The development of geographical information systems for the 1989 kenya population census

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by

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THESIS

THE DEVELOPMENT OF GEOGRAPHICAL INFORMATION SYSTEMS FOR THE 1989 KENYA POPULATION CENSUS

Abstract

This thesis evaluates the potential of geographic information systems (GIS) technology for possible introduction into the analysis of the population census of Kenya. It does so from a starting point of no digital mapping being used at present, and no staff trained in the technology. The one year research programme had a number of aims which would underwrite a fuller evaluation of GIS back in Kenya; to

(i) evaluate the training implications in GIS.
(ii) evaluate the quality and usefulness of base maps produced by the Kenya Statistics office, with a view to automating them for subsequent digital mapping.
(iii) achieve capability and understanding of concepts in the process largely referred to as "digital mapping".

The 1989 census was the first to map the country to the level of Villages which are small subdivisions of the Sub-Locations. Enumeration Areas were based on these Villages. The 1989 census field work was the most detailed of all previous censuses.

About 4000 Sub-Location maps or Enumeration Area maps were prepared for the census. They were used to produce the required copies for the Enumerators and Supervisors who participated in the census enumeration.

The preparation of the District maps for digitising e.g. tracing, identifying and fixing reference points; digitising and editing the coverages; transforming the coverages; and updating the coverage data files took approximately five months. Using this database a population density map was produced.

The study has proved the feasibility of full computer mapping for the analysis of the 1989 Kenya population census. It provides a basis for the development of a full GIS capability. Further, the cartographic information from Kenya, while having limitations, has been combined and integrated to provide a national coverage. Census data, already in the computer form, are relatively easily integrated into the GIS database.

NOTES

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CHAPTER 1

INTRODUCTION

1.1 Background

This thesis aims to evaluate the potential of GIS technology for possible introduction into the analysis of the census of Kenya. It does so from a starting point of no digital mapping being used at present, and no staff trained in the technology. Accordingly the one year research programme had a number of aims which would underwrite a fuller evaluation of GIS back in Kenya. These aims were:

(i) To evaluate the training implications in GIS. The "trainee" in this case who is myself, arriving in England with long background in the Kenya Statistics Office, but with no previous computer expertise of any kind.

(ii) To evaluate the quality and usefulness of base maps produced by the Kenya Statistics Office. This was with a view to automating them for subsequent digital mapping.

(iii) To achieve capability and understanding of concepts in the process largely referred to as "digital mapping" within one year programme, dealing with a new set of technological concepts, and coping with source material being sent from Kenya, it was deemed too complex to move

onto full GIS techniques such as network analysis and overlay. Nevertheless, another of the aims was to become conversant with the techniques and their possible applicability back in Kenya. This will point the way to future areas of research.

1.2 Kenya and its census

The objective of a population census is to produce data that are accurate, timely and useful. Census is the most important source of information about the people, where they live, age, marital status, economic activity, birth place, jobs and many others, which is used by Government and private organisations for development purposes. The unique value of the statistics from the census arises from the completeness of coverage because census is compulsory; the continuity of statistics from census to census, which allow long term changes to be measured; the possibilities of inter-relating various characteristics of the population, the details given by the census about small population either in local areas or in minorities scattered through the country. A modern census is an elaborate and costly exercise. It must be well planned and carefully carried out so that it produces reliable data at reasonable cost. The census results must be processed, analyzed and delivered to the users cheaply, quickly and efficiently.

Kenya has had five population censuses of which the last was

carried out in August, 1989. I was responsible for organising the cartographic work for the census. The cartographic work despite many problems, that are common in the developing countries, was successfully carried out. Considerably more information was collected than in any of the previous censuses, and the cartographic field work facilitated the compilation and production of accurate census maps.

A modern census must have a spatial frame for which data are gathered, tabulated, and reported. This is achieved by the use of appropriate census maps. Chapter 2 will examine the history of taking censuses in Kenya, the role of maps in a census and the type of geographical preparatory work that was organised for the 1989 Kenya population census. The problems of the developing countries are well known regarding topographic mapping. For example Kenya, topographic map coverage is very poor. The preparation of up-to-date census enumeration maps was very difficult because most of the maps found in the Survey of Kenya were out of date. They lacked the necessary information needed for census mapping e.g boundaries for the areas that were adopted in the census, physical features that were needed to mark the Enumeration Area boundaries, locations of structures in the Urban areas. Chapter 3 will explain the procedures that well used to develop a methodology of field mapping for the 1989 Kenya population census.

The 1989 population census maps were produced after undertaking a

very intensive field work. This was the best alternative to collect the information that was needed for the preparation of the Enumeration Area maps. The field mapping staff visited each and every Sub-Location in the country. Chapter 4 will be concerned with the organisation of the field work, techniques that were used in different categories of areas to update the base maps e.g plot many types of boundaries and delineate the Enumeration Areas, estimate households.

The census geographical frame involved very many areas. There were 8 Provinces, 41 Districts, 263 Divisions, 1100 Locations , 3667 Sub-Locations and 37,047 Enumeration Areas. Chapter 5 will be concerned with the development of geographical code scheme which was used for the purpose of identifying all the census areas and for differentiating urban and rural population.

So many different types of maps and other census documents were involved in the census. The various census tasks were performed by very many different people. Chapter 6 will look into the methodology that was developed for indexing and filing census maps and other materials. The most important task after the field work and prior to the census enumeration was the production of the census Enumeration maps. Vast information in terms of boundaries for, Provinces, Districts, Divisions, Locations, Sub-Locations, Villages and Enumeration Areas was collected on maps of different scales and it needed to be put together to create about 4000 census

Enumeration Area maps. This was a complex process and needed to be done very carefully. The staff who were deployed on this work were not qualified and they needed very close supervision. The procedures used to undertake this exercise will be discussed in Chapter 7.

Unlike in the previous censuses a lot in terms of human and financial resources were invested in the 1989 Kenya population census geographical preparatory work. Very good results were achieved especially in terms of mapping the Sub-Location boundaries. This effort was acknowledged by the survey of Kenya[1]. The information regarding Sub-Location boundaries was used to create the census District maps.

In the previous censuses, the census data has been produced and provided to the users in the form of tables. Since the 1962 census very little has been done to map the census data. Census data if had been mapped especially at the Sub-Location level could have assisted the users a lot. After the 1962 census, the census maps remained with the District Commissioners. There were no copies left with the census office in Nairobi. This presented a serious problem in the preparation of the analytical maps. The situation was well described by Morgan (1965) as follows, "it seems most strange and wasteful that census data should be recorded and published down to

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[1]The Department responsible for surveying and production of topographic and other maps.

Sub-Locations but no record is available of the boundaries of these units".

However some work was done concerning preparation of analytical maps after the boundary manuscript maps were retraced and obtained from the field with the assistance of the District Commissioners. The first dot map or population distribution and density maps, both maps at a scale of 1:1,000,000, were prepared under the supervision of Professor Morgan of the Department of Geography, University of Nairobi. There were two types of dots on the map. A red small dot representing 200 persons and a larger red dot representing 1,000 persons. The larger urban centres e.g Nairobi and Mombasa were shown by a thick red line and the total population in figures. The second population density map was in colour. It showed the major urban centres with a black circle and 1962 population figures printed in black (Morgan and Shaffer,1965).

Two population distribution and density maps at a scale of 1:1,000,000 were prepared by the Geography Department of the University of Nairobi, using the final figures of the 1969 population census. The first map was a dot map which used a scale of one dot to 200 persons. Urban areas were shown by graduated black circles. The second map was a population density map which showed the regional differences in population concentrations. After the 1979 population census, the cartographic section, in the Bureau of Statistics, planned to prepare National and District maps

showing population distributions and densities. The population dot map for the whole country at 1:1,000,000 produced but the rest of the maps that were in the plan have never been produced. The national density map was designed by the central Bureau of Statistics and Survey of Kenya. The map is still in the printing stage. It has never been printed due to lack of materials. The problem of having failed to produce various types of maps for the censuses may be summarised as follows below:

1. Lack of organisation.
2. Lack of resources.
3. The inherent problems with manual mapping.

There is generally little doubt of the utility of a computer system as a medium for data storage, analysis and retrieval. It has clear advantages over manual systems in that data may be kept in compact form on magnetic disc or tape and this may be accessible by a number of users. Information retrieval, information updating and data analysis can be rapid and non-tedious, and maps and graphs may be generated automatically more or less as the user requires them. In recent years, the use of computers to map and analyse geographic data has grown dramatically. This technology is known as "geographic information systems". In more precise terms, geographic information systems can be defined as "An organised collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyses, and display all forms of geographically referenced

information" (ESRI, 1990). Chapters 8 and 9 will look at some aspects of analysing the 1989 Kenya population census within a geographical information systems. PC ARC/INFO has been used to digitise the census District maps, clean the boundary network, prepare an initial database of census information, and map some aspects of the census data. This exercise in skill acquisition, and project evaluation, will lead to recommendations being made to the Kenya Government for its possible installation in the census office.

CHAPTER 2

EXAMINING THE NEED FOR CENSUS GEOGRAPHICAL PREPARATORY WORK WITH REFERENCE TO THE 1989 KENYA POPULATION CENSUS

2.1 INTRODUCTION

The concept of the modern population census[1] implies an official Governmental activity, a comprehesive coverage of the entire population and a set of data referring to a specific point in time. A census should be one of a regular series, though many countries have not yet achieved this desirable situation. A few countries take census after every ten years e.g Great Britain, U.S, Kenya, and Tanzania etc. However there are other countries, for example scandinavian countries, who maintain up to date population registers and therefore have a continious record of change in the population of each area of the country.

The modern census also involves much more than a mere counting of heads and puplication of total numbers; it implies in addition the collection and puplication of a wide variety of information such as age, sex, marital status, economic activity, birth place and many others, classified in many ways. Census is the most important source of information which is used by public and private

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[1]Population census has been defined (United Nations 1967) as "the total process of collecting, compiling, evaluating, analysing and puplishing demographic, economic and social data pertaining at a specific time, to all persons in a country or in a well defined part of a country".

organizations for development purposes.

Kenya is among the countries in Africa that have been able to plan and carry out population census as recommended by the U.N e.g at least once every ten years. It has had three censuses since independence in 1969, 1979, and 1989. There were two previous censuses carried out in 1948 and 1962. This chapter will examine the long history of census taking in Kenya, the role of maps in a population census and some aspects of planning the geographical preparatory work for the 1989 Kenya population census.

2.2 THE HISTORY OF POPULATION CENSUS IN KENYA

The first population census was carried out in 1948. It was undertaken at the same time in Tanzania and Uganda. The census was conducted on the Africans.*It was merely counting of the homesteads to get a rough idea about the numbers of the people.It was organised by the colonial Government, which had fears that there was a rapid growth of the African population in certain regions of East Africa. This concern is reflected in one of the interpretations[2] of the terms of reference of the east Africa Royal Commission 1953-1955 Report (H.M.S.O, 1965).

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[2]The particular interpretation states "due to rapid but at present not exactly known rate of increase of parts of the African population there is an acute local congestion on the land and excessive pressure of people and livestock in some Districts in all territories".

*"A census of 'non-natives' was conducted on 25 February 1948 (and also in 1911, 1921, 1926, 1931 and 1947)."

The second census was carried out in 1962. It was conducted just a year before Kenya became independent. The period concided with considerable interest in the boundaries which were to form the basis for a boundary commission.

The third population census was carried out in august, 1969[3]. The decission to carry out a population census in 1969 was influenced by several factors. Many administrative boundaries had been changed following the recommendations of the regional boundaries commission. Although an attempt had been made to adjust the 1962 data to the new boundaries, it was known that this adjustment was only very approximate, so it was impossible to determine with any reliability what the population was in different administrative units. Moreover the results of the 1962 census showed that the population growth was faster than had been estimated. More reliable measures of this growth and distribution were required for the analytical and planning needs.

The 1969 census differs from the two previous censuses in that, for the first time, an attempt was made to enumerate the population on a de facto[4] basis throughout the country. A sample census of 10

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[3]Legal provision for this census was authorised under section 5 of the statistics act, chapter 112 of the law of Kenya. The statistics (census of population) order, 1969, was published under legal notice number 72 (1969, population census, Volume iv, Analytical Report, Central Bureau of Statistics).

[4]Meaning that the census aimed at covering only the people who were in the country at the midnight of 24th August, 1979.

percent of the rural population was simultaneosly carried out in order to secure more detailed data on certain variables.

The fourth and complete census in Kenya was held in august, 1979[5]. The decision to carry out a population census in 1979 was influenced by several factors. Substantial movement of people had taken place with people migrating from areas of high population concentration and settling in urban centres. While most urban centres had grown substantially through migration, the number of urban centres had increased since the previous census. Therefore it was necessary to establish reliably what the population was in the different administrative units of the country. Demographic surveys conducted in the period between 1969 and 1979 indicated that the country's population was growing at very high rate (1979 population census analytical report, volume 2). Reliable measures of the magnitute and trend of the rate of growth were required to facilitate sound planning. In short the population census was taken to determine the number and distribution of the population; determine the rates of fertility and mortality and population growth; determine the nature and rate of internal migration and obtain basic data on population characteristics such as education, age, sex-composition, marital status and household composition.

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[5]Legal provision for the 1979 census of population was under authority of section 5 of the statistics act, chapter 112 and the statistics (census of population) order, 1979 (Volume 2, analytical report, Central Bureau of Statistics).

The 1979 population census was taken on a de facto basis with reference to midnight of 24th August, 1979. The Central Bureau of Statistics was responsible for the census, except for the enumeration itself which was carried out by the provincial administration. In the Bureau of Statistics operations were controlled by a census steering committee under the chairmanship of the Director. The provincial commissioner, Nairobi was appointed census officer to co ordinate the work, and all the District commisioners were appointed as the District census officers responsible for the enumeration. There were close liason between the Bureau of Statistics staff and the officers of the provincial administration at all levels.

The fifth complete census in Kenya was carried out in August, 1989[6]. It was also on de facto basis with reference to the midnight of 24th August, 1989. The population census was conducted to maintain the decennial census programme and to ensure the provision time series of demographic and socio-economic data at National and sub-National Province, District, Division, Location, and Sub-Location levels for planning, research, and administrative purposes. In the past decade the Government began a new era with the establishment of the district focus for rural development which empasises the development of all parts of the country. The 1989 population census data will provide the Government with very useful

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[6]Legal provision for the census of population was under authority of section 5 of the statistics act, chapter 112, and the statistics census population order, 1989.

information about the number and the distribution of the population, the rates of fertility, mortality and population growth. The census will also help to determine the nature and rate of internal migration and to obtain basic data on education.

2.3 THE NEED FOR CENSUS GEOGRAPHICALPREPARATORY WORK

The objective of a census is to produce data that are accurate, timely and useful. To achieve this three fold objective, a modern census must have a spatial frame for which data are gathered, tabulated and reported. The attainment of this can be ensured by use of appropriate census maps. Such maps are prepared through well organised preparatory work.

Census maps help enumeration staff; to locate areas of respective assignments and identify their boundaries correctly and carry out the enumeration effectively and accurately; to prevent omission or duplication of information; to facilitate co-ordination between various offices and between field staff to settle administrative jurisdictional problems; to determine the number and distribution of enumerators and supervisors to be employed; to foster comparability of data from census to census; to determine the best route of travel to determine distances. For example, the enumerator can measure how far it is between an imaginary boundary and some visible features, or he can measure how far it is from the intersection of two roads to a group of houses.

The maps should show village and enumeration area boundaries, locations of structures or major buildings or other landmarks, physical features, streets, roads, and other information as may be considered necessary for conducting an accurate enumeration. These maps should be of relatively large scale especially in the densely populated areas e.g urban areas. A great deal of time and resources should be devoted to preparation and production of the census maps during pre-enumeration phase of census. The accuracy of these maps and their usefulness depend very much on the kind of base maps[7] used in the planning stage and the kind of field work carried out to update the base maps.

2.4 THE PROBLEMS FACED BY THE DEVELOPING NATIONS

In the developed countries where the map coverage is good and very few changes are taking place on the ground e.g development of roads and streets in the urban areas, preparation of census maps can be a simple task. In such situations maps of the previous census can be used with minor changes. For example in the U.K, planning for the 1991 census maps by the OPCS[8] is underway. Planning EDs[9] is being carried out on the OS maps at 1:1,250.

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[7]Census base maps refer to the maps from which census enumeration maps are derived from.

[8]Office of Population Censuses and Surveys

[9]Enumeration Districts

The information on the 1981 EDs is received from Local Authorities about intercensal changes to the housing stock, to give a revised estimate of the number of households in each ED on the basis that, for a new building, one household per dwelling is added and for demolitions, an appropriate number of households is deducted. If this revised base is within the allocated range for the ED, and local and statutory boundary requirements are satisfied, the ED boundary need not be changed, but counts falling outside the range necessitate a re-design of the area. All this type of updating ED maps is done by correspondence with the Local Authorities. There may be very few cases where the OPCS staff have to go on the ground to confirm some changes. In contrast, in the developing countries where the map coverage is poor, for example lack or topographic maps whose scale is small and the information out of date, the census enumeration must be preceded by a very intensive mapping programme which must include very detailed field mapping exercise by the census staff to collect the necessary information in order to prepare the census maps. But the resources of some of these countries are limited e.g finances and their staff may be small and lack the specific skills needed for the job. Most of the developing countries that have carried out population census mapping work, have relied heavily on external assistance. A few have been helped to establish cartographic units within the census organization to carry out the census mapping work. A lot of this help is coordinated by the United Nations.

The assistance provided to many countries is normally in the form of equipment, materials, manpower training, and expertrate cartographers to assist in the census mapping.

In the 1989 Kenya population census, assistance was received from UNFA (training, Equipment and Materials), USAID (training), ODA (data analysis Adviser) and UNECA (short term cartographic consultancy). Most other countries have also benefited from exertanal assistance. In the 1988 population census, Tanzania received assistance from SIDA (Equipment, Materials, short term and long term consultancy), UNFPA (fellowships and transport), ECA (short term consultancy), ODA (fellowships and processing Equipments) and USAID (short term consultancy in data processing).

2.5 THE 1989 POPULATION CENSUS GEOGRAPHICAL PREPARATORY WORK

The objectives of the 1989 Kenya population census mapping programme were:

(i) To Prepare the required enumeration area maps. First by updating the available base maps to include the necessary details for population census purposes and secondly by delineating the required Enumeration Areas on the base maps using identifiable features.

(ii) To determine the location of the population in advance of the enumeration so that a sufficient number of

enumerators and supervisors can be recruited, trained and allocated through out the country.

(iii) To enable the census organisation to provide results for areas whose locations are known e.g Administrative and Enumeration Areas.

2.5.1 CARTOGRAPHIC ORGANIZATION

Planning a census mapping programme is normally the responsibility of the cartography section which should be established as an intergral part of the census office. But in case such a section is not established within the census office, for various reasons, this task should be performed by the census planners, if necessary, with the support of relevant expertise from outside e.g Survey Department and Universities etc.

The mapping programme for the 1969 Kenya population census was organised and carried out by three organisations[10], namely, the university of Nairobi, Geography Depatment, the Department of Lands and Surveys, and the Ministry of planning and National Development which was responsible for the census.

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[10]This organisation was best summarised by Professor S. Ominde as follows, "the 1969 Kenya census mapping is also unique, in that it illustrated what the co-operation betwwen the University based Manpower, Ministry responsible for the census survey, and the Kenya Department of Lands and Surveys could achieve with very limited financial resources".

Each of the three organisations involved in the census mapping was assigned a particular task to perform. The Geography Department, University of Nairobi was involved in the cartographic checking and compilation of the Geographical Enumeration Areas base maps under the direction of Professor S. Ominde. The then statistical division of the Ministry of Economic planning and Development maintained the administrative contact with the field . The final plotting of the enumeration area maps (EA maps) and the detailed compilation of areas were carried out by the Department of Lands and Surveys. This was a good decision because the compilation of the areas was professionally done by the cadestral section of the Kenya Surveys.

A Cartography section was set up in 1976 in the Central Bureau of Statistics. It was set up to plan and carry out the 1979 Kenya population census mapping work because the work was more demanding than in the previous censuses. Census maps were required at a larger scale than in the previous censuses due to the changes in population growth that had taken place. The Sub-Location and Enumeration Area boundaries needed to be identified in the field and this required a lot of time and total commitment. The work needed special attention and the University of Nairobi, Geography Department or the Survey of Kenya who were already tied up with their regular work, could not help. It was believed that the cartography section would put all the effort together to and produce the required maps quickly and efficiently.

Like the 1979 census, all the census mapping activities for the 1989 census were co-ordinated by the Cartographic Section. It was important in the process of planning the mapping programme for the 1989 population census to assess the requirements of personnel that was needed to ensure that the stipulated outputs were achieved within the prescribed time period. Therefore the period between 1984 and July, 1987 when the census cartographic work begun was devoted to preparing the cartographic staff. Recruitment of the additional staff and training were undertaken between this period. Intially the cartographic section was staffed with 15 officers, 6 senior officers and nine clerical officers. Most of the staff who were involved in the 1979 census had left. In March, 1988 after the mapping work had started, it was realised that more people were required for the census and some more were seconded to the census from Survey of Kenya and the District statistical offices.

In preparation for the census mapping work, the cartographic staff were trained locally and abroad before the census mapping work started. Two senior officers of Cartography section were trained at Glasgow University at postgratuate diploma level. Four other senior staff were trained at the Netherlands (Institute for aerial survey and earth scieces) and Kenya polytechnic at diploma level. Ten clerical staff were trained at the survey of Kenya at certificate level. The remaining census staff did not have any formal training. They were however trained by the qualified staff on the job.

In addition all the census staff participanted in various cartographic seminars which were organised to prepare all those who were involved in the census mapping work.

The cartography unit, because of its specialised nature of jobs needed larger space as compared to other divisions of census office. Drafting Staff needed to have adequate space for placing large size drafting tables with enough space around the tables for movement while drafting. Similarly enough space for map filing cabinets was needed. The specialised equipment such as photographic reproduction equipment needed to be housed in separate rooms with adequate working space. Mapping was the only major census activity that took place before the actual census enumeration and there was no problem of housing the census mapping staff and the cartographic equipment and materials.

The other important consideration was about transport. During the 1979 population census, non-availability of sufficient transport was the most severe handicap to carry out the cartographic field work and other related activities. In the planning of the 1989 population census geographical preparatory work, it was recommended that the required number of vehicles should be procured early enough without delay so as not to repeat the same mistake of 1979 population census. In all about 15 new vehicles were needed for cartographic field work which was due to start in July, 1989.

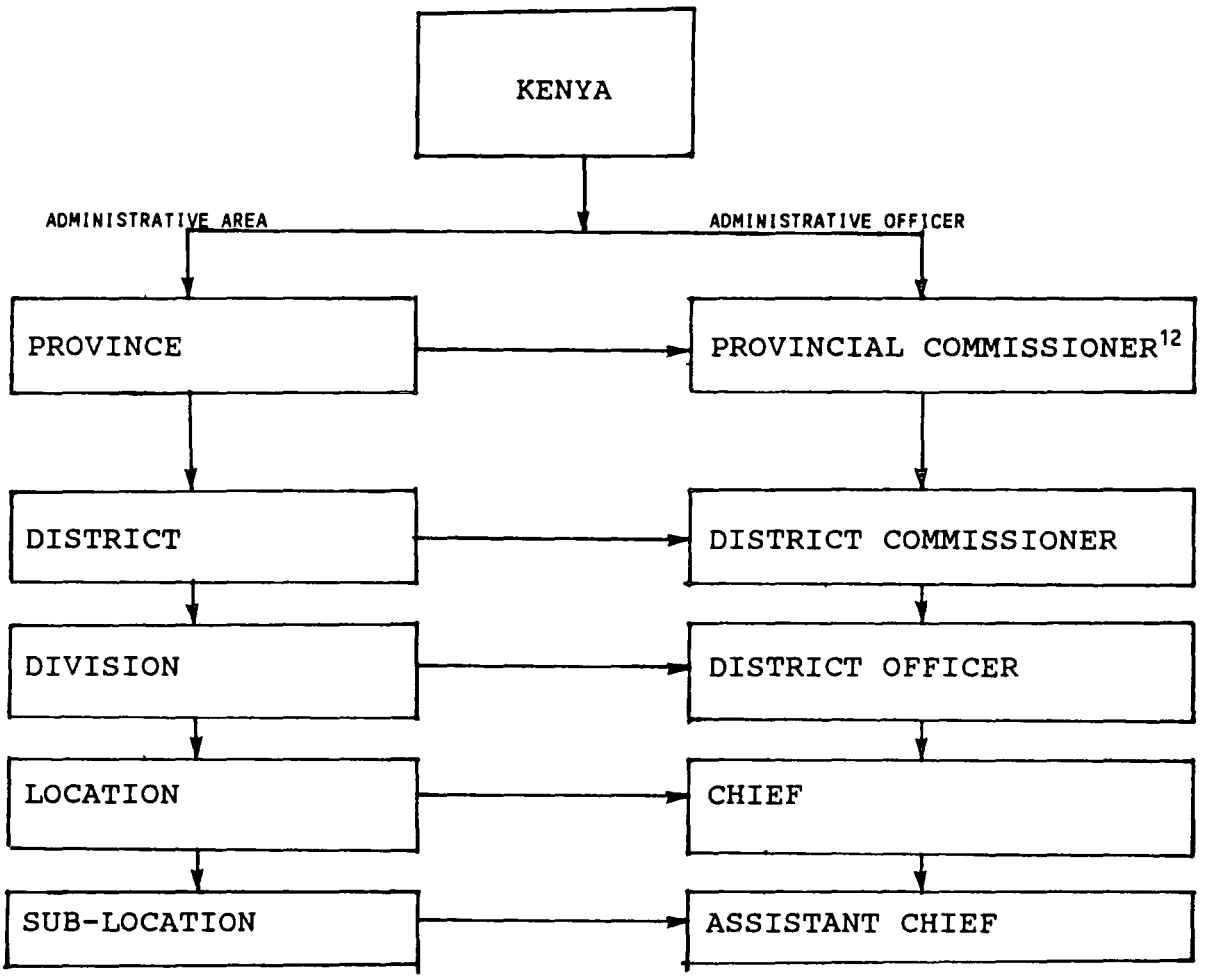
Four Land Rovers were to come from the UNFPA[11] and the rest from the Kenya government. There was some delay in the delivery of the vehicles and this affected the field work. The work started with very old vehicles which were not reliable.

2.5.2 THE CENSUS GEOGRAPHICAL FRAME

In planning the population census preparatory geographical work, an important decision to make was about the areas for which data was to be collected and reported. The administrative geographical frame which includes, provinces, Districts, Divisions, Locations, and sublocations was used in 1969, 1979 and it was recommended for use in 1989. Each administrative area is under the responsibility of a Government officer as shown in the table 2.1 below.

[11]United Nations Fund for population Activities

Table 2.1 The administrative structure of Kenya.



[12]Provincial Commissioner is a Government administrative officer incharge of a Province.

The first thing that was done early in 1987 was to list down all the administrative areas at various levels. This was important before taking up other aspects of planning the census geographical work because the information was used in determining the types and quantities of maps to be prepared, specially during the pre-enumeration phase. The information was compiled from the 1979 census and updated with information from the Office of the President.

In 1979 census, there were eight provinces and forty one Districts which have not changed to date. However the administrative boundaries below the district level before the census underwent considerable changes due creation of new administrative units. Accordingly more than 63 divisions, 395 Locations, and 509 sublocations were created between 1979 and 1987 . These additional administrative areas were created as a result of rapid growth of the population which caused congestion in certain parts of the country.

The Central Bureau of Statistics therefore planed to obtain information concerning the boundary changes for all the administrative areas for the 1989 census through field work. The infomation was to be obtained from the Assistant Chiefs who were conversant with the changes. The decision to create new administrative units e.g sub-locations or Locations is rested with the Government, but the actual boundaries were determined on the

ground by the Assistant Chiefs.

2.5.3 CENSUS BASE MAPS

Preparation of the 1989 population census base maps started in 1986 and completed by the end of the year. First, the maps that were available in the cartographic section were evaluated to determine their suitability for the census use or whether they needed modification, correction, or even redrawing. The evaluation included the consideration of numerous map characteristics such as completeness of area coverage, suitability of map scale, date of preparation, and especially the usefulness and accurancy of the content.

The base maps included the 1979 population census maps, the survey of Kenya topographic maps and National maps showing District boundaries, communication network, locations of important places and Density of population. All the maps that were available in the section were examined and listed down. Those which were found useful for the census preparatory geographical work were selected for reference and use. The 1979 population census maps were of three types, rural Sub-Location EA maps at 1:10,000 showing EA boundaries, topographical and infra-structural details; District maps at 1:100,000 and 1:250,000 showing Sub-Location boundaries; and large scale Urban maps at 1:1000, 1:2,500, and 1:5,000 showing streets and buildup areas. The master transparencies of all the

maps were geographically classified, indexed and stored in the filling cabinents. After indexing and filing the maps, it was discovered that, Some of the Urban maps were missing. Additional maps were acquired from the relevant sources e.g Survey of Kenya, Department of Physical planning, Ministry of Local Government, Ministry of Transport and Communications, Provincial and District Headquarters.

The 1979 population census maps were fairly elaborate showing boundaries down to sub location level. Normally these maps with the necessary updating could have met a major part of the 1989 census mapping requirements. However a number of factors limited their use.

(i) The 1979 population census field work was not done satisfactorily. The Assistant Chiefs were not consulted properly to show their sub location boundaries. At the time of field work the Assistant Chiefs were interviewed at the Divisional Headquarters. Hence the 1979 population census maps could not be relied on as far the administrative boundaries were concerned.

(ii) Enumeration Area boundaries were drawn in the office using the survey of kenya topographical maps. Most of these maps were out of date. Therefore some of the features used as EA boundaries were not existent on the ground. The mapping programme for 1979 population census did not include field

work to update the topographic maps. During the enumeration it was difficult for the enumerators to identify their EAs using the EA maps.

The Survey of Kenya topographic maps at 1:50,000 covered the densely populated areas and 1;250,000 covered the sparsely populated areas. In addition there were topographical maps covering the large urban areas e.g Nairobi, Mombasa, Eldoret, Nakuru, Kisumu, etc. More than 75% of the Survey of Kenya topographic maps had been published long a go and they were out of date. They were drawn in the sixties and early seventies and did not include changes that had taken place just before the census. Since independence there have been a lot of changes regarding roads, administrative boundaries, schools, cattle dips etc. such details were required for planning the census Enumeration Areas.

2.5.4 DETERMINING THE CENSUS MAPPING ACTIVITIES

Before the census work could be started, an important step in the census mapping programme was to work out a detailed list of individual activities that would lead to the preparation and production of various census maps. The list of the cartographic activities was particularly useful in the preparation of the census mapping calender indicating operational sequences and estimated time duration needed for accomplishment of each activity. At the initial stages it was not possible to define precise time

schedules, but tentative time frame within which each activity should be completed were laid down keeping in mind the number and magnitude of total mapping activities and the time available for their implementation. The basic reference date on which the scheduling of the individual activities was based was the census enumeration date.

The cartographic mapping programme should have started at least three years before the enumeration date so as to provide adequate time for completion of various activities but this was not possible due to lack of resources.

2.5.5 PREPARATION OF VARIOUS LISTING AND CONTROL FORMS

Production of maps is a complex process involving chain of several activities performed by different categories of staff and at different points of time. Because of this, various forms were designed to be used during the 1989 population census mapping exercise to control the census mapping work in general. Such forms were used for the first time in Kenya. The forms helped the census mapping teams and Assistant Chiefs to conduct the census work in a uniform and comparable manner throughout the country. The forms were of standardised formats and they were used to organise the mapping work both in the field and in the office.

(i) Form CBS/KPC/89/2

This form was designed for use buy the mapping field staff while working in the Urban areas. The purpose of the form was to estimate the number of housing units or households in each urban centre. The information would later be used to delineate EAs in the urban areas. Households in the urban areas change very often and it was not possible to obtain this information from the Assistant Chiefs correctly. During the field mapping exercise the field staff were asked to visit all the structures in each Sub-Location and assign them each a number. They were asked to use the form to list the number of the structure, the purpose for which the structure was used and the name of the household head. In the urban area structures may be used as dwelling units(DU), business(B), dwelling and business(DU/B), dwelling and kitchen (DU/K), kitchen, vacant or could be used for other purposes not specified (see appendix 4.4).

(ii) FORM CBS/KPC/89/3

This form was to be used in the field by the mapping assistants to describe the boundaries of each Enumeration Area, the location of the EA and how to approach the EA from a known point. Boundary description was done clockwise direction, starting from north (see appendix 4.5).

(iii) FORM CBS/KPC/89/6

This form was used to list down all the delineated EAs in each sublocation. The following items were also noted;the EA code number,number of households in each EA, Remarks to indicate whether the EA was in the urban or in the rural (see appendix 4.3).

(vi) FORM CBS/KPC/89/7

This form was designed to collect information regarding the number of households in each sublocation by villages.The forms were reproduced in sufficient numbers and given to the Assistant chiefs by the field mapping team. The Assistant chiefs were given full explanation on how to fill the forms. This information was to be used by the field mapping team to decide on the EA boundaries (see appendix 4.2).

2.5.6 PROCUREMENT OF MATERIALS AND EQUIPMENT.

The quantities of cartographic Materials and Equipment required for the 1989 population census mapping programme were assessed in view of the nature and magnitude of the various cartographic activities planned, the proposed number of staff to be deployed on these activities and the status of equipment already available with the cartographic section.

The requirement of expendable cartographic materials items were assessed in consideration of the materials needed for the reproduction of base maps, cartographic field work and fair drafting of the base maps , EA and SA maps in the required number of copies. The original list was far from being adquate and the shortfall was taken care during the census. The equipment and materials required for the census were provided by the Government and the UNFPA. The UNFPA procurement was completed October, 1987 and the Government was done in phases January, 1988, July, 1988, and July, 1989. However some of the equipment were already available with cartographic section.

2.6 CONCLUSION

This chapter has briefly explained the history of census taking in Kenya and the importance of census maps. It has been shown that Without good Enumeration Area maps it is difficult to carry out a successful census. The problems faced by many developing countries regarding organising and executing a census mapping programme were examined. To undertake a census mapping programme in these countries can be very expensive because most of them have very poor map coverage and they lack the necessary resources e.g skilled manpower and finances. The contrast of these countries with the developed countries was analysed. It was shown that most of the developed countries have been mapped at very large scales and the base maps show most of the features needed for census purposes. In

the case of Britain, there is not even need to undertake intensive field work to update the census base maps because unlike the developing countries there are very few changes, which affect the EDs for the previous census, that take place in the intercensal period.

CHAPTER 3

DEVELOPING A METHODOLOGY FOR FIELD MAPPING

3.1 INTRODUCTION

The fifth census in Kenya was carried out in August, 1989. The actual enumeration was preceded by immensely time consuming and tedious preparatory geographical work, which constituted a pre-requisite for the success of the enumeration. The need for the preparatory geographical work in the context of the 1989 census operations emanated from the following considerations; the general requirement that all censuses should avoid under-enumeration as well as over-enumeration, to ensure that every person is enumerated on the census day, and to provide the required enumeration maps for the census.

The role played by maps in a census was underscored in chapter 2. The Central Bureau of Statistics was determined to plan and carry out the 1989 population census mapping programme in a better way than any of the previous censuses. To succeed in this undertaking, the Bureau was going use the experiences of the previous mapping programmes in order to improve on the 1989 population census.

During the geographical preparatory work for the 1979 population census, the Government planned to obtain population data for each sublocation. But the sub-location boundaries were not plotted following the correct procedures. The boundaries were not

verified on the ground with the assistance of the assistant chiefs and village elders. The enumeration areas were delineated in the office at Nairobi on the basis of topographical features on the 1:50,000 survey of Kenya maps and the population figures of the 1969 census. The survey of Kenya topographic maps as was explained in chapter 2, were out of date. Because of the inherent procedural drawbacks, the Enumeration Areas delineated as above could not be used effectively at the time of the 1979 census enumeration.

In planning for the 1989 population census mapping programme, the Central Bureau of Statistics did not want to rely much on the 1979 population census maps, but wanted to evolve a suitable methodology for base map up dating and delineation of new enumeration areas. In order to do this discussions were held between the senior cartography staff, Members of the Census Steering Committee and the United Nations Cartographic Adviser and formulated some ideas which obviously required field testing to establish their practicability before defining any methodology for the 1989 population census mapping. These ideas were:

(i) Do the Sub-Locations have any further subdivisions suitable for adaptation in EA delineation? It was agreed that, since EAs would be delineated within each Sub-Location, it would be a good ideas if the EAs were based on some official subdivisions below the sub-location. This meant that at the time of enumeration the EAs would be more identifiable with the assistance

of the Assistant Chiefs and the local people.

(ii) Does the Assistant Chief or any other local administration office maintain record pertaining to the number of households or population of the respective Sub-Locations? If such records existed then they could be requested for through the administrative channels so that they could be used to estimate the number of people or households in order to delineate EAs in each Sub-Location. In case such records were not being maintained, how long would it take the Assistant Chiefs to prepare them for the purpose of the census?

(iii) Will it be feasible to identify and determine the boundaries of each Sub-Location and EAs on the ground with the help of the Assistant Chief and locate and plot the same on the base map in the field? How long would it take a team of three or four mapping personnel to complete the work in one Sub-Location.

(iv) The problems of the nomadic populations are well known. Owing to the conditions that prevail in the areas they live, they move from place to place (mostly long distances) in such for water and pasture for their livestock. Therefore, will it be possible for the mapping teams with the help of the Assistant Chiefs to locate the areas where the people will be found at the time of the census?

(v) How representative of the ground features are the survey of Kenya topographic and the 1979 population census maps? Since these maps were going to be used as the base maps for census mapping, it was important to know their usefulness before planning for the mapping programme.

To test the above ideas, it was found necessary for the cartography staff to undertake field trips to Taita Taveta, Transnzoia, Garissa, West Pokot and Kakamega Districts. The Districts were chosen to represent areas of different characteristics. The findings of these trips are discussed in the following sections of this chapter.

3.2 FIELD TRIP TO TRANSNZOIA AND TAITA TAVETA DISTRICTS

This was the first field trip which was organised to test the ideas that have been discussed above. The field trip was undertaken by five officers from the cartographic section of the Central Bureau of Statistics, census office. The officers were, Messrs Z. Gichohi, I.K. Mwangangi, N. Nyaga, N. Ndubi, and Mrs Odiambo. It was undertaken in November, 1986.

While the team was in the Districts all the necessary arrangements were made by the District Commissioners and District Officers to tour various Sub-Locations. The Assistant Chiefs of the selected Sub-Locations were alerted in advance to prepare

themselves so that they could work with the team. In each sub-location, the team worked with the Assistant Chief and village Elders. Each selected sub-location was canvassed completely and the following observations were made:

(i) All the Assistant Chiefs were conversant with their sublocation boundaries. In the case of two neighbouring Sub-Locations, each Assistant Chief identified the common boundary correctly. As far as imaginary boundaries were concerned each Assistant chief was able to identify households belonging to his Sub-Location along the imaginary boundary. The Assistant Chiefs were visited at different times.

(ii) Most of the physical features used as Sub-Location boundaries could be identified on the Survey of Kenya topographic maps and the 1979 population census enumeration area maps. There were, however some features on the ground which were not reflected on the base maps e.g schools, roads, cattle dips etc.

(iii) In Transnzoia, a lot of people had settled in the district after the 1979 population census. Before independence, the District was composed of large farms. The process of buying the farms through cooperative had been taking place and at the time of the field visit so many people had settled in the District from the other Districts.

(iv) It was noted that due to the population increase, several Sub-Locations had been created in Transnzoia District, since the 1979 population census. In 1979 there were 7 sub locations which had increased to 19 Sub-Locations at the time of the field trip. In Taita Taveta District the sub-locations were 39 during the 1979 population census and they had increased to 45 at the time of the field trip.

(v) It was noted that, out of the total geographical area of Taita Taveta District which measures about 19,959 square kilometres, only about 2,590 square kilometres is inhabited by people. The people were concentrated in certain few areas. The rest of the land area which measures about 13,360 comprises of the Tsavo National Park. There were very few people who lived in the National park. They lived in such places as, the Tourist Hotels, Camps for railway workers, and Game warden Camps. It was explained to us that, the National park area did not fall under any Sub-Location. The Sub Location boundaries ended at the National Park boundary.

3.3 FIELD TRIP TO GARISSA

In april, 1987 the second field trip was undertaken to Garissa District by four officers. These officers were, Messrs Z. Gichohi, I.K. Mwangangi and B. Ndilinge from cartography

section, Census office in Central Bureau of Statistics and Mr M. Mwangi from the Department of Geography, University of Nairobi. The District is inhabited by people who lead a nomadic way of life. In Kenya there are twelve Districts which are classified in this category. These are Turkana, Marsabit, Mandera, Wajir, Isolo, Samburu, Garissa, Tana-River, Lamu, Kajiado, Narok, and West Pokot. Garissa was chosen to represent the rest of the Districts in this category.

The purpose of the trip was to study the pattern of movements of the nomadic people during different times of the year and to find out if the Assistant Chiefs could locate all people within their Sub-Locations.

At the District Commissioner's office arrangements were made for team to visit various parts of the District to meet the District Officers, Chiefs and Assistant Chiefs to discuss the purpose of the field trip. The Sub-Locations selected were Mbalambala, Dadaab, and Liboi in Mbalambala, Dadaab and Liboi Divisions respectively. During the discussions with the Assistant Chiefs of these Sub-Locations, the following observations were made:

(i) More than 95% of the people who lived in the district were pastorists. That is, their livelihood was dependent on Livestock. The district is one of the driest in the country. There is, usually very little rain throughout the year. During the dry periods the people normally move away from their usual places,

sometimes to distant places in search of water and pasture for their livestock. They move regardless of district, provincial or international boundaries. From Garissa District, they can move to Wajir which is a neighbouring district or to Tana River District which is in the neighbouring Province or to Somaliland which neighbours Kenya to the North East.

