis.

The use of GIS as a tool for database development including its integration for district level planning and decision-making and its application for health sector management has been demonstrated in this thesis. It is recommended as an instrument that can be used to device quick, reliable and scientifically valid methods of rapid assessment and utilization for planning, monitoring and evaluation of programmes at the district level.

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APPENDIX I

COMPOSITION OF DISTRICT DEPARTMENTS

Department	Constituents
1. Education, Youth & Sports	1. Education 2. Youth 3. Sports 4. Ghana Library Board
2. Social Welfare & Community Development	1. Social Welfare 2. Community Development
3. Works	1. Public Work Department 2. Department of Feeder Roads 3. Rural Housing
4. Physical Planning	1. Department of Town Planning 2. Department of Parks & Gardens
5. Finance	1. Controller & Accountant General
6. Natural Resource Conservation	1. Forestry 2. Games & Wildlife
7. Central Administration	1. General Administration 2. District Planning Co-ordinating Unit 3. Births & Deaths Registry 4. Information Service Department 5. Statistical Services
8. Trade & Industry	1. Trade 2. Cottage Industry 3. Co-operatives
9. Disaster Prevention	1. Fire Service Department
10.Health	1. Office of District Medical Officer of Health 2. Environment Division of MLG
11. Department of Agriculture	1. Department of Animal Health & Production. 2. Department of Fisheries 3. Department of Agricultural Extension Services 4. Department of Crops Services 5. Department of Agricultural Engineering

Source: Ministry of Local Government and Rural Development

APPENDIX II

QUESTIONNAIRE ON DATA INTEGRATION TO ENHANCE DISTRICT LEVEL DEVELOPMENT PLANNING AND POLICY DECISION-MAKING.

This questionnaire is directed towards District Assembly Departments. It is aimed at ascertaining the spatial data/information requirement for planning and policy decision-making at both departmental and district level. The study will lead to the design of a scheme for spatial data integration and elements for prototype Geographical Information System (GIS) for the District Assemblies.

1. District : GA DISTRICT

2. Name of District Department/Unit.....

3. Year established.....

4. Is this department/unit completely decentralised? Yes / No

5. List the basic functions of the department/unit.

   (i) .....
   (ii) .....
   (iii) .....
   (iv) .....
   (v) .....
   (vi) .....
   (vii) .....

6. What is the structure of the department/unit? (show by an Organisational Chart if any).

7. List the departments/units in the District Assembly that your department relates to by way of data/information sharing?

   (i) .....
   (ii) .....
   (iii) .....
   (iv) .....
   (v) .....
   (vi) .....
   (vii) Others .....

8. List the main data/information categories used in the department/unit.

(i).....(ii).....
(iii).....(iv).....

(v).....(vi).....
(vii).....(viii).....
(ix).....Others .....
.....

9. Which are the other sources of data/information outside the district?

10. Does the department/unit employ the use of computers? Yes / No

11. If yes, what aspect of the department's operations involves the use of computers?

12. In the absence of computers, what system of data/information capture or acquisition, storage, manipulation and analysis is employed in the department?

13. Are you aware of GIS (Geographical Information Systems) technology? Yes / No.

14. If Yes, does the department/unit plan using it and how soon?

15. In what ways do you think the exchange of data/information with other departments/units within the District Assembly is/will be beneficial to the work of the department?

16. What is the nature of the data that the department/unit contribute towards the district plan (e.g., maps, plans, annual reports, charts, tables, etc.)?

17. From which department(s)/office(s) do you receive directives on the framework for plans, annual reports, etc., produced by the department?

18. List the data requirements for such directives?

.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

19. What problems do you encounter by way of data acquisition for planning and other uses?

20. How do you solve the problems?

21. In what ways do you think that an automated (computerised) data system for the district will be beneficial to the work of the department?

22. Do you favour a system where the entire district administration is computer networked to enhance information flow and data exchange among the various departments? If yes, can you give reasons?

APPENDIX III

GEOGRAPHICAL ACCESSIBILITY TO HEALTHCARE FACILITIES IN THE GA DISTRICT

(INFORMATION TO BE PROVIDED BY PATIENTS)

1. Name of Health Sub-district .....

2. Sex: Male ☐ Female ☐ Age .....

3. Name of settlement (place of origin/home) .....

4. Means of transport to the Health Centre:

(a) Trotro/ Bus ☐ (b) Taxi ☐ (c) Walking ☐

(d) Bicycle ☐ (e) Others .....

5. Distance traveled to the health centre (km/miles) .....

6. Cost of transportation to and from the Health Centre ¢ .....

7. Surface-type of road travelled:

(a) Gravel ☐ (b) Bituminous ☐ (c) Asphalt ☐ (d) Earth ☐

(e) Foot path ☐ (f) Others .....

8. How often do you report at the healthcentre in a year?

Once ☐ Two times ☐ Three times ☐ Four times ☐ Others ☐

9. Where else do you receive medical attention?.....

10. How far is that (Q9) healthcare facility from your home?.....

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Towards a framework for delineating sub-districts for primary health care administration in rural Ghana: a case study using GIS

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Kofie, R. Y. & Møller-Jensen, L. 2001. Towards a framework for delineating sub-districts for primary health care administration in rural Ghana: a case study using GIS. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* Vol. 55, 26–33. Oslo. ISSN 0029-1951.

This paper examines the need to carry out primary health care administration, programming and planning beyond the established 110 districts in Ghana. The framework for delimiting the sub-districts is offered by the availability of digital data such as the district boundary, site location, road network and population. Using the specified travel distance from predetermined sites, network analysis generates approximate polygons around the health centres to create functional areas – the health sub-districts. Additional sites are proposed based on a set of criteria which includes proximity, centrality, population and existing level of infrastructural development in an attempt to improve coverage and bring the total utilization of health facilities closer to 100% in the study area.

Keywords: *network analysis, primary health care, sub-districts*

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Introduction

The art of delimiting regions to carry out government business and for the effective implementation of programmes has a long history. In Roman times, for example, censuses were conducted on a city and town basis for the purpose of collecting taxes. The localisation of this system of tax collection was probably meant to make it easier, as records of individuals and their backgrounds would be more readily accessible. Moreover, a more coherent community or functional area would make identification of the eligible taxpayer easier. States have been demarcated into regions, and regions into districts, communes, municipalities, wards, and boroughs. For various reasons, regions have been demarcated using such factors as population, cultural and ethnic homogeneity, accessibility to facilities, etc. In some cases the demarcations have been dictated by the exigencies of the day or for political expediency.

In Ghana, political administration has been devolved from the central government to basic units of government, the district assemblies. It is assumed that bringing policy decisions reflecting local conditions closer to the people will lead to a fuller participation in programmes, and that this will in turn bring about improvement in the well-being of the people. It also has the advantage of transferring competence to the local level (Nordberg 1995). The concept has been captured in a framework for planning which enjoins the co-ordination of plans from the various departments towards the national plan (NDPC 1995). For the effective implementation of policies and programmes, some of these departments have delimited regions into districts for the purpose of effectively implementing their administrative mandates. One such department is Health. The district level administrative machinery is referred to as the District Health Management Teams (DHMTs).

In some of the districts, local initiatives have been developed to further delimit sub-districts on the basis of existing health care facilities – a strategy arguably described as 'putting the cart before the horse'. The creation of sub-districts to administer health care has been dictated by the location of existing facilities. While this strategy cannot be condemned outright but judged as a dictate of available resources, there is the view that simple and unsophisticated digital methods can be used to delimit sub-districts using settlements and their population attributes, district boundaries and road networks.

Justification for localisation

The paper employs network analysis, a utility of ArcView GIS (ESRI 1996), to delineate sub-districts into manageable and more coherent communities or into units for health care programming. It is also a step towards improving access to health services and serves as a strategy for the better targeting of health care towards local needs. The study was carried out in the Ga District of Ghana. It is thought that creating such sub-districts will bring several advantages. For example, it will improve understanding of local perceptions and needs, reduce resistance to change, increase management capacity, encourage community participation, allow for easier crossing of professional boundaries, and improve access to services (Rondinelli et al. 1989). Bullen et al. (1996) indicated that in the UK primary health care delivery has been backed by policies that favoured localism and community as an organisational basis for service delivery. The authors contended that, by basing health care planning on small geographical areas, recognizable and known to the public, there would be greater public involvement in, commitment to and understanding of the disposition of health care resources.