(ii) The team was further told that only the people who look after the Livestock move with all their things away from the normal places of residence. The rest of the people in the families e.g the Assistant Chiefs, elderly people and children normally do not leave their residence in this manner. However, the movement described above is temporary. When conditions improve in the home Sub-Locations, the people who had left move back to their original places.

(iii) At any given time the Assistant Chief know all the people within his Sub-Location, both the people who are normally under him and those who might come from other Sub-Locations.

(iv) Two types of settlements were identified, permanent settlements and the temporary settlements. Permanent settlements comprised of the towns and trading centres where the people lived near water sources. The temporary settlements comprised of areas were people

had moved in due to favourable conditions (water and pasture). When these conditions are no longer favourable, the people would move to different areas with all their belongings including livestock.

3.4 FIELD TRIP TO WEST POKOT AND KAKAMEGA DISTRICTS

In January 1987 the final pilot field trip was undertaken in West Pokot and Kakamenga Districts. The trip was undertaken by Mrs Odhiambo, I.K. Mwangangi and the U.N Regional Adviser in Cartography, Dr R.R Tripathi.

West Pokot District is located in the northern semi-arid track of the Rift Valley Province having a comparatively sparse population distribution and Kakamenga District is located in the densely populated track of Western Province.

The Sub-Locations selected for this field test were Talau and Kisatiru in West Pokot and Kakmenga districts respectively. The trip had similar objectives like the previous ones. The findings of the trip are summarised as in the following sections.

3.4.1 Talau Sub-Location.

Talau sublocation encompasses an area of 21 sq.km and had recorded a population of 5145 in the 1979 population census, when it was divided into three enumerations areas. Before proceeding to Talau Sub-Location, the team visited certain offices at

Kapenguria , the administrative headquarters of West Pokot District. The various issues discussed and proposals made during the visit are explained hereunder:

In the office of the District Officer one, Mr J. G. Kamau who dealt with the administrative matters of the District, the team explained the purpose of the visit as indicated earlier in this chapter.

It was explained that the lists of households at the Sub-Location level were not being maintained but these could be compiled and made available to the census staff either at the headquarters or at the time of actual field work.

The Assistant Chief of Talau Sub-Location who was present in the meeting indicated that for implementation and monitoring of various administrative matters, the Sub-Locations are generally divided into units or villages each put under the responsibility of a village elder who is respected by its residents. He further pointed out that the desired lists of households in respect of Talau Sublocation could be compiled at the most in four days time with the help and support of the village elders who are familiar with all the households living in their villages. The District Officer 1 suggested that for compilation of household lists a formal request from the population census office should be forwarded to his office through the proper administrative channels.

After the meeting with the District Officer 1, the team made a visit to Talau Sub-Location with the company of the Assistant Chief Mr E.C Nyeiyow. The following exercises were carried out:

(i) The Assistant Chief described the Sub-Location boundaries on the ground. The boundaries were plotted on the 1:50,000 topographical maps as well as the 1979 population census Sub-Location maps on the basis of ground features.

(ii) The maps were checked against the ground features and it was found that many features which were on the ground were not on the maps. They were up-dated accordingly e.g new road alignments, new schools, and cattle dips were plotted.

(iii) The Assistant Chief explained that Talau Sub-Location was divided into six units or villages namely, Ptembo, Chewyet, Kapsururu, Chepkoti, Kaibos, Kipkorinya, and Kapenguria trading centre. The boundaries of these units or villages were identified on the ground and accordingly plotted on the base maps.

(iv) Through mere observation and quick count while moving within the sublocation, it was evident that the population had grown more than 5145, the figure which was recorded in the 1979 population census.

3.4.2 Kisatiru Sub-Location.

The trip to kisatiru sublocation was made on a weekend due to unavoidable circumstances. It could not be possible, therefore to visit any of the offices. However the team was able to meet the Assistant Chief Mr Peter Gunyanyi with whom an appointment had been made in advance.

The Sublocation encompasses an area of 8 square kilometres. The activities carried out in the Sub-Location and the discussions that were held with the Assistant Chief are listed below:

(i) The boundaries of the sublocation were identified and verified on the ground with the help of the Assistant Chief. They were plotted on the base maps making the necessary corrections on the boundaries used for the 1979 population census.

(ii) All the existing roads were verified and those found not appearing on the base maps were incorporated while those found abandoned were deleted from the base maps.

(iii) Like Talau Sub-Location , Kisatiru Sub-Location was also found divided into further smaller subdivisions or Villages. Each Village was put under the responsibility of a Village Elder. These Villages are locally known as "Maguru". The boundaries of the Villages were defined using visible ground features such as streams, rivers, roads, footpaths or cadastral

boundaries e.g fences. They were identified on the ground and plotted on the base maps as well.

(iv) Regarding the maintenance of records pertaining topopulation or household count, the Assistant Chief informed the team that, on his own initiative, he had carried head count of the residents of the Sub-Location in 1985 and obtained the results shown on table 4.1 below.

Table 3.1 Estimated population for kisitiru Sub-Location in 1985

Name of village	No.of persons counted-1985	Estimated No. of EAs
Wangulu	2115	4
Mulele	2400	5
Kisatiru	951	2
Wengange	2100	4
Kaveye	1300	3
Lusala	960	2
Kedohi	1060	2
Modegua	1790	3
Ivona	1400	3
Total	13886	28

In 1979 population census Kisatiru Sub-Location was divided into five enumeration areas, when a population of 7631 was enumerated giving a ratio of 1526 per EA. This means that the population had

almost doubled between 1979 and 1985.

3.5 RECOMMENDATIONS BASED ON THE FIELD TESTS

On the basis of the findings made during the field tests in Transnzoia, Taita Taveta, Garissa, West Pokot and Kakamenga Districts, the following recommendations were made:

(i) It was observed in all the districts that the base maps were out of date. There were many features (new developments) on the ground which were not represented on the base maps. The survey of Kenya topographic maps which were being used had been published many years earlier and had not been updated since. Most of the maps were published in the sixties and early seventies. The 1979 population census Sub-location maps did not show extra details apart from the ones on the topographical maps. This was because, before they were drawn, there was no field up dating of the base maps. It was therefore recommended that, the census office should plan and execute a very intensive mapping programme for the 1989 population census that would include detailed field work to up-date the base maps e.g plot all the missing physical features and boundaries of Sub-Locations and Villages.

(ii) Delineation of the EAs would be completed in the field at the time of the field work by taking into account

Sub-Location and Village boundaries as well the size, distribution and the pattern of population within the individual villages. The EA boundaries as much as possible should be delineated along or following identifiable ground features so as to facilitate the enumerators to relocate them correctly and conveniently at the time of census.

(iii) The Assistant Chiefs should be requested to provide up-to-date lists of household heads for the individual villages. The number of EAs should be decided on the basis of the population estimated on these household lists. The requisition for the preparation of these lists should be made by the census office to the concerned district and Sub-Location authorities through the appropriate official channels as early as possible so that copies could be provided to the field mapping staff before the start of the field work.

(iv) Field Mapping exercise in the arid and semi arid areas should be started and completed in August/September 1988. This is because the census is scheduled for August/September the following year 1989. It is being assumed that in august 1989 people would be found where they will be mapped in August/September, 1988.

CHAPTER 4

THE CARTOGRAPHIC FIELD WORK FOR THE 1989 POPULATION CENSUS

4.1 INTRODUCTION

The initial geographical preparatory activities for the 1989 Kenya population census, e.g staff training, recruitment of additional personnel, taking inventory of equipment and materials, procurement, preparation of the work calender etc; were discussed in chapter two. This chapter will be concerned with the cartographic field work for the census. It will consider the workshops organised for the field mapping staff, the organisation of the field work, procedures used in updating base maps, estimating the population, and delineating the Enumeration Areas. The various problems encountered during the field mapping work, regarding transportation, large enumeration areas, treatment of National Parks and Forest areas will also be analyzed.

One problem faced in census geographical work was lack of suitable base maps for EA delineation. The problem was not new because it was faced before in 1962, 1969 and 1979. The procedures that were used to collect information regarding the required physical features, Sub-Location and Village boundaries and the role of the local administration e.g Assistant Chiefs and Village Elders will be explained.

Field work for the 1989 population census started in July, 1987.

The work took off at a very slow pace mainly due to lack of transport. The vehicles earmarked for this work were delivered in December, 1987 and October, 1988. In the initial plans it was envisaged that the work would be completed by early 1989, so that there could be enough time for the preparation of the EA maps. The adjustments made in order to complete the field work will be considered.

4.2 WORKSHOPS FOR THE FIELD MAPPING STAFF

The 1989 census field mapping work required the mapping staff to cover (canvass) the entire geographical area of the country. The task needed people who were dedicated to their work and who could be relied on. In addition it required people who were organised, qualified and with the necessary skills and proper training. This is because the cartographic work needed to be done more extensively and rather in a comprehensive manner than the previous censuses. Hence training of the field mapping staff was inevitable, and was taken very seriously.

The field mapping staff and the other Officers involved in census mapping work were trained in the seminars that were organised in Machakos, Kakamega, Nakuru, and Kisumu. The first training was conducted in Machakos, in July, 1987, just before the field work started, for field mapping personnel from the cartographic section. It was attended by 70 participants.

The District statistical Officers[1] and other senior members of the Central Bureau of Statistics who were involved in the census work were trained in Kakamega and Nakuru in November, 1987 and March, 1988 respectively. The workshops for District Statistical Officers were held to review the work progress regarding field work and to introduce them to the techniques that were being used so that they could monitor the mapping work in their Districts. Initially when the mapping work started the District Statistical Officers were not involved. The decision to involve them was taken later. During the Workshops, they visited some Sub-Locations where the work was in progress. Their comments at the end of each seminar were taken seriously. They were used to update the field mapping manual.

Two more seminars were held in Kisumu and Machakos in April and May, 1988 respectively. They were conducted for the District statistical staff. The decision to deploy the District statistical staff was taken March, 1988 when it became obvious that more staff was required in order to complete the field work in time. Each District statistical office seconded three Enumerators to the population census work on full time basis.

The Enumerators from Kiambu, Kirinyaga, Muranga, Nyandarua, Nyeri, Kisumu, Siaya, Kisii, South Nyanza, Baringo, Elgyo marakwet, Kericho, Nakuru, Nandi,Narok, Transnzoia, Uasin Gishu, and West Pokot Districts were trained in kisumu and the

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[1] District Statistical Officers are the representatives of the Department of Statistics in the Districts. The Department is known as, the Central Bureau of Statistics.

Enumerators from Kilifi,Kwale, Lamu, Mombasa, Taita Taveta, Tana River, Kitui, Embu, Isiolo, Machakos, Meru, and Kajiado Districts were trained in Machakos. By this time field work had been completed in Kakamega, Bungoma and Busia Districts and there no Enumerators trained from these Districts. It was a good decision to deploy the District Statistical Staff in the mapping exercise because they very qualified in map reading and they knew their Districts very well.

Participants in the field mapping seminars were trained through class room lectures, field demonstrations and formal objective tests to ensure that the various mapping concepts were understood. The training was based on a mapping manual which had been prepared by the senior cartography staff in consultation with Survey of Kenya and Geography Department, University of Nairobi. The manual was also used as a reference document during the field mapping exercise.

The field mapping manual explained in details all the aspects of the field mapping and what the field staff were supposed to do while in the field. The following topics were covered in the field mapping manual:

(i) The role of maps in a population census.

(ii) The objectives of the geographical preparatory work for the census.

(iii) The role of the District Statistical Officers, Team leaders, mapping assistants, Assistant Chiefs and Village Elders, etc.

(iv) Discipline and cooperation among the team members and how to enlist support of the local administration.

(v) How to approach the general public during the mapping exercise.

(vi) Some principles of mapping e.g the map scale, various ways of measuring distance on a map using a string or a piece of paper and on the ground using the vehicle.

(Vii) How to plot points on a map.

(viii) Procedures for updating the base maps and delineating the Enumeration Areas.

(ix) The coding scheme.

(x) Organisational aspects such as specific tasks assigned to various categories of the mapping staff.

(xi) Line of operational control.

(xii) Concepts and definitions applicable to the field mapping work.

(xiii) Handling of field equipment.

4.3 ORGANISATION OF THE FIELD MAPPING EXERCISE

The field mapping exercise or the cartographic field work for the 1989 population census was much more demanding than any of the previous censuses in Kenya. Most of the details collected during the field work had not been collected before. They included:

(i) Collecting the latest maps and other materials showing roads, boundaries, population centres etc, from the provincial and District offices e.g Ministry of Local Government, Survey of Kenya field Offices, Municipal, Town and Urban Councils and private organisations and use them to update the base maps.

(ii) Obtaining the list of the newly created administrative units and details of the territorial coverage in respect of each, if available from the office of the District Commissioners.

(iii) Obtaining estimates of households or housing units.

(iv) Identifying, verifying and plotting accurately all the Sub-Location and Village boundaries.

(v) Verifying the topographical features shown on the base maps and plotting the ones not included.

(vi) Delineating Enumeration Areas of equitable and prescribed population size on the basis of visible ground features and household estimates

There were five mapping teams initially but they increased to ten at the climax of the field mapping work. Each team comprised a team leader and three mapping assistants. The team leader was the overall in charge of the team. He/She was academically highly qualified than the mapping assistants and a senior officer of the cartographic section. The responsibilities of the team leader were as follows:

(i) To assign duties to the mapping assistants.

(ii) To maintain and foster discipline and cooperation among the mapping assistants.

(iii) To organise the field mapping work satisfactorily by controlling all the facilities like maps, equipment and the vehicle.

(iv) To contact the local officials and make appointments to carry out field work in their administrative areas or Sub-Locations.

(v) To provide a report to the head of census mapping about the progress concerning field work. This was done in

the form of a detailed written report.

The Administrative Officials e.g the District Commissioner, the District Officers, the Chiefs and Assistant Chiefs in each District were kept informed about the census field mapping. Also the Mayors and chairmen of municipal, town and urban councils were briefed about the exercise. It was the responsibility of the team leader to contact these Officials and solicit for their support. It was necessary to make them understand what was involved in the mapping exercise. Each Assistant Chief with the assistance of his Village Elders[2] had to take the mapping team round his Sub-Location boundaries so that they could be plotted on the maps correctly.

Before proceeding to the Sub-Locations, the mapping staff held a meeting with all the Assistant Chiefs at the District Officer's office. The purpose of the meeting was to:

(i) Brief the Assistant Chiefs about their role in the census field mapping.

(ii) Ask the Assistant Chiefs together with their Village Elders to identify and familiarise themselves with the Sub-Location and village boundaries before the mapping staff arrived.

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[2]A Village is a small sub division of the Sub-Location. A Village Elder is a person who is responsible for the Village. He reports to the Assistant Chief about every thing that goes on in the Village. He must be a person who is acceptable by the members of the village.

(iii) Resolve all the boundary conflicts with the adjacent Sub-Locations before mapping could start.

(iv) Complete the listing of households on form CBS/KPC/89/7[3] and hand it over to the mapping staff when they arrived in the Sub-Location for mapping.

(v) Make appointments with the Assistant Chiefs regarding mapping their Sub-Locations.

Field work was completed in each Sub-Location in a comprehensive manner. All the tasks of updating the base maps and delineating EAs were completed before proceeding to the next Sub-Location. At each Sub-Location the mapping staff worked closely with the Assistant Chief and village Elders most of whom knew the Sub-Location and village boundaries thoroughly well. The role of the Assistant Chiefs and Village Elders was to identify the boundaries of the Sub-Locations and Villages for the mapping staff who plotted them on the base maps accordingly. At the same time, most of the other features were plotted e.g roads, footpaths, schools, cattle dips and all other prominent features. The mapping team, including the Assistant Chiefs and Village Elders used the vehicle which had been assigned to them to move round each Sub-Location.

At the start of the 1989 Kenya population census field work,

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[3] CBS/KPC/89/7 is a form that was designed and used by the Assistant Chiefs to list down all the names of the Household Heads in each Village. The exercise was done prior to field work in each Sub-Location

there were five field mapping teams who comprised of the cartographic staff only. However, in April, 1988, some adjustments were made when it became clear that the number of the mapping staff was small. The mapping Teams were increased to ten. The additional mapping assistants were drawn from the District statistical staff. The involvement of the District statistical staff was a very good one because they were very conversant with the local areas. In addition they were very good map users because through out their normal field work they had been used to various survey maps.

After increasing the field mapping Teams, the District Statistical Officers were appointed by the Director of Statistics to coordinate the mapping work in the Districts. Due to this new role of the District Statistical Officer, the mapping team leader had to work closely with him. The District Statistical Officer introduced the mapping staff to the Administrative Officials before they could carry on with the mapping exercise.

At the beginning of the field work, there were no good vehicles, in particular four wheel drive Land Rovers suitable for the field conditions. The teams started with very poor vehicles which could not be relied on. They broke down very often and this delayed the field mapping work. However the arrival of eleven new vehicles in October, 1988 made it possible to increase the Teams to ten.

Each field mapping Team was assigned a number of Districts to carry out the field mapping work. The time required to complete

the field work in each District had been calculated on the basis the number of the Sub-Locations. The mapping teams were asked to adhere to the mapping timetable as much as possible. The procedure of putting more than one mapping Team to work in one District in a sweeping manner had been tried earlier but was found not suitable because it was difficult to edit field work e.g to check if there were overlaps between adjacent Sub-Locations mapped by different Teams.

4.4 UPDATING THE BASE MAPS AND DELINEATING ENUMERATION AREAS

Updating and preparation of the base maps was inevitable field task which needed to be accomplished before taking up the delineation and mapping of Enumeration Areas. Successful EA[4] delineation was depended on the updated base maps. Also well delineated EAs facilitated the preparation of detailed EA maps which were used by the census enumeration personnel ensuring complete enumeration of the population without any gaps or overlaps.

One of the most important tasks that was undertaken before starting the geographical field work was to prepare an inventory of the available maps which was used as a basis for developing the 1989 population census EA maps. A statement relating to the availability of the base maps was provided in chapter 2. The 1979 population census maps and the survey of Kenya topographic maps were mostly used.

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[4] EA is a short form for Enumeration Area

An important determinant of the scope of the geographical field work was the nature of the available base maps. In the case of base maps that showed little or no details (enough to help in the preparation of the census maps), the field teams were required to do thorough updating. The amount of detail that could be added on the base maps was determined by the scale used for each particular area.

For sake of defining precise field base map updating and EA delineation methodologies, the country was divided into three distinct categories according to the density of population i.e Urban areas with very high population density, dry and semi-dry Northern and North-Eastern parts having sparse population distribution and the rest of the country having comparatively dense population distribution.

The sparsely populated areas broadly spread over 13 Districts which altogether account for about 69% of the total area of the country as against only 12 % of its population. The areas characterised with dense population distribution cover the remaining 28 Districts forming 31% of the land area of the country and 88% of the population (the 1979 population analytical report). Since delineation of EAs needed to take into account both the population size as well as the geographical area coverage, the choice of base maps was made keeping in view the density variations. Figure 4.1 and Table 4.1 below show the density of population by District in the 1969 and 1979 population censuses. The density of population was highest in Nairobi,

Mombasa, Western Province, Nyanza and Central Province. Also it can be observed from figure 4.1 that the density of population increased in almost all the Districts between 1969 and 1979. While planning for the 1989 census, it was assumed that the population density had increased further since 1979.

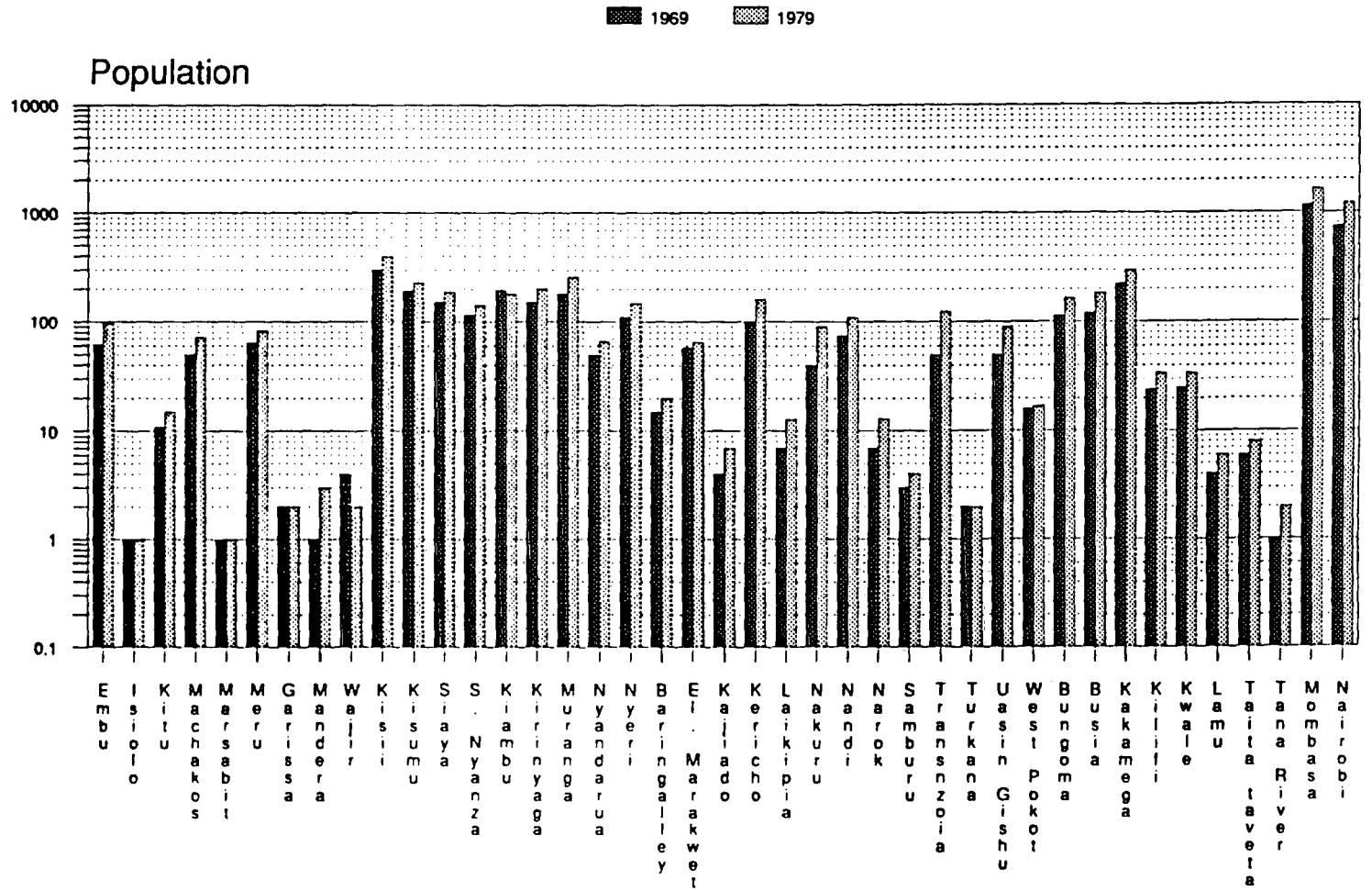
Table 4.1 Population and Density by District in 1969 and 1979.

PROVINCE/ DISTRICT	AREA SQ.KM	POPULATION 1969	POPULATION 1979	DENSITY 69	DENSITY 79
NAIROBI	684	509,286	827,775	746	1,210
KIAMBU	2,448	475,576	686,290	194	280
KIRINYAGA	1,437	216,988	291,431	151	202
MURANGA	2,476	445,310	648,333	180	261
NYANDARUA	3,528	176,928	233,302	50	66
NYERI	3,284	360,845	486,477	110	148
KILIFI	12,414	307,568	430,986	24	34
KWALE	8,257	205,602	288,363	25	34
LAMU	6,506	22,401	42,299	4	6
MOMBASA	210	247,073	341,148	1,155	1,622
TAITA TAVETA	16,959	110,742	147,597	6	8
TANA RIVER	38,694	50,696	92,401	1	2
EMBU	2,714	178,912	263,173	62	96
ISIOLO	25,605	30,135	43,478	1	1
KITUI	29,388	342,953	464,283	11	15
MACHAKOS	14,178	707,214	1,022,522	50	72
MARSABIT	73,952	51,581	96,216	1	1
MERU	9,922	596,506	830,179	63	83

GARISSA	43,931	64,521	128,867	2	2
MANDERA	26,470	95,006	105,609	1	3
WAJIR	56,501	86,230	139,319	4	2
KISII	2,196	675,041	869,787	304	395
KISUMU	2,093	400,643	482,327	192	230
SIAYA	2,522	383,188	474,516	151	188
SOUTH NYANZA	5,714	663,173	817,601	114	143
BARINGO	9,885	161,741	203,793	15	20
E. MARAKWET	2,279	159,265	148,868	57	65
KAJIADO	19,605	85,903	149,005	4	7
KERICHO	3,931	479,135	633,348	97	161
LAIKIPIA	9,718	66,506	134,524	7	13
NAKURU	5,769	290,853	522,709	40	90
NANDI	2,745	209,068	299,319	75	109
NAROK	16,115	125,219	210,306	7	13
SAMBURU	17,521	69,519	76,908	3	4
TRANS NZOIA	2,078	124,361	259,503	50	124
TURKANA	61,768	165,225	142,702	2	2
UASIN GISHU	3,378	191,036	300,766	50	89
WEST POKOT	9,090	82,458	158,652	16	17
BUNGOMA	3,077	345,226	503,935	113	163
BUSIA	1,626	200,486	297,841	119	183
KAKAMEGA	3,495	782,586	1,030,887	220	294

SOURCE: Republic of Kenya, Central Bureau of Statistics, 1979 Population Census, Volume 2, Analytical report.

Population Density in Kenya
By District



The 1:50,000 and 1:250,000 Survey of Kenya topographical maps were used for the densely populated areas and sparsely populated areas respectively, as the base maps. In the densely populated areas, they were supplemented with the 1979 census EA maps. The 1979 census maps were used extensively since they were large scale maps. They provided a good base for collecting as much detail as was required. For the areas with denser population, the maps were further enlarged to larger scale suitable for the field work.

Base maps for most of the urban areas were acquired from the 1979 census but a complete inventory was obtained from the Municipalities, Town and Urban Councils and from other private agencies. In the situations where suitable maps were not available, the mapping staff was encouraged to make sketches, especially for slum areas.

4.4.1 Enumeration Areas. What are they ?

The prime purpose of the 1989 population census geographical preparatory work was to ensure that Enumerators[5] were allocated in such a way that it was possible to obtain complete coverage of the population in the time allocated, to ensure that every person in the country on the census day was enumerated without duplication or omission. It was very essential to count every body. Nobody had to be counted more than once.

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[5] An Enumerator refers to the person who was responsible for counting people within one enumeration area during the census

The basic geographic units for the collection of census data are called Enumeration Areas. An Enumeration Area (EA) may be defined as a well delineated territorial unit containing the prescribed population size and which the enumeration is carried out by a single Enumerator. The idea size of an EA can be defined as the number of households or persons that one Enumerator can enumerate within the specified period of the enumeration. The EA size can differ from country to country.

During the 1989 Kenya population census geographical preparatory work, the whole land space of the country was allocated to about 42,000 Enumeration Areas at the time of the cartographic field work. Every part of the country was checked for the existence of Households at the time of the field work. This was to ensure that every Household was allocated to an EA. Enumeration areas were delineated on the basis of the Village boundaries.

An Enumeration Area for the 1989 population census was planned to contain 100 households. However it was known that this size would differ between different geographical areas. For example in the Arid and Semi-Arid areas, the size was expected to be lower and the geographical area larger while in the densely populated areas it was expected to be higher and the geographical area smaller.

Generally one Enumerator was responsible for enumerating all the people within the EA. The maximum time that was allowed for enumeration was seven days in the most difficult areas. The

Enumerator's workload was determined on the basis of the length of enumeration period, number of questions that were to be asked during the census, availability of Enumerators and the cost involved in the payment of the Enumerators and Supervisors.

The most important principle which was followed in delineating the EAs was that, under no circumstances an EA could cut across any existing Sub-Location boundaries. Each census counting area or Enumeration Area was assigned to a Village(s) and each Village was assigned to a Sub-Location.

While delineating EAs, the mapping staff made sure that, as far as possible, the boundaries of EAs were made following identifiable or visible ground features whenever possible, such as roads, footpaths, fences, streams, rivers etc. Whenever imaginary boundaries had to be made, this was done with reference to prominent features e.g churches, schools, houses of prominent people were plotted along the imaginary EA boundaries.

The 1989 population census EAs were mapped without making reference to the EAs of 1979 population census of the following by the following reasons:

(i) Most of the 1979 EAs were large (in population and area) because they were mapped in the office.

(ii) There was no detailed field work to determine the population in the villages or Sub-Locations before

the EAs were delineated. Hence there was no way of knowing how many Households each EA contained.

(iii) Enumeration Areas were delineated with no regard to Village boundaries and the local leaders were not involved. Therefore they were not understood by the local Villages Elders.

(iv) The EAs were mapped without field work and there was no way of confirming whether their boundaries existed on the ground. Some physical features used as EA boundaries as they were shown on the base maps were non existence on the ground.

(v) There was a substantial intercensal population growth. The EAs which had the right population size in 1979 population census had grown larger.

In practice, in the 1989 population census, it was not possible to delineate Enumeration Areas of the prescribed size of 100 households all the time due to various factors e.g alignment of physical features for defining EA boundaries was always not good, the geographical terrain in some areas was flat and featureless, information regarding population estimates were received late from some of the Assistant Chiefs. However, the field mapping staff were asked to keep the population size variation within acceptable ranges e.g 50 to 150 Households. In cases where it was difficult to delineate EAs of the prescribed size, composite EAs

were allowed and arrangements were made to assign more Enumerators to such EAs at the time of enumeration.

4.4.2 Obtaining population estimates

The basic containing unit for delineating EAs in the 1989 population census was the Sub-Location. Therefore estimates of population and housing units were needed for planning the individual enumeration areas and for planning the total number of Enumerators and Supervisors and quantities of materials that were needed for the entire census operation.

The Central Bureau of Statistics requested the Provincial Administration to provide the information regarding the number of Households in each Sub-Location by Villages. The information was provided by the Assistant Chiefs. They used forms CBS/KPC/89/7 shown in appendix 4.1 to list all the names of household heads in each Village.

Information regarding Household or Population estimates for the Urban areas was collected during the field mapping exercise by the field mapping staff. They used forms CBS/KPC/89/2 shown in appendix 4.3 to list all the structures in each Sub-Location and identified those which were used as dwelling units.

The population estimates in each Village were used to decide on the boundaries of the Enumeration Areas as well as determining the number of Enumerators that would be deployed in the

enumeration. Table 4.2 below shows the number of Households, population, Enumerators and Supervisors by District and Province for the Census.

Table 4.2 Households, Population, Enumerators and Supervisors

PRO/DIST.	HOUSEHOLDS	POPULATION	ENUMERATORS	SUPERVISORS
KENYA	3,828,526	19,142,615	42,493	8,499
NAIROBI	369,779	1,848,880	3,913	783
CENTRAL	609,599	3,047,995	6,773	1,356
KIAMBU	184,668	923,340	1,953	391
KIRINYAGA	73,129	365,645	808	162
MURANGA	163,077	815,385	1,730	346
NYANDARUA	62,352	311,760	713	143
NYERI	126,373	631,865	1,569	314
COAST	372,591	1,862,955	4,177	835
KILIFI	107,724	538,620	1,264	253
KWALE	61,158	305,790	696	139
LAMU	10,898	54,490	110	22
MOMBASA	128,412	642,060	1,233	247
TAITA TAVETA	45,313	226,565	579	116
TANA RIVER	19,086	95,430	295	59
EASTERN	609,136	3,045,680	6,730	1,346
EMBU	63,591	317,955	738	148
ISIOLO	19,609	98,045	212	42
KITUI	110,826	554,130	1,354	271
MACHAKOS	202,400	1,012,000	2,024	405
MARSABIT	27,310	136,550	548	110
MERU	185,400	927,000	1,854	371
N. EASTERN	77,628	388,140	1,078	216
GARISSA	20,822	104,110	272	54
MANDERA	46,280	231,400	546	109

WAJIR	10,526	52,630	260	52
NYANZA	539,372	2,696,860	6,046	1,209
KISII	173,743	868,715	1,755	351
KISUMU	105,000	525,000	1,050	210
SIAYA	108,156	540,780	1,235	247
S. NYANZA	152,473	762,365	2,006	401
RIFT VALLEY	835,067	4,175,335	9,361	1,872
KAJIADO	48,397	241,985	508	102
KERICHO	131,636	658,180	1,381	276
LAIKIPIA	43,901	219,505	478	96
NAKURU	170,956	854,780	1,631	326
NANDI	69,321	346,605	765	153
NAROK	49,230	246,150	748	150
BARINGO	51,339	256695	717	143
EL. MARAKWET	47,943	239,715	581	116
SAMBURU	14,857	74,285	269	54
TRANS NZOIA	60,400	302,000	604	121
TURKANA	34,200	171,000	342	68
UASIN GISHU	75,300	376,500	753	151
WEST POKOT	37,587	187,935	584	117
WESTERN	835,067	4,175,335	9,361	1,872
BUNGOMA	108,504	542,520	1,090	218
BUSIA	69,287	346,435	794	159
KAKAMEGA	237,563	1,187,815	2,531	506

SOURCE: 1989 Kenya population census

4.4.3 Mapping Areas with dense population

Field work in the densely populated areas was taken up according to priority and was supposed to be completed in a comprehensive manner. This was because although these Districts form a small percentage of the whole country in area, most of the population is located there. The field mapping work consisted of going to one Sub-Location at a time and completing the task of updating the base maps and delineating the EAs before moving to the next Sub-Location.

In each Sub-Location the mapping staff worked closely with the Assistant Chief and Village Elders. The Assistant Chief assisted by the Village Elders briefed the mapping staff about the Sub-Location and Village boundaries. The procedural steps involved at this stage are indicated below:

(i) The mapping Staff requested for the completed household listing forms, CBS/KPC/89/7 which had already been supplied to the assistant Chiefs.

(ii) After receiving and checking the forms containing names of the Household Heads in each Village for the Sub-Location, the mapping staff proceeded to update the base maps e.g plotting roads, footpaths, schools, cattle dips, and all the other prominent landmarks.

The mapping Team, guided by the Assistant Chief moved with in each Sub-Location using the vehicle which was provided by the census office. The Sub-Location and Village boundaries were identified and verified with the assistance of the Assistant Chief and Village Elders and plotted on the base maps. In most of the cases, the Sub-Location and Village boundaries were marked following identifiable physical features. However there were a few cases were the boundaries were marked without following any physical features. In such cases the mapping staff plotted prominent landmarks on either side of the boundary e.g names of Household Heads etc.

After updating the base maps and plotting the Sub-Location boundaries the next important step was to delineate the enumeration areas. Enumeration areas were delineated on the basis of the Villages and the information already supplied by the Assistant Chiefs about the number of households in each Village. Each enumeration area was to contain about 100 households. There were three situations, an EA could be formed:

(i) Constituting every single Village; or

(ii) Putting together two or more Villages; or

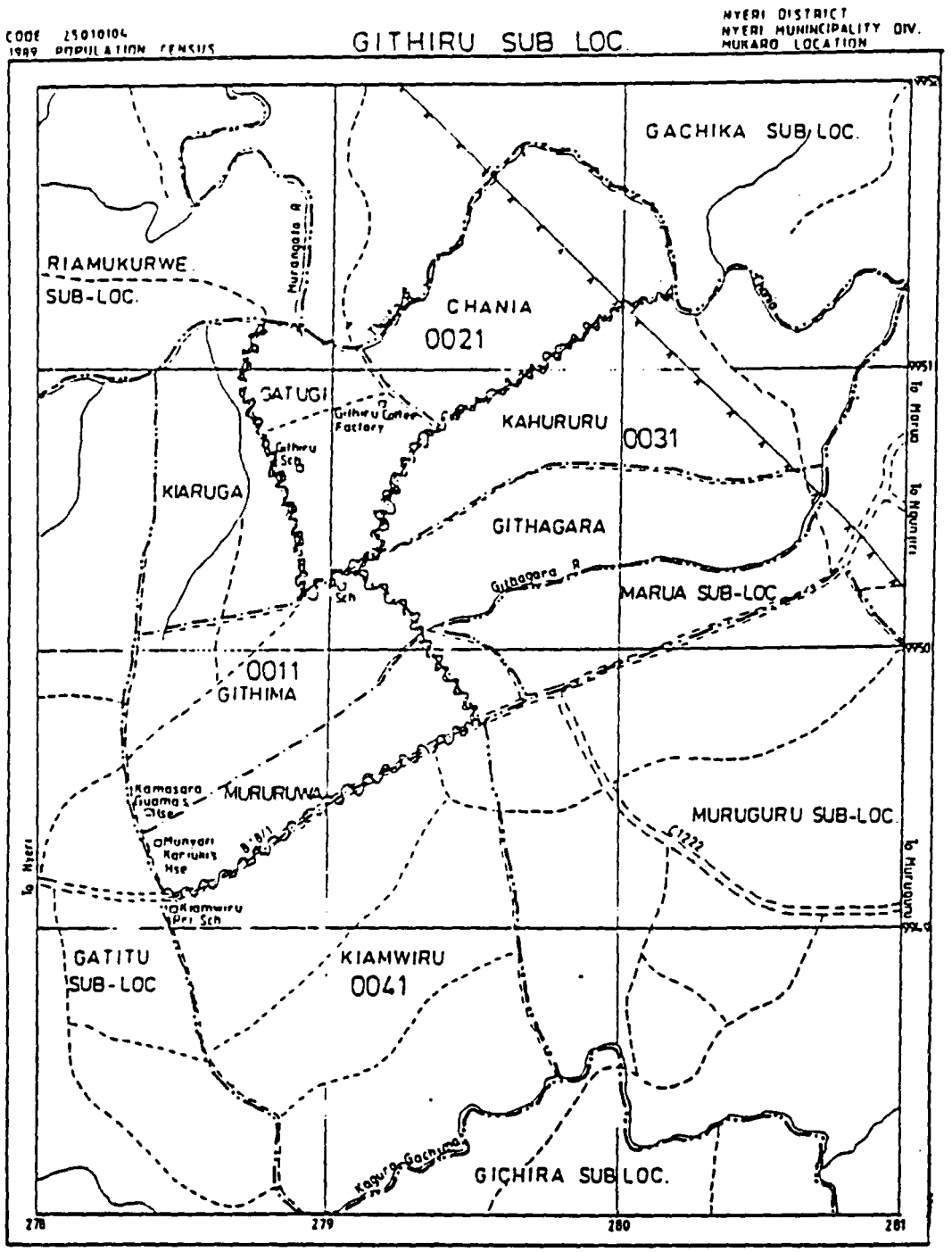
(iii) Dividing or splitting a large Village into a number of EAs.

In each case the identity of the village was maintained. This

made it possible to use the Assistant Chiefs and Village Elders to assist in the identification of the difficult EAs during the census enumeration. Thus in no circumstances an EA was created by taking the parts of two or more adjoining villages. If a village was slightly bigger or smaller than the prescribed size of EA, it was delineated into one EA without subtracting from or adding to it a part to get the recommended population size.

Fig. 4.2 below shows an EA map representing Githiru Sub-Location in Nyeri District. According to the map, EA 0011 was formed from Mururuwa, Githima and Kiaruga Villages; EA 0021 was formed from Gatugi and Chania Villages; EA 0031 was formed from Kahururu and Githagara Villages; and EA 0041 was formed from Kiamwiru Village.

GURE 4.2 GITHIRU SUB-LOCATION



EA NUMBER	ENUMERATORS
0011	1
0021	1
0031	1
0041	1

SOURCE: 1989 KENYA POPULATION CENSUS.

If a Village (on the basis households) needed to be split further to obtain EAs of the prescribed size (100 households) this was done in the field with the help of the Assistant Chiefs and the Village Elders. The splitting was based on the distribution of the Households in the Village concerned. As far as possible, it was done using identifiable features. In a featureless terrain the splitting was done with the help of other benchmarks such as schools, shops, homesteads belonging to the Assistant Chief, Village Elders or other prominent people. Such benchmarks were plotted on the base maps.

4.4.4 Mapping Enumeration areas in Urban centres

It is not easy to find a single definition for urban areas. Urban areas can be defined by using the following characteristics:

(i) Population size.

(ii) Percentage of non-agricultural workers.

(iii) Administrative status.

(iv) Public amenities which define urban way of life.

For the purpose of the 1989 population census, all City Councils, Municipal Councils, Town and Urban Councils, all District Headquarters and all the towns and trading centres having a minimum population of 2000 and potential for future growth were

classified as urban areas. This definition had been used earlier for the 1979 census. There were 174 urban areas in the 1979 census (volume one , Kenya population census, 1979) but there were other trading centres which may have recorded less than 2000 people census and which had grown very fast in the intercensal period. These were treated as urban areas during the mapping work.

Delineation of EAs in urban areas sometimes presented unique problems due to rapid expansion of their population in areas of high degree of congestion particulary in squatter areas.

Suitable base maps , covering new expansions and peripheral areas some Urban areas were often not available necessitating the preparation of field sketch maps. Such areas were the densely populated slums of the major urban centres e.g Mathari, Kariobangi and Kibera areas in Nairobi.

The field procedures used in the urban areas, included base map updating, listing of structures[6] and quick counting of households to derive population estimates and accordingly delineate the EAs on the urban base maps.

All the structures were plotted on the base maps. Each structure was assigned a number. The number was written on the structure

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[6]A structure was defined as any unit of construction irrespective of the type of material used, which had four walls or an all round wall, a roof and at least one door. Toilets or latrines and open shelters were excluded from this definition.

as well as on the base map. This was meant to facilitate quick identification of the structures in the EAs on the ground as well as on the EA map at the time of the census. This exercise of listing the structures and obtaining Household estimate was done for the first time.

The delineation of the EAs was carried out on the base maps on the basis of the estimated number of households. Each EA was approximately to contain about 100 households like in the rural areas.