Amonoo-Lartson et al. (1984, 14–19) have also empha-

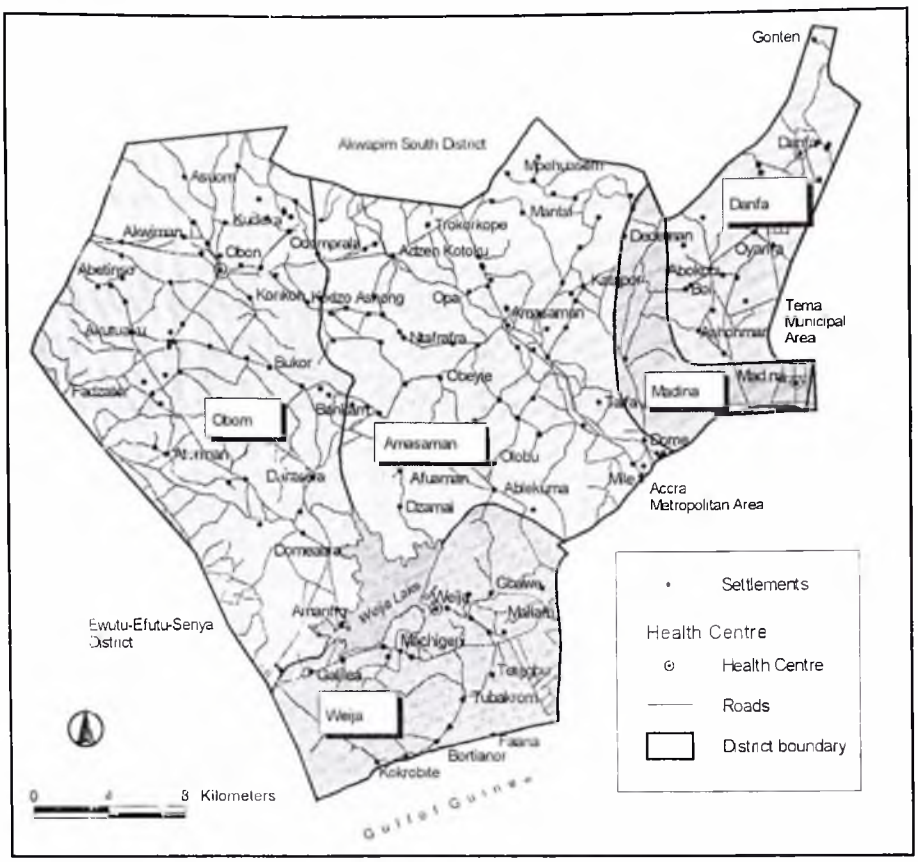

Fig. 1. Health sub-districts and location of major health centres in the Ga District, Ghana.

sised the importance of decentralizing health care programming and administration. They stated, for example, that primary health care should be carried out at the community level, because it is the community that knows how the health workers' knowledge can best be applied. There is therefore the 'need to get to know the community, be trusted by the people in it, and work with local people to provide the services they need.' They stated further that involving the communities in the identification of their needs, planning health programmes, implementing and evaluating them, raises the levels of awareness of their health and other problems and commits them to doing something about the problems. This also implies that by the time they are accepted such programmes are already tailored to the needs of the target group and fit in with their local traditions.

Tradition of localism

The practice of local level planning as a form of grass-roots government and administration in Ghana is not new. It has been a feature of the country's development programmes since colonial times (MLGRD 1994, 2–7). Native authorities were, for example, empowered to administer law and order in their localities with limited involvement by the colonial government. Communities built around groups, traditions and cultures or around paramountcies and occupations facilitated the identification of regions for the implementation of government programmes and projects. The delimitation of enumeration areas for population censuses also characterized the colonial and post-colonial era. It is therefores possible to find in the census reports records of details such as the categories of amenities and facilities, occupation, migration, housing types and occupancy rates.

Other sectors of government business are replete with examples of local and community-based delimitation. Electoral areas form the basis for representation in the district assemblies. At present, there are 110 agricultural districts for the implementation of agricultural programmes and the promotion of extension activities. These coincide with the 110 basic units of government or the District Assemblies. In a similar vein, there are the education districts referred to as the District Directorates of Education.

The health sector has institutionalized the DHMTs in

Table 1. Institutions providing health services by sub-district in the Ga District, Ghana.

Sub-district	Ministry of Health institutions		Quasi-govt. institutions	NGO built clinics	Total health institutions
	Health centre	MCH/FP* clinic			
Amasaman	1	0	0	2	3
Danfa	1	2	0	1	4
Madina	0	1	1	0	2
Obom	1	0	0	2	3
Weija	1	1	0	1	3
Total	4	4	1	6	15

Source: Ga District Health Management Team.
* Maternal and Child Health/Family Planning.

every district. However, the availability of health care services at the sub-district level is of critical importance. Health services, even though more expensive to locate, in many cases are required beyond the established 110 administrative districts. For example, emerging diseases such as buruli ulcer require additional facilities for local treatment and monitoring. There is the need to further decentralize health care from the district level to the sub-district level in order to reduce the responsibilities of overcommitted central bureaucracies, and to facilitate community participation in health care. This will help produce the relevant information for planning and programming.