The boundaries of some municipalities, towns and urban councils as defined by the Ministry of Local Government generally encompass one or more Sub-Locations in their entirety. Thus these urban and town councils often include areas which are not of urban character by any reckonening. Therefore while delineating these urban areas into EAs , the limit of the actual urban area was identified and the EAs carved out within the same. The EAs were coded differently for identification purposes so as to facilitate reporting of the data for the "core urban" and "peri-urban".

In updating the base maps and delineating EAs in the urban areas, each Sub-Location was divided into blocks[7] using major features like roads,streets, rivers, railway lines,etc. In the major urban areas each block was made comprising of one or two housing

[7]Each Sub-Location in the Urban Areas was subdivided into smaller units called Blocks for the convenience of field work. Eas were delineated with in the Blocks.

estates making sure that slum areas were not put together with other planned housing estates.

Each block was assigned to two mapping assistants to list the structures and estimate the total number of households in the block.

In the block the structures were numbered continuously without any break. The structure numbers were written on the structures themselves as CBS/KPC/001, CBS/KPC/002, CBS/KPC/003 etc and on the base maps as 1, 2, 3, 4 etc. Figure 4.3 below represents a part of an EA map for Umoja Sub-Location in Nairobi. Each structure on the is identifiable with a number. For example in EA 0122, the structures were numbered from 51 to 101. The numbers on the structures were written where they could be traced by any body without difficult and at the same time be out of reach from children who could erase them. In the case of structures which had clearly more than one housing unit they were numbered using "/" after the structure number as CBS/KPC/001/1, CBS/KPC/001/2, CBS/KPC/001/3 etc. Here a housing unit was considered to be synonymous with a single flat in an apartment. The structure numbers plotted on the maps were used at the time of enumeration to identify the enumeration areas. At the same time the structure numbers were written on the structure/listing form shown in appendix 4.4.

While in the process of numbering the structures, the Mapping Assistants noted the purpose for which the structure was used.

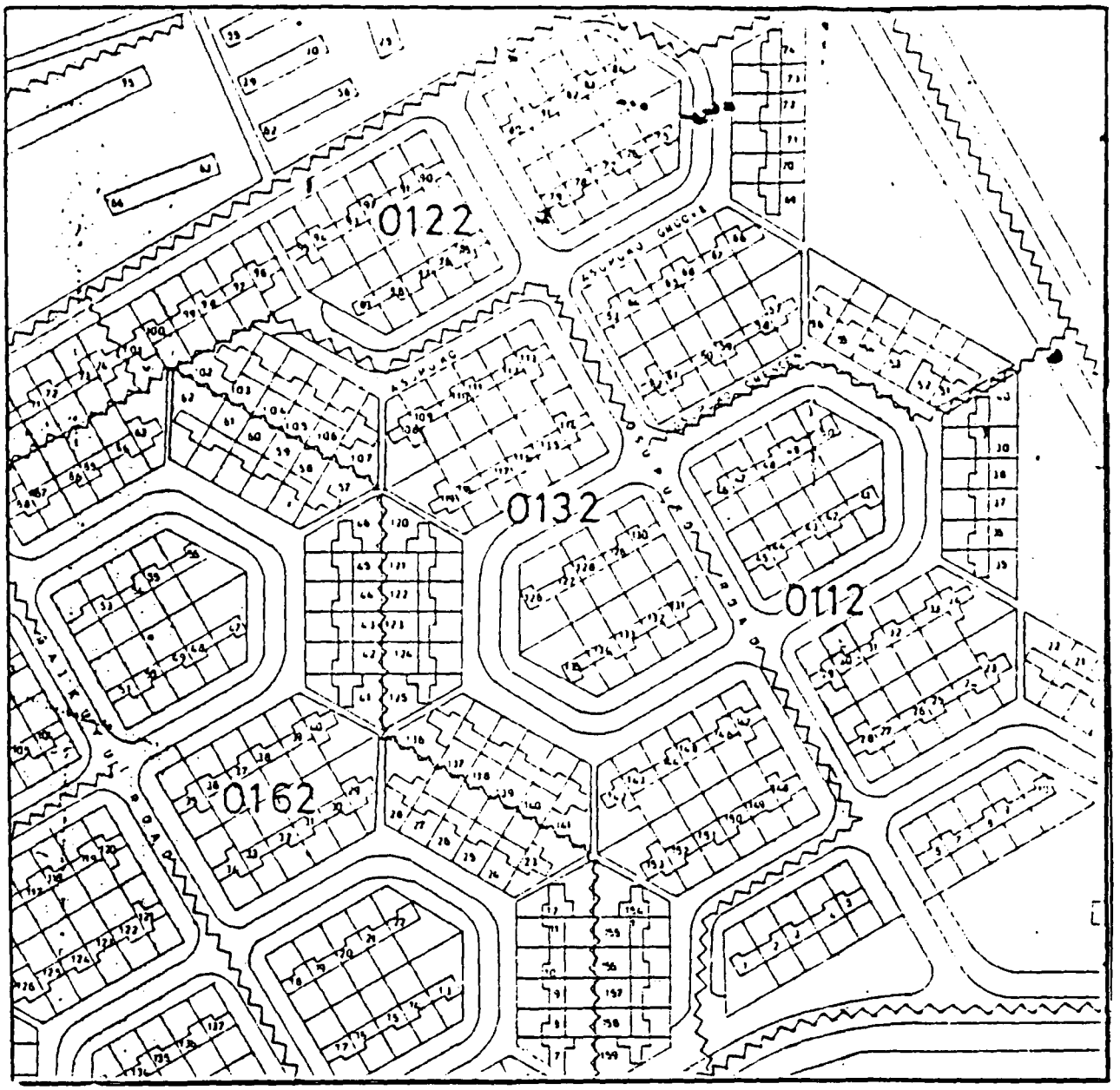
This was done by asking the people around the it. The importance of doing this was that out of all the structures listed in a place it was possible to know how many of them were used for dwelling purposes.

FIGURE 4.3 UMOJA SUB-LOCATION

CODE 10070201
1989 POPULATION CENSUS

UMOJA SUB-LOCATION SHEET 1

NAIROBI DISTRICT
EMBAKASI DIVISION
NJIRU LOCATION



SOURCE: 1989 KENYA POPULATION CENSUS.

There were many purposes for which different structures were used. They were used for dwelling purposes[8], for business and as Kitchens. Sometimes could be used for dwelling as well as for business, and for dwelling as well as Kitchen. The mapping staff noted down the purposes for which all the structures were used. Such information was shown on form CBS/KPC.89/2 as DU, B, K, DU/B, DU/K, V and O if the structure was used for dwelling, business, kitchen, vacant and any other purpose not specified respectively.

The total number of structures which were classified as DU, DU/B, and DU/K were taken to be equivalent to the total number of households in a given block. This in formation was used to delineate EAs of approximately 100 households within each block.

4.4.5 Mapping Areas with sparse population.

The Districts classified in this category are the ones inhabited by nomadic and semi-nomadic people (people whose mode of life make it difficult for the census organization to incorporate them in the preparatory geographical work). They include, Turkana, Samburu, Marsabit, Isiolo, Mandera, Wijir, Garissa, Tana River, Lamu, Narok, and Kajiado Districts. Field work in these Districts was purposely started simultaneously on 26 August, 1988. The timing of the field work was purposely selected to determine the whereabouts and patterns of the nomadic population during this

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[8]A "dwelling Unit" was defined as any structure or building, permanent or temporary, where people sleep. It could be a store with a sleeping room at the back or sides.

particular season as the census enumeration was scheduled to take place during the same time in August the following year (1989).

Prior to the commencement of field work a meeting of the team leaders assigned to these Districts was convened on 18th August, 1988 at the census headquarters to be briefed on the general strategies and other issues pertinent to the field work.

Field work in these areas was planned and carried out with greater involvement of the local administration personnel who generally have knowledge about the seasonality and direction of the movement of the nomadic people in their areas. The Assistant Chiefs and the Local Elders who are generally familiar with the modes of life of the local people were used throughout the field work exercise.

An added advantage of the involvement of the Assistant Chiefs and the local Elders in the mapping exercise was the utilization of their knowledge and experience about the area which was considered very crucial in the absence of any other source of information. The understanding of EA maps by them, at the time of the field mapping made them make their best use at the time of the census enumeration.

Field mapping in the arid and semi-arid Districts had to be completed within one month. This was important since the people had to be located where they were in August 1988 because it was hoped that, they would return to the same places the following

year. The following activities were to be performed within a short period:

(i) Obtaining lists of administrative divisions from the concerned authorities at the District headquarters and briefing the District Commissioner and the District Officers about the mapping work.

(ii) Providing copies of form CBS/KPC/89/7 in adequate numbers to the assistant Chiefs and explaining to them the relevant concepts and procedures involved in filling them at the Divisional Headquarters.

(iii) Fixing appointments with the assistant Chiefs to visit their respective Sub-Locations for collection of the completed forms CBS/KPC/89/7 and carry out the field work.

(iv) Plotting the locations of the settlement centres on the base maps with the help of the assistant Chiefs.

In the nomadic areas size of the EA was mainly determined in terms of the distance and the walking time without laying much emphasis on the population size. An EA contained one or several settlements depending on the distance between them. Enumeration area boundaries were fixed arbitrarily to encompass the settlement(s) already forming the EA(s). The most important thing was the location of the settlement but not the EA boundary.

There were two types of EAs delineated, namely EAs covering permanent settlements and EAs covering temporary settlements. The locations for permanent and temporary settlements were shown on the base maps differently. Large Urban areas were treated in the same way like any other Urban Centres.

4.4.6 Mapping EAs in the National Parks.

In Kenya, National Parks and large Forest areas such as Tsavo National Park, Mount Kenya Forest and Mount Elgon Forest are not administered under any Sub-Location. There are, however people who work and live in these areas. Arrangements had to be made to enumerate all these people at the time of the census.

At the time of mapping for the census, the National Parks and Forest areas were treated and coded at the level of Sub-Locations or Locations or Divisions depending on their sizes. The mapping staff consulted with the officials concerned who provided the information concerning the composition of the people and their locations. The locations of the people were marked on the base maps and the EAs were delineated in the same manner as in the Arid and Semi-Arid areas i.e emphasis was put on the locations of the settlement centres.

4.4.7 Treatment of special areas.

This category of EAs may include collective households such as Hospitals, Hostels, Prisons, Army camps, etc. The procedures

which were applied for delineating EAs comprising collective households were more or less the same as for the normal EAs. The important difference was that they were to be enumerated by officials from these institutions.

If the population of any collective household was less than the prescribed size range, it was put together with other neighbouring population for the purpose of EA delineation. However this procedure was not applicable to some households of classified nature like the army, police and prison camps for which the enumeration arrangements were generally made by the concerned authorities and carried out by their staff.

4.4.8 Symbols used during the field mapping.

Before EA field mapping for the 1989 population census started, the Cartographic section worked out a symbolisation scheme that was used throughout the field mapping exercise. It was essential to annotate the base maps properly in the field because the maps were to be used in the compilation of the final EA maps by people who did not participate in the field work. It was important for the office compilation and drafting staff to understand clearly the information on the base maps from the field.

The symbols for representing Administrative, Village and EA boundaries, place names and EA numbers were chosen very carefully. While choosing the symbols care was taken to avoid overcrowding the base maps. It was important to make sure that

while updating the base maps other topographical features were not covered. The various symbols used are shown in table 4.3 below. Transparent colours were used to annotate the maps . This technique provided clarity without blocking other background topographical features.

Table 4.3 Symbols used during the field mapping.

Element	Symbol	Colour	Size
District boundary		Red	Large
Divisional boundary		Red	Large
Locational boundary		Green	Large
Sub-Locational boundary		Blue	Large
Village boundary		Yellow	Fine
Enumeration area boundary		red	F i n e
Permanent Settlement		Blank	Fine
Temporary Settlement		Black	Fine
Division Names		Red	Lage
Location Names		Green	Fine
Sub-Locational Names		Blue	Fine
Village/EA Names		Red	Fine
Other Names		Black	Fine

The EA boundary like the administrative and Village boundaries was shown with a unique line symbol. The symbol used for the EA was a red "wiggly" line. It stood out clearly and did not cover the other features on the base maps. This style of showing EA

boundaries was used in the 1979 population census and it was also used in the 1982 population census of Zimbabwe (International yearbook of Cartography, 1988, Census cartography in Zimbabwe, pp 31) and the 1988 population census of Tanzania.

4.4.9 Numbering the Enumeration Areas

The EAs in each Sub-Location were systematically numbered e.g 001, 002, 003, 004 etc making sure that consecutive numbers were placed next to each other. This was necessary in order to locate EAs by the numbers on the maps quickly. They were numbered beginning at the North-West or the North-East and moving in the clockwise direction. Numbering the EAs was done immediately after completing delineating them in each Sub-Location. A record was made of all the EAs on form CBS/KPC/89/6 shown in appendix 4.3.

The boundaries of all the EAs in each Sub-Location were described using form CBS/KPC/89/3 shown in appendix 4.5. The boundaries of each EA were described from North-East in the clockwise direction. A convenient point was chosen as a starting point and the description was done in giving names of the features that were used as EA boundaries and others that were close to the EA boundary. Space was provided at the bottom of the form to give additional details about the EA e.g mentioning about special EAs, Forest and National Park EAs, Labour lines, Prisons etc. Also it was necessary to explain the best route of reaching the EA from a known point that was shown on the EA map. Both forms CBS/KPC/89/6 and CBS/KPC/89/3 were filed in the Sub-Location file

and send to Cartographic Section in Nairobi. They were used for reference during the compilation and drafting of the final EA maps.

4.4.10 Large Enumeration Areas

The pilot census undertaken in November, 1988 provided valuable experiences which afforded a sound base for improvement as far as EA delineation was concerned. According to reports from the pilot census, EA boundaries were easily identifiable in almost all the Sub-Locations which had been selected for the census pilot. However the reports showed that, there were some variations in the EA sizes regarding the population sizes. A few EAs contained more than 100 households. This made it difficult for the Enumerators to finish their work within the specified period.

The variations in the EA sizes were however expected because of the following reasons:

(i) In some areas EAs were delineated without HouseHold estimates. The Assistant Chiefs had not completed forms CBS/KPC/89/7 by the time field work undertaken in their Sub-Locations.

(ii) In some other cases, although the Assistant Chiefs had provided the HouseHold estimates, it proved too difficult for the field mapping staff to subdivide

some Villages to obtain the required EAs due to lack of good EA boundaries on the ground.

(iii) In some Urban Centres, in slum areas and areas with very big blocks containing several hundreds of HouseHolds, It was difficult to show very small EAs (area wise) on the base maps.

At the time of the census enumeration, District Officers were asked to deploy more Enumerators on the large EAs. Forms CBS/KPC/89/7 were used for each District to prepare a documentation on each EA map showing the number of Enumerators and supervisors required for the census. For example Figure 4.2 shows that four Enumerators were deployed in Githiru Sub-Location.

A total of 37048 Enumeration Areas were delineated in the whole country of which 20% had houseHold estimates in the region of 150-300. The number of EAs that had more than 300 Household was very small in the whole country. According to table 4.2, a total of 42493 Enumerators and 8,499 Supervisors were deployed in the census.

4.4.11 Sub-Location boundary problems

The field mapping staff visited 3667 Sub-Locations in the country during the 1989 population census field mapping. One of the most important tasks which the mapping staff undertook during the

field mapping work was to plot the Sub-Location boundaries as correctly as possible. They performed this task with the assistance of the Assistant Chiefs and Village Elders most of whom understood the Sub-Locations very well.

There were however problems that were encountered by the field mapping staff in the field regarding the boundaries. The problems were however followed until all were completely solved before the census enumeration. After the first round of field mapping, some overlaps regarding Sub-Location boundaries were noted in the Sub-Locations shown in appendix 4.1. The reasons for the overlaps were:

(i) Some Assistant Chiefs were not conversant with the correct Sub-Location boundaries because they were newly recruited.

(ii) Some Assistant Chiefs wanted to include into their areas people who had migrated out of their Sub-Locations to the Neighbouring Sub-Locations.

(iii) Some Assistant Chiefs' homes were located in the neighbouring Sub-Locations and they wanted to be counted were they were already administering.

(iv) Some Assistant Chiefs ignored the Sub-Location boundaries to administer according to clans.

The information concerning Sub-Locations with boundary problems was communicated to the District Commissioners who arranged for the boundary problems to be solved administratively after which the mapping staff re-visited the affected Sub-Locations and mapped them accordingly.

Copies of all the drafted EA maps were send the Assistant Chiefs to Confirm the Sub-Location boundaries. The Assistant Chiefs were asked to check and correct (with the assistance of the C.B.S field staff) the Sub-Location boundaries and satisfy with their stamps. In June, 1989, all the corrected Sub-Location maps were returned to Cartography section. Generally most maps,about 98%, were okay as far as Sub-Location and Village boundaries were concerned. There however few problems with spelling of names and misplacement of features. After checking with the original field copies, it was found that most of these problems resulted in the compilation and drafting stage. All the maps were corrected in the office and were ready for the census in time.

4.5 CONCLUSION

The 1989 population census needed accurate and up-to-date Enumeration Area maps. Despite the problems that faced the cartographic field work, for example lack of suitable base maps, a lot was achieved through the effort of the planners and the cartographic staff. By planning a detailed field mapping programme, it was possible to collect the required information from the field which was useful in the preparation of the final

census enumeration maps.

The Sub-Location-Location and Village boundaries on which Enumeration Areas were based and which were lacking on the base maps were plotted with the help of the Assistant Chiefs and Village Elders. These boundaries had never been plotted in this manner before. Most of the topographical features that were needed for the delineation of the Enumeration Areas and which had been missing were plotted. This exercise involved visiting all the Sub-Locations in the country, which measures about 580,000 sq.km and which comprised of 3,667 Sub-Locations at the time. It was the most difficult and expensive undertaking of all the census activities. More than 50% of the administrative boundaries were not on maps before the field work. It was the first time in the history of census in Kenya that information regarding Sub-Locations boundaries was gathered from the Assistant Chiefs. Boundary problems which were encountered were solved before the enumeration.

Also Household estimates which were very useful in deciding on the EA boundaries were obtained for all the Sub-Locations for the first time. On the basis of the Household estimates, it was possible to control the sizes of the EAs delineated during the field work. This was an advancement from the previous censuses.

The availability of Household estimates also made it possible to estimate the number of Enumerators, Supervisors and the quantities of materials required for entire census enumeration.

A total of 37048 Enumeration Areas were delineated about 42,493 Enumerators and 8,499 Supervisors were deployed in the census. The information about Enumerators and Supervisors for each Sub-Location was particulary useful in distributing the census materials e.g questionnaires.

The decision to involve Assistant Chiefs and village Elders and the Central Bureau District Statistics field staff was very good. The Assistant Chiefs and Village Elders helped to identify Sub-Location and Village boundaries correctly because they new them very well. This was sensible because they were used later at the time of the census enumeration to identify Sub-Location and village boundaries which could not be identified easily by the Enumerators.

The Central Bureau District Statistical Field Staff were very experienced having worked with maps in the field for a long time. They knew their Districts very well and they assisted field mapping staff from Headquarters a great deal. Although they were deployed in the field mapping work late, they caught up very quickly and their contribution was highly acknowledged. They should be used to continually update the census maps in their Districts in the intercensal period.

Despite several adjustments of the deadline which had been set for completing field work, field work was not generally completed in some Districts until May, 1989, just a few months before enumeration. In some areas, call backs to solve boundary problems

continued to be undertaken until a few days to enumeration. Delays in the production of clean copies of EA maps by draughtsmen, determination of the number of Enumerators and supervisors, and determining the volume of materials for each District were inevitable. There were further delays in the packing and despatch of the enumeration materials.

In conclusion, the 1989 Kenya population census field work was a big success. This was reflected from the quality of EA maps which were finally drawn and used in the census enumeration. During the census there were no major problems in the identification of the enumeration areas. This success can be attributed to dedication of the field mapping staff. The U.N cartographic Adviser who was informed in the planning of the census mapping work made the following observations (which summarises the cartographic field work) during a mission to Kenya:

(i) The field staff in most of the Districts visited by the regional Adviser were found in high moral and with a remarkable spirit of dedication to work assigned to them. This was well reflected in the good quality of work turned out by them.

(ii) The identification of boundaries up to Village level on the ground by the field staff with the help of local Assistant Chiefs and Village Elders and putting the same on maps is in fact the most

ambitious activity ever under taken by any Government department in the country. The significance of this information has already been appreciated by other concerned authorities in correctly defining and demarcating the administrative boundaries on the survey maps. This information therefore should be consolidated properly and later brought out in the form of maps and gazetteers for reference and use by all the concerned.

CHAPTER 5.

THE CENSUS GEOGRAPHICAL CODING METHODOLOGY

5.1 INTRODUCTION

The most crude method of identifying an area or place is by its name but this method may prove not to be good when the multi-hierarchial classifications of areas are involved and the areas of lower order are required to be identified within the higher order divisions indicating chain of hierarchial units falling in between. Occurrences of common names, which are conspicuous features in Africa and Kenya in particular, may still pose another problem to accurately identify places. However the inconveniences and short- comings of the above method can best be resolved by the use of an appropriate code scheme, through which each discrete area unit is defined by a unique code formed of numerals.

The use of geographical code[1] scheme in the census is primarily required to identify uniquely the geographical areas of various levels for which the data are to be reported, and tie the constituent Enumeration Areas to each of these areas in a systematic manner in order to derive precise data aggregates without any omission or duplication. The code scheme therefore needs to be comprehensive to include all the area units adopted

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[1]Geographic code refers to a method by which the locations of any discrete areas or other geographical entities of locational character can be described and identified precisely in terms of their placement within the divisions of higher order.

for reporting and data collection in a consistent manner. It is advisable to have the code scheme developed in the initial stage of census planning so that it is available at the time of cartographic work for field verification, and assigning codes to EAs as well as other data collection areas. This chapter will introduce the methodology used to develop unique geographical codes.

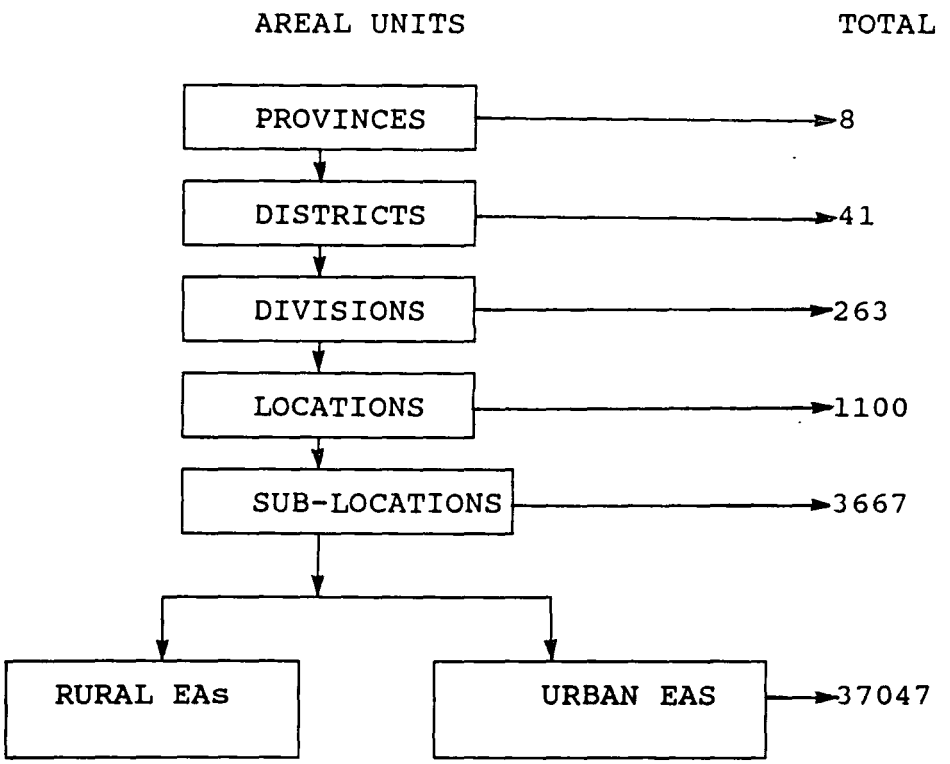
5.2 THE CENSUS AREAL UNITS

At the time of the census, there were 8 Provinces, 41 Districts, 263 Divisions, 110 Locations and 3667 Sub-Locations. The Sub-Locations were further subdivided into 37,047 Enumeration Areas. All the Provinces, except Rift Valley, had less than 10 Districts. There were four Districts having more than 10 Divisions. Machakos had 11, Meru had 13, Kisii had 12, and Kakamega had 13. In average there were 26 Locations in a Division and 4 Sub-Locations in a Location. There were, however, a few cases in Siaya, Kitui, Nyeri, Kiambu and Machakos Districts where there were more than 10 Sub-Locations in a Location. The average number of Enumeration Areas in the Sub-Locations was about 11. But there were several cases, especially in the Urban Areas where there were more than 100 Enumeration Areas in a Sub-Location.

Rift valley Province, for the convenience of the code scheme was divided into 2 parts, North and South. North Rift Valley comprised of Baringo, Elgeyo Marakwet, Samburu, Transnzoia, Turkana, Uasin Gishu, and West Pokot Districts and South Rift

Valley comprised of Kajiado, Kericho, Laikipia, Nakuru Nandi, and Narok Districts. Figure 5.1 below shows these areal units.

Fig.5.1 The census areal units



5.3 THE CODE SCHEME

The Main procedural steps involved in the development of a census geographical code scheme based on the administrative structure were as follows:

(i) Preparing lists of all the administrative areas at various levels for which census data were to be collected and reported. The 1979 census list was used and it was updated during the field work.

(ii) Establishing a hierarchy in the various administrative areas in order to determine the number of coding fields, and the order of their arrangement in a composite code scheme. In the hierarchy any area at a particular level must be assignable to one of the areas of the next higher level. The hierarchy as shown in figure 5.1 was straight forward.

(iii) Finding out maximum number of sub-divisions that any area units at the individual administrative levels may have in order to decide about the number of digits for the respective coding fields. The 1979 population census geographical file was used and later updated during the geographical field work.

(iv) Deciding about sub-classifications of places by which the data were to be tabulated in order to determine the number of type codes and their placements in the code

scheme. The Urban and rural population was differentiated at the level of Enumeration Area.

The code scheme used 12 digits which enables the census to identify the geographical location of each Enumeration Area as well as the nature of population covered (i.e whether the population urban or rural). The highest number of Districts, Divisions, Locations, Sub-Locations and Enumeration Areas in the Provinces, Districts, Divisions, Locations and Sub-Locations respectively influenced the coding scheme. Figure 5.2 below shows diagrammatically the number of digits in the code scheme used for the Administrative Areas at the various levels and Enumeration Areas.

The first digit in the code system was allocated to Provinces. The Province codes were allocated from 1 to 9 because Rift Valley Province was divided into two parts. The second digit was reserved for the Districts within each Province with the first District always coded as 1. The third and fourth digits were assigned to Divisions within each District, the fifth and sixth digits were assigned to the Locations within each Division, the seventh and eighth digits were assigned to the Sub-Locations within each Location and the ninth, tenth and eleventh digits were assigned to the Enumeration Areas within each Sub-Location. The twelveth digit was reserved for the type of the population. It was a "1" if the EA was rural in character or it was a "2" if the EA was Urban in character.

Fig.5.2 The twelve digit code scheme

Province	1
District	2
Division	3
	4
Location	5
	6
Sub-Location	7
	8
Enumeration Area	9
	10
	11
EA type, urban or rural	12

5.3.1 The Province and District codes

The Province and District codes are shown in Table 5.1 below. Nairobi province was given code 1, Central province was given code 2, coast Province was given code 3, Eastern Province was given code 4, North Eastern Province code 5, Nyanza Province code 6, South Rift Province code 7, North Rift Province code 8, western Province code 9. Rift Valley Province was divided into two parts because there were thirteen Districts.

District codes were assigned with in each Province. Thus, in Eastern Province, there were six Districts namely Embu, Isiolo,

Kitui, Machakos, Marsabit and Meru and they were coded 41, 42, 43, 44, 45 and 46 respectively. Note that the District code must contain the provincial code because all the District codes start with a "4" which is the code for Eastern Province.

Table 5.1 Province and District codes

PROVINCE/DISTRICT	CODE
NAIROBI	1
NAIROBI	1 1
CENTRAL	2
KIAMBU	2 1
KIRINYAGA	2 2
MURANGA	2 3
NYANDARUA	2 4
NYERI	2 5
COAST	3
KILIFI	3 1
KWALE	3 2
LAMU	3 3
MOMBASA	3 4
TAITA TAVETA	3 5
TANA RIVER	3 6
EASTERN	4
EMBU	4 1
ISIOLO	4 2
KITUI	4 3
MACHAKOS	4 4
MARSABIT	4 5
MERU	4 6
NERTH EASTERN	5
GARISSA	5 1
MANDERA	5 2

WAJIR	5	3
NYANZA	6	
KISII	6	1
KISUMU	6	2
SIAYA	6	3
SOUTH NYANZA	6	4
SOUTH RIFT VALLEY	7	
KAJIADO	7	1
KERICHO	7	2
LAIKIPIA	7	3
NAKURU	7	4
NANDI	7	5
NAROK	7	6
NORTH RIFT VALLEY	8	
BARINGO	8	1
ELGEYO MARAKWET	8	2
SAMBURU	8	3
TRANSNZOIA	8	4
TURKANA	8	5
UASIN GISHU	8	6
WEST POKOT	8	7
WESTERN	9	
BUNGOMA	9	1
BUSIA	9	2
KAKAMEGA	9	3

SOURCE: 1989 Kenya population census

5.3.2 Division Codes

The table below represents the Divisions in Embu District and their census geographical codes. The code for each Division must start with 41 where by 4 represents Eastern Province and 1 represents Embu District Eastern Province. Runyenjes Division was assigned code 4101, Manyatta code 4102, Siakago code 4103 and Gachoka code 4104.

Table 5.2 Divisions in Embu District

DIVISION	CODE
RUNYENJES	4101
MANYATTA	4102
SIAKAGO	4103
GACHOKA	4104

5.3.3 Location Codes

Table 5.3 below shows all the Locations in Gachoka Division in Embu District with their codes. Each Location code must start with 4104.

The first digit represents Eastern province, the second represents Embu District within Eastern province and the third and fourth represent Gachoka Division within Embu District. There are seven Locations in Gachoka Division and the codes were assigned as shown in Table 5.3 below.

Table 5.3 Location codes in Gachoka Division

LOCATION	CODE
MBETI NORTH LOC.	410401
MBETI SOUTH LOC.	410402
KIAMBERE LOC.	410403
MAVURIA LOC.	410404
MAKIMA LOC	410405
KARABA LOC	410406
EMBU MUNICIPALITY LOC	410407

5.3.4 Sub-Location codes

All the Sub-Locations in Municipality Location are shown with their codes in table 5.4 below. Each Sub-Location code must start with 410407 which is the code for Embu Municipality Location.

Table 5.4 Sub-Locations in Embu Municipality Location

SUB-LOCATION	CODE
NTHAMBO	41040701
NJUKIRI	41040702
DALLAS/STADIUM	41040703
KAMIU	41040704

5.3.5 EA Codes

Table 5.5 shows all the EAs and their codes in Kamiu Sub-Location. Kamiu Sub-Location is in Municipality Location shown in table 5.4 above. All the EA codes must start with 41040704 which is the code for Kamiu Sub-Location. There were six EAs and they were all assigned different codes with in the Sub-Location. The code for the first EA which is G.K Prison is 41040704001 which is different from all the rest. Also there was no other EA in the country which was having the same code. However, all the EAs in table 5.5 are similar because they all contain a "2" at the end. The "2" was added to show that all those EAs were Urban in character. The EAs in the rural areas were differentiated with a "1" at the end of the code. Table 5.6 shows the EA codes in Riakanau Sub-Location which were all in the rural.

Table 5.5 Enumeration Areas in Kamiu Sub-Location

ENUMERATION AREA	CODE
G.K. PRISON	410407040012
MAJIMBO	410407040022
KIAMBUTHI	410407040032
KIAMBUTHI (SPRING VALLEY)	410407040042
KAMIU	410407040052
IUECE	410407040062

Table 5.6 Enumeration Areas in Riakanau Sub-Location

ENUMERATION AREA	CODE
MAALI	410406030011
KILIA	410406030021
MALIKANI 'A'	410406030031
MALIKANI 'B'	410406030041
KAMBITI	410406030051
RIAKANAU	410406030061
NTHINGINI	410406030071

Table 5.7 below shows the relationship between the census areal units and their geographical codes. It shows how the EA code for G.K Prison is formed using the codes of the census areas higher in the geographical frame which is also the administrative structure. It can be seen that the EA code include all the codes for the areas higher in the hierarchy.

Area	Code
Eastern Province	4
Embu District	41
Gachoka Division	4104
Embu Municipality Location	410407
Kamiu Sub-Location	41040704
G.K Prison (EA)	4104070400 12

5.4 CONCLUSION

The 1989 population census geographical frame forms an hierarchy and hence the coding scheme was straight forward. Each Province, District, Division, Location, Sub-Location and Enumeration Area was assigned a unique code number There were many areal units at different level used for the census. Several of them shared similar names and it would have been difficult to differentiate them.

The census geographical code was used to identify each area. There were no two or more Enumeration areas with the same code. Also all the areas were represented, there were on omissions or duplications. The code scheme differentiated between Urban population was and Rural population. This will be important for the purpose of studying urbanization.

The coding scheme was worked out closely with the data processing section in the Central Bureau of Statistics. It was tested and found to be workable for data processing purposes. The code system also lends itself to aggregation at higher level areal units such as Sub-Locations, Locations, Divisions, Districts, and Provinces and the whole country.

CHAPTER 6

MONITORING THE CENSUS MAPS AND DOCUMENTS.

6.1 INTRODUCTION.

In a meeting of a working group on recommendations for the 1990 round of Population and Housing census, it was observed that indexing and storage of various maps pertaining to 1990-1991 round of censuses had not been carried out properly in majority of the countries. The resource maps collected from different secondary sources were mostly either misplaced or damaged and torn during the course of their use. In most of the countries preparing for the 1990-91 round of censuses these maps were found non-existent and needed to be prepared again. However the maps of enumeration areas and supervision areas, whenever prepared, had been listed and stored in the census offices of most of the countries. But those which were misplaced were generally not reprepared to make the coverage complete (working group on recommendations for the 1990 round of Population and Housing census in Africa, Addis Ababa, 18-12, May, 1987).

In Kenya, prior to the 1989 census geographical work, there was no system of indexing and storing census maps. The 1979 population EA and District maps were kept in the filing cabinets by Districts. This method involved a lot of delays while retrieving the maps. The topographic maps which had been used in the census 1979 were difficult to find.

During the pre-enumeration phase of the 1989 Kenya population

census, a host of resource maps and other associated documents were procured by the cartographic section from all the possible sources for use in the census mapping. These maps and documents were used in the preparation of the census maps. The census mapping programme involved very many people and the final EA maps were prepared through very many stages. There was a lot of movement of the census documents. This chapter will discuss the methods used in, indexing, storing and monitoring the census materials.

6.2 THE NEED FOR A FILING AND INDEXING SYSTEM

The preparation of the final EA maps involved the following processes:

(i) The procurement of the base maps.

(ii) Data collection or field work.

(iii) Map compilation which involved combining information from different sources (often from maps at different scales).

(iv) Drafting the final EA maps (whereby the compilation manuscript was traced off).

(v) Editing the final EA map (which involved checking the drafted EA map against the compilation manuscript, original field copies etc).

(vi) Correcting the drafted maps after they were edited.

(vii) Confirmation of the Sub-Location boundaries by the Assistant Chiefs.

(viii) Reproducing enough copies of the EA maps for enumeration.

(ix) Packing (by Sub-Location, Location, Division and District) and dispatching the EA maps to the right places.

In view of the fact that very many people were involved in the census mapping work which involved very many tasks, there was need for developing a good filing and storing system. The Cartographic section was responsible at the time of planning for the census mapping programme, for designing such a system of filing and storage to:

(i) Ensure that all the tasks were performed smoothly and efficiently.

(ii) Ensure that the maps and documents used in the census were retrieved easily whenever they were required.

(iii) Provide easy cross referencing of the census mapping information since it was contained in different source materials.

(iv) Ensure accountability of census maps and documents.

6.3 INDEXING AND FILING THE CENSUS MAPS AND DOCUMENTS.

All the 1989 Kenya population census maps and documents were controlled from a central office. The office was looked after by five officers. The Officers were accountable for each and every map or document that was recorded in the office. The maps and documents included:

(i) Survey of Kenya topographic maps.

(ii) The 1979 population census EA maps.

(iii) Forms CBS/KPC/89/2, CBS/KPC/89/3, CBS/KPC/89/6, CBS/KPC/89/7.

(iv) Sketch maps made in the field during the field work.

(v) The drafted 1989 census EA maps.

(vi) Edited copies of the 1989 population census EA maps

(vii) EA maps checked, verified, and returned by the Assistant Chiefs.

(viii) Other miscellaneous documents related to the census mapping work.

The filing and indexing system devised by the cartographic section involved three records namely:

(i) Topographic maps.

(ii) Sub-Location files; and

(iii) The final drafted EA maps.

6.4 THE TOPOGRAPHIC MAPS.

After all the toposheets were received from the field, each toposheet was assigned an identification number that was referred to as "CBS index number". The first toposheet was assigned CBS/KPC/89/001, the second was assigned CBS/KPC/89/002 etc. The toposheets were numbered consecutively for each District. For example, tables 6.1 and 6.2 below show both the CBS and the Survey of Kenya index numbers for the toposheets covering Embu District and Wajir District respectively. From table 6.1, it can be noted that toposheet (s.o.k index numbers) 122/4 and 136/2 were used more than once within the same District but each sheet was assigned a different CBS index number. The CBS index numbers and S.O.K numbers were marked appropriately in the respective Sub-Location files and on the EA maps. They used for filing and retrieving the toposheets from the filing cabinets.

Table 6.1 Census Topographic maps-Embu District

S.o.K Index Number	C.B.S Index number
122/3	001
122/4*	002
136/1	003
136/2*	004
136/3	005
136/4	006
121/2	007
121/4	008
135/2	009
135/4	010
136/2*	011
122/4*	012

SOURCE: 1989 Kenya population census.

Table 6.2 Census Topographic maps-Wajir District

S.O.K Index Number	CBS Index number
NA-37-15	315
NA-37-16	316
NA-37-11	317
NA-37-12	318
NA-37-7	319
NA-37-8	320
NA-37-3	321

SOURCE: 1989 Kenya population census.

There were 780 topographic maps received and recorded for all the Districts after the field work. Each topographic map was attached to a filing strip. They were all filed in one cabinet. The cabinet was levelled "the 1989 population census topographic maps". Whenever a particular toposheet was required in the course of map compilation, drafting, editing etc, it was retrieved from the cabinet using the CBS index number. There was a form which was used to monitor the movement of each toposheet. An example of that form is shown in table 6.3.

Table 6.3. Toposheet Control Form

Sheet no.....of....sheets.

TOPOSHEET CONTROL FORM.

DISTRICT.....

CBS INDEX NUMBER.....
S.O.K INDEX NUMBER.....MAP SCALE.....
RECEIVED BY.....
DATE RECEIVED.....

TOPOSHEET MOVEMENT RECORDS.				
Date borrowed	Signature	Name	Signature	Date Returned

SOURCE: 1989 Kenya population census.

6.5 THE SUB LOCATION FILES.

There was a file for each Sub-Location opened in the field by the Team Leaders. The file was identified with the code number of the Sub-Location. The code number was written boldly on top of the Sub-Location file. Each Sub-Location file contained the following items:

(i) The 1979 EA maps returned from the field containing details on the Sub-Location, Village and Enumeration Area boundaries.

(ii) Form CBS/KPC/89/2 containing structure numbers and names of Household Heads for the Urban areas.

(iii) Form CBS/KPC/89/3 containing the description of the EAs.

(iv) Form CBS/KPC/89/6 containing information about EAs, their codes and number of HouseHolds in each village.

(v) CBS/KPC/89/7 containing names of Household Heads for rural areas.

(vi) Sketch maps whenever applicable.

(vii) Miscellaneous maps/documents associated with each Sub-

Location.

(viii) Enumeration Area map compilation manuscript.

(ix) Certified copies of EA maps returned by the Assistant Chiefs after checking and verification on the ground.

If a Sub-Location file was full, a second file was opened with the same code number. The first file was designated PART A and the second file was designated PART B. Most of the Sub-Locations which covered Urban areas had more than one file. This is because Urban Areas were mapped using large scale maps. Forms CBS/KPC/89/2 were also many per Sub-Location. Each form contained an average of 15 households.

All the Sub-Location files were filed in the lateral filing cabinets by Province, District, Division and Location using the code numbers. Their movement was controlled using the form shown in table 6.4.

Each Sub-location file was the basic record which described the information that was available for each Sub-Location. For example, the index numbers for the Topographic maps covering a particular Sub-Location were contained in forms CBS/KPC/89/2 and CBS/KPC/89/6 which were already filed in the Sub-Location file. It was therefore necessary to get the Sub-Location file before getting the topographic map(s) for any given Sub-Location.

Table 6.4. Sub-Location File Control Form

SUB-LOCATION FILE CONTROL FORM.

Sheet no.....of.....Sheets)

DISTRICT.....CODE.....
DIVISION.....CODE.....
LOCATION.....CODE.....
SUB-LOCATION.....CODE.....PART.....
RECEIVED BY.....
DATE RECEIVED.....

SUB-LOCATION FILE MOVEMENT RECORDS				
Date borrowed	Name	Signature	Date returned	Signature

SOURCE: 1989 Kenya population census.

6.6 THE DRAFTED ENUMERATION AREA MAPS.

Each time an EA map was ready, it was handed over to the records office. The officer responsible for the records office signed for receiving each map.

All the EA or Sub-Location maps were fitted with filling strips and filed in the vertical filing cabinets by Province, District, Division and Location using the code numbers. There were eight filing cabinets which were used for this purpose.