In a study of existing health information systems in East Africa, Nordberg (1995) indicated that surveys with local community and staff involvement can generate the data required and stimulate local initiative. Thus, decentralization and surveys are related and mutually supportive. The World Health Organisation (WHO) recognized the relevance of both intersectoral collaboration between service providers and of community participation in its 'Global Health for All' strategy (WHO 1981). This study contends that rural areas in Ghana do not have a well-developed road network system and should therefore have health services at close range. It is in the light of this that this paper proposes a framework for delineating sub-districts to enhance health care delivery, especially in the rural areas.

Health care policy

The health system in Ghana is a combination of the government health system, private and non-governmental services, and the traditional health system. Primary health care is based on a three-tier delivery system designed by the Ministry of Health (Ministry of Health 1978; Adjei 1989). These are A-, B- and C-level facilities. A-level facilities are located in the communities and are usually staffed with minimally trained health workers who provide basic curative services. B-level facilities are the first referral level for the communities' health workers and are intended to cover a radius of 8 km. They are usually staffed with a medical assistant, a community health nurse/midwife, a health inspection assistant and a senior field technician for communicable diseases control. C-level facilities are usually the management level for the entire system and are based on the district hospital. The management team is made up of at least one medical officer and provides mostly curative services including in-patient care and some preventive services.

Health care delivery in Ghana was, until the advent of structural adjustment programmes (SAP) in the early 1980s, based on government subsidies. The liberalization of the economy following SAP brought with it the 'cash and carry' (user fee) system where patients pay as they call. The problem associated with this policy has been the inability of most patients to afford services provided at the various health institutions, leading to the decline in the utilization of health services. The result is that the government's objective of achieving basic primary health care for 80% of the population of the country as far back as 1990 has still not been met. Accessibility to health resources has become increasingly dependent upon one's ability to pay. This has made the health system increasingly inaccessible to many rural and urban poor who have therefore resorted to unorthodox health practitioners for their health care. At present, the advocacy has been for health insurance schemes. The problem of economic accessibility has, however, not

Table 2. Ga District health sub-districts and population projection, 1998.

Sub-district	Approx. no. of communities in catchment area	Health facilities	1998 projected population	No. of outreach points
Amasaman	151	Amasaman Health Centre, Oduman Health Centre	87,482	46
Danfa	31	Danfa Health Centre, Abokobi Maternal and Child Health Clinic	22,809	29
Madina	13	Madina Maternal and Child Health Clinic/FP	43,222	14
Obom	10	Obom Rural Health Centre, Kwameanum Maternal and Child Health Clinic	43,045	90
Weija	24	CDH, Communicable Diseases Hospital, Weija Public Health Nursing Demonstration Clinic, Malam, Amanfio Health Centre	39,530	18

Source: Ga District Health Management Team.

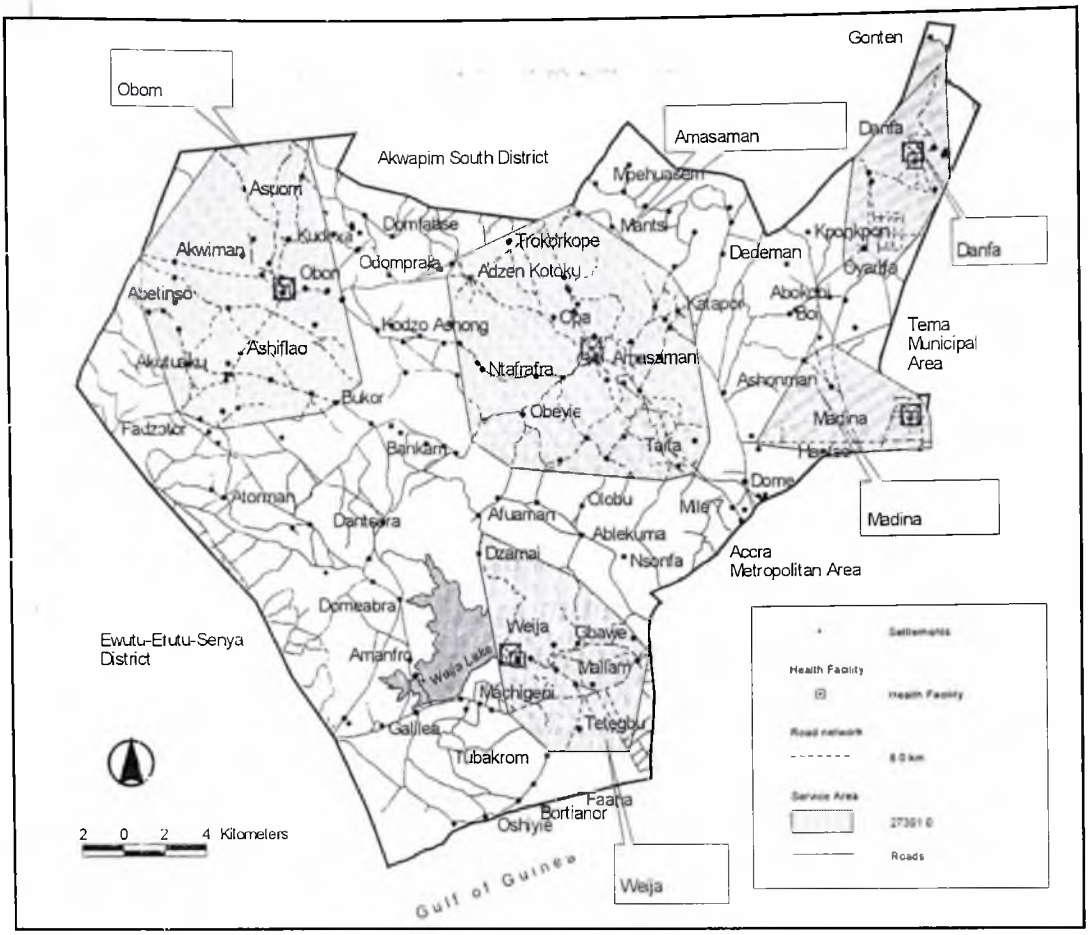

Fig. 2. Approximate polygons around health centres, Ga District.

deterred the government from pursuing its policy of decentralizing health care and carrying it down to the community level.

The study area

The Ga District is one of the five districts which make up the Greater Accra Region and is predominantly rural, even though less than 80% of the population live in the rural areas. It is located to the west and partly to the north of the Region. It has a total land area of 859 sq. km. and a population of c. 300,000 (GDA 1996, 5–23). The district is divided into 42 electoral areas. There are about 21 departments, decentralized, semi-decentralized and centralized in the district, each carrying out central government-type activities.

For health sector planning and programming the district has been subdivided into five health catchment areas or sub-districts namely, Amasaman, Danfa, Madina, Obom and Weija. Each of these sub-districts is host to a B-level health care facility. The five facilities serve *c.* 550 communities. Figure 1 shows the sub-districts and the main health centres after which they have been named.

Table 1 gives the number of government, quasi-government and non-governmental institutions providing health services in the district. Table 2 presents the main sub-district, the number of communities that constitute the catchment area for the health facilities, and the projected population for 1998. According to this projection the district's estimated population was 236,088 in 1988. In the light of estimates made by the District Health Management Team (DHMT) that were based on the routine immunisation exercises done, the total population was put at 290,000.