The EA maps were retrieved from the cabinets using the code numbers. The movement of the EA maps, especially at the time of editing and re-production of the required copies was monitored using the form shown in table 6.5 below:

Table 6.5. EA Map Control Form Sheet no.....of.....sheets.

EA MAP CONTROL FORM.

District.....Code.....
Division.....code.....
Location.....Code.....
Sub-Location.....code.....mapscale.....
Received by.....Sheet no.....
Date received.....

EA MAP MOVEMENT RECORDS				
Date borrowed	Name	Signature	Date returned	Signature

SOURCE: 1989 Kenya population census:

6.7 CONCLUSION.

This chapter has discussed how the 1989 Kenya population census maps and documents were stored, filed and monitored making sure that the mapping work continued smoothly and efficiently. The system was adequate because throughout the mapping period, no map or document was either misplaced or lost. All the maps and documents were accounted for in the records office at any given time during the mapping exercise. There were five Officers working in the records office. They were very dedicated to the work and this made the system a big success.

When all the census mapping tasks were being carried out at the same time e.g field work, map compilation, drafting of the EA maps and printing and packing etc there were a lot of movements of all the census mapping documents between very many people. Without the filing system, it would have been very difficult to monitor and locate the census maps and documents.

It took approximately one minute to retrieve the census topographic maps, Sub-Location files and the EA maps from the filing cabinets. If any of the above documents was not in the filing cabinets, it was possible to trace it with the people using the control forms.

There were 780 topographic maps used for the census and they were given CBS index numbers from 001 to 780. The CBS index numbers were marked in the respective Sub-Location files. It was

therefore possible to find the CBS index number(s) and retrieve the topographic maps covering each Sub-Location whenever required.

The Sub-Location file contained all the mapping information for the Sub-Location apart from the toposheet(s) and the final EA map(s). Each Sub-Location file was identified with the geographical code for the Sub-Location. The code number was written boldly on the cover of the Sub-Location file. There were 3667 Sub-Locations in the census but the Sub-Location files were more since some Sub-Locations had more than one file.

The most important item in the 1989 population census was the EA map. It was identified with the Sub-Location geographical code. If a Sub-Location had several sheets, they were identified with one code number but as different sheets e.g sheet A, sheet B etc. All the EA maps were fitted with filing strips and filed in the vertical filing cabinets. The code number was written above the top margin, right hand corner where it could easily be seen while the map was still in the filing cabinet.

In the 1979 population census mapping programme, there was no indexing of census maps. Comparatively there were more maps and documents used in the 1989 population census mapping and the work could have been difficult without a way of monitoring the documents. The system should be continued up to the next census. In the intercensal period it will be useful in retrieving census maps for users and for conducting sample surveys.

CHAPTER 7

PREPARATION AND REPRODUCTION OF CENSUS ENUMERATION AREA MAPS.

7.1 INTRODUCTION.

The Purpose of this chapter is to show the steps that were taken in the preparation of the 1989 population census maps. The following issues will be raised:

(i) Map compilation.

(ii) Symbol specifications and map layout.

(iii) Drafting the EA maps.

(iv) Map reproduction.

The ultimate objective of the census geographical work was to prepare the appropriate Enumeration Area maps for use by Enumerators at the time of enumeration. Ordinarily census offices do not construct original maps that require complex surveying and highly skilled surveyors and cartographers, but they do use information from a variety of sources to produce maps for enumeration and publication purposes (US, Department of Commerce, Bureau of the Census, 1978).

The census mapping section (the Cartographic section of the Central Bureau of Statistics) acquired a host of base maps at the

population census planning stage which acted as reference materials in preparation and generation of the census EA maps. During pre-enumeration phase the base maps were mainly used, especially during the field work, to collect additional information, e.g administrative boundaries, village boundaries, EA boundaries and physical features.

Preparation and reproduction of census maps using information from various sources was a complicated process and therefore needed to be carried out systematically. The process involved very many people most of whom were inexperienced in map making. They were given training for a very short time after which they were deployed to produce thousands of maps in a very short period.

7.2 MAP SPECIFICATIONS AND GENERAL LAYOUT

It was important to keep the content and format of all the EA maps identical. This was achieved by designing symbol specifications shown in table 7.1 and the general map layout shown in figure 7.2 which were followed in map compilation and drafting. As far possible the census symbol scheme was derived from the convectional symbols used for topographic mapping for better understanding by the census field Enumerators. However, there were cases where completely new symbols were created for the census purposes. Every person who was involved in the preparation of the census maps was provided with a copy of the symbol specifications and the map layout. They were asked to

follow them strictly.

TABLE 7.1 SYMBOL SPECIFICATIONS

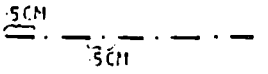
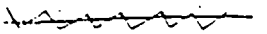
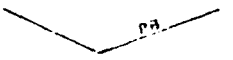
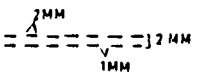
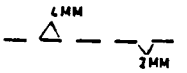
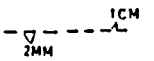
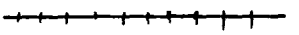
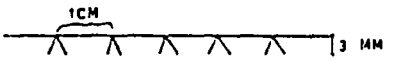
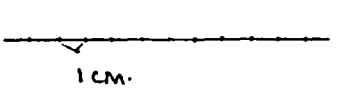
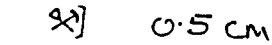
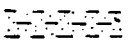
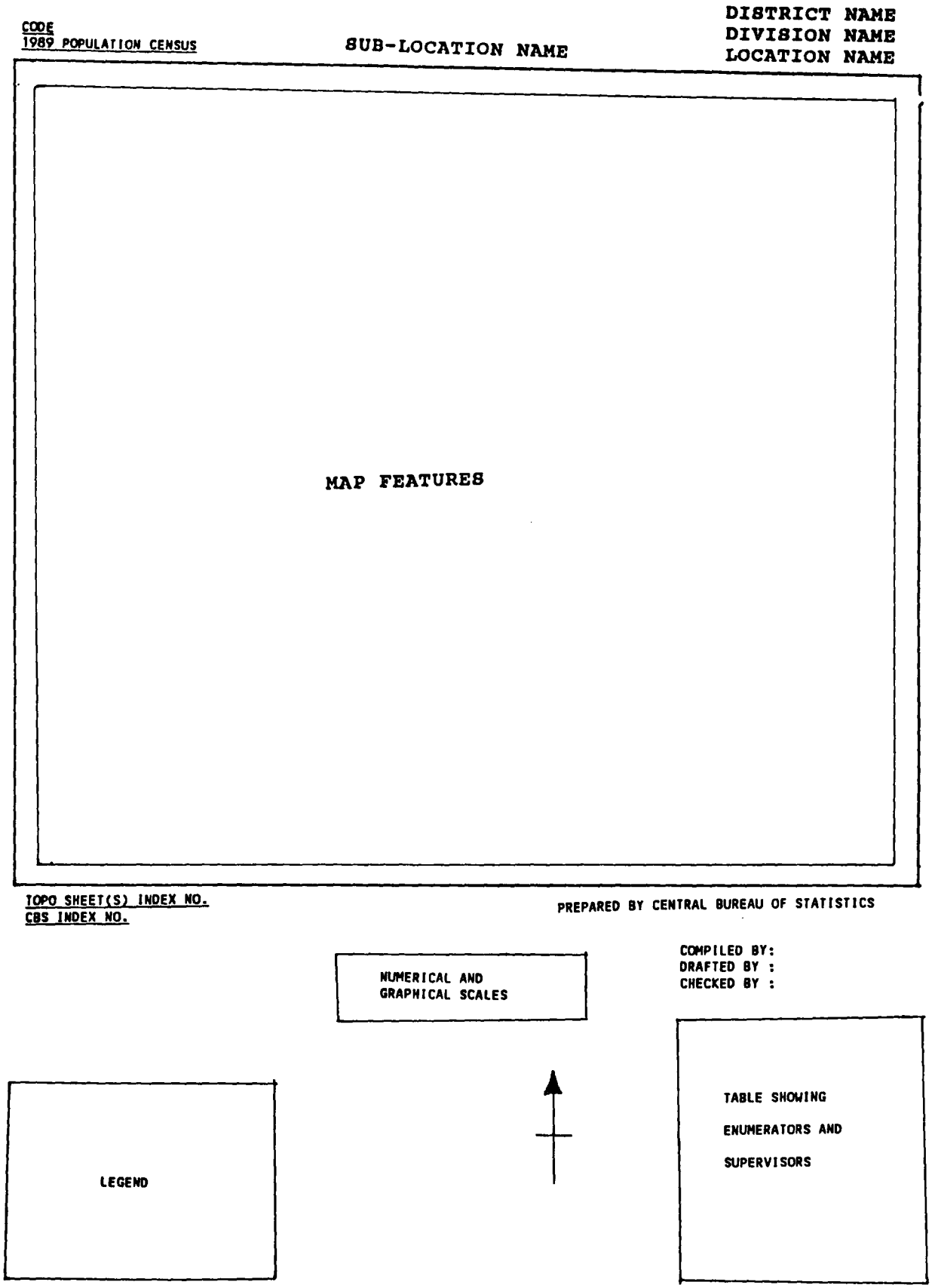
FEATURE NAME	SYMBOL SPECIFICATION	
	PEN SIZE	SYMBOL
SUB-LOCATION BOUNDARY	1	
VILLAGE BOUNDARY	0·5	
ENUMERATION AREA	·25	
PROPERTY BOUNDARY	0·25	
FOREST BOUNDARY	·25	
LINEAR FEATURES		
ROAD	·25	
TRACK	·35	
FOOT PATH	·25	
RAILWAY LINE	·25	
POWER TRANSMISSION LINE	·25	
TELEPHONE LINE	0·25	
AIRPORT / AIRFIELD	·25	
MINERAL WORKS	·25	
SWAMP	0·25	

Figure 7.2 General map layout



On the general map layout design, emphasis was put on placing various map elements in a standard manner at the appropriate places. However it should be noted that, the placement of various map elements was finally determined by the shape of the individual EA map.

According to the layout design, the Sub-Location name was used as the title of the EA map. It was written boldly and placed on top of the margin in the middle. The title was easily seen while searching for the EA maps in the filing cabinets. The code number for the Sub-Location was written at the left hand corner on top of the margin. It was used for filing purposes. The Central Bureau of Statistics and the Survey of Kenya index numbers were written below the margin at the bottom left hand corner. They were used, particularly the CBS index number, to retrieve the toposheet(s) on which each Sub-Location was plotted. On each EA map, there was a table showing the recommended number of enumerators for each EA and supervisors for each Sub-Location. This table was used to recruit the enumerators and supervisors for each Sub-Location during the census enumeration. The table was derived on the basis of the number of Households in each Village.

There was consistent placement and format of the legend, Graphic scale, North arrow (use as a directional guide). They were given at the bottom part of the map. To the possible extent the map was oriented to keep the north arrow pointing upward.

A number of copies were needed of each EA map. The original copy of the base map, therefore, had to be on material from which it was possible to make suitable copies quickly, easily and at low cost. Drafting film was recommended for this purpose. It was chosen because it retains dimensional stability, facilitates quick reproduction and it withstands rough and protracted use. Lines drawn on the film were clear, neat and sharp.

Since Census EA maps need to be handy in order to make their handling and storage convenient, a decision concerning the size of each EA maps was made. The maximum size recommended for each EA map was 1M x 1M. With this size, it was possible to fit the EA maps in the filling cabinets conveniently. Also this proved to be reasonable size for the draughtsmen while drawing the maps. They were even more useful during the census because the Enumerators could handle them with ease.

7.3 EA MAP COMPILATION

Map compilation is the process of preparing maps by bring information together from various sources (these sources could be maps at different scales). This is a complicated process and it needs to be carried out systematically. In the 1989 population census, the information required in the preparation of the final EA maps was contained in various maps and documents which included the following:

(i) Topographic maps (1:50,000 and 1:250,000) showing

District, Division, Location, Sub-Location, Village, and the delineated EA boundaries, settlement centres in the arid and semi-arid areas etc.

(ii) The 1979 census EA maps at 1:10,000 for rural areas showing Sub-Location, Village and EA boundaries, and other features.

(iii) Urban EA maps at 1:1:1000, 1:2500, 1:5000 showing Sub-Location and EA boundaries, locations of structures and their numbers

(iii) Other documents in the Sub-Location file e.g forms CBS/KPC/89/2 (showing the structure numbers and names of Heads of households in the urban areas), CBS/KPC/89/3 (containing descriptions of the EAs), CBS/KPC/89/6 (showing the delineated EAs with their codes and number of households) and CBS/KPC/89/7 (showing names of household heads in the rural areas).

(iv) Sketch maps etc.

Enumeration Area maps are "special purpose" maps, designed with specific objectives in mind. These maps provide the way in which a country is divided into EAs without omissions or duplications of areas. They should therefore contain information that is necessary for correct identification of the area covered under each EA to assist the enumeration of the entire population lying

within it.

In addition, Enumeration Area and District census maps, provide data base which is essential for the study of various aspects of population geography e.g mapping and analysis of population density and other population characteristics.

Since the preparation of the EA maps was fundamental to the success of the census, the duty of the map compilers was to show everything that would be useful to the field staff in order to canvass each census area completely and accurately. The following features were shown:

(i) Boundaries of all the areas that were included in the census frame e.g Sub-Location, Village and EA boundaries. The boundaries were formed by visible physical or cultural features and were easily located on the ground.

(ii) Transportation and communication features such as rivers, canals, bridges, roads, railways, major telephone and power lines, and ridge lines, streams etc.

(iii) Land markers such as schools, churches, parks, cemeteries, play ground; and large Government, commercial, and industrial buildings, hills, escarpments, marshes, etc.

(iv) Structure numbers in the case of Urban maps.

(v) Place names and feature names spelled correctly and located so that there was no doubt as to which features each name referred to. The correct place and feature names were obtained from the field at the time of field work.

Having determined map specifications and format or general layout design, the level of details needed for the EA maps, the next steps involved:

(i) Determining the scale of each EA map.

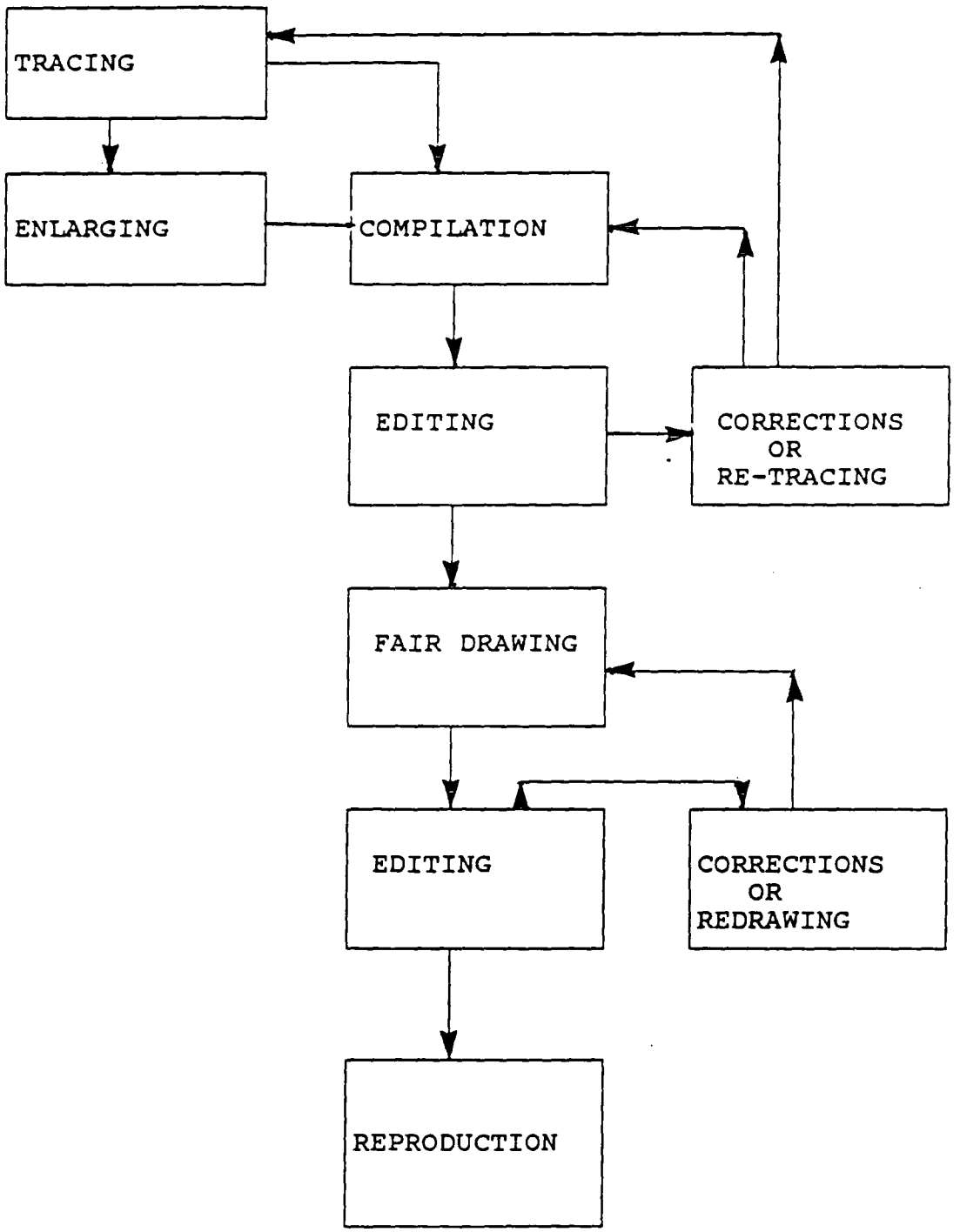
(ii) Tracing the Sub-Location outlines from the topographic maps; and

(iii) Enlarging Sub-Location outlines to the required scale.

(iv) Updating compilation manuscript.

The steps are summarised in figure 7.1 below:

FIGURE 7.1 EA MAP PRODUCTION FLOW CHART



7.4.1 DETERMINING THE SCALE OF EACH EA MAP.

The selection of the appropriate scale for each EA map was of crucial significance to the over all quality and usefulness of the census EA maps. It was done with careful consideration of all the relevant factors such as density of population, the map details and the original base map for each given area. It was necessary to keep the number of scales to minimum in order to avoid confusion and facilitate the overlying of adjacent Sub-Location maps for editing purposes. Ideally there should not have been more than three scales in the rural areas and two scales in urban areas. As a general rule EA maps had to be prepared on reasonably large scales in order to show enough details for enumeration purposes.

Generally population density was taken as the guiding factor in choosing the map scales as indicated below in table 7.2 below:

Table 7.2. Density ranges and Suitable EA Map scales

Population density range (no. of persons per sq.km)	Scale of EA map
below 25	1:250,000
25-50	1:50,000
50-200	1:25,000
above 200	1:10,000, 1:5,000 1:2,500, 1:2,000 1:1,000

There were two main classes into which the country was divided:

(i) Areas for which base map coverage was on suitable scale for EA maps; and

(ii) Areas for which base map coverage was not on suitable scale for EA maps.

7.4.2 TRACING SUB-LOCATION OUTLINES

The outline of each Sub-Location was traced from the base map(s). There were two cases, Sub-Locations whose EA maps were to be drawn at the same scale of the base maps and the other case involved Sub-Locations whose EA maps were to be drawn at an enlarged scale from the one of the base maps.

In the areas of the first category for which the base maps were on suitable scales recommended for the EA maps, the EA maps were produced directly. The Sub-Location maps were traced with all the features and annotated accordingly. Fair drafting was done on the basis of the tracings. This procedure consumed lesser time without affecting the quality of maps. Maps for Urban and arid and semi-arid areas, the National parks and Forest areas were drawn using this procedure i.e they were drawn at the same scale as the base maps. There were very few cases in the Urban areas where the EA maps were drawn at different scales rather than that of the base maps e.g slum areas. Most Urban EA maps were drawn at 1:1,000, 1:2,500, and 1:5,000.

On the other hand most Rural areas fell in the second category for which base maps were not on the scales recommended for EA mapping. The base maps were the Survey of Kenya topographic maps e.g 1:50,00 and the EA maps were required at 1:10,000, 1:25,000 and 1:5,000. In Kenya these areas represent about 80% of the total population. The outline of each Sub-Location was traced first from the topographic maps including all the linear features.g boundaries, roads, rivers, power transmission lines and locational features e.g schools, churches. The locational features were marked with a dot and the roads were shown with a double line, the gap between the two lines being made very small. Also grid lines were traced and used later in joining various portions of the map tracings.

While tracing the Sub-Location outlines, care was taken to keep the shapes of adjacent Sub-Locations identical as it was on the base maps. This was necessary in order to get common boundaries on the maps of the adjoining Sub-Locations prepared at the same scale to perfectly coincide with each other.

7.4.3 ENLARGING SUB-LOCATION OUTLINES TO THE REQUIRED SCALE

The traced outlines of the Sub-Locations were enlarged to the required scales using a photocopier. The photocopier was capable of enlarging by 200% which was twice the original scale.

The maximum paper size the photocopier could take was A3. So if a map needed to be enlarged to a bigger size than A3, the

original tracing had to be divided into portions. Enlarging was done in steps. A tracing at 1:50,000 was enlarged five times in steps to a scale of 1:10,000. The various portions of enlargements were joint together guided by the grid lines. After identifying the grid line to be used in joining two adjacent portions, one of the portions was cut very carefully in the middle of the grid line. It was then pasted onto the adjacent portion. This procedure was repeated for all the portions until a complete outline of the original tracing was formed.

7.4.4 PLOTTING EXTRA INFORMATION ON THE MAP COMPILATION

It should be noted that, only a fraction of the map details were included on the map compilation before enlargement. Various map elements e.g names, symbols etc were left out intentionally because they would have interfered with the results of the enlargements. However, these details were used to update the compilation manuscript after it was enlarged. In order to get a good enhancement of the map compilation and to avoid confusion at the time of drafting, the map features were plotted on the compilation using the colours discussed earlier in chapter 4. The compilers used the general layout map to place various map elements e.g the legend, the map title, the Sub-Location code, north arrow, graphical scale in a standardised manner.

7.4.5 CHECKING AND VERIFICATION OF MAP COMPILATION

The task of compilation was undertaken by the mapping staff who were involved in the field mapping exercise. It was easier for them to understand the various maps and documents that they prepared in the field. Each compilation manuscript was edited by the field mapping team leader who was responsible for field work in the Sub-Location. Editing involved checking and verification of map details on the compilation manuscript against the original field copies e.g the Survey topographic maps, the 1979 EA maps and other documents contained in the Sub-Location file. The spelling of place and feature names were checked and verified to ensure their correctness. The placement of various map elements were also checked and the necessary adjustments made to have utmost balanced presentation of the map. Although a general layout had been provided, the placement of some of the map elements e.g legend, map scale etc were finally determined by the shape of each Sub-Location map.

7.5 FAIR DRAFTING OF EA MAPS

After editing each map compilation manuscript and making the necessary corrections, it was assigned to the drafting staff for drawing. The work of the drafting staff was simply to draw the map features as they had been shown on the compilation manuscript. In the process of drafting the laid down specifications were used. Each of the drafting staff was given a copy of the drafting instructions. In the compilation

manuscript, the features were not plotted according to the symbol specifications in terms of pen sizes. The drafting staff were to draw these features according to the specifications. They were asked to use the right pen size for each feature as specified. In the compilation manuscript, place and feature names were written free hand but they were drafted using stencils and pens according to the specifications. Some adjustments, however, were made to enhance clarity and eliminate clustering to the possible extent. The sizes of lettering selected for various types of names was sharp, clear and appropriate for reproduction. Good quality ink (e.g Rotring ink) was used. This contributed more to the clarity of the map features on the diazo copies.

After they were drafted, the EA maps were edited again by the compilers and Team Leaders. They were checked and verified against the compilation manuscript and the other field returns. Editing of the drafted EA map involved checking:

(i) Whether the EA map was legible and easy to read.

(ii) Whether all lettering and symbols were clearly seen and easily understood.

(iii) Whether the map was simple and contained all the information which was relevant to the enumeration and needs of the user. Unnecessarily detailed and complicated map could have confused the users since most individuals involved in the census were not well experienced in the use of maps.

(iv) Whether the EA map was reasonably accurate e.g whether points and lines showed the same general relationships to one another as they did on the ground.

(v) Whether shapes and turns of roads, blocks, rivers etc corresponded with their ground positions.

(vi) Whether boundaries were shown clearly and accurately in relation to other features of the landscape.

The necessary corrections e.g omissions and items to be deleted were shown on the master copy. The master copy was taken for corrections. After the EA map was certified correct, it was handed over in the records office for recording after which it was filed in the vertical filing cabinets. Figure 7.3 shows how the final EA map looked like.

7.6 MAP REPRODUCTION

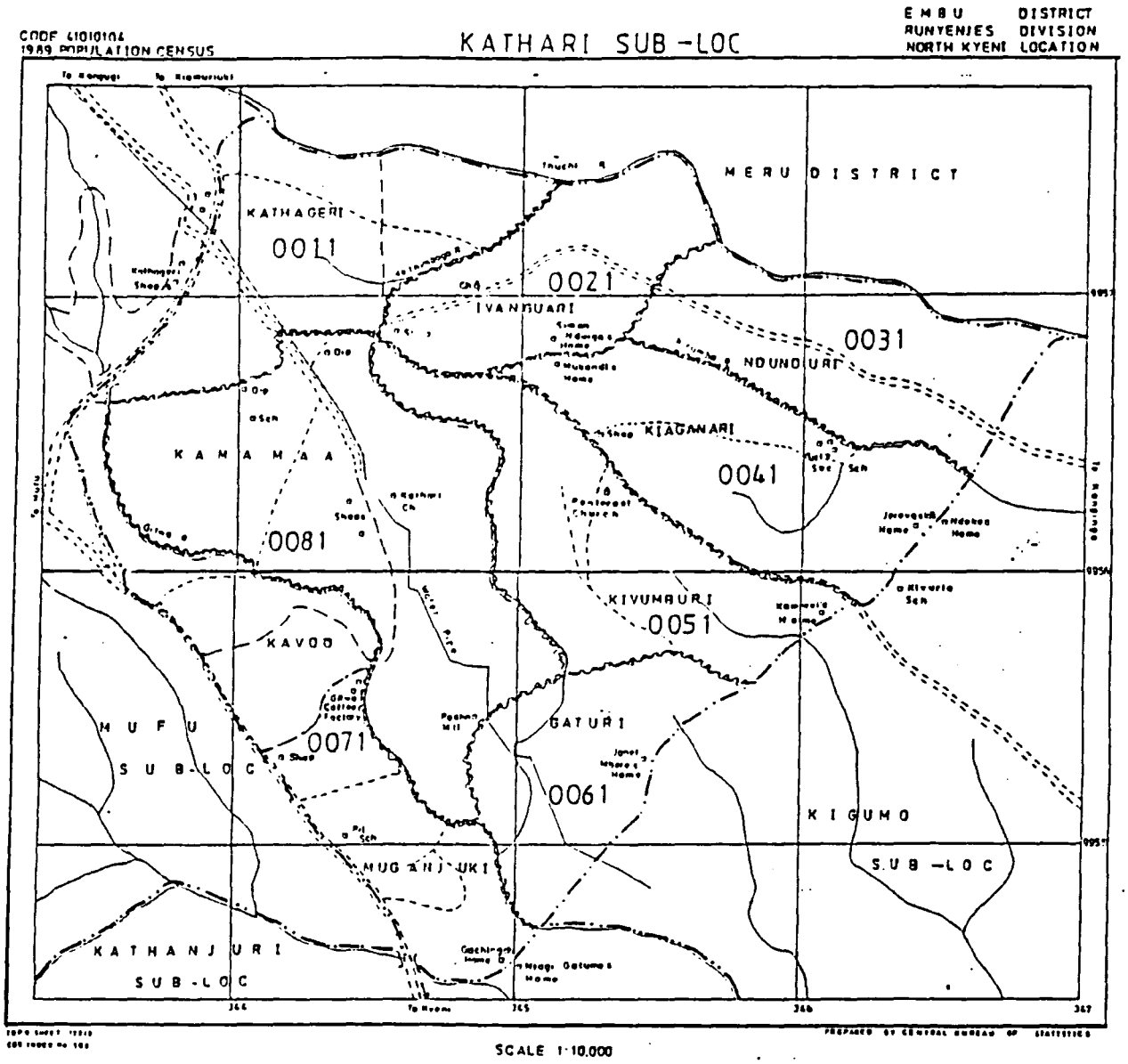
The EA maps were reproduced in the required numbers using ammonia diazo printer. They were produced for the Assistant Chiefs, District Statistical Officers, Supervisors, and Enumerators. The Assistant Chiefs and District Statistical Officers, each received one copy for each Sub-Location. The Supervisors received copies for each of their supervision areas. A supervision area could have been a whole Sub-Location or part of a Sub-Location. Each Enumerator received the EA map showing his/her Enumeration Area boundaries marked in red.

In total about 6000 rolls of ammonia printing paper were used in the printing of the census maps. This includes printing copies that were used in the office for editing and for the Assistant chiefs for confirmation of boundaries.

In the Cartographic section there were two diazo printing machines that were used in the census map reproduction. One of the Machines was used in the 1979 population census and the second was acquired for the 1989 population census. Both Machines were acquired through the U.N. At the climax of the printing work they could not cope with the work and help was sought from the University of Nairobi (Geography Department), Survey of Kenya, and Forestry Department. Printing was planned to start in december, 1888 and proceed until may, 1989. But due to delays in the finalisation of field work, printing could not be started as planned. However most of the printing was finished by end of july, 1989 except for Nairobi and Kilifi Districts whose maps were not printed until a few days before enumeration.

Printed maps for each Sub-Location were put in one envelope. They were tied together by Locations and Divisions. The envelopes containing maps for each District were put in one Carton and stored in the records office. They where collected and signed for by the census field staff.

FIGURE 7.3 EA MAP



EA Number	Enumerators
0011	1
0021	1
0031	1
0041	1
0051	1
0061	1
0071	1
0081	1

7.7 CONCLUSION.

This chapter has discussed the stages through which the 1989 Kenya population census maps were prepared. The preparation of the maps did not require complex surveying and highly skilled surveyors and cartographers. The mapping staff e.g map compilers and draughtsmen were recruited and trained for a short period. They were trained on the job through close supervision by the qualified staff in the cartographic section. They were not assigned regular work of EA map preparation until they acquired the prescribed standards. The first copies of EA maps produced by some of the drafting staff were very crude and even had departures from the prescribed format and contents but with of practice the work improved greatly.

Maps of very high quality for the census purposes were drawn. The quality of the maps was confirmed by the Assistant Chiefs and District Statistical Officers after testing them on the ground before the census. The Assistant Chiefs were impressed with the maps. Most of them expressed their wish to keep them after the census. Also at the time of the pilot census, the maps were found to be very good. There were however several cases of EAs that had more than the prescribed number of households. This situation was sorted out in the census enumeration by providing a table (on the EA map) showing the recommended number of enumerators for deployment in each EA. The estimate of the Enumerators per EA was based on the Household numbers that had been provided by the Assistant Chiefs. The EA boundaries both in

the pilot census and in the main enumeration were identifiable in almost all the cases.

The purpose of the EA maps was to show the country divided into EAs without omissions or duplications, so that the population could be enumerated completely. Everything possible that could be done in the preparation of the EA maps to help the enumerators to identify their EAs was done. All the effort was made to include enough features on the final EA maps. It was the duty of the compilation staff to include on the EA maps most of the information that had been obtained during the census field work correctly, accurately and in a standardized manner. The compilation and drafting staff were provided with symbol specifications and a general map layout. These two items guided them to produce maps of the prescribed standards and format. The importance of showing features on the EA maps in their correct relationships on the ground was stressed.

The scale of the EA maps was chosen very carefully. Scales that would have resulted to large sheets of EA maps were avoided. Most of the maps produced for the 1989 population census were small in size. They were easy to store and handle during drafting and in the field at the time of enumeration. In this regard, it was a big improvement from 1979 population census. The EA maps produced for the 1979 population census were large and difficult to handle and store.

The various steps through which the maps were prepared were

discussed. These stages included tracing of the Sub-location outlines from the toposheets, enlarging the outlines using the photocopier, adding details on the traced or enlarged Sub-Location outlines, drafting the EA map from the map compilation, editing the map compilation and the drafted EA map, and the reproduction of the required number of EA maps for the enumeration. Tracing all the EA maps from the toposheets had two advantages. First, it helped to avoid omissions and duplication because adjacent Sub-Locations were traced using the common boundary on the toposheet. Secondly the Sub-Location outlines were enlarged accurately to specific scale. Scale distortions through enlarging with the photocopier were minimal.

Each enlargement was checked to confirm the scale with a pair of dividers. Enlarging census maps using the photocopier was done for the first in Kenya. In 1979 population census the exercise was carried out using plan-variographs. Comparatively, enlarging by photocopier proved to be more accurate and faster. If boundaries of adjacent Sub-Locations, whose maps were on the same scale were overlaid, they coincided perfectly well. A lot of very expensive paper was used for the purpose of enlarging the maps but it was worthy in view of the fact that, the maps were very accurate. There was no omissions or duplications because all the maps were enlarged directly from the toposheets.

The map compilations and the drafted maps were checked by the qualified cartographers in the cartography section. The checking involved matching Sub-Location boundaries with those of adjoining

Sub-Locations to ensure complete coverage, checking the correctness and placement of all names, checking the use of symbols and the map layouts. Poorly compiled or drafted maps were returned for re-compilation or re-drafting. Most of the maps were found to be good, however a few had problems with spellings of place names.

It was discovered that, while some spelling errors arose either from compilation or drafting, most of them arose from the field work. The people who carried out the field work were not necessarily from those areas and they did not understand the local dialects. In addition many places were known by different names.

Lastly the problem of printing was discussed. It was thought that printing would be started in december, 1988 and be completed in may, 1989. This was with accordance with the United Nations recommendations (United Nations, 1980). Unfortunately there was a delay in finishing the field work which also affected the production of the EA maps. Some EA maps especially for Nairobi and Kilifi were not printed until a few days before the enumeration. The situation would have been much worse but it was helped by getting assistance from other institutions e.g University of Nairobi, Survey of Kenya, Forestry department, and the Department of physical planning.

CHAPTER 8

DIGITISING THE 1989 POPULATION CENSUS GEOGRAPHICAL BASE

8.1 INTRODUCTION

This chapter addresses the technical preparation of the census District maps, the status of the maps before they were digitised (in terms of scale and number of sheets) and the problems which were encountered in preparing the maps for digitising. It will discuss the procedures used in checking errors and the digitising techniques. The various errors resulting from the digitising exercise, and the procedures used to detect, edit and correct digitising errors are also assessed. The coal was to produce a single, clean and consistent coverage file with all the areas for population mapping. The exercise also allowed an assessment of preparation and checking time for digitising of large thematic map coverages.

Some Districts were covered by very large single maps and others were covered by several map sheets so work had to be undertaken to join them together to form a single coverage. The boundary coverages represented the administrative areas e.g Sub-Locations. Each Sub-Location in the geographical file has a unique code and codes had to be assigned to the relevant polygons in the PAT[1] tables. The digitized coverages were in digitizer inches. The techniques used to change them to state plane coordinates will

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[1]Polygon Attribute Table used to store polygon coverage attribute information. The table is automatically created by ARC/INFO (Environmental Systems Research Institute, Inc. 1990)

be analyzed.

8.2 SYSTEM AND EQUIPMENT

The development of the geographical frame for the 1989 Kenya population census has been discussed in chapters 1 to 7. All the administrative areas of Kenya were properly plotted on the topographical maps from which the census Enumeration maps and the District maps were developed. The District maps represent the Administrative boundaries at the Sub-Location level as they were at the time of the census.

The Kenya population census District maps were digitised using facilities in the, Geography Department, University of Durham. They were digitised using PC ARC/INFO. PC ARC/INFO is a geographical information system (GIS) used to automate, manipulate, analyse and display geographic data in digital form. It is characterised by: its data model, the GIS functions it performs, its modular design, its ability for developing application specific user interfaces, its own macro language (SML), and its ability to operate on many types of computers with a variety of graphics hardware (ESRI, 1989, ARC/INFO starter kit). It is a set of software products which run on IBM PC/ATs (or AT compatible computers). They include:

(i) PC ARC/INFO STARTER KIT

(ii) PC OVERLAY

(iii) PC DATA CONVERSION

(iv) PC ARCPLOT

(v) PC ARCEDIT

(vi) PC NETWORK

A Summagraphics series, model, MG 3648, digitiser[2] was used to digitise the Kenya population census District maps. It consists of a tablet which measures 36 x 48 inches (91.44 cm x 121.92 cm). Attached to it is a cursor (with cross-hairs for precisely sighting the points). The cursor has 16 buttons which were used for various functions in the digitising exercise. The coordinates of a point were digitised by placing the cross-hairs over it and pressing a sequence of buttons.

8.2 MAP SOURCES

The census geographical frame of Kenya comprises of 41 Districts, 263 Divisions, 1110 Locations and 3667 sub-Locations. The boundaries of these census areas are shown on the District maps together with some cultural, infrastructural and topographical information e.g roads, towns, rivers etc.

The District maps were prepared by the Cartographic section in the Bureau of Statistics. They were prepared using the 1989 Kenya population census enumeration area maps. The enumeration area maps had been prepared for each Sub-Location using information collected from the field and plotted on the 1:50,000 Survey of

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[2]A device consisting of a table and a cursor with crosshairs and keys used to record the locations of map features as x,y cartesian coordinates (Environmental Systems Research Institute, Inc. 1990).

Kenya topographic maps.

The information regarding the sub-Location boundaries was plotted on the Survey of Kenya District maps to produce the census District maps showing boundaries for the Divisions, Locations, and Sub-Locations.

The census Sub-Location maps were at various scales e.g 1:1,000, 1:2,500 1:5,000 for Urban areas and 1:5000, 1:10,000, 1:20,000, 1:25,000, 1:50,000 and in some few cases 1:250,000 for Rural areas. They were used to prepare the District maps at the scale 1:50,000, 1:100,000 and 1:250,000. Most of the Districts in the densely populated areas were covered on 1:100,000 while the Districts in the sparsely populated areas were covered on 1:250,000. Nairobi and Mombasa were covered on 1:50,000.

The map information on the Sub-Location maps was transferred onto the District maps by direct tracing and by photographic procedures. Most Districts were covered by one map sheet but there were a few that were covered in several sheets e.g Kwale, South Nyanza, Turkana, Baringo, West Pokot, Meru, and Mombasa. The map sheets were of various sizes. Some map sheets were too large to fit on the digitiser tablet e.g Meru, Elgeyo Marakwet, Wajir, Kitui, etc. On some District maps reference points e.g the graticule intersections were shown while on others they were not shown. This is because the maps were digitized before they were completely edited in the cartographic section, in Nairobi. Table

8.1 below shows the status of the District maps.

Table 8.1 The 1989 Kenya population census District maps.

District	Map Scale	Sheets	Size	Remarks
Kirinyaga	1:100,000	1	60cmx80cm	
Nyandarua	1:100,000	1	64cmx120cm	
Muranga	1:100,000	1	60cmx90cm	
Nyeri	1:100,000	1	85cmx90cm	
Nairobi	1:100,000	1	100cmx68cm	No graticule
Marsabit	1:100,000	1	42cmx40cm	
Embu	1:100,000	1	85cmx76cm	
Machakos	1:250,000	1	74cmx100cm	
Isiolo	1:100,000	1	98cmx124cm	No graticule
Kitui	1:250,000	1	70cmx140cm	Two sections
Bungoma	1:100,000	1	82cmx80cm	
Kakamega	1:100,000	1	110cmx93cm	
Busia	1:100,000	1	92cmx63cm	
Wajir	1:250,000	1	151cmx98cm	Two sections
Garissa	1:500,000	1	72cmx70cm	No graticules
Mandera	1:250,000	1	96cmx98cm	No graticules
Kilifi	1:200,000	1	94cmx66cm	No graticules
Kwale	1:100,000	2	75cmx129cm	Two sections
			67cmx100cm	
Lamu	1:250,000	1	60cmx45cm	No graticules
Taita	1:250,000	1	66cmx83cm	No graticules
Tana R.	1:250,000	1	137cmx104cm	No graticules

Kisumu	1:100,000	1	60cmx107cm	
S.Nyanza	1:100,000	2	104cmx74cm	Two sections
			130cmx60cm	
Siaya	1:100,000	1	86cmx85cm	No graticules
Kisii	1:100,000	1	72cmx57cm	No graticules
Kiambu	1:100,000	1	60cmx80cm	No graticules
Kericho	1:100,000	1	81cmx120cm	
Turkana	1:250,000	2	93cmx95cm	No graticules
			110cmx98cm	No graticules
Baringo	1:100,000	2	99cmx100cm	No graticules
			100cmx99cm	No graticules
Laikipia	1:250,000	1	60cmx60cm	
EMarakwet	1:100,000	1	160cmx70cm	Two sections
U.Gishu	1:100,000	1	108cmx86cm	No graticules
T.nzoia	1:100,000	1	90cmx60cm	
Wpokot	1:100,000	2	117cmx95cm	Two sections
			60cmx84cm	
Nakuru	1:250,000	1	63cmx55cm	
Narok	1:250,000	1	80cmx74cm	No graticule
Kajiado	1:250,000	1	98cmx89cm	No graticules
Nandi	1:100,000	1	82cmx86cm	
Samburu	1:250,000	1	84cmx90cm	No graticules
Mombasa	1:50,000	2	56cmx63cm	No graticules
	1:14,000		48cmx48cm	No graticules
Meru	1:100,000	2	80cmx145cm	Two sections
			60cmx148cm	

8.3 PREPARING THE DISTRICT MAPS FOR DIGITISING

(a) Immediate problems

(i) Figure 8.1 shows that some of the District maps were too large and it was difficult to digitise such maps as single coverages.