Materials and methods

The Ga District is made up of five health sub-districts for

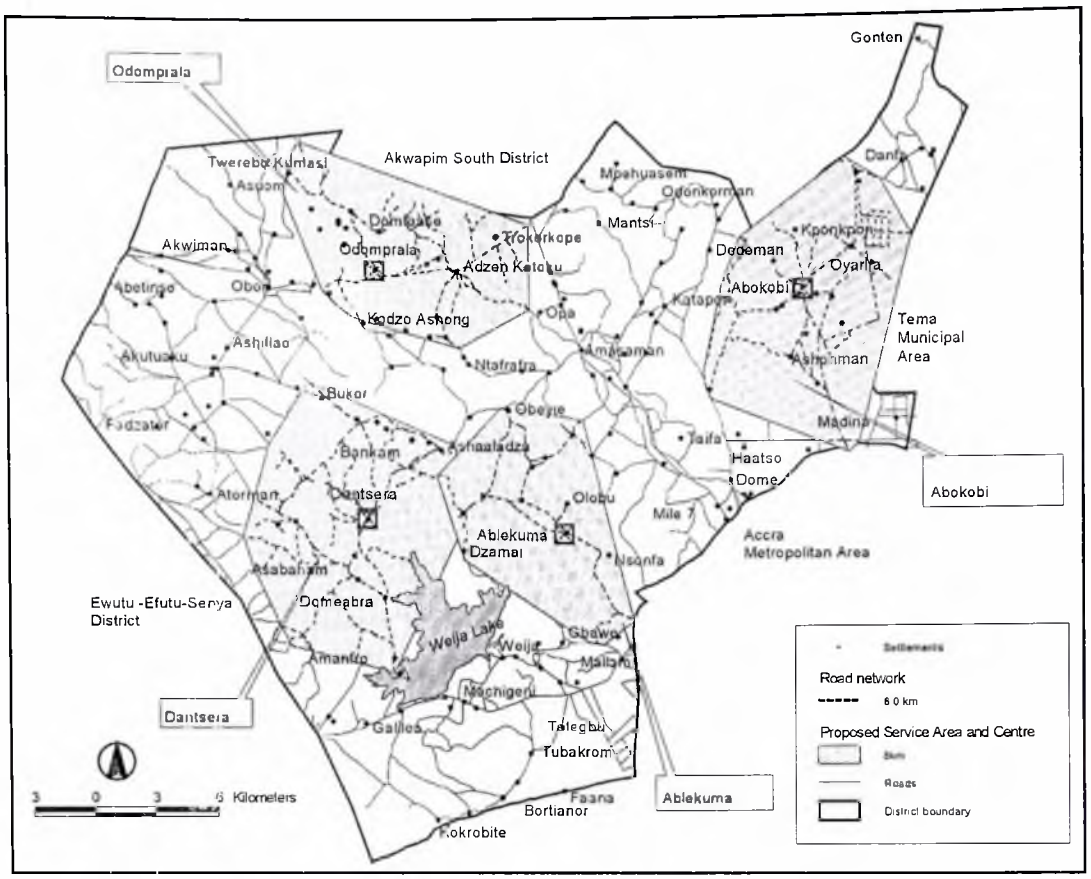

Fig. 3. Approximate polygons around proposed sites, Ga District.

health programming and health care administration. These sub-districts are to serve as catchment areas for the five MOH facilities and were delineated on the basis of their nearness to the communities closest by. Even though the rationale to locate health services near to communities and to delimit the catchment boundaries as small and manageable programming units could be seen as a step in the right direction, the geographical arrangement showed a spatial imbalance that has made accessibility to some of these facilities difficult for many communities. It is this arrangement that has led to the suggestion that these facilities are inadequate to meet the goals of primary health care in the district (Mensah-Quainoo 1997, 14). The study therefore aimed at finding ways of optimizing the location of the facilities as they are currently constituted based on digital road network data, in order to identify communities which fall within specified travelling distances to the facilities.

Digital data and coverages

A digital base map of the district was obtained from the Remote Sensing Applications Unit of the University of Ghana. This provided the boundary outline and other basic data, such as settlements, population, road network and their attributes. The data sets had problems – a situation that is common to many areas in Africa where maps are generally out of date and even sets of more recent ad-hoc maps are heterogeneous and of questionable authority. The district boundary, for example, did not reflect the situation on the ground as many settlements were excluded completely from the district. Trips made in the company of some district

Table 3. Population and communities within 8 km distance from health care facilities along main road network.

Site	Population	Communities
Amasaman	40,123	113
Danfa	9,968	38
Obom	27,421	119
Weija	24,934	14
Madina	62,088	12
Total	164,534	296

Table 4. Population and communities covered by proposed sites.

Site	Population	Population of service area	No. of communities
Dantsera	628	7,700	35
Abokobi	1,028	14,311	62
Ablekuma	365	6,954	16
Odumprala	580	23,286	81
Total	2,601	52,251	194

Table 5. Improved level of accessibility to health care services.

	Population covered	No. of communities
Original facilities	164,534	296
Proposed facilities	52,251	194
Total	216,785	490

assembly officials with local knowledge of the district facilitated the location of many of the settlements with the aid of topographic maps and this enabled the boundary to be re-aligned. Supplementary digital data were obtained from the Survey Department of Ghana, which contained topographic information and, more importantly, the detailed road network data. In spite of this, additional road network data had to be generated by the use of a continuously logging 12 XL Garmin GPS. This took stock of new roads that had been constructed, since the original digital data sets were based on analogue maps produced about 25 years ago and which have since not been updated.

Population data

The latest census from which all population information was derived is 16 years old. The study therefore relied on projections made to 1998 for the district. The annual growth rate of population for the district was 6.2%, which is 2.8% higher than the national average of 3.4%. All settlements in the district were covered by the population as attribute data.