(ii) There were District map sheets that did not have reference points e.g graticule intersections (intersections of latitudes and longitudes) and this presented problems. It can be seen from figure 8.1 that, the maps that did not have graticules formed a big proportion of the total. Before the maps were digitized, they needed to have tic or reference points that could be assigned real world coordinates e.g latitudes and longitudes. These points had to be transferred from the adjacent maps.

(iii) Due to handling, the maps had crumbled and it was difficult to stretch them to lay flat on the digitiser. This may have contributed to some distortions on the digitised coverages.

(iv) The Districts that had been mapped on several sheets and those covered by large map sheets presented another problem. A decision had to be reached on how to define the various sections to be digitised.

(v) Some Sub-Location boundaries were missing on some maps. There were two common cases, where the Sub-Location name was shown on the maps without the boundary and the other case was a situation were a Sub-Location was listed in the geographical file but missing on the maps.

(vi) The maps covering the densely populated Districts comprised of very small areas. The arcs[3] forming these areas were very short. Digitising these arcs was rather difficult. The digitising exercise for maps covering these Districts proceeded very slowly.

(b) Error checking and map copying

(i) For each of the 41 Districts, all the administrative boundaries, major roads and major towns were traced on a plastic film. This was necessary to make digitising easy. The Division boundaries were shown in red line, Location boundaries in a continuous blue line, and the Sub- Locations were shown in blue dashed line. The roads were shown in a green continuous line and the towns were shown with red dots. Fine tipped, permanent markers (pens) were used for this exercise.

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[3]An arc is line or a continuous string of x,y coordinate pairs (vertices) beginning at one location and ending at another location, having length but no area. Arcs represent line features, the borders of area features, or both (Environmental Systems Research Institute, Inc. 1990).

(ii) At this stage, the District maps were edited against the 1989 population census geographical file to make sure that both records agreed. An attempt was made to make some corrections. If two Sub-Locations were shown without a common boundary, an arbitrary boundary was fixed between them. If a Sub-Location was shown on the maps but was not listed in the geographical file, it was treated together with one of the adjacent Sub-Locations in the same Location e.g it was assigned a geographical code for one of the Sub-Locations. Such Sub-Locations include Randago and Nyamsenda in Siaya District and some islands in Lake Victoria and the Indian Ocean. These cases should be checked with the census documents stored at the cartographic section in the Central Bureau of Statistics for correction.

(iii) At least four tic points were identified on each map sheet. It was important to choose tic points that were identifiable with real world coordinates e.g graticule intersections. As some map sheets did not have graticule intersections, the graticules were plotted geometrically from the adjacent map sheets (which were on the same scale) on which they had been shown. In some cases they were plotted photographically from the adjacent District maps (which were at different scales).

(c) Time taken to prepare District maps for digitising

It took approximately 3 hours to prepare each District for digitising. The map Sheets covering the densely populated areas e.g Kakamega, Kiambu, Muranga, Kirinyaga, Nyeri, Kirinyaga etc took more time. Since they contained very many Sub-Locations which were very small in area, they had to be traced carefully taking care not to omit some lines. The map sheets covering the sparsely populated Districts e.g Turkana, Wajir, Garissa, Mandera etc took shorter time to prepare for digitising.

8.4 DATA CAPTURE.

Map features are digitised in the form of a coverage[4]. A coverage is digital version of a map. It may represent a homogeneous class of data within a map e.g boundaries or roads. It may contain both locational data (which define points, lines and areas) and attribute data (which describe points,lines and areas) about each feature. Some features of a coverage are, arcs, label points, polygons, nodes[5], tics, coverage extent, and annotation. The first four features represent lines, points, areas and end points of arcs respectively.

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[4]A digital analog of a single map sheet forming the basic unit of data storage. In a coverage, map features are stored as primary features, such as arcs, nodes, polygons, and label points, and secondary features, such as tics, boundary extent, and annotation.

[5]The beginning and ending locations of an arc. To digitise an arc, first a node is digitised followed by a string of vertices then a second node is digitised to signify the end of the arc.

Tic points represent the registration marks for the coverages. Boundary extent marks a rectangle containing the coverage features. Annotation refers to the text that describe the coverage features.

In each District three types of coverages were digitised representing boundaries, roads and towns with an exception of Nairobi and Mombasa which did not have coverages for towns. In all, 121 coverages were digitised. **ADS**[6] command in PC ARC/INFO STARTER KIT was used to create the coverages. It was used to digitise the coverage boundary extent, tics, arcs and label points for each coverage at the digitising station. The boundary coverage for each District was digitised first and the road and town coverages were digitised using the tic and BND files of the boundary coverage. This was necessary in order for the three coverages in each District to register together exactly. For example appendix 8.1 shows the three coverages for Kakamega District i.e the boundary, road, and town coverages separately and after they were registered onto each other. The coverages registered to each other so well because the same tic points and BND files were used when they were being digitised.

The tics for KAKAR (Road coverage for Kakamega) and KAKAT (Town coverage for Kakamega) had to be digitised as accurately as possible. An RMS[7] was displayed which described the accuracy of

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[6]Arc Digitizing System

[7]Root mean square error- a statistic which indicates the accuracy with which a digitiser operator places the cursor on a selected parts of a map.

the tic registration with the KAKAB coverage. The RMS had to be less or equals to 0.003 inches.

8.4.2 Digitising the coverage features

Arcs were digitised for the boundary and road coverages and Label points were digitised for the boundary and town coverages. In the boundary coverages, arcs represented the boundaries for the administrative areas (Polygons) and in the road coverages they represented sections of the various roads. Label points in the boundary coverages were used to assign User-IDs[8] for the Polygons and in the Town coverage they represented the Locations as well as the User-IDs for the towns.

User-IDs for Arcs and Label points were assigned automatically as digitising commenced. The increment was set to 1 but it could be changed at any stage during an ADS session.

8.4.3 Errors detected during digitising.

After digitising the maps there were errors that immediately identifiable and which needed to be corrected. These errors were:

(i) Arcs digitised by mistake.

(ii) Missing Arcs.

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[8]A number assigned to each feature by the user. It can be used to relate additional attribute information to the feature.

(iii) Missing Label points.

(iv) Polygons with more than one label points.

(i) Identifying and correcting digitizing errors

To check and identify the digitizing errors, the coverage features were drawn the screen while on **ADS**. The features that could be drawn were, tics with their User-IDs, arcs with or without their User-IDs, all Nodes or only Nodes with possible errors (e.g only dangling nodes[9] or only pseudo Nodes), Labels points with or without their User-IDs. In this way it was possible to identify and correct some of the digitising errors listed above.

Missing arcs could easily be identified by the pseudo nodes[10]. Polygons with more than one label points could also be easily identified. It was rather difficult to identify arcs that had been digitised by mistake. These were identified at and corrected after some plots had been made which were compared with the original maps.

The missing Arcs and Label points were added in the coverages in the same manner discussed earlier. While adding new arcs and

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[9]The end point of a dangling arc. Dangling arc is an arc having the same polygon on both its left and right sides and having at least one node that does not connect to any other arc.

[10]A node at which two and only two arcs intersect, or a single arc connects with itself. They may be digitised by mistake or caused by removing arcs.

label points care was taken to change the User-IDs accordingly. Adding an arc to join to two existing pseudo nodes was straight forward. If an arc was required to be added where there was no existing pseudo nodes on the arcs to which the new arc was to join, the pseudo nodes had to be created first by splitting the appropriate arcs. Unwanted Arcs and Label points were selected and removed.

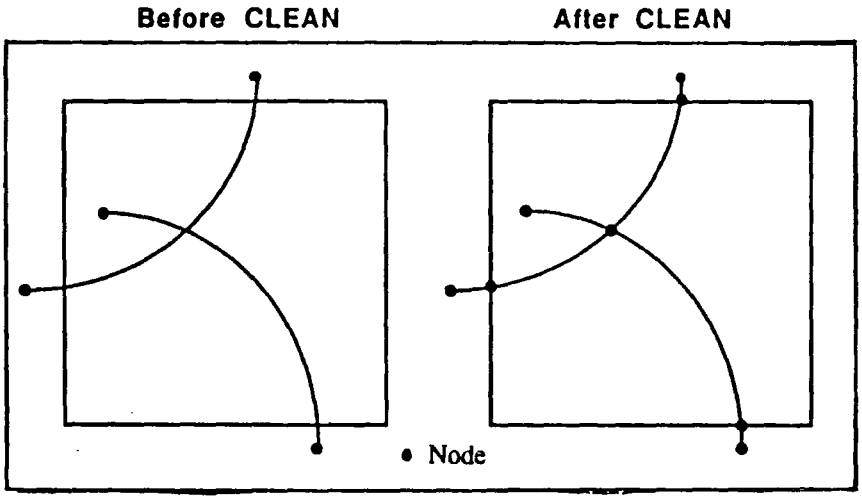
8.4.4 Coverage topology and attribute tables.

PC ARC/INFO explicitly represents all map features by sets of lines (arcs) and Label points and as relationships between connected lines and points. The relationships used to represent the connectivity or contiguity of these features is referred to as topology (PC ARC/INFO STARTER KIT). PC ARC/INFO automatically creates and maintains coverage feature topology through commands **CLEAN** and **BUILD**. Feature locations and feature topology are stored in special coverage files in a subdirectory having the coverage name. PC ARC/INFO also creates an INFO directory when a coverage is created. The INFO directory maintains the descriptive, or attribute, data files for the coverage e.g AAT for a line coverage, PAT for polygon or point coverages.

When **CLEAN** is used, it generates a coverage with correct polygon topology, edits and corrects geometric coordinate errors, assembles arcs into polygons, and creates feature attribute information for each polygon. **BUILD,** on the other hand creates or updates a feature attribute table for a coverage and defines

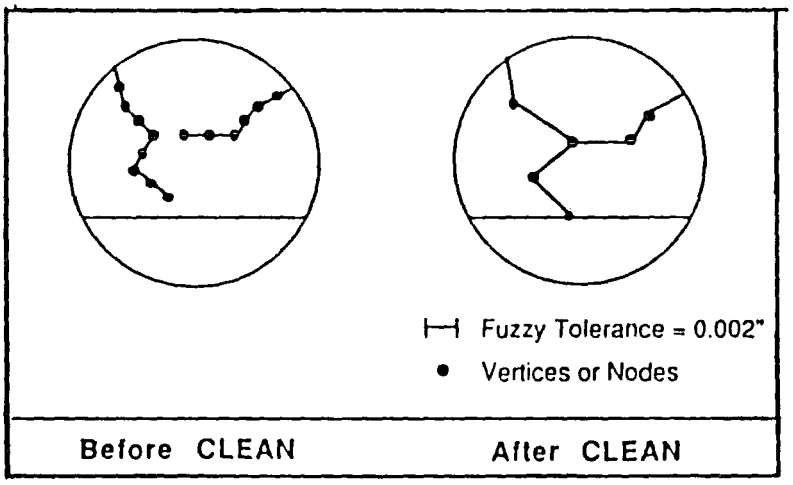
polygon and arc-node topology. The functions of **CLEAN** and **BUILD** are illustrated with diagrams below:

Figure 8.2 Splitting arc intersections



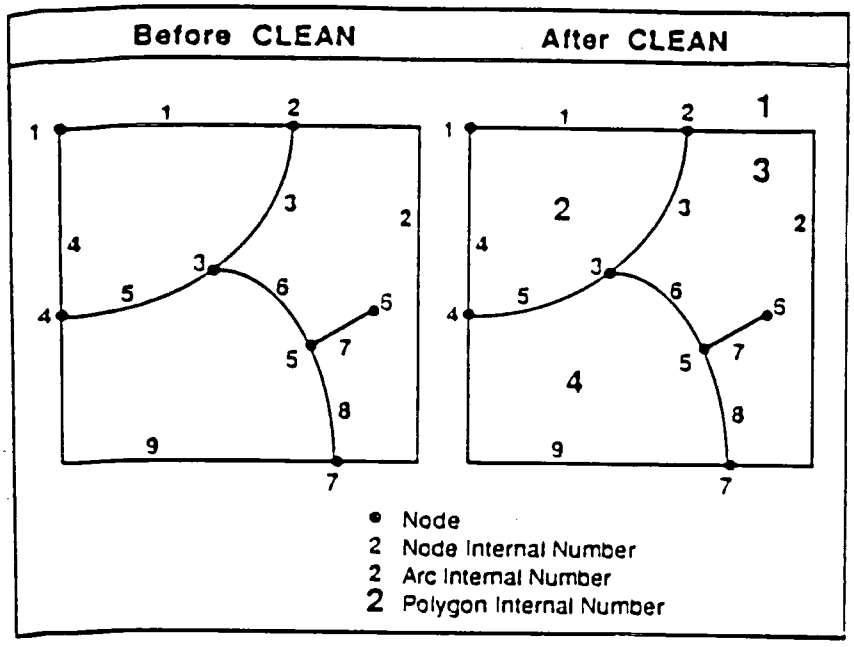
SOURCE: ESRI, 1987.

Figure 8.3 Snapping Vertices or Nodes



SOURCE: ESRI, 1987.

Figure 8.4 Polygon topology



Set of arcs enclosing each polygon

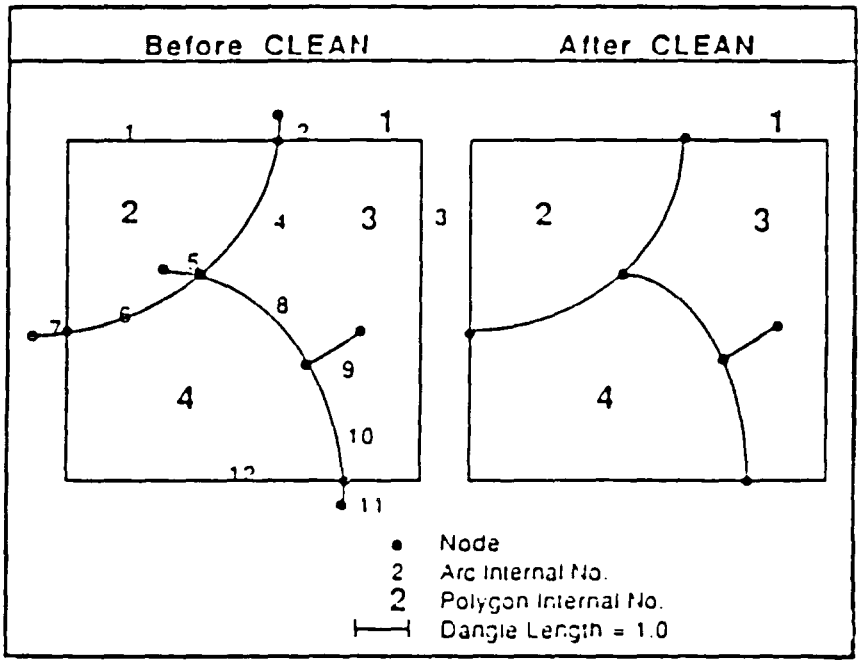
Polygon Number	Number of Arcs	Arc Numbers
1	4	1,2,9,4
2	4	1,3,5,4
3	4	2,8,6,3
4	4	6,8,9,5

Polygons to the left & right side of each arc

Arc Number	From-Node	To-Node	Left Poly	Right Poly
1	1	2	1	2
2	2	7	1	3
3	2	3	3	2
4	4	1	1	2
5	4	3	2	4
6	5	3	4	3
7	5	6	3	3
8	7	5	4	3
9	7	4	1	4

SOURCE: ESRI, 1987

Figure 8.5 Dangling arcs



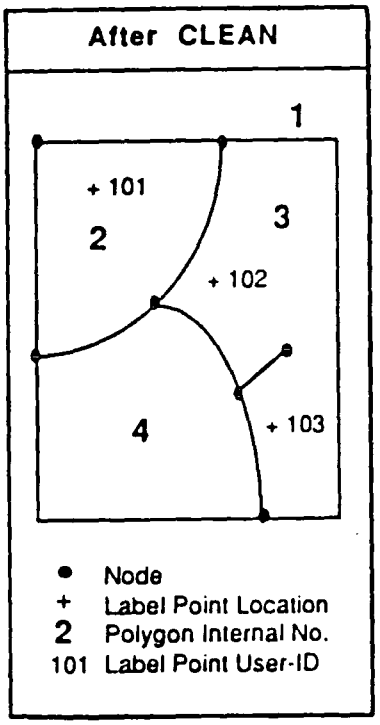
Arc Number	Left Poly	Right Poly	Length
1	1	2	5.0
* 2	1	1	0.2
3	1	3	8.8
4	2	3	1.2
* 5	2	2	0.2
6	2	4	1.3
* 7	1	1	0.2
8	4	3	1.9
* 9	3	3	1.5+
10	4	3	1.9
*11	1	1	0.2
12	4	1	3.1

* Dangling arcs.

+ Arc length is longer than dangle length = 1.0. Arc 9 is kept in coverage. Arcs 2,5,7 and 11 are shorter than dangle length and are removed.

SOURCE: ESRI, 1987

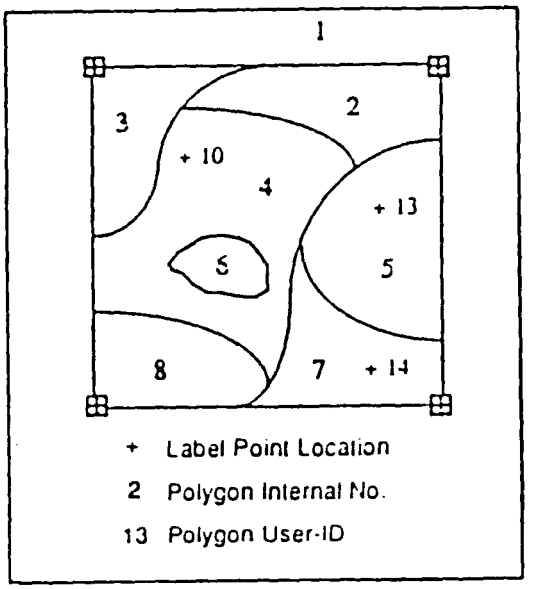
Figure 8.6 Polygon User-Ids



Polygon Internal No.	Polygon User-ID
1	0
2	101
3	102
4	0

OURCE: ESRI, 1987.

Figure 8.7 The coverage PAT Table



EXCOV.PAT before CLEAN

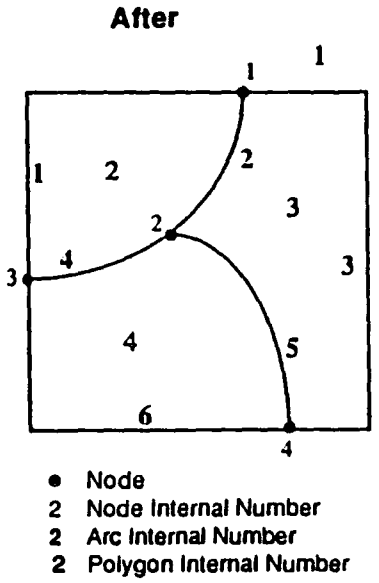
AREA	PERIMETER	EXCOV#	EXCOV-ID	COVER-TYPE
-25.0	20.0	1	0	
2.0	7.5	2	0	
3.0	9.0	3	0	
9.0	11.0	4	10	Grass
3.5	8.0	5	13	Forest
1.0	2.5	6	0	Water
4.5	9.0	7	14	Shrub
2.0	5.0	8	0	

EXCOV.PAT after CLEAN

AREA	PERIMETER	EXCOV#	EXCOV-ID	COVER-TYPE
-25.0	20.0	1	0	
2.0	7.5	2	0	
3.0	9.0	3	0	
9.0	11.0	4	10	Grass
3.5	8.0	5	13	Forest
1.0	2.5	6	0	
4.5	9.0	7	14	Shrub
2.0	5.0	8	0	

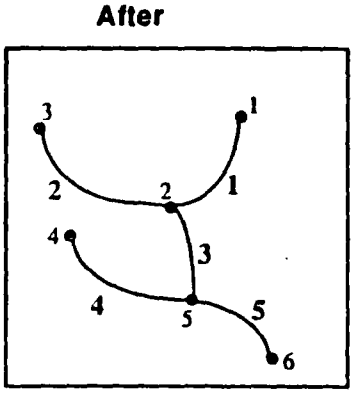
SOURCE: ESRI, 1987

Figure 8.8A An AAT table for a line coverage with polygons



FNODE	TNODE	LPOLY	RPOLY	VEG#	LENGTH	VEG-ID
1	3	2	1	1	5.0	1
1	2	3	2	2	2.0	2
1	4	1	3	3	10.0	3
2	3	4	2	4	1.9	4
4	2	4	3	5	3.9	5
3	4	4	1	6	5.1	6

Figure 8.8A An AAT table of a line coverage without polygons



Items from ROADS.AAT after

FNODE	TNODE	LPOLY	RPOLY	ROADS#	LENGTH	ROADS-ID
1	2	0	0	1	1.0	1
2	3	0	0	2	1.2	2
2	5	0	0	3	0.8	3
5	4	0	0	4	0.9	4
5	6	0	0	5	1.0	5

SOURCE: ESRI, 1987.

8.5 EDITING THE COVERAGE FEATURES.

Three types of coverages were digitized for each District, but due to lack of time, only the boundary coverage was processed using CLEAN and BUILD commands. After CLEAN was executed on the boundary coverages, some digitizing errors were corrected but a few remained. The remaining errors were edited and corrected using **PC ARCEDIT** commands (PC ARCEDIT is one of the specialised PC ARC/INFO products designed to add interactive coordinate and attribute editing capabilities to an existing PC ARC/INFO workstation).

First **EDITPLOT** command in PC ARC/INFO STARTER KIT was used to produce coverage plots using the plotter. The plots were used to identify the digitising errors. The following errors could be identified:

(i) Wrongly digitised Arcs.

(ii) Arcs which were missing from the coverage.

(iii) Polygons with Label errors (e.g a polygon with two label points due to a missing arc).

(iv) Dangling nodes due to overshoot arcs.

(v) Dangling nodes due to undershoot arcs.

(vi) Pseudo nodes due to missing arcs.

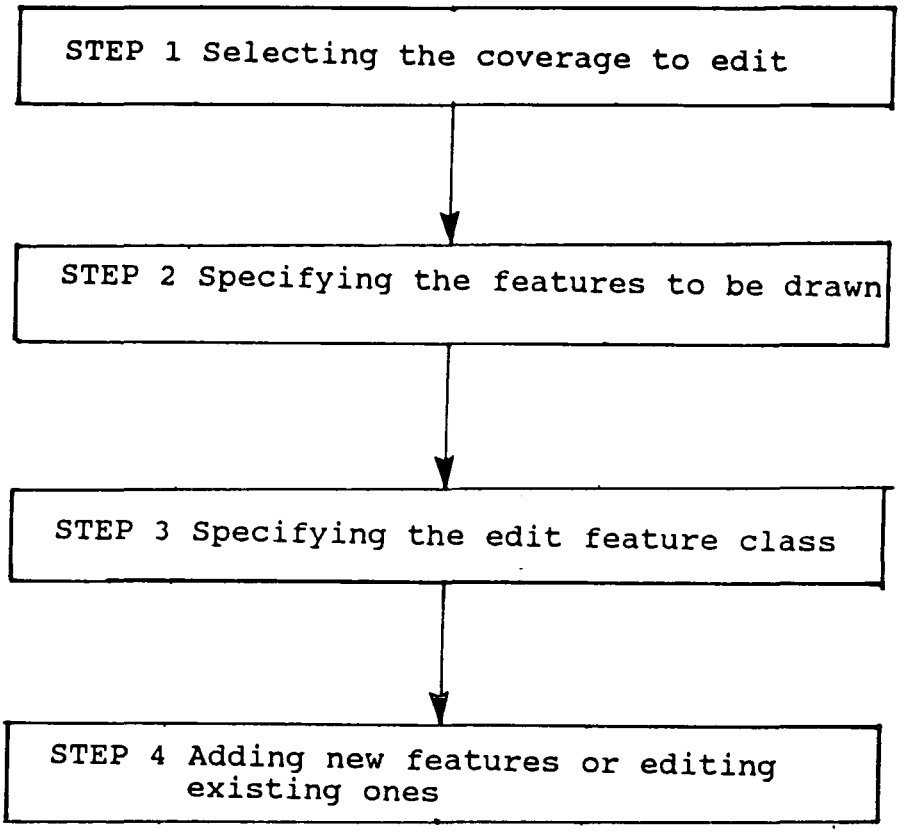
(vii) Dangling nodes due to unclosed (Islands) polygons.

(viii) Label points with wrong Label User-Ids.

The required corrections were marked on the edit plots and then missing arcs and label points were added, unwanted label points and arcs that had been digitised by mistake were deleted, dangle nodes representing undershoots and overshoots were moved to snap to the relevant nodes, and pseudo nodes representing the areas were unwanted arcs had been deleted were removed. By snapping the dangle nodes representing the overshoots, the dangle arcs were automatically removed.

The various steps followed in editing the coverage features are shown in figure 8.9 below:

Fig. 8.9 Steps for editing coverage features



8.5.1 Selecting a coverage to edit

The coverage features were edited interactively on the screen. To edit an existing coverage, it was selected or specified with the **EDITCOVERAGE** command. If a boundary coverage was being edited, a road coverage of the same District or for a neighbouring District could also be displayed (with the **BACKCOVERAGE** command) as a background coverage. Both coverages could be displayed at the same time. It was therefore possible

to see how the features for both coverages related to each other.

8.5.2 Drawing coverage features

Before editing a coverage, it was necessary first to decide which coverage features were be displayed for editing. All the edit coverage features could be drawn (arcs,label points, tics etc) or a subset of the feature types e.g arcs. Additionally, features of the background coverage other than the current edit coverage could be drawn with a different symbol.

The edit coverage and the background coverage features were specified with the **DRAWEVINRONMENT** and **BACKENVIRONMENT** commands respectively. They were drawn with the **DRAW** command after specifying the map extent with the **MAPEXENT** command. The **MAPEXTENT** command specified the geographic area to be drawn, for example the area of the coverage that would be visible on the graphic display screen. Any parts of coverage area that fell out side this area would not be drawn. **MAPEXENT DEFAULT** set the map extent to the BND of the current edit coverage and MAPEXENT * set the map extent to a box which was defined using the cursor. The **MAPEXENT** command could be given any number of times during a PC ARCEDIT session. It was particulary useful because it was possible to zoom on or enlarge very small areas of a coverage.

8.5.3 Adding Arcs and Label points

Missing Arcs and Label points were added into the coverage with the **ADD** command. The feature type to be added was first determined with the **EDITFEATURE** command. This means that if arcs were being added first, the current edit feature had to be specified as ARC, to add label points next, the edit feature class had to be changed from ARC to LABEL.

Many times when adding arcs, label points or tics, the User-IDs had to be incremented by a certain value from one feature to the next one. This ensured that the User-ID assigned to each added feature was unique. First starting User-Id was established by specifying an increment immediately after the **ADD** command. After doing this, each feature added, had its user-id greater than the previously added feature.

Missing arcs were added to the other arcs at the pseudo nodes. If there were no nodes, they were added before the new arc could be added. They were added by splitting the concerned arcs with the **SPLIT** command.To add missing label points, first the edit feature was specified as Label. Then the command **ADD** was used to add the label points accordingly.

8.5.4 Deleting Arcs and Label points

Unwanted coverage features e.g arcs, label points were removed using **DELETE** command. First, the EDITFEATURE command was used to

select the feature type for deletion. Before a feature e.g arc could be deleted, it was first selected using the **SELECT** command.

8.5.5 Removing Pseudo nodes

Some pseudo nodes resulted from the digitizing and others were left behind when unwanted arcs were removed. To remove each Pseudo node, first the two arcs connecting to it were selected and then the command **UNSPLIT** was used to remove the pseudo node. If the arcs selected had different User-IDs, then **CALCULATE** command was used to assign the resulting arc a User-ID of one of the arcs.

8.5.6 Snapping nodes together

Some nodes representing undershoots and overshoots were snapped to the relevant nodes closing the affected polygons and deleting the dangle arcs involved respectively. This was done by using the **MOVE** command and specifying a reasonable snap distance.

8.5.7 Recreating topology

Editing the spatial characteristics of each coverage altered the coverage topology. In each case the topology was reconstructed to reestablish the spatial relationships by using **CLEAN** or **BUILD** commands.

8.6 TRANSFORMING THE COVERAGE FEATURES AFTER DIGITIZING

All the coverages were digitized in digitizer units e.g inches. It was therefore necessary to change or transform them to state plane coordinates. This was essential in order to prepare maps to scale. The PC ARC\INFO STARTER KIT **TRANSFORM** command was used to perform this task.

Each coverage had been assigned at least four tic points. Each tic point was identifiable in the original maps with its longitude and latitude e.g degrees. The degrees were changed to kilometres. The intersection of 33 degrees longitititude and 0 degrees latitude was taken as the origin. Each degree of longitude and latitude was taken to be equivalent to 111.19 kilometres.

In the following example, the feature coordinates for the **SIAYB** coverage were transformed from digitizer inches to state plane coordinates. First a new empty coverage SIAYP was created based upon the TIC and BND files of SIAYB. It was created using the **CREATE** command in PC ARC/INFO STARTER KIT. The SIAYB.TIC and SIAYP.TIC files are shown in figures 8.11 and 8.12 respectively below. The two tic files are the same since SIAYP was created upon the TIC and BND files of SIAYB.

FIGURE 8.11 SIAYB.TIC

RECORD	IDTIC	XTIC	YTIC
1	1	14.571	30.757
2	2	36.493	31.076
3	3	36.770	9.321
4	4	14.872	8.948

FIGURE 8.12 SIAYT.TIC

RECORD	IDTIC	XTIC	YTIC
1	1	14.571	30.757
2	2	36.493	31.071
3	3	36.770	9.321
4	4	14.872	8.948

The tic locations on the original map for SIAYB in degrees and kilometres are shown in figure 8.14 below. Note that the Y coordinates for tics 2, 3, and 4 are negative due to the choice of the origin mentioned above.

FIGURE 8.13 SIAYB TIC COORDINATES IN DEGREES AND KILOMETRES

	DEGREES		KILOMETRES	
TIC	X	Y	X	Y
1	34.0	0.25	111.190	27.797
2	34.5	0.25	166.785	-27.797
3	34.5	-0.25	166.785	-27.797
4	34.0	-0.25	111.190	-27.797

Next, SIAYP.TIC file was updated with the tic coordinates shown in figure 8.13 for SIAYB. This was done using the UPDATE command in TABLES. The updated SIAYP.TIC file is shown in figure 8.14 below:

FIGURE 8.14 SIAYP.TIC FILE AFTER UPDATING.

RECORD	IDTIC	XTIC	YTIC
1	1	111.190	27.797
2	2	166.785	-27.797
3	3	166.785	-27.797
4	4	111.190	-27.797

Then the coverage features for SIAYB which were in digitizer inches were transformed onto SIAYP which was in state plane coordinates using the **TRANSFORM** command. A transformation error (RMS error) less than 0.003 was displayed during the transformation and it was acceptable.

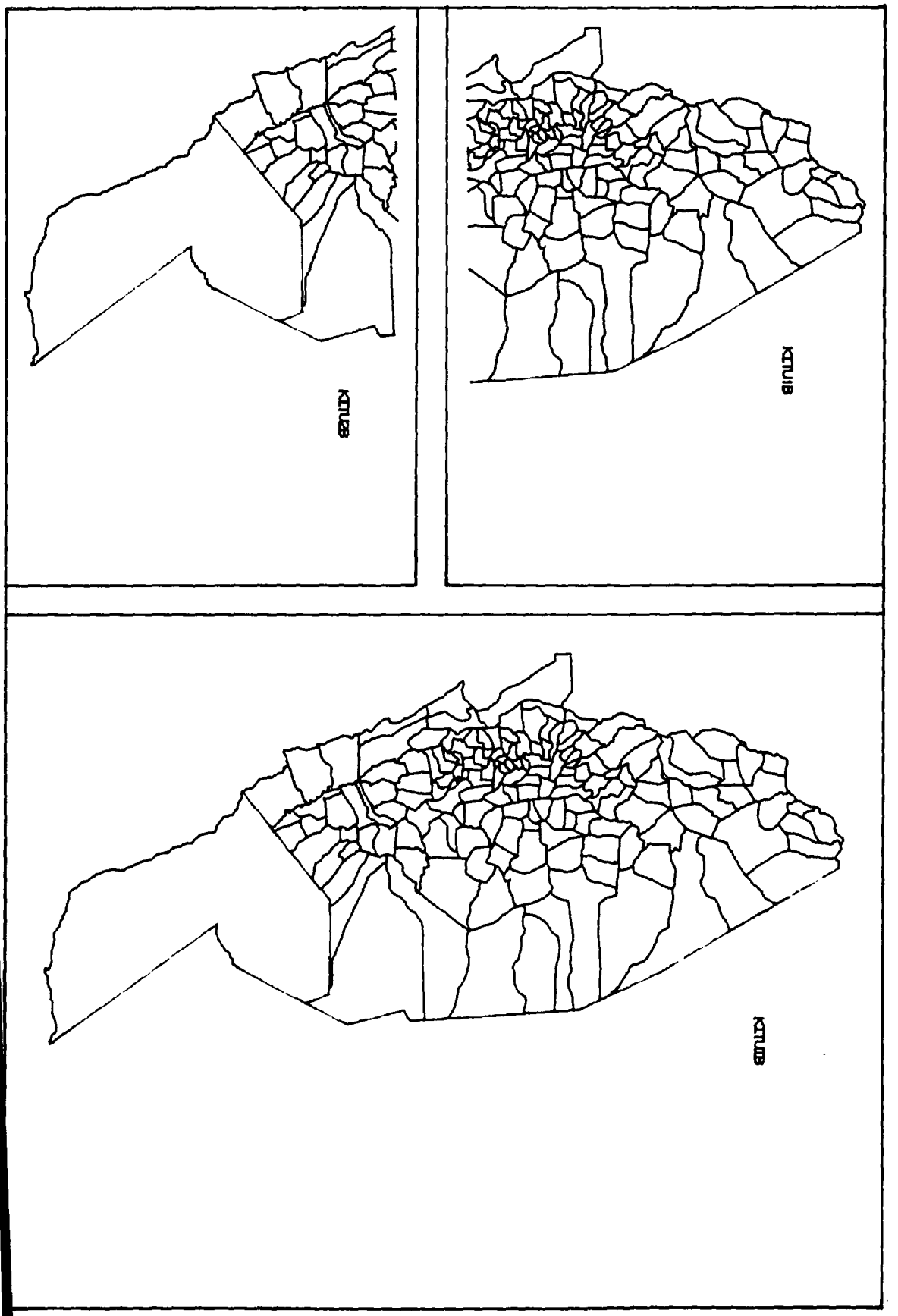
8.7 JOINING THE DISTRICT COVERAGES

Some Districts had more than one boundary coverages for example, Meru 4 boundary coverages, Kwale, Baringo, Turkana and West pokot had each 3, and Wajir, Kitui, South Nyanza, Tana River and Elgeyo Marakwet had each 2.

After the transformation of the coverages into state plane coordinates, it was possible to create a single boundary coverage for each of the Districts mentioned above. This was done using

the **APPEND** command in PC ARC\INFO STARTER KIT. After executing the command, both coordinate and feature attribute tables for each coverage were appended to a new coverage and feature User-ID offsets calculated accordingly. Figure 8.15 shows the boundary coverages for Kitui District before and after the use of **APPEND**.

FIGURE 8.15 Kitui District boundary coverage



8.8 UPDATING THE PAT TABLES FOR THE BOUNDARY COVERAGES.

Each polygon in the boundary coverages represents a Sub-Location. Each Sub-Location in the 1989 population census geographical file is identifiable with an eight digit code. This code was assigned to each polygon in the boundary coverage PAT table for each District. This was done first by adding an item "code" in each boundary coverage PAT table. The **ADDITEM** command in the PC ARC\INFO STATER KIT was used for this purpose and the **UPDATE** command in TABLES was used to update e.g assign the codes to each polygon in the PAT tables. Figure 8.16 below shows the PAT table for Lamu boundary coverage including the new item i.e code.

Figure 8.16 LAMUB.PAT

AREA	PERIMETER	SIAY#	SIAY-ID	CODE
-6318.171	893.419	1	0	0
379.050	94.648	2	29	33030101
239.048	81.236	3	28	33030103
835.226	154.807	4	27	33030103
630.157	130.945	5	26	33030105
1114.098	198.960	6	6	33050202
114.621	58.091	7	30	33030102
1091.974	172.267	8	12	33020301
3.170	8.392	9	25	33030103
1.656	6.259	10	24	33030103
6.081	14.886	11	22	33040104
1118.484	154.059	12	14	33010101
1.704	5.107	13	23	33040104

7.134	12.875	14	21	33040101
16.114	26.928	15	20	33010101
38.438	37.925	16	18	33040202
23.394	29.278	17	17	33040201
3.684	9.639	18	19	33040102
1.320	4.861	19	15	33040202
2.154	5.711	20	16	33040202
50.222	50.805	21	5	33050201
48.848	56.846	22	4	33050103
44.825	37.646	23	1	33050102
5.568	9.471	24	3	33050101
3.408	7.948	25	2	33050103
52.184	33.228	26	11	33020102
32.537	27.121	27	10	33020202
173.198	64.314	28	13	33010101
142.962	84.536	29	7	33020203
97.691	41.717	30	9	33020201
39.220	26.677	31	8	33020101

The geographical codes for each polygon were obtained by cross referencing the 1989 population census geographical files, the original District maps, and the boundary coverage edit plot showing the User-IDs for the polygons. The geographical file for each District provided the name and code for each Sub-Location and the District maps provided the name for each Sub-Location. By comparing the original District maps and the edit plots, it was possible to know which polygon represented which Sub-Location. Then the geographical code was included in each PAT

table using the polygon User-Id.

8.9 CONCLUSION

Preparation of the District maps for digitizing e.g tracing, fixing and identifying tic coordinates, digitizing the coverages e.g boundary, roads and towns, editing the digitized coverages, transforming the coverages and updating the PAT tables took approximately five working months.

Despite all the problems associated with the original maps e.g lack of reference points that could be used as tic points etc digitizing exercise was carried out satisfactorily. All the maps were edited before digitizing and the necessary corrections made. PC ARC\INFO offered very many options in digitizing and editing the coverages. Digitizing errors were corrected during the digitizing sessions or after during the editing sessions. Checking, identifying and correcting the digitizing errors in ARCEDIT was rather a slow process.

The procedures used in transforming coverage features from digitizer units e.g inches to state plane coordinates were discussed. About 50% of the District maps did not originally have reference points that could be used to identify tic points. These were however transferred geometrically or photographically from the adjacent maps. This procedure was slow. A lot of calculations had to be done to find the X, Y coordinates in Kilometres for all the tic points with reference to the origin that had been

identified i.e the intersection of 33 degrees longitude and 0 degrees latitude. Each degree of longitude or latitude was taken equivalent to 111.19 kilometres. Despite all the calculations, the results after transformation were very encouraging. These good results facilitated the joining of the boundary coverages wherever there were more than one in a District.

A lot of time and effort was put into the preparation of the 1989 Kenya population census geographical database. It is hoped that, apart from the work being useful for academic purposes, it will form a basis for further mapping and data analysis. Digitizing census maps at the lowest administrative level e.g the Sub-Location has been a big undertaking. In view of the fact that the census population data is already in computer readable form, it can be merged with the geographical information very easily to produce maps that could accompany the census reports. Also maps can be produced to accompany census data supplied to the users from time to time.

CHAPTER 9

MAPPING AND ANALYZING THE 1989 KENYA POPULATION CENSUS DATA

9.1 INTRODUCTION

This chapter will consider digital mapping and data analysis with reference to the 1989 Kenya population census geographical and population data. It will show the use of ARCPLOT commands in mapping and data analysis. The previous chapter outlined the various procedures involved in digitising the census maps e.g boundaries, roads and towns. This information forms a basis for the mapping, analysis and manipulation of the census data using PC ARCPLOT. First it will be explained using a sample District how the digital information can be organised to form a simple District map showing Sub-Location boundaries and names, roads and towns with their names. Secondly the techniques and procedures used to create a single boundaries coverage for Kenya will be analyzed. Thirdly the census data will be used to create a population density map of Kenya using the boundaries coverage. Finally PC ARC/INFO package will be evaluated with a view of remending it for use by the Kenya Government in future mapping and census analysis.

PC ARCPLOT contains very efficient commands for mapping. There are three options in which mapping can be undertaken i.e by making a 1039 plot file[1], interactively to create a map

[1]1039 plot file is created during an ARC/PLOT session. Instead of graphics being shown on the screen, they are saved in the above file and can be send to a plotter to get a hard copy

composition and by preparing an SML[2] file (SML is a set of commands which constitute a simple programming language for building macros with some of the features of a high-level programming language) containing the necessary commands. The last option has been used widely here to produce maps which will be discussed in this chapter.

9.2 A SAMPLE DISTRICT MAP

The Busia District map shown in Figure 9.9 was created using the boundary, road and town coverages. This is a sample map to show what can be done with the numerous geographical data base for each District which has been created using the 1989 census maps. The map shows the Sub-Locations with their names, roads and the towns with their names in Busia District. The Sub-Location names are contained in the boundaries Coverage feature attribute table (PAT) table under the item "Names" and the Town names are contained in the town coverage PAT table under the same name. The names in both files were used to draw names for Sub-Locations and towns on the map. The SML file created containing the PC ARCPLOT commands that were used in the creation of the map are shown below. Each line in the SML file contains an ARCPLOT command to draw a particular map element on the map.

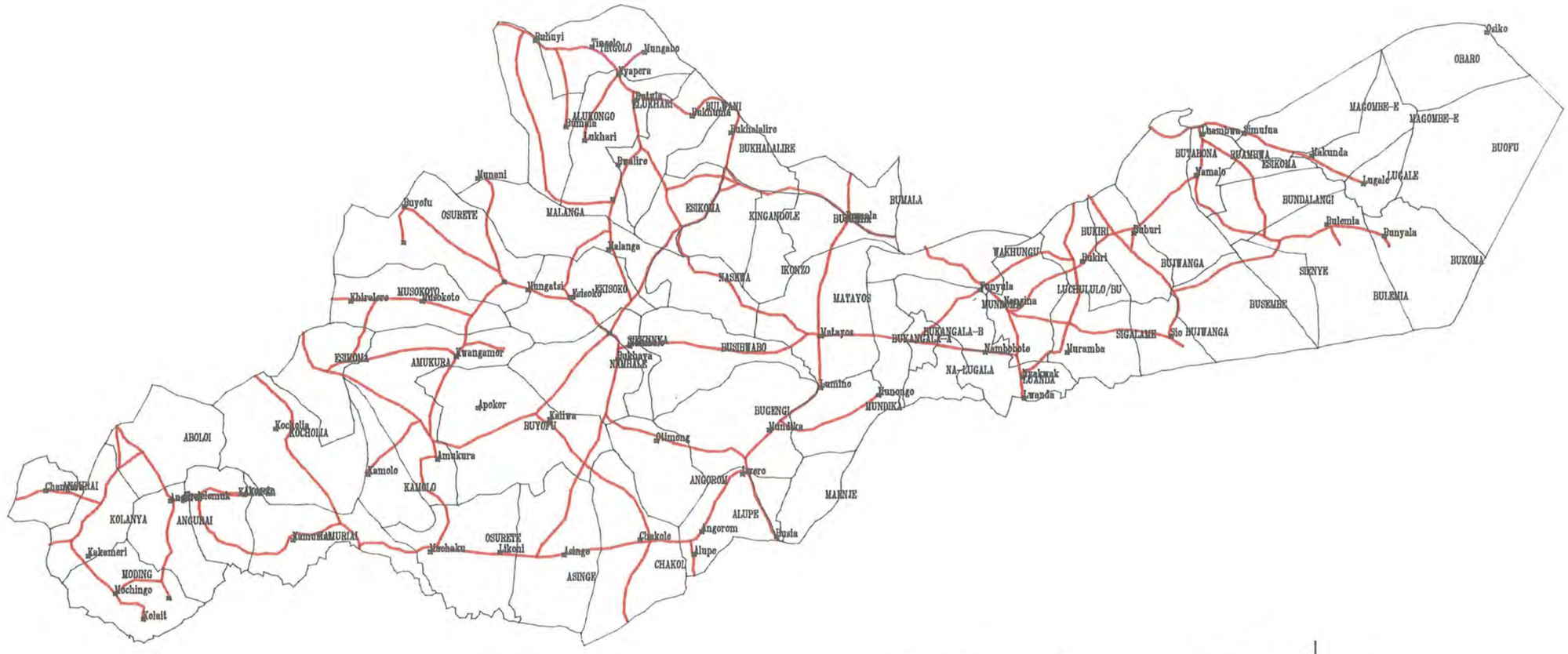
---

of the map being created.

[2]Simple Macro Language used in ARC/INFO to execute a set of commands.

FIGURE 9.9 BUSIA DISTRICT

Sub—Locations, Urban areas and Transportation network



— Boundary

— Road

▪ Town

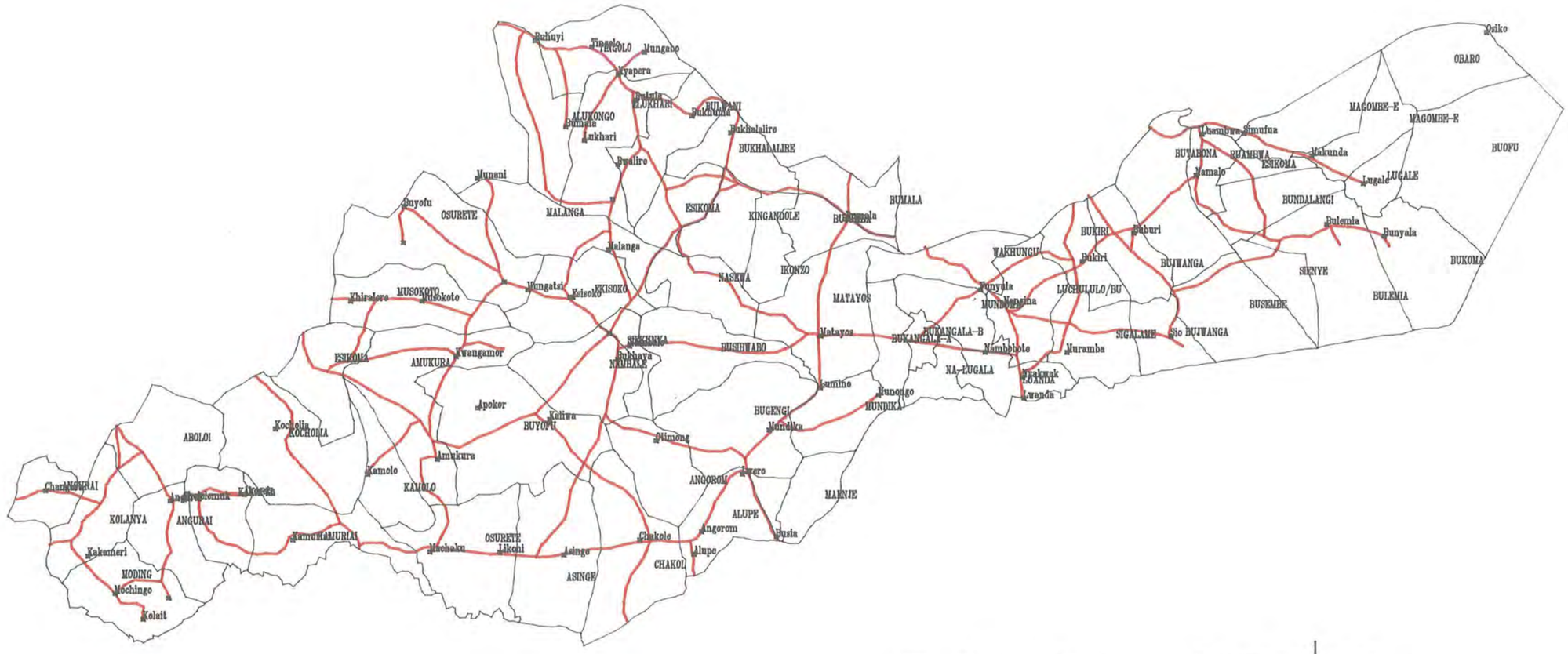
Bunyala Town Name

BUOFU Sub—Location Name

scale 1:300,000

FIGURE 9.9 BUSIA DISTRICT

Sub—Locations, Urban areas and Transportation network



— Boundary

— Road

▪ Town

Bunyala Town Name

BUOFU Sub—Location Name

scale 1:300,000

Table 9.1 BUSI.SML FILE

```
display  1
mape busi
pagesize  16   11
maplimits 0.5 0.5  15.8  11
mapposition cen cen
mapangle 135
mapunits 0.0000254
mapscale 300000
linesymbol 1
polys busi
linesymbol 6
arcs busir
textsymbol 25
polygontext busi name
textsymbol 25
markersymbol 17
points  busit
pointtext busit name
linesymbol 9
box 0.4  0.4  15.6  10.6
linesymbol 5
box 0.5  0.5  15.5  10.5
textsymbol 41
textfont 5
textsize  0.2
move 6   10.2
```

```
text 'FIGURE 9.9 BUSIA DISTRICT'
textsymbol 37
move  3  9.8
text  'Sub-Locations, Urban areas and Transportation network'
keyposition 9 3
keybox 0.25 0
keyline busi.key nobox
keyposition 9  2.25
keybox 0.25 0
keymarker busit.key nobox
move 9 1.55
text 'BUOFU Sub-Location Name'
move 9 1.8
text 'Bunyala Town Name'
line 13 3 11.5 3
line 11.5 3 12 2.8
line 12 2.8 12 3
line 12.5  2.8  12.5  3.2
shadesymbol 85
shade 11.5 3 12 2.8 12  3
move 6 0.8
text 'scale 1:300,000'
```

The Busia District map discussed above was prepared to serve as an example to show that the same could have been done with the the rest of the Districts. It would have taken a long time to make maps of this type for the Districts because to update the feature attribute tables with area names takes a long time.

This will properly be done later as a separate mapping programme for the 1989 Kenya population census.

9.3 CREATING A SINGLE BOUNDARY COVERAGE FOR KENYA

All the District boundary coverages were updated to include an item "pop" which was added in the feature attribute table for each District using **ADDITEM** command. The population data were added in the feature attribute tables using **UPDATE** command. Both commands are in PC ARC/INFO STARTER KIT. Each District boundary coverage PAT file after updating contained the following items, area, perimeter, cover# (polygon internal number) cover-id (an identification number for each polygon), pop (population for each polygon or Sub-Location), and code (the geographical code for each Sub-Location).

For the purpose of creating a single boundaries coverage for Kenya, the whole area of Kenya was divided into six areas. The Districts forming each of the areas are shown in table 10.1 below:

Table 9.2 Districts under each area

AREA	DISTRICTS
Area1	Kajiado, Narok, Nakuru, Kericho,South Nyanza, Siaya, Kisumu and Kisii.
Area2	Kiambu, Nairobi, Muranga, Nyandarua, Laikipia, Nyeri, Kirinyaga, Embu, and Meru.
Area3	Kilifi, Taita Taveta, Kwale and Mombasa.
Area4	Machakos, Kitui, Tana River District and Garissa.
Area5	Wajir, Mandera, Marsabit, Samburu, Isiolo, Turkana, West Pokot.
Area6	Busia, Bungoma, Kakamega, Nandi, Uasin Gishu, Elgeyo Marakwet, Baringo, and Transnzoia.

The reasons for dividing the country in the above manner were:

(i) To monitor problems within individual coverages and rectify them quickly. For example, after joining the coverages there were sliver polygons, pseudo nodes and dangle arcs and nodes that needed to be edited.

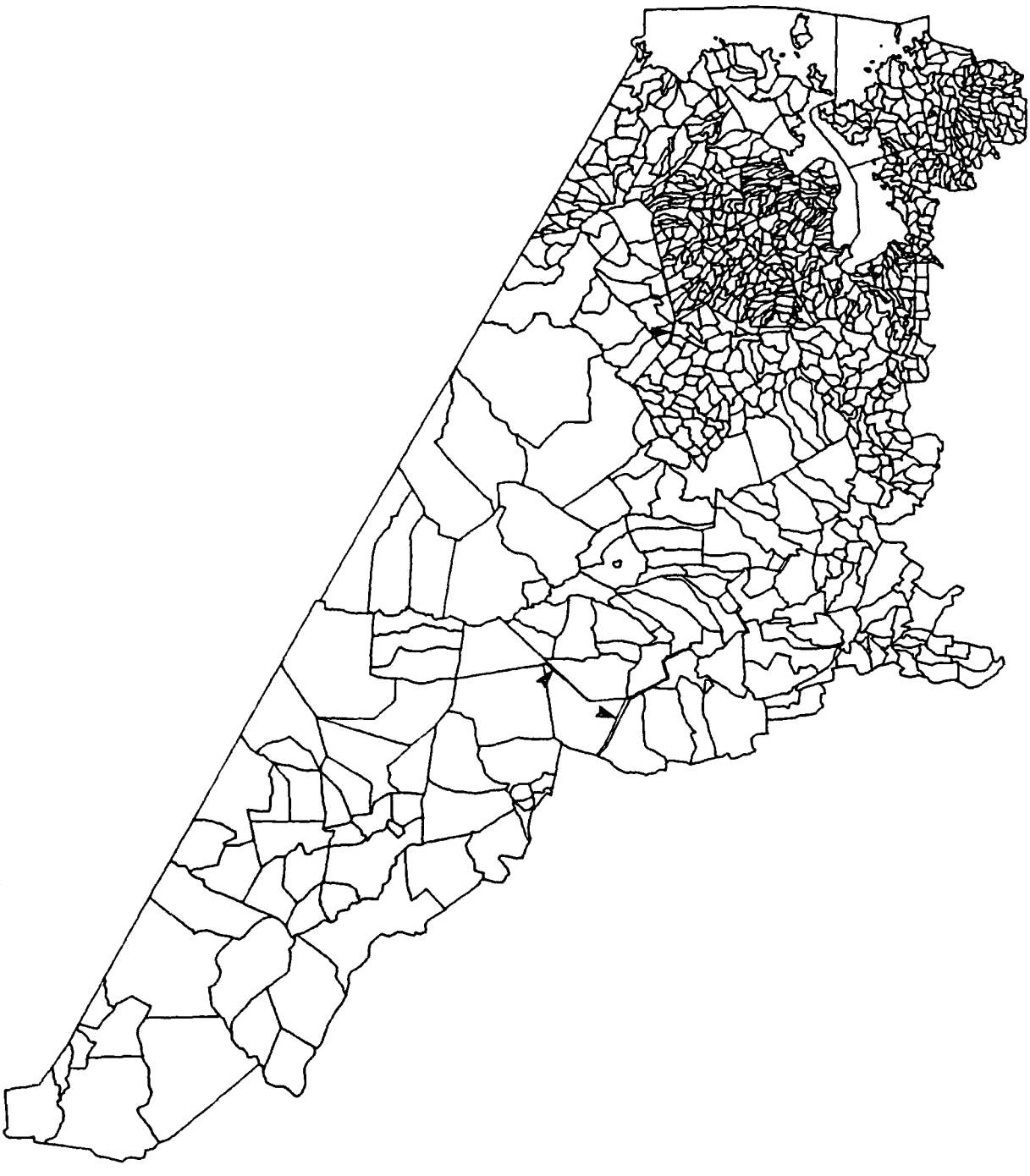
(ii) It was easier to edit a smaller coverage than a large one formed for the whole country. Also the PAT table for the whole country would be too large to check and edit. It would not have been easy to identify data for correct areas or Sub-Locations in the final large coverage for example it was in the final large coverage noticed during the joining exercise that Isiolo District was missing the population data and this was rectified without affecting other coverages.

(iii) The space in the computer was not enough to handle some big processing programs like ELIMINATE and CLEAN with one large coverage. ARC/INFO requires a lot of space to execute some of these programs because during the execution, it creates so many temporary files.

(iv) Also it took a long time draw the on the screen features of one single coverage for the whole country. This would have slowed down the editing.

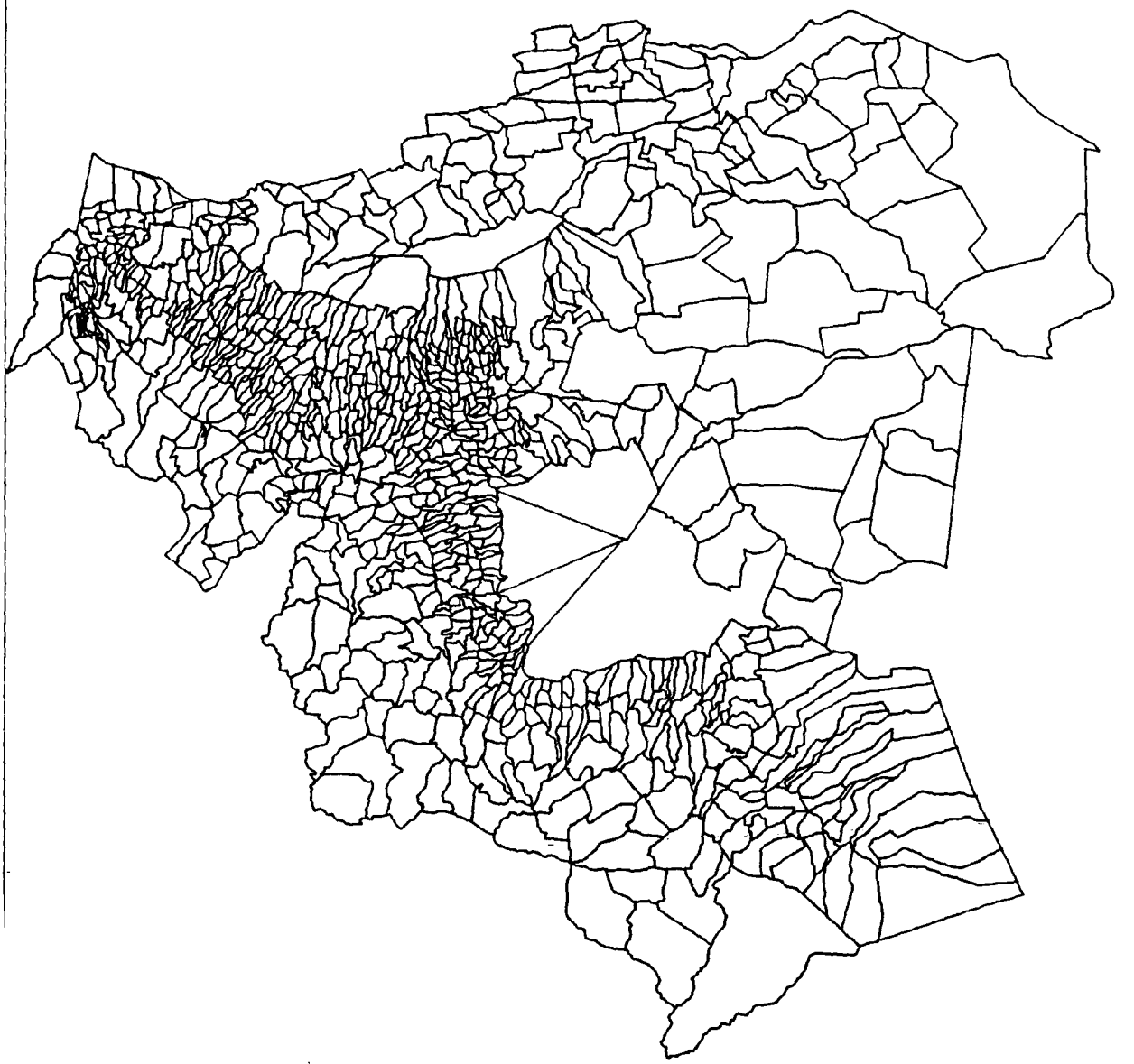
District coverages falling in each area were joined to create coverages Area1, Area2, Area3, Area4, Area5 and Area6. Then these coverages were joined to create a boundaries coverage for the whole country. To join the coverages, **MAPJOIN** command in PC OVERLAY was used. **MAPJOIN** merges adjacent polygon coverages into a single coverage. The six coverages are shown in figures 9.2A, 9.3A, 9.4A, 9.5A, 9.6A and 9.7A.

FIGURE 9.2A AREA 1



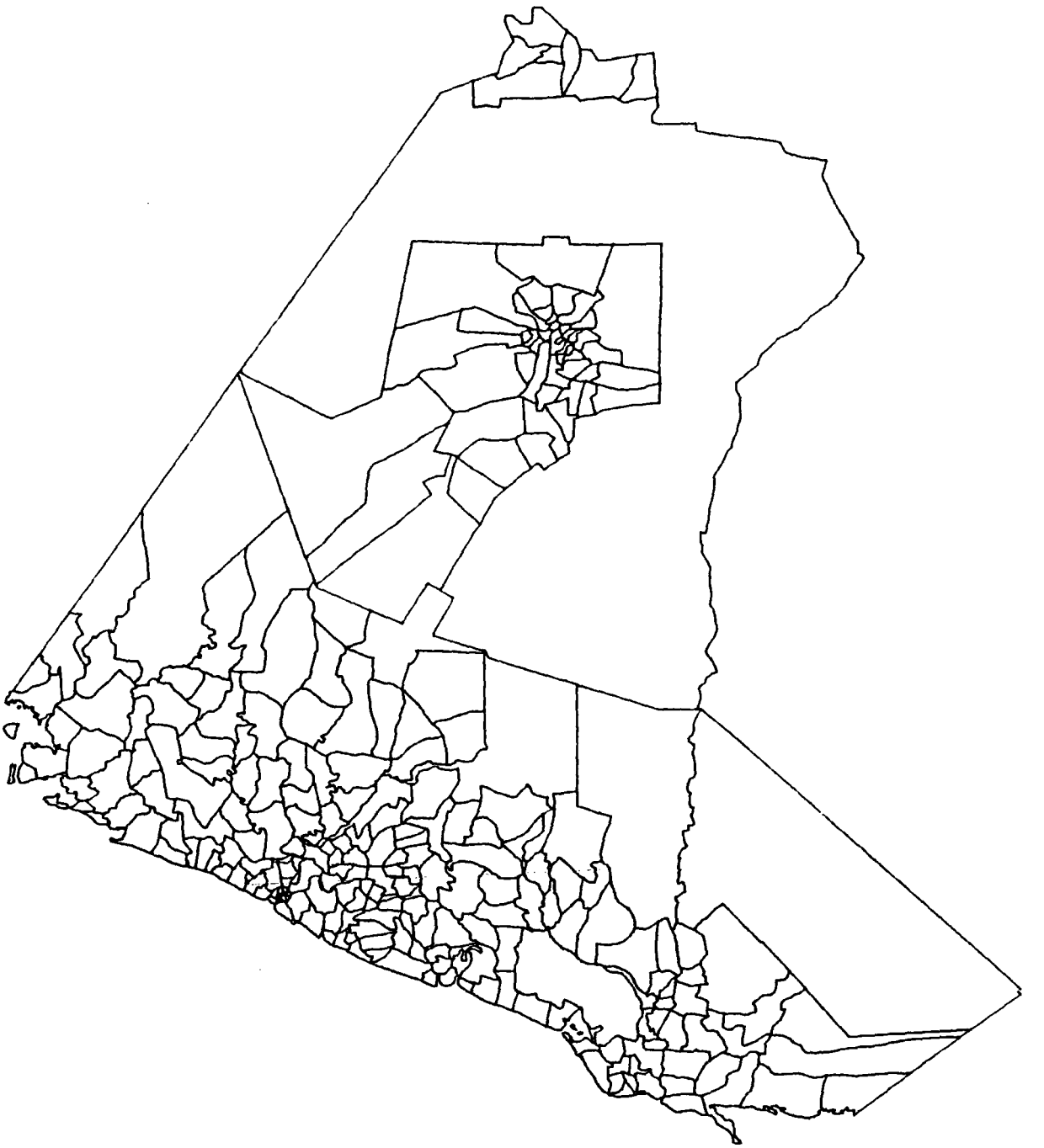
BEFORE EDITING

FIGURE 9.3A AREA 2



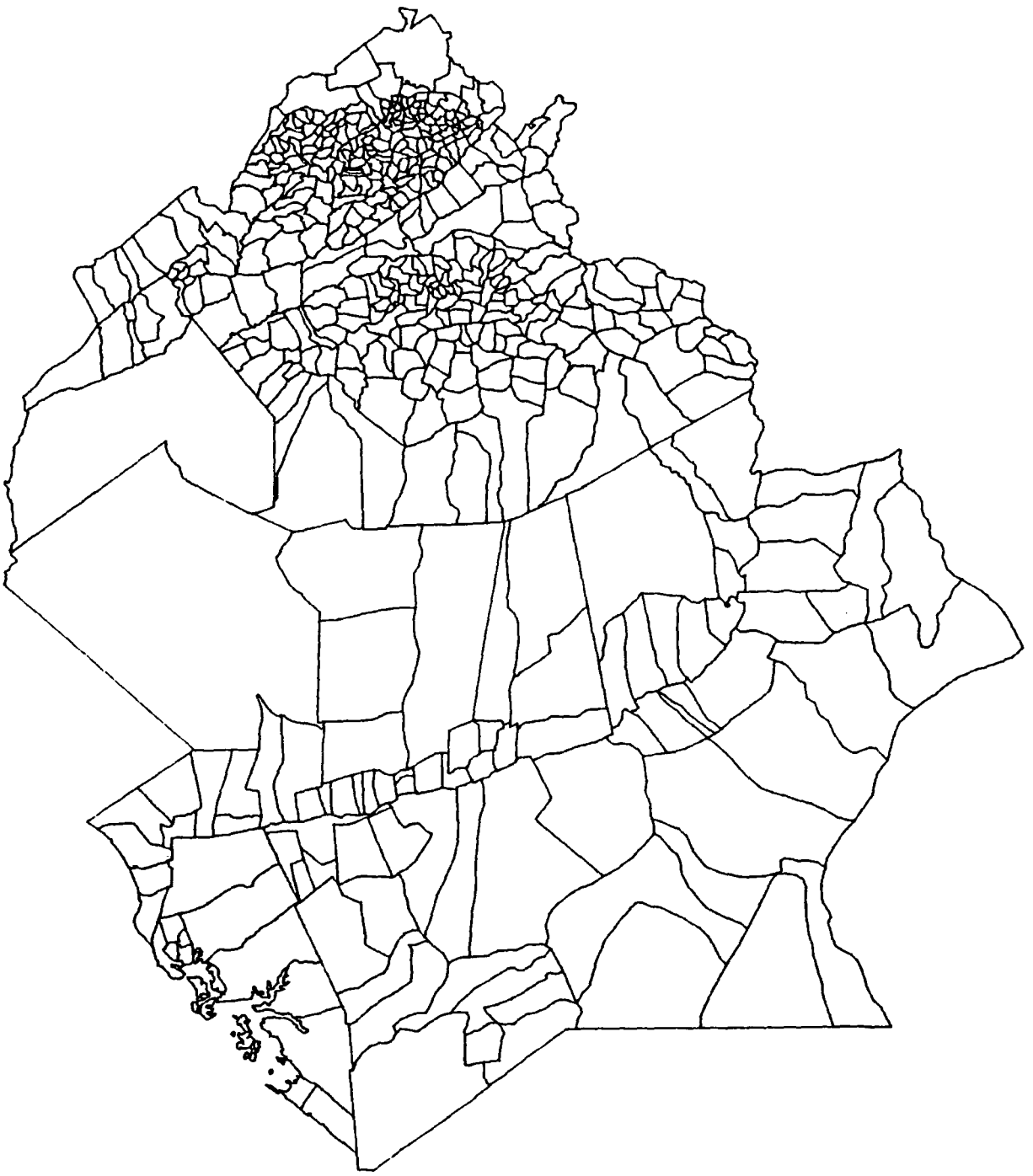
BEFORE EDITING

FIGURE 9.4A AREA 3



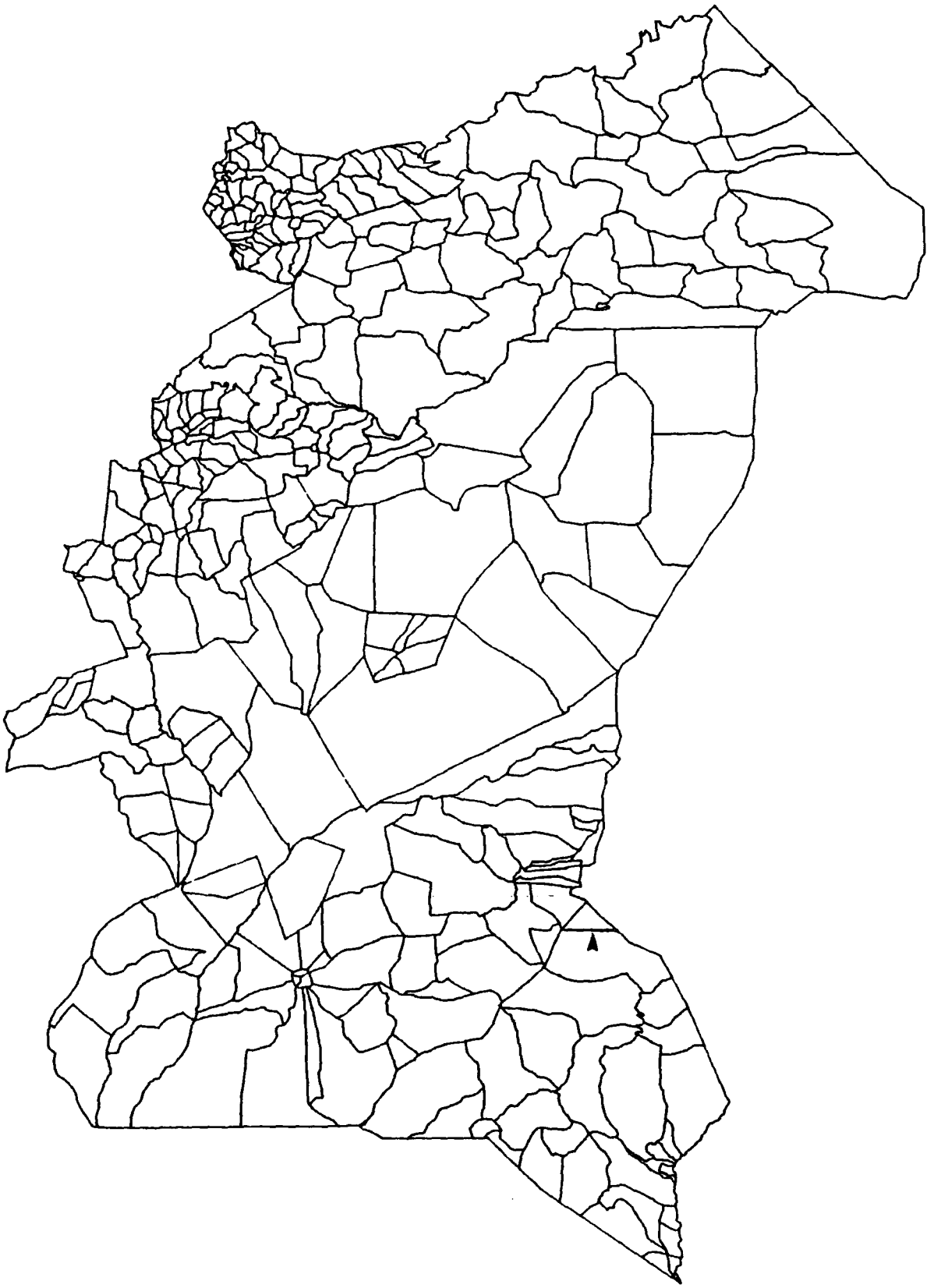
BEFORE EDITING

FIGURE 9.5A AREA 4



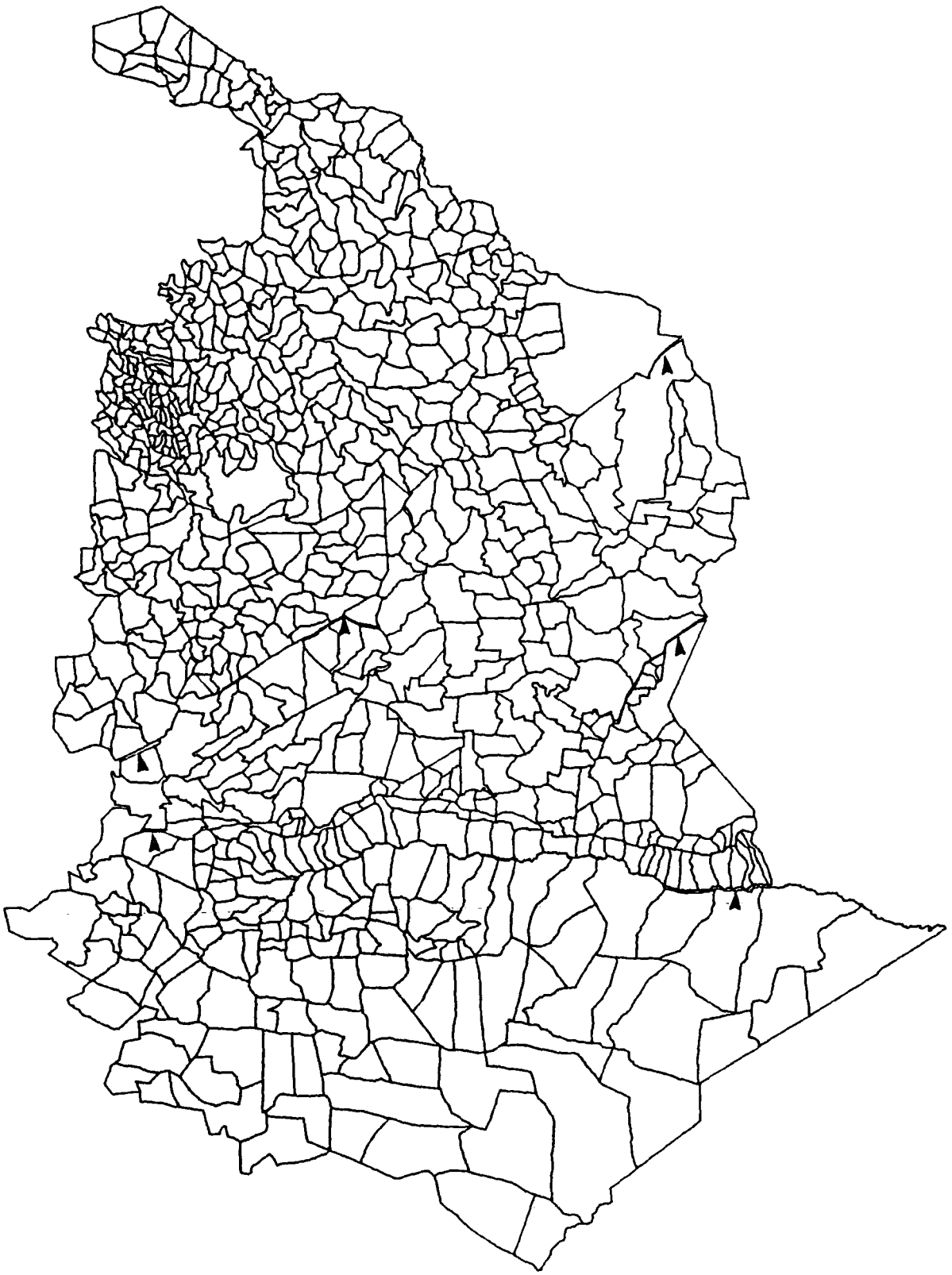
BEFORE EDITING

FIGURE 9.6A AREA 5



BEFORE EDITING

FIGURE 9.7A AREA 6



BEFORE EDITING

After joining the individual area coverages, there were very many sliver polygons, some of which were too small to be seen with naked eyes. They were removed using **ELIMINATE** command in PC OVERLAY. For the sliver polygons to be removed, first they had to be selected using a logical expression. For example in area1, they were selected using Area1 = 0. That is all the polygons whose User-Ids were zero were selected. This was an effective way of selecting the sliver polygon because it was known that they did not have any User-Ids. All the other polygons were identifiable with their label points or user ids but the silver polygons did not. **ELIMINATE** command was used and it was able to trace and remove all the unwanted polygons e.g all the polygons that had zero user Ids. For example area1 had 1376 polygon after, according to the PAT file and they were reduced to 991 after **ELIMINATE** was used on the coverage.

Coverages Area2, Area3 and Area5 did not have serious sliver polygon[3] left after **ELIMINATE** command was used (see figures 9.3A, 9.4A and 9.6A). They did not require editing. Coverages Area1, Area4 and Area6 had some sliver polygons left after **ELIMINATE** command (see figures 9.2A, 9.5A and 9.7A). These coverages had to be edited to clear these sliver polygons. Figures 9.2B, 9.6B and 9.7B show the coverages after they were edited. The affected areas are shown with arrows, before and after editing. Figures 9.1A and 9.1b show how Busia, Bungoma and

[3]Sliver polygon is a small polygon occurring along the borders of polygons following the overlay of two or more coverage. It can also be created when two coverages are joined to each other.

Kakamega Districts joint to each other. The sliver polygons in the common bonders are shown clearly. But they were all cleared by **ELIMINATE** command. This illustrates how useful the command was. Also it illustrates that the digitising was done fairly well given the types and problems which were common with the census maps.

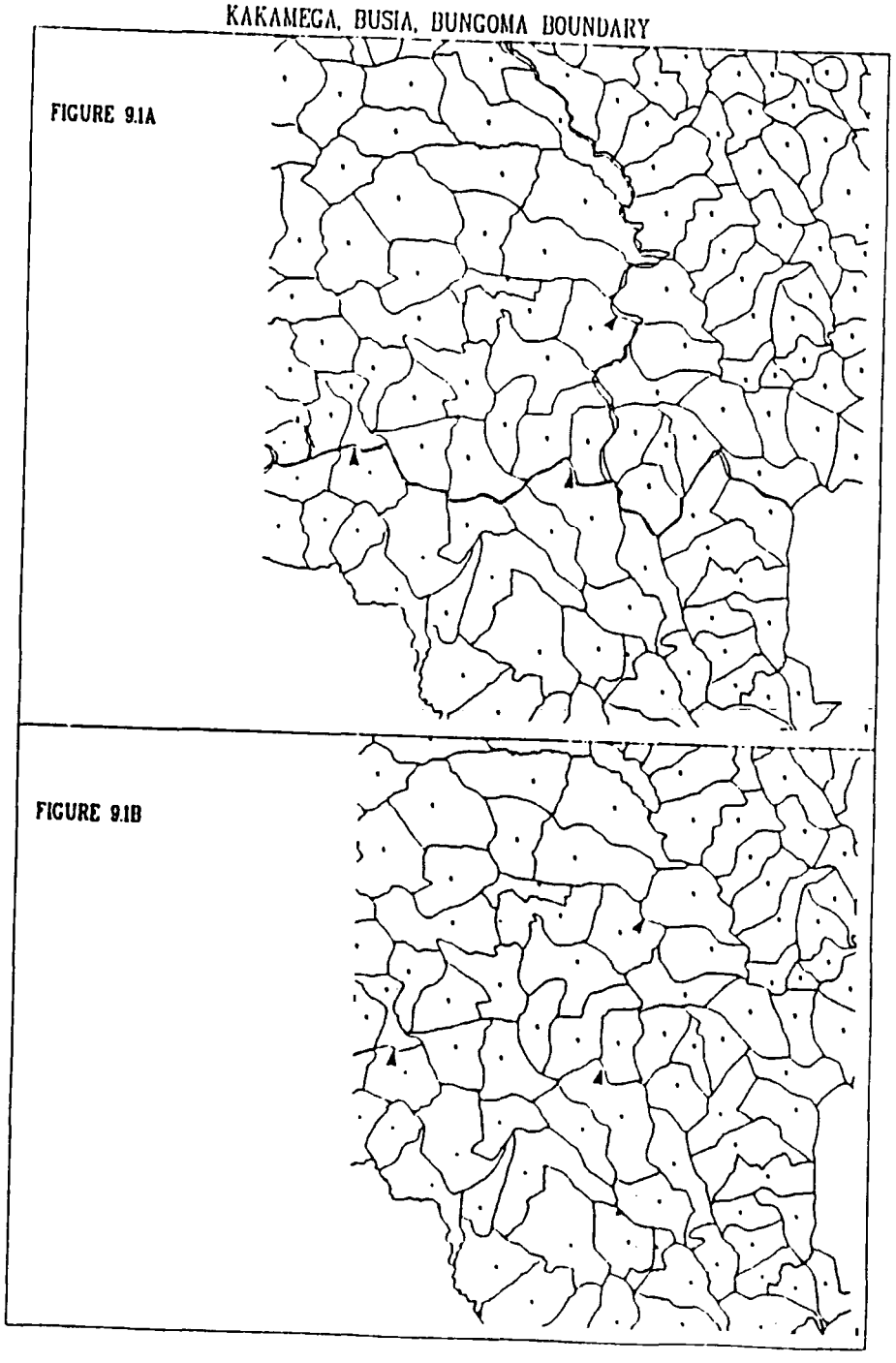
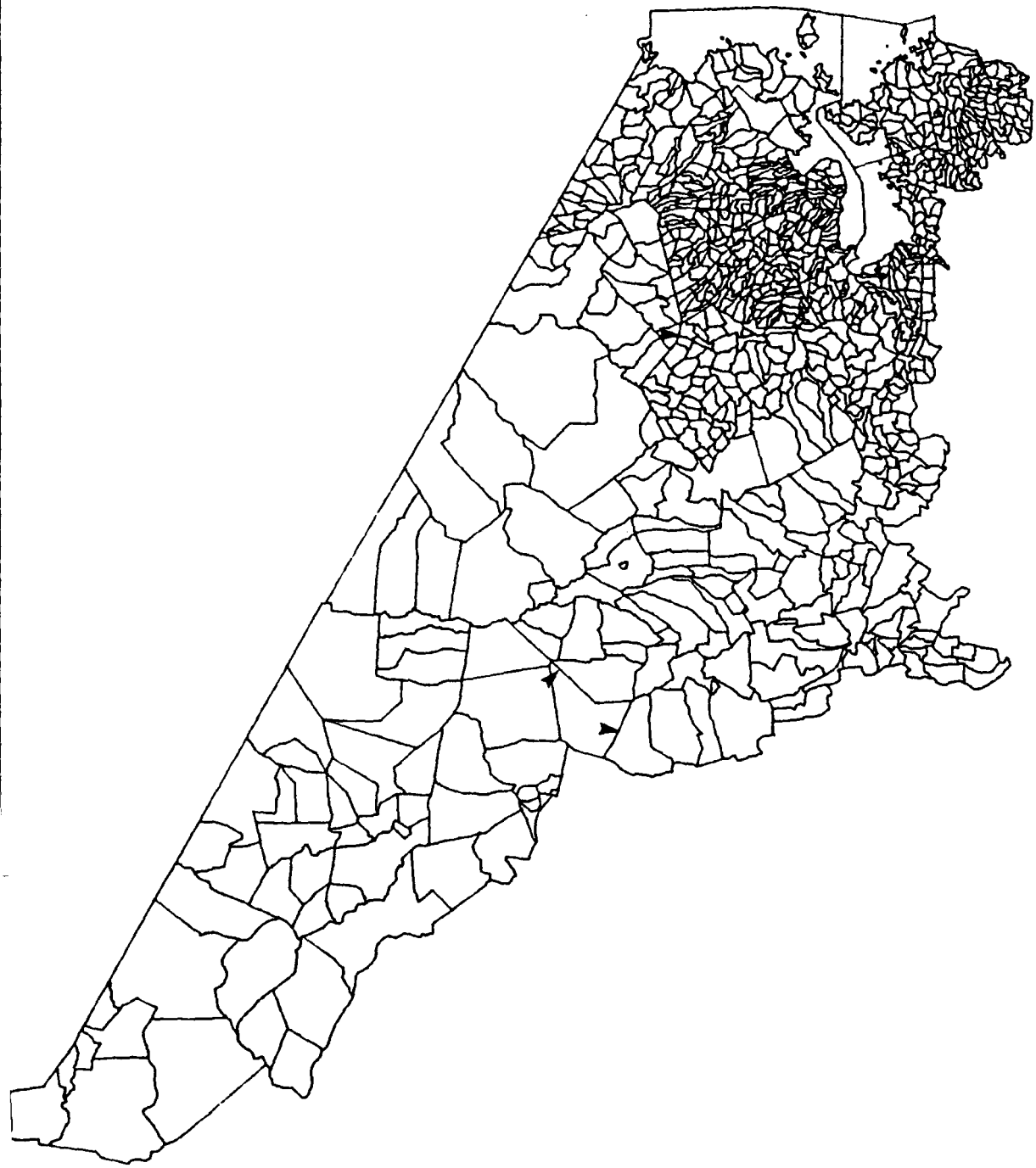
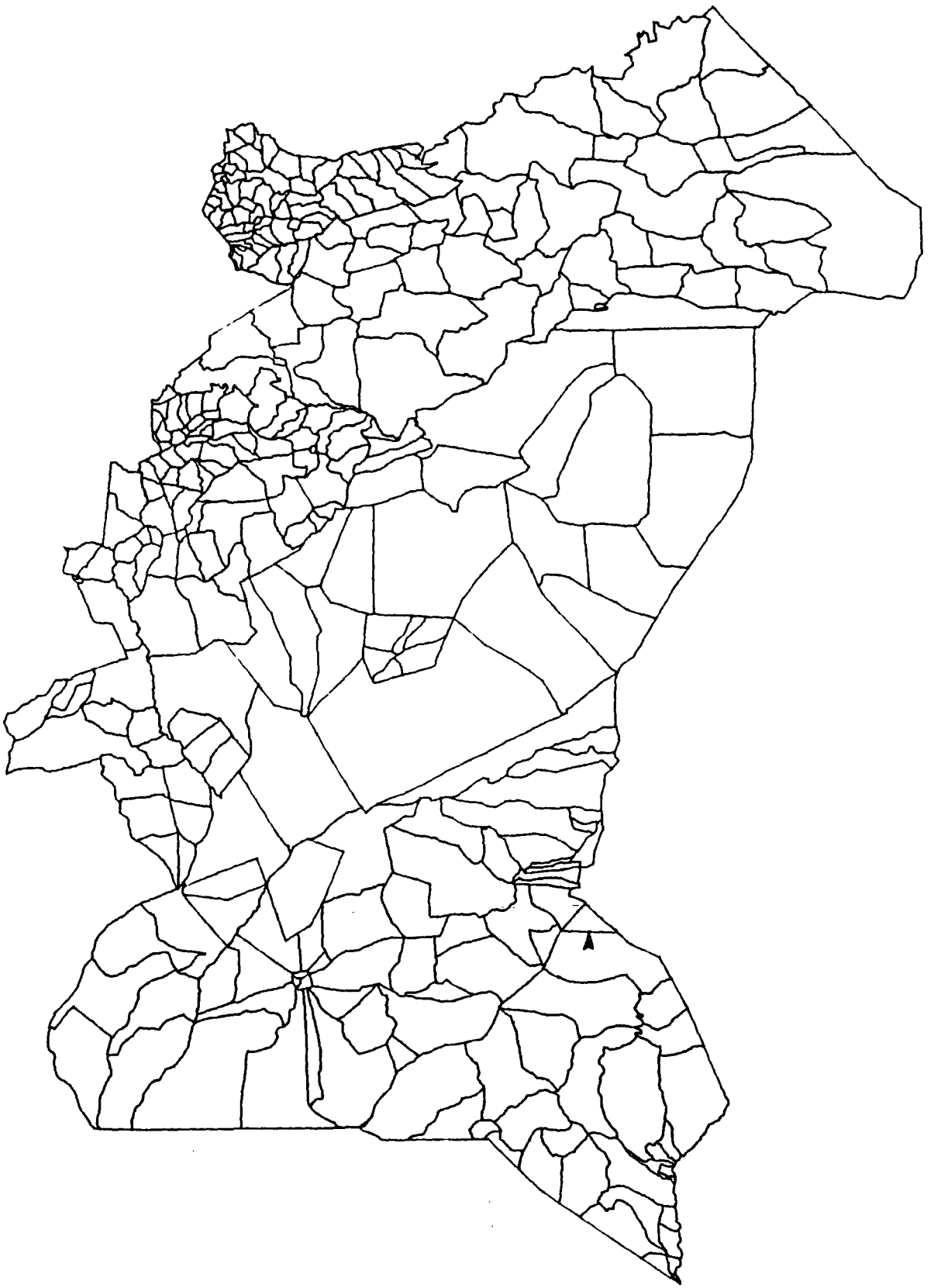