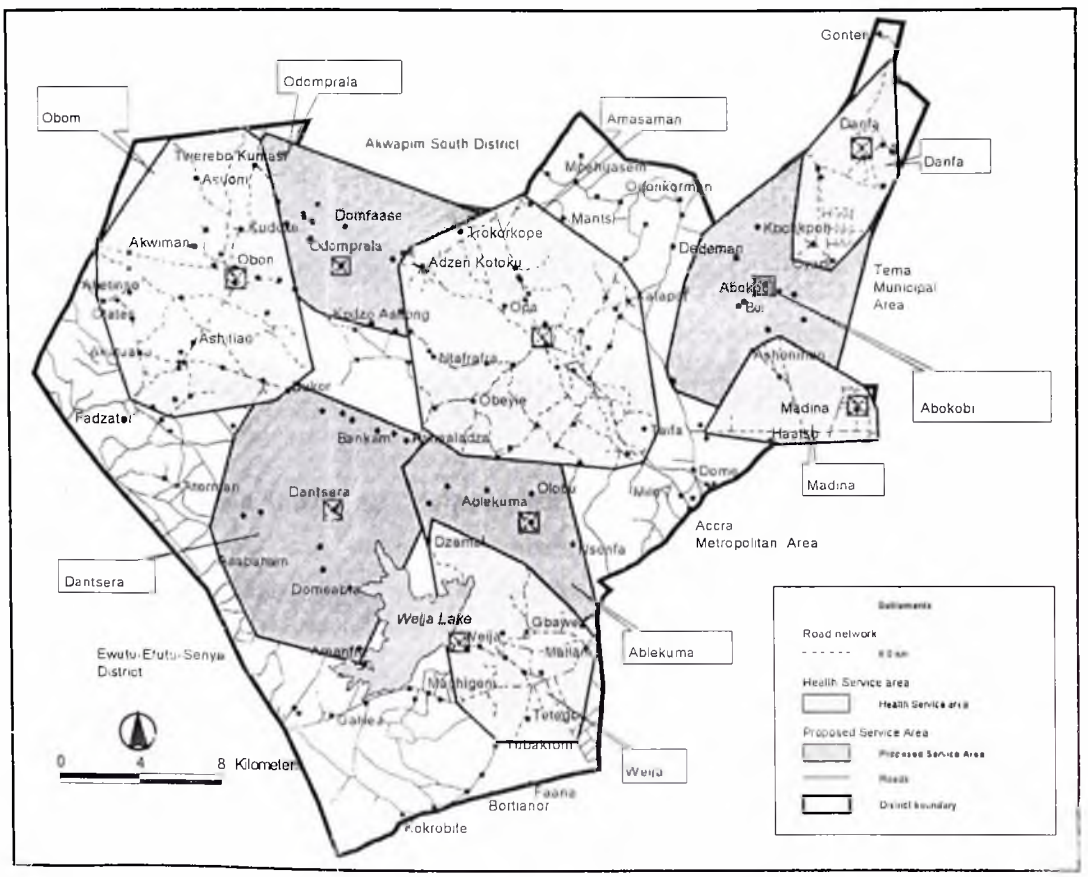

Fig. 4 Sub-districts of existing and proposed health centres, Ga District.

The first step was to specify centres or sites which represent the location of the five health centres around which the service areas or sub-districts were built. These sites were Amasaman, Obom, Weija, Madina and Danfa (Fig. 1). To determine the extent of the area around these health centres, a travel distance of 8 km was used. This is the maximum distance within which a B-level facility should be accessible to a community according to the national health policy (Ministry of Health 1978). What the network analysis did was to connect all communities lying 8 km from the specified sites or health centre. In this way, five service areas were generated showing the real 'catchment' area of each health centre and the road network to and from the centres. These are shown as polygons. It must be noted that the lines connecting the various communities are the existing road networks and it is these that are utilized by the network analysis.

Four additional sites were selected as candidate communities in an attempt to improve coverage, given that the five existing B-level facilities and the catchment areas they serve were inadequate. A number of methods are available for finding optimal locations in a road network (e.g. minimizing total travel time) and for computing the corresponding overall accessibility. In many cases, however, the selected sites are unfit for actual use due to a number of factors. The strategy of this paper has been to focus on a human guided approach that may be more suitable within the current planning context. Using the GIS platform, a number of factors may be examined and planners may experiment with new location scenarios based on their findings and general knowledge of the physical environment, accessibility, population, etc. The four additional sites suggested here should be considered as one possible scenario.

The basic criteria used to select the communities, which should host A-level facilities staffed with minimally trained health workers providing basic curative services, are proximity to the nearest B-level facilities, centrality to the communities that they are supposed to serve, the population of the catchment area, and the existing level of infrastructural development of the selected community.

Results

Figure 2 shows the areas or approximate polygons generated around the five sites or health centres, namely Amasaman, Obom, Weija, Madina and Danfa. The road network and the settlements that were covered are shown inside the approximate polygons. The total population and number of communities thus covered by these centres are given in Table 3. Approximately 54% of the total number of communities or 64% of the population in the district has access to the health facilities. Given the criteria that the maximum travelling distance for access to health care is 8 km, these approximate areas could constitute functional areas for effective health care delivery. When compared to the original sub-district boundaries shown in Fig. 1, it is observed that the new approximate boundaries created are relatively smaller but reflect the true picture of accessibility, since these evolve from a specified distance. In rural areas where the main form of transportation is on foot, it is vital to adopt a strategy that improves access to health care facilities by making them available within reasonable travelling distance or time.