FIGURE 9.2B AREA 1



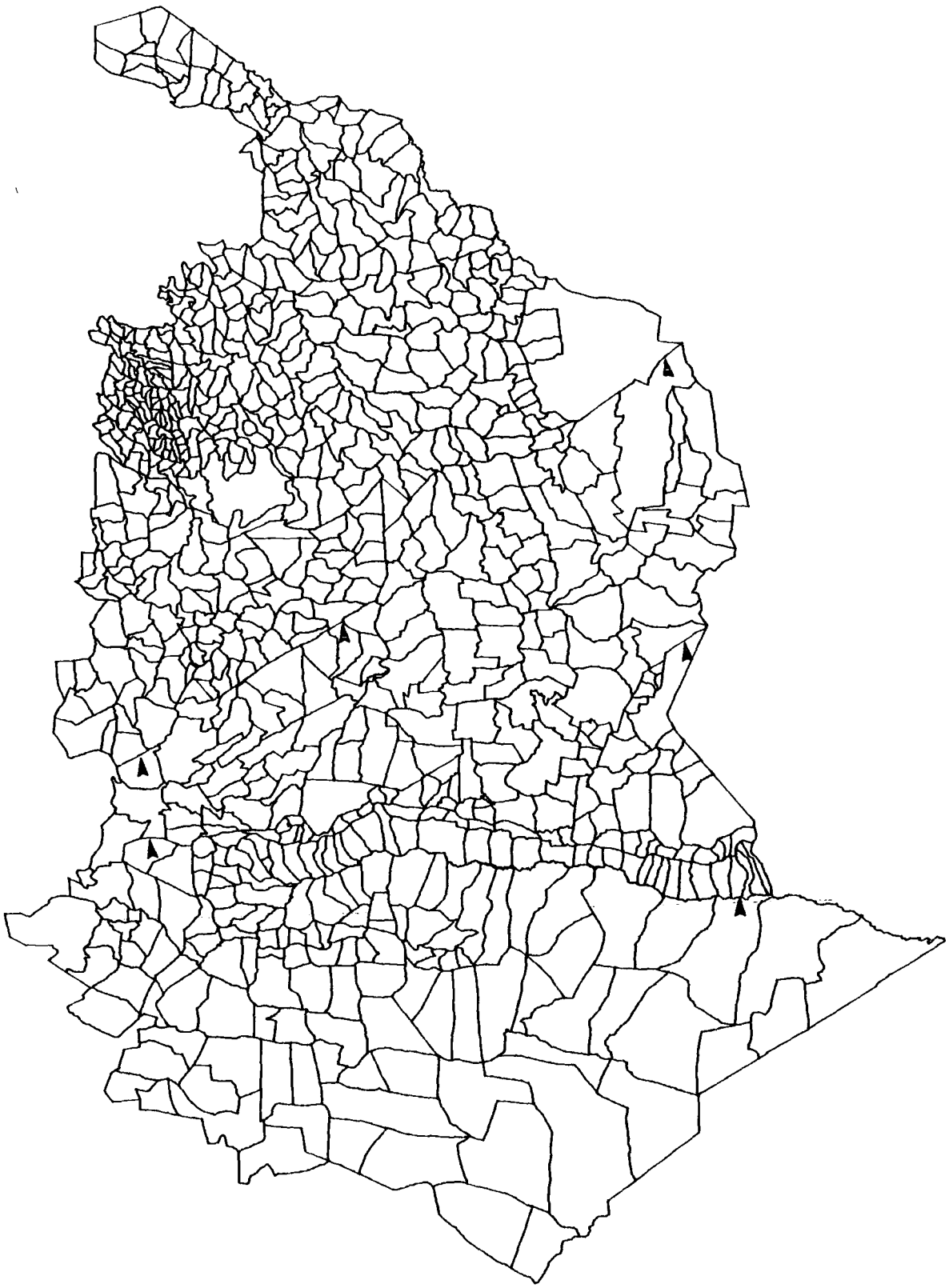
AFTER EDITING

FIGURE 9.6B AREA 5



AFTER EDITING

FIGURE 9.7B AREA 6



AFTER EDITING

The PAT table for each of the six coverages was updated with an additional item named "popden" meaning population density. The item was added using **ADDITEM** command in PC ARC/INFO STARTER KIT. It represents population density for each polygon or Sub-Location. The density values for each polygon were calculated using **CALCULATE** command in PC ARCEDIT. The PAT table for area2 showing the densities is shown in Appendix 9.1. The following items are shown Area, Perimeter, Rec (the internal or record number for each polygon), the User-Id (identification number for each polygon), popden (population density for each Sub-Location or polygon), pop (population for each Sub-Location or polygon) and the census geographical code for each Sub-Location or polygon).

All the six coverages and their PAT files were edited thoroughly after which they were joined to form a single coverage for the whole country. As before there were sliver polygons and other errors e.g dangle arcs and nodes in the final single coverage. As before they were removed in the same manner as discussed. ~~Figure 9.10 shows the single coverage before editing and~~ Figure 9.8 shows the edited coverage.

9.4 THE DENSITY MAPS

The final census population information was not ready at the time of this research. It should however, be noted that the data used here reflects the general situation in Kenya. The procedures followed in collected the data were explained in chapters two and

four. The Assistant Chiefs provided the Central bureau of Statistics with the estimate of households for each Sub-Location. The national average for the size of a Household e.g five persons per Household, was used to estimate the population for each Sub-Location. When the final census data will be available, it will be used to produce a second density map which can then be compared with the current map. This will be possible because the census geographical database will be available for this purpose.

The digitised census geographical information was used to produce the population density maps shown in figures 9.11, 9.12, 9.13, 9.14 and 9.17. The population density for each polygon or Sub-Location was calculated for each of the six areas before they were joined. The density was calculated by dividing population (pop values in the PAT file) with area. This was done by using the command **CALCULATE** in ARCEDIT. Appendix 9.1 shows the updated PAT file for Area2.

Table 9.3 shown below represents the lookup table used to assign polygons different shade symbols based on the popden item in the feature attribute tables. The lookup table was created in tables. The lookup table was created to store an item POPDEN as the lookup item. It also stored the symbol numbers. Successive records in the lookup table defined ranges of values from the lookup item i.e popden. This made it possible to assign the polygons different shade symbols. ARCPLOT used this table to get a value for the lookup item in the feature attribute table (PAT) then it looks for a match in the lookup table. If it does not

find a matching value, it used the next greater value for the lookup item. According to the lookup table shown below, the shade symbols for various popden ranges were assigned as follows:

Polygons with popden less than or equals to 5 were assigned shade symbol 5, polygons with popden values greater than 5 and less than or equal to 25 were assigned symbol 17, polygon with popden values greater than 25 and less than or equal to 50 were assigned symbol 21, polygons with popden values greater than 50 and less than or equal to 100 were assigned symbol 13, polygons with popden values greater than 100 and less than or equal to 200 were assigned symbol 25, polygons with popden values greater than 200 and equal to 400 or less were assigned symbol 61, polygons with popden values greater than 400 and less than or equal to 800 were assigned symbol 14, polygons with popden values greater than 800 and less or equal to 1600 were assigned symbol 26, polygons with popden values greater than 1600 and equal or less than 3200 were assigned symbol 62, polygons with popden greater than 3200 and less or equal or less than 6400 were assigned symbol 86 and polygons with popden values greater than 6400 were assigned symbol 1.

Table 9.3 POPDEN.LUT

Density Range	Symbol
5	5
25	17
50	21
100	13
200	25
400	61
800	14
1600	26
3200	62
6400	86
12800	1

Table 9.4 below represents the instructs that were used to draw the shade key for the maps. It shows the various population density ranges which have been discussed above.

Table 9.4 PDENSITY.KEY FILE

.5

<=5

.17

6-25

.21

26-50

.13

51-100

.25

101-200

.61

201-400

.14

401-800

.26

801-1600

.62

1601-3200

.86

3201-6400

.1

> 6400

The ARCPLOT commands used to draw the density maps shown in figures 9.11 and 9.13 are shown in tables 9.5 and 9.6 respectively. Each line in these files represents an ARCPLOT command which draws a particular map element.

Table 9.5 KE123456.SML FILE

```
display 1
pagesize 33 23
mapextent arcs ke123456
maplimits 0.5 0.5 32.5 22.5
mapposition cen  cen
mapunits 0.0000254
mapscale 1700000
mapangle 90
polygonshades ke123456 popden popden.lut
arcs ke123456
linesymbol 9
box 0.4 0.4 32.6 22.6
linesymbol 1
box 0.5 0.5 32.5 22.5
linesymbol 1
textsymbol 21
textangle 90
textfont 5
textsize 0.3
move 0.9  7
text 'FIGURE  9.11 KENYA POPULATION DENSITY MAP'
```

```
textsymbol 37
textsize 0.17
textsymbol 33
textangle 90
move 31.8 1.1
text 'SOURCE: THE 1989 POPULATION CENSUS'
move 32.1 1.1
text 'The Sub-Location boundary and population information was
provided by'
move   32.4 1.1
text 'the Assistant Chiefs during the population census field
mapping exercise'
move 32.25 15
text 'Scale 1:700000'
keybox 0.2 0.2
keyseparation 0.1   1
keyposition 26   3.5
keyshade pdensity.key
move 25.6 1.5
text 'PERSONS PER SQ.KM'
textsymbol  45
textangle  90
move 25   1.5
text 'K E Y'
```

Table 9.6 AREA2E.SML FILE

```
display 1
pagesize 33 23
mapextent arcs area2e
maplimits 0.5 0.5 32.5 22.5
mapposition cen  cen
mapunits 0.0000254
mapscale 400000
mapangle  90
polygonshades area2e   popden popden.lut
arcs area2e
linesymbol 9
box 0.4 0.4 32.6 22.6
linesymbol 1
box 0.5 0.5 32.5 22.5
linesymbol 1
textsymbol 21
textangle 90
textfont 5
textsize 0.3
move 0.9  7
text 'FIGURE  9.13 AREA2 POPULATION DENSITY MAP'
textsymbol 37
textsize 0.17
textsymbol 33
textangle 90
move 31.8 1.1
```

```
text 'SOURCE: THE 1989 POPULATION CENSUS'
move 32.1 1.1
text 'The Sub-Location boundary and population information was
provided by'
move   32.4 1.1
text 'the Assistant Chiefs during the population census field
mapping exercise'
move 32.25 15
text 'Scale 1:400000'
keybox 0.2 0.2
keyseparation 0.1   1
keyposition 26   3.5
keyshade pdensity.key
move 25.6 1.5
text 'PERSONS PER SQ.KM'
textsymbol  45
textangle  90
move 25   1.5
text 'K E Y'
```

From the Kenya population map shown in Fig. 9.11, it appears that most of the population of Kenya is living on less than 1/10 of the land area. Three main regions of population concentrations may be defined:

(i) The Lake Victoria Basin, comprising of Nyanza and Western provinces.

(ii) The east and west Rift Valley highlands comprising Nairobi,Central Province, Rift Valley Province (but excluding Turkana, Samburu, Baringo, Laikipia, West Pokot, and parts of Kajiado and Narok) and Eastern Province (excluding Isiolo, Marsabit, and parts of Machakos).

(iii) The coastal belt comprising of Mombasa, the coastal areas of Kwale and Kilifi, and parts of Taita Taveta. These major population concentrations separate vast areas of low population densities in Northern and Southern Kenya.

9.5 EVALUATING PC ARC/INFO

ARC/INFO offers the most extensive range of software tools. Powerful data management manipulation and modelling tools allow user retrieve data rapidly, perform sophisticated analysis and out put the results as tabular reports or high quality maps.
A relational database interface (RDBI) allows users to integrate ARC/INFO with tabular database management system of their choice. ARC/INFO GIS software runs on a wide range of hardware; Micros, workstations, Mini and mainframe computers giving users the freedom to choose the system that meets their corporate requirements. ARC/INFO has over 3000 installations worldwide. Its applications are many and varied including, local Government property and planning, highway information systems. In the U.K it is used in a wide range of Universities, (it is the core GIS

for higher education after a recent national purchase), Local Government organisations, utilities, and private sector companies (Doric Computer Systems, 1989).

ARC/INFO is a very user friendly piece of software. Its digitising capabilities are many and quite advanced. It was used to digitise, interactively, large coverages of the 1989 Kenya population census District maps. Both arcs and label points were digitised using **ADS** command. It includes facilities to edit coverage features while in ADS for example arcs and label points digitised by mistake could be removed, missing arcs and label points could be added. Small parts of a coverage could be enlarged on the screen and this helps to identify digitising errors. Also after digitising, a plot file could be prepared using **EDITPLOT** and send to the plotter to produce a hard copy which could be used to identify digitising errors.

CLEAN and **BUILD** are two very important commands in ARC/INFO which were used to process the digitised coverages. Both were used to build coverage topology and to create AAT and PAT tables. Topology arc-node or polygon topology is very important in coverages. The PAT files for the boundary coverages for the 1989 Kenya population census District maps contained the area, perimeter, user-id, population density, population, and code for each polygon. The last three items were added into the coverages' PAT using the polygon User-Id as the relate item. The PAT files were capable of holding a lot more information about each polygon or Sub-Location.

The editing capabilities of ARC/INFO are many using ARCEDIT commands. Interactive editing allowed arcs, label points, nodes, etc to be removed or added. The edit coverage could also be displayed together with a neighbouring coverage so that both could be compared while editing.

The ability of ARC/INFO to join coverages made it possible to create one large coverage for the 1989 Kenya population census coverages. MAPJOIN command was used to join all the boundary coverages including their feature attribute tables. The resulting sliver polygons were removed using ELIMINATE command.

PC ARCPLOT has all the necessary facilities that can be used for mapping. It has capabilities for displaying maps, positioning features, specifying symbols, drawing features, labelling features, adding titles and making map compositions interactively and saving them as plot files. While creating maps interactively in ARCPLOT, map elements can be changed at any time. Also a set of ARCPLOT commands can be organised in the form of an SML file which can be used to draw maps.

PC ARC/INFO is supplied with manuals, videos, and workbooks. Recently a documentation by the name "understanding GIS" has be released. All these materials if used well can offer all the necessary information required to work with ARC/INFO. The necessary GIS concepts are found in the manuals and in understanding GIS. The videos and the workbooks provide the technical aspects. The trainee listening to the video lessons can

follow some of the issues which might be difficult to understand from the manuals. Also the workbooks provide a lot of information that if read carefully can be very useful. There are questions after every lesson. The workbooks are supposed to be used together with the videos.

9.6 CHOOSING A GIS FOR KENYA

Census data are for use by the Government and other agencies for applications such as planning, population development and economic development. The census is used in the planning of educational facilities, health facilities, roads, and for demarcating administrative and civic areas. The 1989 population census will provide updated information which will be useful. In the past the census data has been analysed in tabular form. Little has been done in analyzing the census data with maps due to, lack of qualified personnel, lack of funds, lack of good census maps and lack of equipment. Since the Central Bureau has failed to do enough analysis with the census data using traditional cartographic methods, it should now adopt computer mapping. The major advantages according to Burrough,(1986) are:

(i) To make existing maps more quickly.

(ii) To make existing maps more cheaply.

(iii) To make maps for specific user needs.

(iv) To speedup the delivery of census data to clients.

(vi) To make the analysis more cost effective.

(vii) To enable the integration of the census data with other data.

The digitised 1989 Kenya population census geographical data forms a basis for starting a geographical information systems for the census. There are however some important considerations to be made regarding:

(i) Hardware.

(ii) Choosing the system.

(iii) Personnel.

(iv) Funding

About 100 PC computers were purchased for the 1989 population census project through the United Nations. At the moment these computers are being used for processing the census results. When the data processing workload is reduced some of the computers can be used for mapping the census results. Also under the census project, 2 digitisers and 2 plotters were purchased.

In the Central Bureau of Statistics, there are no staff who have

knowledge of geographical information systems. I am the first to have developed expertise. I have gained some skills that can be utilised in starting a geographical information systems in the census office at a managerial level, could coordinate the training of some staff of the cartographic office who will be required to undertake some mapping aspects using computers. Also some more cartographic officers can undergo formal training by a system vendor- either within Kenya, or abroad where they can study other national census operations.

It will not take very long before we start analysing the census data first using the geographical database which has already been created all that is needed is to add extra variables into the database. It may not be necessary at the moment to think of digitising census information at lower levels than the Sub-Location.

A geographical information system is not cheap, and requires skilled and knowledgeable staff. Administrators need to be convinced that they must provide the required funding and that the cost benefit justify the investment being made. The census project has been budgeted upto 1992 and there has been no provision for the project I have proposed above. But the UN is funding the project, it is fully aware about the advantages of developing a GIS, it can be requested to review the census funding and include an item for computer mapping. However, the final decision rests with the Director of Statistics who could advise the Government accordingly.

9.7 CONCLUSION

The procedures of updating the attribute tables for various coverages with population data have been explained. The techniques used to put together all the boundary coverages to create a single coverage for Kenya were also reviewed. The steps followed in the production of the 1989 Kenya population census Density map were explained. It was noted that the data used to prepare the density map may have not been very accurate given that the information regarding households was provided by the Assistant Chiefs. The final population census date was not available because there has been delays in the processing. When it becomes available it will be used to prepare a second population density map, using the geographical database, which can then be compared with current map. This can be a good opportunity to assess the work of the Assistant Chiefs.

The digitised census information forms a geographical data base that in future can be used for manipulating, mapping and analyzing the census data. Using this base some other aspects of census mapping may be considered, for example:

(i) Mapping census data with other environmental data e.g tourism, transportation network, land use, hydrology etc.

(ii) Mapping inter-censal population increase by major tribal groupings.

(iii) Mapping Population distribution by tribe and Nationality broken into male and female.

(iv) Percentage distribution of population age 10-14 with no education and age 20-24 with education form1 by District.

(v) Percentage distribution of population by age and educational attainment etc.

Some proposals have been made regarding developing a geographical information systems for the 1989 population census. The advantages of doing so have also been provided. Most of the requirements will be available e.g computers, digitisers, plotters, and the necessary managerial skills. The geographical data base that can be used for the initial census mapping is also available. the usefulness of PC ARC/INFO as a mapping and data analysis system. It was suggested that the Director of Statistics should request the UN who is funding the census project to review the census project and include an item on population census computer mapping.

CHAPTER 10

CONCLUSION

A primary aim of this research has been to evaluate the potential of GIS technology for possible introduction into the analysis of the census of Kenya. Accordingly one year research programme was undertaken with the following aims.

(i) To evaluate the training implications in GIS.

(ii) To evaluate the quality and usefulness of base maps produced by the Kenya Statistics Office. This was with a view to automating them for subsequent digital mapping.

(iii) To achieve capability and understanding of concepts in the process largely referred to as "digital mapping". Within one year programme, dealing with a new set of technological concepts, and coping with source material being sent from Kenya, it was deemed too complex to move onto full GIS techniques such as network analysis and overlay. Nevertheless, another of the aims was to become conversant with the techniques and their possible applicability back in Kenya. This will point the way to future areas of research.

It was shown that maps are very essential for carrying out a census. However there have been many problems that have made it difficult to prepare good maps for Kenya censuses. These problems

which include lack of base maps, personnel and funds affect most developing countries. Because of these problems it has not been possible previously to prepare census analytical maps for Kenya. Although some density maps were prepared for the 1962 and 1969 population censuses, these were few and small scales. The programme to prepare maps for the 1979 census never succeeded and the ones prepared earlier are already out of date. There was therefore need to make better arrangements for the 1989 population census. The 1989 census mapping programme was planned with the knowledge of all the problems that affected the previous censuses. The initial considerations made in the planning stage were discussed; for example recruitment and training of personnel, updating the census geographical frame, taking inventory of the base maps and acquiring the additional maps, taking inventory of the cartographic equipment and materials and acquiring additional ones, preparation of forms for controlling the mapping work, and listing the mapping activities and making the mapping calender. Field work for the census mapping was considered to be very important. The procedures used to develop the field mapping methodology were discussed in chapter 3.

Chapter 4 was concerned with the cartographic field work. The recommendations made in chapter 3 were deployed in the field mapping exercise. The field organisation, training of the field mapping staff, the procedures used in updating the base maps and delineating EAs in different areas were discussed. The role of the Assistant Chiefs in guiding the field mapping staff, showing them the Sub-Location and Village boundaries and providing

household estimates for every Village was stressed. Treatment of National Parks, Forest areas, Large enumeration areas, special areas, and Sub-Locations with boundary problems was discussed. Before the final EA maps were printed for use in the field, the Assistant Chiefs were given the maps to confirm if they were correct. Most of the boundaries e.g for Sub-Locations and Villages were satisfied correct.

This was the first time in the history of the Kenya census that field work was undertaken at the Village level. For the field staff to map all the Sub-Location and Village boundaries on the census, they needed a lot of support, in particular effective transport. It was observed by the UN cartographic Adviser that the work turned out was good and the needed to be information be consolidated in the form of gazetteers and maps for use by many people.

Chapter 5 was concerned with the geographical code scheme for the census. This geographic scheme was required to assist in uniquely identifying the census areas. Without such a code scheme there would have been problems with the identification of the census areas especially in Kenya where there were about 37,047 Enumeration Areas. Also it was observed that a lot of areas shared common names and the best thing was to assign them code numbers. Each census area was therefore assigned a unique number, there were no two or more areas with the same number. Also the other important feature about the code was that it differentiated urban and rural population.

Very many census maps and documents were being handled in the census mapping work by very many different people. It was essential therefore to develop a methodology that could be used to monitor the maps and materials making sure that they were not lost or misplaced. Such a filing and indexing scheme was analysed in chapter 6. The method was so effective because throughout the mapping exercise there was no single maps or census mapping document that was lost or misplaced. Chapter 7 was concerned with the preparation of the final EA maps and reproducing the required copies. It was seen that unqualified staff was used to prepare the maps but with very close supervision, good census maps were prepared. However there was delay in the production of the maps but this was caused by the delay in field work.

There is generally little doubt of the utility of a computer system as a medium for data storage, analysis and retrieval. Its advantages over manual mapping techniques were discussed. Information retrieval, information updating and data analysis can be rapid and non-tedious, and maps and graphs may be generated automatically more or less as the user requires them. Chapters 8 and 9 looked at some aspects of analysing the 1989 Kenya population census within a geographical information systems. PC ARC/INFO was used to digitise the census District maps, clean the boundary network, prepare an initial database of census information, and map some aspects of the census data. The procedures used to digitise and put together all the District coverages to create one single coverage were explained. The steps

followed to update the coverage PAT files and the production of the 1989 Kenya population census Density map were discussed. Having used ARC/INFO to create a large coverage for Kenya population census District maps, it was assessed and found to be very useful GIS system. On the basis of the skills gained in the use of ARC/INFO it was recommended for installation in the census office and the implications of doing so were assessed.

It was pointed out that, a geographical information system is not cheap, and requires skilled and knowledgeable staff. A proposal will need to convince the Director of Statistics that funding the proposed project is necessary and that the cost-benefits justify the investment being made. Funding in the immediate future might be a problem but it was suggested that the Director of Statistics should approach the UN which is funding the census project, to review the project and include an item on population census computer mapping. The UN is already fully aware about the advantages of installing a GIS in the census office.

About 100 PC computers were purchased for the 1989 population census project through the United Nations. At the moment these computers are being used for processing the census results. When the data processing workload is reduced some of the computers could be used for mapping the census results. Also under the census project, 2 digitisers and 2 plotters were purchased. The assessment of personnel requirements was also made. In the Central Bureau of Statistics, there are no staff who have knowledge of geographical information systems. I am the first to have developed expertise. The skills I have gained could be utilised in starting a geographical information systems in the census office at a managerial level, where I could coordinate the training of some staff who would be required to undertake some mapping aspects using computers.It was also suggested that some more cartographic officers could undergo formal training by a system vendor- either within Kenya, or abroad where they could study other national census operations. The proposed GIS would use the already created geographical database and possibly add extra variables into it. It may not be necessary at the moment to think of digitising census information at lower levels than the Sub-Location but the digitised census information forms a geographical data base that can be used now and in the near future for manipulating, mapping and analyzing the census data. Using this base some other aspects of census mapping may be considered, for example:

(i) Mapping census data with other <u>environmental</u> data e.g

tourism, transportation network, land use, hydrology etc.

(ii) Mapping inter-censal population dynamics by major tribal groupings.

(iii) Ethnicity, mapping Population distribution by tribe and Nationality broken into male and female.

(iv) For education - Percentage distribution of population age 10-14 with no education and age 20-24 with education form1 by District. Percentage distribution of population by age and educational attainment etc.

(v) Transportation. Using road network, demographic and environmental information for future transportation planning.

This study has proved the feasibility of full computer mapping for the analysis of the 1989 Kenya population census. It provides a basis for the development of a full GIS capability. Existing systems, in particular PC ARC/INFO, have been shown to be highly effective in that their provision of training materials. In a period of 12 months, from no previous computer expertise, I have acquired skills in computer mapping, word processing, and graphics. Furthermore, the cartographic information from Kenya, while having limitations (such as lack of reference points) has been combined and integrated to provide a national coverage.

Census data, already in computer form, are relatively easily integrated into the GIS database.

To build on this start, the Central Bureau of Statistics can start to develop a full operational specifications for an operational GIS. This will need assessment of financial requirements, staff development strategies, and information provision. This, is the next stage of research and development.

APPENDIX 4.1

SUB-LOCATIONS WITH BOUNDARY PROBLEMS

DISTRICT	SUB-LOCATION
Kiambu	Thongoto, Gikambura
Nyandarua	Njab, Bamboo, Rwanyambo, Mukeu, Githabai
Meru	Michiune, Upper, Chure, Kothine Karia, Giku, Amwathi Antubetwe/Kiongo, Athiru/Rujine Antubetwe/Njoune, Liliaba, Auki, Kirindine, Miathenge Athinga, Athanja, Kiathrene Anduamburi, Karama, Kitheo, Athwana, Nchooro, Mituntu
Kisii	Getenga, Nyataaro, Nyaramba S.Mugirango/Boige Borabu, Nyanguru, Kingoro
Kitui	Museve/Ivaini, Kamandio/Malili, Mutune Nzeluni, Kanzanzu, Katawa Thaana Nzau, Itoloni Ndakani, Kalia Katune Kivyuni, Kasunguni, Ngungi

	Nzamba
Samburu	Ndoto, Arsi
Garissa	All sub-Loc along Tana River
Tana River	All the Sub-Locations along Tana River
Turkana	A problem at the bounder with West Pokot
U.Gishu Ainabkoi	Chesogo, Timboro, Koiluget
	Kapkoi, Kelji, Sergoit
	Ziwa, Matunda, Chebarus
Mandera	Hareri, Sala
W.Pokot	Kale, Kakwotendwo
	Ortum, Parua
	Chesira
Taita	Miasini, Kaloleni, Kishamba
Kajiado	Lorongswa, Illpartimaro,
	Bissil, Osilalei, Olnyo Nyukie
	Shampole, Kimana, Mbirikani
Kisumu	Kasule, Nyalunya, Songhor East
	Kabar West, Sidho Central, Kamaga

	Mohoroni West, Nyangore
Bungoma	Kanduyi Township
Busia	Busia Township, Maenje, Bujuma Matoyos
Baringo	Muchongoi, Sibilo, Loruk/Kechii Kipcherere, Salabani
Laikipia	Ngoru, Muthengera, Salama, Ngoru
Nakuru	Elburgon, Maella
Kericho	Londian, Kipkelion
Isiolo	Isiolo East, Isiolo Central
South Nyanza	S. Kamamwango, N. Kamawango, Kameji, E. Kogelo, K/K/Kawour, Kabura, Kamdar Kawanga, Karading, Kobila, Kokoko, Komenya, Kanyiriema, Gongo, Kanam, Kowili, Kaura, Kamenya, Korayo, Kanyach Kachar, Kogwang, Kabuola, Katuma, Kanyaruanda, Kowidi, Kasewe, Kamuma, Kanjira, Mugatonde, Kowour,
Lamu	Witu, Pandanguo

Machakos	Kitwii, Kikambuani, Kangundo Urban, Tala t.c, Makiliva, Embui, Kalyambeu, Masii Loc, Masii Loc, Itumbule, Kalamba, Ndithini, Kavumbu, Mitamboni, Athie River town, Kathiani t.c, Mitaboni t.c, Kiteta Loc, Utangwa, Kitundu, Uvuu, Mumela, Sultan Hamud, Konza South, Settled Area, Ngelani, Kimakimwe, Kathonzweni Loc, Makueni Loc, Kitise, Kiangini, Kwakavisi, Muvau, Kyua, Ekalakala, Ndalani, Mavoloni, Ndithini, Manaja, Milaani, Kambu, Muthingini
Kakamega	Malaha, Budonga, Iguhu, Shitoli, Wambulishe, Mundombelwa, Madivini, Ebusamia, Mugomari, Shivagala, Lubao, Shamberere
Siaya	Mageta island, Bar-Chando, Got Abiero

APPENDIX 4.2

FORM CBS/KPC/89/7 SHEET NO.....OF SHEETS

HEADS OF HOUSEHOLDS LISTING

1989 POPULATION CENSUS

PROVINCE.....LOCATION.....

DISTRICT.....SUB-LOC.....

DIVISION.....

VILLAGE/ESTATE..... .....ASSISTANT CHIEF.....DATE.....

SERIAL NO	NAME OF HEAD OF HOUSEHOLD	SERIAL NO	NAME OF HEAD OF HOUSEHOLD
1		41	
2		42	
3		43	
4		44	
5		45	
6		46	
7		47	
8		48	
9		49	
10		50	
11		51	
12		52	
13		53	
14		54	
15		55	
16		56	
17		57	
18		58	
19		59	
20		60	
21		61	
22		62	
23		63	
24		64	
25		65	
26		66	
27		67	
28		68	
29		69	
30		70	
31		71	
32		72	
33		73	
34		74	
35		75	
36		76	
37		77	
38		78	
39		79	
40		80	

APPENDIX 4.3

FORM CBS/KPC/89/6 SHEET NO.....OF SHEETS

LIST OF THE DELINEATED EAs

1989 POPULATION CENSUS

PROVINCE.....CODE.....

DISTRICT.....CODE.....

DIVISION.....CODE.....

LOCATION.....CODE.....

SUB-LOC.....CODE.....

REFERENCE: TOPOSHEET NO:.....MAPPING ASSISTANT.....DATE.....

CBS INDEX NO.....TEAM LEADER.....DATE.....

SERIAL NO.	VILLAGE/ESTATE	EA CODE NO	HOUSEHOLDS	URBAN IF APPLICABLE
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				

APPENDIX 4.4

FORM CBS/KPC/89/2

SHEET NO.....OF SHEETS

STRUCTURE/HOUSEHOLD LISTING

1989 POPULATION CENSUS

PROVINCE.....CODE.....
DISTRICT.....CODE.....
DIVISION.....CODE.....
LOCATION.....CODE.....
SUB-LOC.....CODE.....

VILLAGE/ESTATE..... .....MAPPING ASSISTANT.....DATE.....

EA CODE.....TEAM LEADER.....DATE.....

REFERENCE: TOPOSHEET NO.....

CBS INDEX NO.....

SERIAL NO.	STRUCTURE NO. NUMBER						USE OF STRUCTURE DU,B,DU/B,K,DU/K,V,O	FULL NAMES OF HOUSEHOLD HEAD IF USED FOR DWELLING	REMARKS
1	KPC								
2	KPC								
3	KPC								
4	KPC								
5	KPC								
6	KPC								
7	KPC								
8	KPC								
9	KPC								
10	KPC								
11	KPC								
12	KPC								
13	KPC								
14	KPC								
15	KPC								
16	KPC								
17	KPC								
18	KPC								
19	KPC								
20	KPC								
21	KPC								
22	KPC								
23	KPC								
24	KPC								
25	KPC								
26	KPC								
27	KPC								
28	KPC								
29	KPC								
30	KPC								
31	KPC								
32	KPC								
33	KPC								
34	KPC								
35	KPC								

COMPLETE THE SECTION BELOW ON EVERY SHEET FOR EACH EA AFTER YOU HAVE LISTED THE LAST STRUCTURE

TOTAL STRUCTURES.....TOTAL DUs.....

ESTIMATED POPULATION.....ASSUMING 5 PERSONS PER DU

APPENDIX 4.5

FORM CBS/KPC/89/3 SHEET NO.....OF SHEETS

EA BOUNDARY DESCRIPTION
1989 POPULATION CENSUS

PROVINCE.....CODE.....
DISTRICT.....CODE.....
DIVISION.....CODE.....
LOCATION.....CODE.....
SUB-LOC.....CODE.....

VILLAGE/ESTATE..... .....MAPPING ASSISTANT.....DATE.....

EA CODE.....TEAM LEADER.....DATE.....

DESCRIBE THE EA BOUNDARY FROM THE NORTH AND MOVE CLOCKWISE DIRECTION

DIRECTION	DESCRIPTION
NORTH	
EAST	
SOUTH	
WEST	

REMARKS.....
.....
.....
.....