The analysis shows that *c.* 46% of the communities and *c.* 36% of the population do not have access to the health care facilities. There is the need, therefore, to identify additional sites that could host new health care facilities in order to improve overall accessibility. This may be frowned at since it requires additional resources, but this paper contends that different levels of facilities may be required to address specific needs in specific areas. For example, the health care facility at Abokobi in the district is an outpost of the health centre at Danfa. In many of these communities the facilities are housed in one or two rooms provided by the communities or through the assistance of some NGOs.

Figure 3 shows that four sites were selected, namely Dantsera, Abokobi, Ablekuma and Odomprala. These sites have service areas with a population of over 52,000 and serve 194 communities. Table 4 gives the details of each site. Along with the population of service areas covered by the Amasaman, Danfa, Madina, Obom and Weija sites (Table 3), a considerable improvement in coverage was made. This is given in Table 5 where a total population of 216,785 and 490 communities have physical access to health care services. This brings the total coverage rate to 84% for the population and 89% for the communities. A combination of data sets of existing and proposed health centres, and the nine sub-districts created through this superimposition, is illustrated in Fig. 4. Quite evident is the fact that the sub-district boundaries overlap.

The analysis shows that health services are inaccessible to *c.* 16% of the population of the entire district, notwithstanding the increase in the total number of health care facilities from the existing five to nine. It also shows that only 11% of the communities will remain uncovered or will be without access at the 8 km specified travel distance. It has not been possible to achieve 100% coverage for the entire district owing to the geometry of the district, the nature of road network, the uneven distribution of population centres, and to the human phenomenon of bypassing facilities closest by even where there is good coverage.

Discussion

The application of network analysis to delimit sub-districts has been prompted by the view that it is more objective and scientific. It aims at delimiting the sub-districts for health care programming on the basis of specified travelling distances. Traditional methods of delimiting districts or catchment zones have tended to use Euclidean distances and radii. In this paper, however, the view is that such criteria open real accessibility to question. First, nowhere will people be able to, or wish to, walk along straight lines between two points for the specified 8 km distance, especially in the rural areas. Second, the determination of catchment areas using radius only shows areas that are enclosed within a specified distance without considering whether such areas are actually accessible through any road network. Third, the impression is

created that large areas have been covered by the facility whereas in actual fact this may not be the case.

The additional sites proposed to improve coverage of health care services are not necessarily meant to increase the existing system of facilities but are to complement them as outreach points. The facility at Abokobi, which has been proposed in this paper, is already serving as an outstation of the Danfa Health Centre. Ablekuma, which falls within the Amasaman sub-district, could rightly serve as an outreach point for the Amasaman Health Centre, while the proposed site of Odumprala could serve as the outreach point for the Obom Health Centre. The site of Dantsera was proposed for geographical and population reasons. It is located not less than 12 km away from the nearest health facilities. Dantsera has a population of 971 within its immediate environs and would serve, at most, a population of 7,700. We agree with the policy where certain categories of facilities managed by certain categories of personnel are located at defined sites in an attempt to improve health care coverage.

Conclusion

The increasing use of GIS for health studies and planning is exemplified by the works of Scholten & de Lepper (1991), Ritchie (1993), Kolars (1995), Yoon (1995), Cliff & Haggett (1996), and Clarke et al. (1997). Its use by health authorities, and more especially for health planning and profiling of local areas, has been demonstrated in recent times by Bullen et al. (1996). This study has been concerned with the aspects of delimiting sub-districts for the purpose of health care programming, especially within a rural context. It is possible to delimit already existing districts into sub-districts with the availability of digital data for effective health administration. Most localities in Ghana have been organised around ethnic groups or tribes and already form coherent spatial units for the implementation of government programmes. Health sub-districts have been delimited on the basis of the nearest facility, which has made accessibility difficult for some communities.

The use of GIS to enhance the process of delimiting the sub-districts is based on the availability of the following basic data sets: local boundary (polygon), settlements (points), population (attribute of settlements) and road network (linear). A GIS integrates these data sets and facilitates network analysis. The interactive querying of the database also enables the determination of population within the approximate polygons or sub-districts that have been created. The maps composed give a visual impression about the situations on the ground and therefore could help planners, administrators and policy-makers take more informed decisions.

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