FIGURE 8.1 KAKAMEGA DISTRICT COVERAGES

BOUNDARIES COVERAGE

ROADS COVERAGE

TOWNS COVERAGE

COMBINED COVERAGES

APPENDIX 8.1

Appendix 9.1

AREA2E.PAT FILE

AREA	PERIMETER	REC	USER-ID	POPDEN	POP	CODE
664.776	126.568	1	795	1	1070	73030701
1234.572	171.663	2	807	5	7025	73040401
323.356	90.654	3	885	26	8420	46070202
125.718	76.531	4	884	57	7255	46070203
224.388	74.479	5	883	62	14010	46070201
185.750	88.072	6	882	194	36200	46070102
411.939	93.409	7	794	1	725	73030702
208.076	88.444	8	881	35	7425	46070103
132.221	54.084	9	823	3	490	73020301
218.360	79.778	10	822	9	2165	73020302
274.824	77.020	11	793	5	1415	73030703
150.361	53.092	12	821	14	2170	73020101
125.579	64.884	13	878	25	3260	46080302
129.945	45.499	14	806	39	5145	73040502
347.148	76.191	15	820	4	1580	73020102
272.047	84.415	16	824	2	575	73010302
173.042	99.985	17	906	48	8420	46090403
198.523	115.588	18	900	36	7280	46090802
76.081	42.081	19	805	119	9095	73040501
131.392	96.209	20	847	45	5985	46090804
84.592	37.479	21	804	98	8340	73040302
383.154	97.963	22	796	5	2275	73030302
516.741	112.833	23	815	7	3705	73010603
40.946	51.389	24	879	152	6255	46080501
146.213	52.390	25	818	11	1750	73020202
94.836	45.269	26	792	54	5145	73050602
330.498	125.865	27	785	15	5025	73030201
55.510	35.557	28	803	56	3120	73040301
58.975	50.881	29	880	337	19895	46070101
80.255	59.380	30	917	90	7255	46090501
47.711	65.228	31	905	70	3340	46090401
58.563	74.461	32	907	129	7555	46090402
463.797	106.943	33	832	1	725	73010301
133.856	57.934	34	819	11	1520	73020201
144.842	55.672	35	915	41	5985	46070301
136.788	52.204	36	801	50	6885	73040201
101.808	43.419	37	802	55	5685	73040101
389.822	90.051	38	816	30	11950	73010601
362.243	103.321	39	812	6	2375	73010303
870.434	159.689	40	868	8	7085	46100101
81.716	59.859	41	846	81	6620	46090901
88.140	42.177	42	791	58	5145	73050601
133.753	62.518	43	845	65	8705	46050501
26.884	31.972	44	877	137	3690	46080301
97.706	47.606	45	908	41	4010	46070401
166.761	74.729	46	790	14	2480	73030102
132.143	73.369	47	798	17	2365	73030502
29.216	27.245	48	916	126	3690	46080301
17.146	18.577	49	876	497	8525	46080502
319.454	82.103	50	817	17	5645	73010602

146.578	59.944	51	856	14	2155	46060103
104.034	47.293	52	857	23	2420	46060102
43.285	50.235	53	875	169	7320	46080102
67.224	41.504	54	863	89	6050	46050401
33.257	26.231	55	873	130	4330	46080101
151.020	76.366	56	800	32	4840	73030501
26.204	20.912	57	872	98	2570	46080103
72.421	37.981	58	874	45	3260	46080404
38.193	27.241	59	855	76	2930	46040303
37.369	28.617	60	899	223	8360	46090601
19.368	22.378	61	870	292	5660	46080403
19.089	23.898	62	788	180	3450	73030104
54.482	35.761	63	871	133	7280	46080402
19.148	22.250	64	787	122	2350	73030101
340.488	93.004	65	797	11	3920	73030301
22.600	22.391	66	902	432	9765	46090201
31.777	34.434	67	886	268	8525	46090701
26.131	25.464	68	898	98	2570	46090202
65.692	43.000	69	869	56	3690	46080401
50.336	32.445	70	786	75	3780	73030103
1255.534	205.854	71	858	6	8705	46120101
35.628	25.422	72	903	165	5900	46090102
197.231	68.080	73	859	24	4860	46060301
17.884	17.869	74	854	349	6255	46040301
38.410	33.211	75	834	56	2175	46050205
55.366	43.351	76	841	454	25155	46050101
17.405	19.292	77	853	343	5985	46040304
32.548	27.308	78	799	72	2365	73030502
18.916	21.060	79	897	370	7000	46090101
25.635	24.895	80	896	322	8260	46090604
48.350	32.946	81	890	146	7085	46090603
15.778	17.162	82	887	254	4010	46090704
9.927	13.681	83	891	733	7280	46090602
37.291	27.610	84	844	227	8485	46050402
17.234	21.096	85	835	382	6585	46050204
45.031	32.381	86	904	143	6480	46050202
34.098	26.527	87	469	164	5610	24010301
45.175	33.272	88	1033	112	5065	46040302
37.118	28.979	89	894	273	10145	46090301
42.628	30.992	90	888	67	2890	46090702
27.064	31.404	91	783	88	2405	73030402
227.833	86.281	92	809	7	1635	73010501
258.315	74.178	93	810	7	2005	73010202
42.788	39.728	94	895	67	2890	46050301
16.597	18.769	95	468	127	2110	24010302
98.722	45.782	96	813	155	15325	73010101
69.769	41.085	97	860	85	5935	46060302
224.362	72.477	98	861	33	7575	46060201
41.633	29.863	99	889	107	4460	46090703
54.457	37.050	100	467	99	5405	24010202
10.504	16.269	101	497	134	1410	24010401
36.268	31.658	102	814	669	24280	73010102
51.001	38.264	103	784	33	1695	73030401
6.219	11.193	104	864	74	465	46050403
34.273	32.859	105	464	51	1770	24010105
174.259	79.593	106	920	28	4990	46030202

4.560	9.541	107	836	748	3415	46050201
37.943	32.831	108	852	133	5065	46040302
12.966	24.726	109	892	200	2605	46090302
50.330	46.524	110	466	43	2185	24010102
5.444	10.821	111	843	561	3055	46050105
10.490	17.071	112	840	1107	11620	46050102
69.628	40.487	113	866	61	4260	46030201
48.550	30.634	114	470	79	3870	24010201
8.797	15.637	115	837	388	3415	46050201
234.638	71.890	116	808	28	6660	73010401
6.484	15.458	117	838	764	4955	46050103
27.430	25.395	118	471	271	7450	24010402
8.992	15.054	119	842	559	5030	46050104
37.642	31.842	120	893	117	4405	46050302
70.473	43.894	121	473	76	5395	24020201
9.888	16.671	122	839	486	4815	46050106
278.391	75.531	123	919	12	3615	46030103
82.269	49.922	124	474	77	6405	24020203
82.978	51.249	125	631	90	7535	25060301
38.878	36.968	126	933	138	5385	46040202
25.079	24.945	127	934	579	14525	46040401
423.504	112.664	128	811	23	9860	73010201
54.818	36.958	129	475	131	7225	24020202
21.217	24.875	130	941	273	5805	46040102
106.390	45.351	131	922	81	8620	46030404
30.619	26.969	132	939	158	4845	46040403
81.302	51.656	133	465	61	5010	24010101
17.830	26.076	134	940	438	7825	46040103
93.088	39.625	135	931	90	8430	46040206
37.782	36.900	136	935	173	6550	46040204
23.371	26.465	137	959	167	3920	46020104
22.245	26.031	138	936	281	6255	46040205
51.432	37.062	139	472	70	3630	24010103
16.526	29.895	140	958	453	7490	46020103
100.848	49.158	141	632	78	7955	25060303
30.703	31.930	142	937	192	5910	46040201
25.986	22.879	143	938	144	3765	46040203
83.422	41.212	144	480	58	4875	24020102
8.613	13.199	145	956	724	6240	46020102
49.863	32.683	146	926	34	1725	46030401
26.334	31.775	147	943	176	4650	46020602
9.873	20.925	148	957	406	4010	46020101
11.507	16.776	149	954	5	65	46020302
89.524	40.840	150	923	40	3650	46030101
43.831	30.326	151	479	176	7745	24020104
38.092	27.787	152	633	66	2525	25060302
18.762	20.336	153	955	3	65	46020301
118.603	54.639	154	925	43	5115	46030402
8.672	14.192	155	951	7	65	46020303
26.235	28.295	156	478	56	1480	24020101
452.837	103.685	157	640	2	1160	25080101
45.830	27.954	158	463	52	2400	24010502
25.326	28.817	159	462	83	2115	24010501
23.539	30.256	160	952	502	11830	46020201
48.704	29.436	161	942	99	4825	46020601
100.225	78.156	162	652	51	5145	25070304

16.276	20.752	163	950	450	7325	46020701
66.136	49.111	164	460	46	3085	24010104
26.888	24.918	165	477	100	2710	24030403
48.556	40.002	166	944	129	6275	46020702
54.043	35.477	167	634	133	7210	25060102
29.436	27.779	168	953	401	11830	46020202
189.191	74.115	169	651	38	7260	25070302
31.824	24.043	170	476	205	6540	24030402
95.284	43.326	171	927	84	8050	46030302
114.329	52.256	172	928	30	3435	46030403
218.831	63.814	173	924	16	3580	46030102
54.367	42.815	174	461	56	3055	24010504
31.460	26.106	175	949	165	5195	46020402
171.437	59.429	176	459	19	3310	24010505
19.400	22.370	177	495	43	835	24020103
17.623	19.409	178	948	334	5890	46020401
33.230	25.974	179	945	218	7245	46020403
62.706	57.837	180	458	39	2470	24010503
28.727	22.255	181	484	52	1520	24030401
344.903	91.681	182	781	0	0	22040101
79.388	42.561	183	978	117	9365	46010502
57.459	42.645	184	636	102	5890	25060101
35.709	31.551	185	482	110	3960	24030502
182.059	84.322	186	65	0	0	41050101
39.811	37.834	187	635	185	7395	25060103
63.685	38.209	188	481	79	5055	24030501
41.189	37.312	189	485	114	4720	24030404
19.510	24.578	190	947	233	4550	46020501
36.630	31.436	191	483	48	1760	24030503
22.349	28.844	192	946	203	4550	46020502
19.932	20.383	193	988	341	6805	46010701
16.820	19.748	194	960	401	6760	46010504
27.652	31.650	195	650	40	1120	25070105
22.058	25.804	196	494	65	1445	24030203
11.200	15.982	197	998	212	2380	46010503
5.867	11.896	198	999	420	2465	46010703
60.618	41.745	199	637	80	4875	25060205
23.280	22.172	200	639	127	2960	25060203
37.521	42.532	201	646	61	2320	25070103
66.765	46.732	202	977	80	5350	46010603
50.501	43.465	203	653	54	2765	25070301
91.010	44.573	204	929	47	4355	46030301
48.216	39.755	205	489	115	5575	24030301
27.954	26.171	206	987	348	9745	46010702
18.490	32.002	207	961	323	5985	46010505
48.137	45.336	208	644	78	3760	25070106
185.675	68.557	209	457	35	6680	24040102
25.027	23.701	210	654	78	1975	25070303
20.680	23.109	211	962	338	7010	46010501
22.136	27.322	212	649	114	2535	25070202
15.012	28.586	213	648	314	4715	25070201
54.507	39.096	214	488	86	4715	24030102
59.405	38.567	215	487	25	1490	24030202
45.232	32.178	216	486	125	5660	24030201
105.405	53.043	217	456	75	7990	24040101
10.240	13.174	218	986	272	2790	46010405

39.630	28.149	219	645	69	2755	25070104
6.359	11.314	220	985	308	1960	46010403
9.942	14.335	221	963	312	3105	46010406
115.555	54.167	222	930	50	5790	46030303
15.276	18.239	223	638	136	2090	25060202
40.116	41.294	224	641	133	5345	25060201
47.877	34.593	225	491	60	2915	24030101
24.763	31.584	226	964	154	3820	46010404
16.318	20.743	227	984	151	2470	46010402
285.217	92.691	228	702	8	2535	25090101
16.376	27.876	229	647	112	1850	25070203
20.436	31.834	230	965	224	4580	46010401
23.262	21.985	231	655	118	2765	25070204
54.228	33.161	232	974	84	4595	46010305
229.514	102.947	233	642	40	9410	25070101
9.302	13.991	234	982	654	6090	46010308
13.887	16.795	235	966	295	4105	46010306
48.314	33.875	236	975	83	4015	46010601
19.070	23.175	237	643	190	3640	25070102
49.345	32.512	238	613	78	3885	25060204
5.360	9.276	239	983	574	3080	46010307
18.201	24.357	240	627	563	10255	25030101
40.402	37.298	241	626	56	2275	25030604
62.140	37.600	242	490	37	2330	24030302
14.576	18.643	243	981	416	6070	46010301
9.542	16.504	244	630	243	2325	25030102
13.465	15.598	245	967	361	4865	46010302
7.404	12.922	246	980	42	315	46010201
73.357	50.327	247	115	50	3675	41030302
13.956	20.591	248	89	308	4305	41010303
18.277	25.465	249	979	398	7290	46010103
41.255	29.073	250	973	85	3540	46010304
10.892	15.256	251	604	189	2065	25010203
14.831	18.724	252	84	261	3880	41020302
29.798	28.251	253	976	80	2405	46010602
10.728	17.756	254	88	344	3700	41010301
12.570	17.469	255	68	505	6355	41020401
6.785	16.377	256	628	455	3090	25030104
6.070	13.708	257	603	907	5510	25010202
15.913	25.511	258	625	142	2270	25030305
43.402	34.344	259	594	157	6840	25010114
8.382	16.885	260	99	437	3665	41010103
21.758	21.369	261	968	226	4935	46010303
8.671	12.196	262	989	367	3185	46010202
48.095	38.035	263	455	121	5830	24040301
6.737	18.334	264	98	389	2625	41010101
8.932	15.412	265	629	307	2745	25030103
23.020	21.977	266	453	172	3970	24040401
6.746	11.871	267	612	231	1565	25030204
9.891	14.667	268	621	662	6555	25030605
5.098	13.541	269	85	469	2395	41010305
9.528	14.427	270	969	291	2780	46010203
5.865	11.998	271	97	342	2010	41010102
11.872	15.568	272	67	703	8355	41020402
27.218	23.701	273	451	173	4730	24040402
4.540	8.126	274	620	465	2115	25030606

14.401	15.398	275	454	215	3105	24040403
8.277	13.516	276	703	273	2260	25030202
35.321	32.550	277	578	25	890	25020102
10.989	14.834	278	610	538	5920	25030201
20.352	19.224	279	970	276	5635	46010102
7.614	13.696	280	87	263	2010	41010102
5.109	9.618	281	96	523	2675	41010104
3.973	10.633	282	579	284	1130	25020101
43.510	37.871	283	972	58	2555	46010101
50.965	39.332	284	114	101	5150	41030303
12.760	16.648	285	78	370	4730	41020104
9.622	13.258	286	602	333	3205	25010201
12.371	22.739	287	104	321	3975	41010202
5.518	11.474	288	580	395	2185	25020105
21.281	30.884	289	596	609	12965	25010102
9.660	12.808	290	618	359	3475	25030505
10.726	17.510	291	86	403	4325	41010302
6.063	10.791	292	611	444	2695	25030203
7.101	11.286	293	619	468	3330	25030603
9.355	14.059	294	624	400	3745	25030304
7.887	15.442	295	749	403	3185	22030202
3.466	9.958	296	581	545	1890	25020106
21.319	20.254	297	971	92	1975	46010104
10.334	18.422	298	93	564	5830	41010402
7.956	14.373	299	595	3671	29205	25010101
5.283	13.765	300	74	562	2970	41020307
8.996	17.237	301	748	384	3460	22030204
7.307	13.398	302	622	366	2675	25030602
40.002	35.272	303	577	38	1555	25020103
3.968	8.484	304	583	258	1025	25020107
32.630	26.893	305	450	91	2985	24040201
11.095	15.469	306	103	483	5365	41010201
3.917	9.017	307	582	431	1690	25020104
12.686	16.792	308	758	534	6780	22030104
6.612	15.924	309	751	682	4510	22030404
9.825	13.724	310	452	380	3740	24040404
14.414	16.727	311	750	552	7960	22030405
10.926	17.975	312	734	697	7625	22010502
14.980	17.537	313	731	571	8555	22010503
11.157	17.527	314	609	401	4475	25030703
8.226	16.831	315	752	545	4485	22030403
8.310	16.247	316	95	1022	8495	41010403
13.019	19.950	317	735	521	6795	22030101
14.720	18.855	318	66	518	7630	41020403
11.235	18.544	319	721	283	3185	22010402
10.701	14.724	320	76	437	4680	41020101
20.113	21.931	321	101	264	5315	41010205
6.686	20.120	322	588	1118	7475	25010112
2.923	7.507	323	593	704	2060	25010106
7.665	14.846	324	616	717	5500	25030601
62.652	42.892	325	447	52	3295	24050201
7.126	12.428	326	77	464	3310	41020103
7.135	12.170	327	601	338	2415	25010204
20.776	22.188	328	723	260	5410	22010703
5.264	13.108	329	722	3233	17025	22010401
6.565	12.955	330	73	585	3845	41020301

9.329	14.097	331	94	597	5570	41010401
2.015	6.347	332	592	600	1210	25010116
76.471	43.048	333	448	73	5630	24040302
4.063	10.700	334	72	493	2005	41020305
4.499	10.388	335	591	462	2080	25010107
12.012	19.178	336	605	256	3080	25020301
2.736	8.633	337	590	878	2405	25010115
13.613	16.795	338	747	317	4325	22030201
8.802	14.580	339	617	525	4625	25030506
5.429	16.530	340	585	389	2115	25010110
9.608	17.675	341	607	556	5350	25030702
6.634	10.758	342	623	1054	6995	25030302
4.547	10.567	343	606	401	1825	25020304
13.110	19.750	344	102	276	3630	41010204
48.078	40.512	345	446	91	4395	24050202
5.175	10.940	346	598	415	2150	25010104
3.627	8.969	347	587	522	1895	25010109
41.211	36.305	348	90	133	5510	41010406
6.340	14.100	349	572	463	2940	25020302
6.405	10.757	350	589	601	3850	25010113
15.559	22.068	351	724	659	10255	22010104
8.848	13.272	352	586	473	4185	25010117
54.035	34.868	353	113	141	7650	41030301
4.749	12.838	354	600	418	1985	25010111
62.333	39.499	355	449	60	3745	24040202
7.547	12.001	356	75	577	4355	41020102
5.451	9.721	357	597	284	1550	25010108
57.282	37.444	358	576	19	1110	25020410
7.316	13.213	359	71	656	4805	41020304
8.009	13.585	360	701	628	5035	25030701
8.682	14.964	361	614	460	3995	25030306
4.500	11.047	362	608	782	3520	25030704
5.921	12.478	363	615	624	3695	25030303
5.828	10.708	364	757	688	4010	22030103
5.426	11.534	365	599	484	2630	25010105
7.537	11.430	366	753	525	3960	22030203
5.131	13.425	367	69	403	2070	41020303
4.647	9.561	368	571	399	1855	25020303
8.749	12.753	369	567	686	6005	25020405
9.722	16.056	370	746	364	3540	22030304
3.418	7.716	371	573	324	1110	25020412
5.839	9.906	372	562	537	3140	25020207
7.399	13.818	373	79	376	2785	41020201
32.024	28.893	374	91	174	5575	41010404
7.425	11.311	375	754	443	3290	22030406
8.020	15.965	376	729	515	4135	22010504
8.224	12.499	377	700	401	3305	25030504
2.513	9.169	378	699	1659	4170	25030401
9.828	15.379	379	80	343	3375	41020202
8.036	13.872	380	525	627	5045	25030707
3.100	7.754	381	563	728	2260	25020401
4.784	11.670	382	720	413	1980	22010403
6.524	11.807	383	70	632	4125	41020306
5.654	11.363	384	92	402	2275	41010405
5.675	12.240	385	755	579	3290	22030407
17.695	20.821	386	730	962	17025	22010601

5.968	10.759	387	560	461	2755	25020206
3.369	9.727	388	574	553	1865	25020409
68.969	38.954	389	111	47	3285	41030202
5.505	11.450	390	570	445	2450	25020406
8.297	13.697	391	100	106	885	41010203
2.671	7.077	392	566	688	1840	25020403
10.079	15.599	393	719	549	5535	22010404
10.188	13.092	394	561	554	5645	25020205
5.868	9.995	395	575	273	1605	25020411
7.538	11.702	396	564	640	4830	25020402
14.527	22.545	397	81	386	5620	41020203
6.396	10.832	398	526	1093	6995	25030706
38.935	32.313	399	444	75	2945	24050203
6.787	14.526	400	524	554	3765	25030705
12.551	20.335	401	82	339	4265	41020204
11.972	14.912	402	135	268	3215	41040101
19.015	22.386	403	745	205	3905	22030302
6.629	17.281	404	740	490	3250	22030106
4.525	9.700	405	565	704	3190	25020404
5.951	12.083	406	528	730	4350	25030501
11.476	16.123	407	733	427	4905	22010701
3.753	10.503	408	559	535	2010	25020204
4.710	9.663	409	569	693	3265	25020407
105.490	54.885	410	445	57	6110	24050204
9.986	14.309	411	527	383	3825	25030301
7.273	10.865	412	568	679	4945	25020408
8.191	13.605	413	741	558	4575	22030402
4.689	9.719	414	756	776	3640	22030401
21.244	23.143	415	744	202	4300	22030301
17.380	26.611	416	716	320	5565	22010301
65.385	38.108	417	110	87	5745	41030201
9.748	15.469	418	557	579	5645	25020201
18.607	22.578	419	83	198	3690	41020205
7.402	19.147	420	137	509	3770	41040701
6.867	15.282	421	739	447	3075	22030107
37.841	35.418	422	554	63	2410	25050408
6.269	11.082	423	558	795	4985	25020202
3.548	9.167	424	552	629	2235	25050404
5.970	11.024	425	555	356	2130	25050405
5.399	11.360	426	548	637	3440	25050402
11.418	18.186	427	713	0	0	22010102
9.749	17.099	428	522	553	5395	25030503
15.313	17.056	429	523	520	7970	25030502
5.274	9.770	430	138	780	4115	41040702
12.239	17.938	431	742	335	4110	22030408
3.572	7.807	432	551	802	2865	25050409
12.563	18.660	433	743	178	2240	22030303
6.015	10.864	434	584	671	4040	25020203
3.461	9.559	435	759	845	2925	22010602
5.938	11.255	436	549	737	4380	25050403
8.365	12.854	437	529	546	4575	25050301
15.304	22.147	438	728	433	6630	22010604
7.774	22.574	439	727	726	5650	22010406
7.057	13.631	440	547	729	5145	25050401
7.436	11.714	441	533	516	3840	25050302
64.190	50.268	442	106	70	4530	41030103

66.542	41.465	443	112	43	2885	41030203
5.840	11.238	444	507	646	3775	25040504
9.937	19.786	445	725	558	5550	22010405
5.531	12.273	446	136	389	2155	41040704
6.773	14.770	447	505	675	4575	25040507
7.607	13.433	448	500	577	4390	25040204
9.728	18.675	449	517	517	5035	25040303
11.012	15.680	450	712	235	2590	22010101
42.386	38.678	451	134	105	4460	41040102
3.773	10.684	452	550	653	2465	25050406
5.130	15.216	453	553	332	1705	25050407
4.390	12.998	454	506	756	3320	25040503
8.694	15.872	455	737	466	4060	22030102
3.937	9.173	456	502	676	2665	25040201
9.098	13.153	457	738	286	2605	22030105
73.266	41.412	458	443	76	5595	24050501
4.564	9.887	459	139	5109	23320	41040703
7.047	13.302	460	530	536	3780	25050303
38.122	39.410	461	556	166	6355	25050206
11.006	16.779	462	736	375	4135	22010603
12.919	18.894	463	711	175	2265	22010203
6.698	12.481	464	546	427	2865	25050208
7.464	12.203	465	714	482	3600	22010702
7.117	13.046	466	545	464	3305	25050207
6.945	16.112	467	726	460	3200	22010408
162.465	67.876	468	109	24	3905	41030401
6.621	13.185	469	504	446	2955	25040502
11.980	15.622	470	516	388	4650	25040304
6.139	10.439	471	532	655	4025	25050305
26.756	22.442	472	107	97	2610	41030101
20.803	19.038	473	772	181	3780	22020502
6.528	10.832	474	501	546	3570	25040203
96.180	51.663	475	442	74	7145	24050502
42.040	37.049	476	133	68	2895	41040201
5.418	10.116	477	531	610	3305	25050304
8.915	12.607	478	715	426	3805	22010302
5.596	12.008	479	499	869	4865	25040202
4.121	8.681	480	503	916	3775	25040504
6.193	11.608	481	544	558	3460	25050204
31.648	33.488	482	541	57	1830	25050105
4.266	10.087	483	543	392	1675	25050203
9.764	12.920	484	518	541	5290	25040305
13.195	15.310	485	710	375	4960	22010103
18.244	21.471	486	771	209	3815	22020504
95.605	47.377	487	108	54	5230	41030402
10.009	20.197	488	542	242	2430	25050202
31.435	27.927	489	770	205	6465	22020501
9.085	13.882	490	769	173	1575	22020402
45.608	40.916	491	105	78	3590	41030102
25.248	24.870	492	768	311	7860	22020403
8.483	14.185	493	514	382	3245	25040302
8.685	14.336	494	717	414	3600	22010407
7.035	12.051	495	509	444	3125	25040505
3.835	11.335	496	538	451	1730	25050108
5.650	9.268	497	515	375	2120	25040306
181.192	61.967	498	429	0	15	23020701

6.057	11.792	499	508	548	3320	25040503
4.524	12.374	500	535	657	2975	25050101
3.592	9.212	501	534	1647	5920	25050102
10.803	17.068	502	510	667	7215	25040401
7.148	13.984	503	732	356	2550	22010201
10.723	13.270	504	709	297	3185	22010303
7.354	10.626	505	539	412	3035	25050104
17.822	25.010	506	767	363	6485	22020205
61.136	33.907	507	441	74	4530	24050503
12.500	22.803	508	540	179	2250	25050107
12.537	16.037	509	513	490	6155	25040301
9.233	20.892	510	428	1740	16070	23020203
10.457	15.565	511	537	343	3590	25050106
11.052	17.056	512	414	660	7300	23020102
13.098	18.900	513	521	224	2935	25040103
90.354	44.934	514	773	17	1570	22020503
21.312	20.778	515	708	243	5195	22010304
9.543	14.798	516	415	495	4725	23020101
3.693	9.913	517	536	649	2400	25050103
59.888	43.775	518	132	47	2825	41040202
16.432	23.318	519	780	278	4570	22020404
7.644	16.016	520	511	424	3245	25040402
9.017	17.408	521	426	261	2360	23020202
10.896	15.769	522	766	338	3690	22020204
18.040	23.903	523	705	315	5690	22010202
14.094	18.208	524	707	266	3750	22010204
8.381	12.219	525	413	625	5240	23020103
24.328	22.712	526	425	233	5690	23020606
8.396	15.719	527	520	275	2315	25040101
9.406	17.838	528	765	241	2275	22020203
7.206	13.266	529	412	594	4285	23020104
11.558	16.707	530	416	676	7815	23020205
9.768	13.880	531	519	261	2550	25040102
12.287	15.174	532	427	343	4220	23020204
59.829	51.582	533	440	69	4130	24050103
14.126	23.383	534	396	380	5370	23010505
51.234	32.756	535	121	114	5870	41040404
10.680	15.624	536	411	1555	16615	23020201
68.180	39.396	537	131	53	3645	41040203
39.798	35.802	538	763	101	4020	22020207
6.169	13.170	539	774	252	1560	22020401
7.427	13.978	540	512	508	3775	25040504
57.370	60.318	541	777	269	15460	22020101
14.137	20.742	542	398	589	8330	23010504
158.868	73.374	543	117	32	5185	41040302
3.475	9.506	544	432	447	1555	23020605
19.150	17.451	545	764	340	6515	22020202
12.598	16.986	546	417	445	5615	23020604
8.379	14.285	547	410	652	5465	23020304
26.809	28.778	548	423	268	7200	23020602
6.661	11.143	549	424	707	4710	23020603
33.465	34.696	550	394	196	6590	23010503
16.859	20.476	551	397	387	6525	23010502
18.497	21.033	552	706	262	4850	22010205
42.133	31.742	553	122	113	4775	41040401
9.042	15.711	554	406	653	5910	23020302

17.076	18.635	555	779	283	4845	22020301
11.098	14.109	556	775	278	3090	22020102
24.005	22.711	557	439	128	3090	24050102
8.635	13.246	558	409	779	6730	23020305
15.673	26.780	559	400	420	6595	23020301
12.677	15.646	560	418	431	5465	23020601
14.390	21.200	561	776	315	4535	22020103
94.745	49.882	562	434	133	12645	24050101
5.408	12.335	563	405	698	3775	23020303
24.406	21.478	564	395	205	5015	23010501
21.308	22.684	565	421	248	5305	23020503
68.728	36.869	566	120	82	5645	41040403
9.974	20.238	567	408	826	8240	23020406
9.492	13.669	568	404	638	6065	23020403
45.714	36.870	569	333	12	550	23030407
27.384	26.878	570	393	92	2545	23010602
15.316	20.427	571	419	446	6840	23020502
6.220	11.262	572	401	1185	7375	23020407
6.940	11.435	573	403	1256	8720	23020405
15.391	15.408	574	778	329	5075	22020303
28.807	24.119	575	762	119	3445	22020201
9.918	14.378	576	407	597	5925	23020404
10.603	17.349	577	399	401	4260	23020401
75.787	48.432	578	371	11	900	23060307
63.040	38.611	579	438	72	4545	24050403
131.863	48.002	580	116	12	1625	41040303
11.812	16.661	581	420	578	6830	23020501
10.814	19.341	582	402	473	5120	23020402
93.169	46.727	583	119	40	3740	41040402
99.018	59.296	584	118	85	8495	41040301
62.923	48.856	585	761	120	7565	22020302
15.800	18.006	586	422	191	3025	23020504
6.291	14.413	587	386	662	4170	23010306
14.152	16.189	588	373	318	4505	23010201
8.529	14.069	589	385	680	5805	23010302
7.916	11.276	590	380	672	5325	23010303
6.932	11.040	591	384	457	3170	23010305
10.014	20.545	592	389	381	3820	23010401
11.033	17.930	593	390	2012	22200	23010404
18.062	23.193	594	372	252	4555	23010202
13.304	21.420	595	388	643	8565	23010403
8.246	11.543	596	374	542	4470	23010205
10.922	15.633	597	378	699	7645	23010301
23.875	26.040	598	329	489	11695	23030405
20.716	25.606	599	391	210	4365	23010603
33.207	26.152	600	392	117	3915	23010601
11.606	16.841	601	383	481	5590	23010304
23.261	31.762	602	760	158	3685	22020206
8.890	16.895	603	379	538	4785	23010203
37.425	30.129	604	437	111	4170	24050302
103.550	51.796	605	125	26	2745	41040501
46.874	32.125	606	124	58	2740	41040502
10.270	17.046	607	382	500	5145	23010102
13.803	20.744	608	377	547	7555	23010101
23.879	28.584	609	330	166	3985	23030406
31.258	25.515	610	493	282	8835	24050401

10.560	13.725	611	375	531	5615	23010204
26.081	23.112	612	127	124	3255	41040602
21.370	23.914	613	387	400	8565	23010403
22.995	29.273	614	331	256	5895	23030402
21.073	29.427	615	309	435	9170	23030106
18.649	20.480	616	381	516	9630	23010103
26.733	26.323	617	303	104	2805	23030107
25.694	27.547	618	308	35	915	23030108
16.409	20.807	619	376	516	8470	23010104
34.563	27.369	620	130	159	5515	41040604
50.953	38.748	621	129	62	3185	41040601
15.557	17.448	622	328	379	5900	23030404
40.019	40.237	623	248	19	800	21060105
12.044	27.368	624	304	173	2095	23030504
24.212	23.442	625	332	186	4520	23030403
14.257	19.592	626	324	545	7775	23030301
17.322	19.005	627	492	422	7315	24050402
12.212	18.329	628	317	637	7780	23030104
16.119	20.533	629	327	469	7565	23030401
20.744	20.217	630	296	177	3685	23040201
18.469	25.000	631	370	148	2740	23060304
47.614	33.817	632	123	10	515	41040504
6.457	14.454	633	325	516	3335	23030303
9.540	14.831	634	323	721	6880	23030302
10.680	15.623	635	316	876	9365	23030105
17.988	22.501	636	310	510	9180	23030101
36.695	32.528	637	436	179	6575	24050303
59.671	38.263	638	128	97	5790	41040603
13.003	16.912	639	305	250	3260	23030503
19.765	20.484	640	352	277	5485	23050302
6.394	15.254	641	318	712	4555	23030103
149.957	57.057	642	126	23	3460	41040503
8.588	17.738	643	353	206	1775	23050301
3.840	10.933	644	326	563	2165	23030304
7.287	13.127	645	315	741	5400	23030102
17.186	22.547	646	369	153	2645	23060303
16.856	19.398	647	350	693	11695	23050304
7.936	15.684	648	319	721	5725	23030203
124.574	49.892	649	216	18	2300	21070305
12.385	18.653	650	295	1297	16070	23040202
11.674	18.876	651	349	475	5550	23050305
14.441	20.605	652	322	667	9640	23030305
35.216	27.732	653	249	100	3555	21060107
8.668	13.730	654	306	428	3710	23030505
8.042	12.542	655	320	686	5520	23030202
22.106	21.305	656	311	426	9425	23030201
14.197	17.529	657	366	216	3075	23060302
3.124	8.360	658	314	816	2550	23030205
17.047	29.525	659	368	246	4210	23060306
9.576	18.201	660	307	362	3470	23030502
2.018	9.634	661	294	445	900	23040204
13.430	25.100	662	342	667	8970	23050403
12.408	14.732	663	351	568	7055	23050303
6.684	11.029	664	321	727	4860	23030206
14.133	17.240	665	356	395	5590	23060305
11.123	16.676	666	367	233	2600	23060301

11.436	13.893	667	313	575	6585	23030207
15.718	17.319	668	291	154	2435	23040104
17.985	19.704	669	215	186	3350	21070405
16.119	24.299	670	343	596	9610	23050401
12.696	19.735	671	344	621	7890	23050202
12.167	20.030	672	430	827	10070	23030501
3.383	7.989	673	348	586	1985	23050203
21.928	25.352	674	292	165	3625	23040103
5.459	11.215	675	293	558	3050	23040203
10.608	14.397	676	312	379	4030	23030204
78.775	41.729	677	297	133	10530	23040302
8.403	12.285	678	347	602	5060	23050201
114.931	72.543	679	250	54	6280	21060108
13.500	22.484	680	357	1190	16070	23060202
47.711	39.901	681	290	93	4460	23040102
10.707	16.137	682	435	338	3620	24050301
7.377	12.356	683	345	839	6190	23050204
13.387	20.084	684	217	264	3535	21070306
14.958	22.506	685	340	1110	16615	23050406
7.346	11.970	686	341	460	3385	23050405
8.261	12.265	687	214	345	2855	21070406
13.232	20.970	688	247	215	2855	21070302
16.489	25.104	689	358	415	6850	23060103
14.638	23.761	690	360	634	9285	23060203
5.449	11.092	691	346	755	4115	23050205
6.749	15.467	692	359	1284	8670	23060205
13.880	25.021	693	337	461	6410	23050103
8.324	11.770	694	213	305	2545	21070402
22.557	28.079	695	289	72	1635	23040101
21.176	25.836	696	336	561	11880	23050101
7.763	19.769	697	246	195	1520	21070301
8.844	13.368	698	218	338	2990	21070407
6.588	10.690	699	339	1119	7375	23050404
10.700	20.583	700	335	618	6615	23050104
16.182	17.006	701	338	605	9805	23050402
16.488	25.683	702	245	237	3910	21070307
9.931	19.029	703	334	575	5720	23050102
15.044	23.235	704	244	247	3725	21070304
10.217	13.928	705	212	462	4725	21070401
6.122	12.750	706	361	756	4630	23060201
9.559	17.028	707	240	331	3170	21070309
17.829	29.043	708	242	260	4640	21070108
14.857	17.149	709	302	322	4785	23040401
42.335	33.786	710	251	31	1330	21060101
9.418	13.590	711	219	420	3960	21070408
4.820	9.484	712	254	0	0	0
4.771	12.834	713	364	661	3155	23060101
10.079	18.031	714	362	783	7900	23060204
11.668	14.713	715	211	938	10955	21070403
9.408	18.037	716	365	614	5785	23060102
8.870	13.677	717	241	374	3325	21070308
6.548	14.076	718	255	525	3440	21060106
8.695	14.804	719	363	373	3250	23060104
10.955	22.514	720	243	209	2300	21070109
7.192	11.322	721	239	453	3265	21070303
54.922	38.602	722	288	71	3900	23040603

5.867	12.025	723	252	978	5740	21060103
3.586	12.056	724	253	847	3040	21060104
8.870	13.690	725	225	478	4245	21070310
26.326	23.538	726	354	199	5245	23040502
8.911	14.904	727	210	1229	10955	21070403
6.855	13.270	728	220	704	4831	21070703
77.442	39.629	729	298	101	7835	23040303
19.902	28.340	730	268	266	5295	21060304
7.058	13.470	731	256	266	1880	21060102
36.535	27.110	732	355	245	8980	23040501
52.693	35.970	733	286	139	7340	23040601
12.529	22.150	734	237	357	4485	21070102
16.923	19.426	735	269	228	3865	21060303
4.038	14.827	736	223	947	3825	21070206
23.569	21.430	737	301	282	6650	23040402
4.981	11.296	738	224	512	2555	21070204
8.960	13.830	739	238	507	4545	21070104
7.439	17.817	740	236	567	4220	21070107
8.626	17.655	741	226	575	4965	21070504
13.224	21.851	742	208	403	5340	21030104
30.557	32.088	743	277	138	4245	21040104
15.226	24.333	744	266	362	5520	21060301
16.496	16.435	745	257	314	5190	21060203
4.319	8.888	746	209	967	4180	21070202
6.824	13.281	747	227	638	4360	21070503
6.906	14.099	748	235	1049	7245	21070101
6.847	11.571	749	221	771	5280	21070201
6.789	14.757	750	259	573	3890	21060202
27.679	25.094	751	300	217	6030	23040403
9.130	15.367	752	234	408	3730	21070103
37.515	32.403	753	287	208	7835	23040303
9.349	15.315	754	258	383	3585	21060206
4.910	11.636	755	222	561	2755	21070205
15.467	17.836	756	260	163	2530	21060207
10.068	19.868	757	228	279	2810	21070505
11.166	22.761	758	229	646	7220	21070502
40.270	31.941	759	276	157	6355	21040203
6.250	11.634	760	233	799	4995	21070106
10.217	14.963	761	267	352	3605	21060305
17.435	24.922	762	265	316	5525	21060306
6.674	15.142	763	231	719	4800	21070501
13.143	21.171	764	232	753	9905	21070105
59.713	40.083	765	299	105	6315	23040301
46.656	40.559	766	284	145	6780	21040301
11.374	16.980	767	207	680	7740	21030105
51.587	35.483	768	283	313	16185	21040103
14.490	19.124	769	264	187	2715	21060302
8.471	13.276	770	262	370	3140	21060204
19.181	20.855	771	261	47	910	21060205
3.418	11.792	772	278	4735	16185	21040103
17.451	19.612	773	263	329	5755	21060201
8.544	14.550	774	230	565	4831	21070506
44.894	33.415	775	274	427	19190	21040202
38.898	38.363	776	282	582	22655	21040101
6.536	15.229	777	202	361	2360	21030102
16.253	17.867	778	195	738	12005	21030204

8.603	15.256	779	206	943	8115	21030101
25.700	23.642	780	279	2363	60735	21040102
8.114	15.047	781	200	629	5110	21030203
11.571	16.384	782	193	373	4325	21030302
7.523	13.583	783	203	495	3725	21030106
24.043	29.535	784	273	137	3315	21040404
9.970	14.193	785	192	337	3360	21030301
2.389	8.386	786	205	1243	2970	21030103
66.543	59.241	787	271	133	8860	21040402
9.692	21.375	788	201	544	5280	21030206
151.864	64.861	789	280	109	16615	21040201
22.052	20.394	790	169	608	13425	21010302
56.113	39.926	791	176	448	25145	21010202
10.060	16.491	792	168	158	1590	21010402
5.813	13.772	793	199	584	3395	21030205
12.981	17.235	794	196	272	3540	21030201
9.076	18.333	795	204	576	5235	21030202
19.163	19.535	796	194	449	8620	21030303
16.922	25.107	797	170	568	9620	21010303
15.714	20.724	798	197	878	13805	21030304
31.905	31.071	799	281	156	4980	21040302
6.654	14.827	800	198	773	5150	21030305
50.181	36.722	801	272	779	39135	21040401
38.243	34.661	802	184	294	11265	21020401
25.833	32.271	803	167	101	2615	21010401
39.262	32.374	804	191	283	11145	21020402
0.599	3.228	805	171	7332	4390	21010301
42.720	32.761	806	175	221	9450	21010201
9.203	12.797	807	190	890	8195	21020101
37.706	28.630	808	166	117	4420	21010403
8.203	12.016	809	188	1114	9140	21020103
7.822	15.907	810	172	724	5665	21010102
153.870	76.924	811	270	128	19715	21040403
7.181	16.412	812	185	840	6035	21020203
8.819	15.459	813	189	1186	10460	21020102
4.937	10.474	814	183	820	4050	21020204
1.809	5.816	815	174	1053	1905	21010101
9.091	15.361	816	173	0	0	0
14.779	20.028	817	152	649	9605	21050601
15.622	16.067	818	59	1184	18500	10080301
9.395	12.467	819	180	2472	23225	21020202
5.225	11.645	820	182	802	4195	21020205
1.443	5.438	821	187	5662	8170	21020403
31.436	33.924	822	186	199	6260	21020404
56.024	32.864	823	165	198	11100	21010404
7.044	18.494	824	179	788	5555	21020303
6.254	15.517	825	153	1651	10325	21050103
7.453	10.974	826	181	594	4430	21020201
5.321	9.947	827	155	719	3830	21050201
5.323	15.287	828	178	1370	7295	21020301
5.377	12.827	829	58	6075	32670	10080302
5.099	10.788	830	156	936	4775	21050202
6.632	16.286	831	150	982	6515	21050603
5.445	11.480	832	154	757	4125	21050101
30.835	28.367	833	53	360	11110	10080501
4.332	10.177	834	157	1683	7295	21050203

14.455	16.677	835	151	126	1825	21050602
26.756	32.739	836	49	369	9880	10040105
2.852	8.206	837	164	1465	4180	21050302
7.320	13.163	838	177	939	6875	21020302
106.632	54.977	839	28	45	4805	10070202
3.725	8.423	840	158	899	3350	21050204
16.314	19.701	841	57	639	10435	10080402
3.078	8.925	842	163	529	1630	21050304
4.168	10.365	843	159	681	2840	21050301
4.074	9.075	844	149	1935	7885	21050102
4.825	9.200	845	160	1507	7275	21050303
9.247	12.076	846	142	354	3275	21050504
23.726	31.432	847	26	410	9745	10070203
6.948	11.457	848	161	847	5890	21050104
14.818	23.279	849	48	747	11075	10040102
16.914	24.856	850	146	325	5510	21050604
9.282	22.092	851	51	1037	9630	10040104
65.047	35.128	852	141	41	2680	21050502
6.768	17.303	853	56	12562	85020	10080401
4.943	10.259	854	145	424	2100	21050501
6.217	10.687	855	148	828	5150	21050401
4.266	13.566	856	25	36674	156465	10070301
13.314	16.911	857	52	1535	20445	10040103
1.138	7.154	858	63	66242	75360	10080202
2.106	6.048	859	162	4349	9160	21050402
5.174	10.813	860	50	3347	17320	10040101
1.145	4.676	861	62	30472	34885	10080201
1.414	5.357	862	55	66840	94520	10080102
10.807	14.814	863	144	1081	11685	21050503
11.522	17.151	864	143	369	4255	21050505
3.789	7.879	865	47	6773	25665	10040106
15.208	19.827	866	147	571	8690	21050403
19.415	20.438	867	23	2462	47805	10070201
1.667	7.126	868	24	5916	9865	10070302
1.947	8.015	869	54	43820	85315	10080101
5.944	11.023	870	41	1356	8065	10010202
3.750	13.539	871	46	2995	11235	10040204
28.455	23.201	872	27	64	1830	10070102
6.615	11.389	873	14	5675	37540	10050302
5.614	12.064	874	37	9659	54230	10010201
1.805	5.657	875	1	14127	25495	10030201
5.967	14.513	876	44	2634	15720	10040203
1.232	7.093	877	13	11013	13565	10050101
7.533	13.207	878	43	2546	19185	10040202
1.384	5.262	879	6	12191	16875	10030101
1.349	5.732	880	5	9496	12810	10030102
4.241	9.849	881	38	16614	70455	10010401
5.417	10.604	882	40	2788	15105	10010101
9.435	14.081	883	45	4156	39215	10040201
1.586	6.130	884	4	4661	7395	10030204
1.598	6.057	885	12	9315	14890	10060103
6.598	14.096	886	39	8798	58050	10010301
0.863	3.840	887	2	9656	8330	10030202
1.132	5.643	888	10	33176	37540	10050302
0.536	3.936	889	9	39316	21085	10050201
1.298	5.707	890	3	7509	9745	10030203

3.528	11.256	891	42	3509	12380	10010501
1.649	7.310	892	21	9311	15355	10060102
1.026	5.374	893	11	20609	21145	10050102
0.956	5.392	894	8	15283	14615	10050401
0.527	3.891	895	7	24757	13050	10050402
60.280	44.223	896	22	382	23060	10070101
1.005	5.154	897	60	14626	14695	10060301
5.572	11.534	898	15	3765	20980	10060401
0.967	4.651	899	20	24386	23580	10060101
0.540	3.599	900	17	8474	4575	10060201
2.813	7.411	901	31	4415	12420	10020301
0.689	3.286	902	18	29237	20155	10060202
30.494	29.488	903	36	295	9010	10020201
0.669	4.503	904	19	24630	16475	10060302
8.724	14.771	905	16	5626	49090	10060402
2.563	6.510	906	32	3072	7875	10020302
4.666	11.598	907	34	2244	10475	10020102
9.895	18.066	908	30	2189	21660	10020402
46.876	29.361	909	35	349	16360	10020202
3.338	11.081	910	33	15346	51220	10020101
145.477	75.039	911	29	152	22130	10020401

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