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PROBLEMS OF POPULATION MAPPING

IN DEVELOPING COUNTRIES

By

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ABSTRACT

PROBLEMS OF POPULATION MAPPING
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This study investigates population mapping in developing countries. The basis of population mapping in developed countries is first established by reviewing their population mapping history in the context of thematic cartography from the late 18th century to the present. Discussion includes symbols and techniques applied to population mapping over that period, with particular emphasis given to point, line, and areal symbology. Population mapping activities of the U.S. Census Bureau and the Japanese Statistical Bureau are examined, and programs and products of the two are taken as "ideal" models of population mapping in developed countries. Using these models, a minimum set of 11 criteria is established by which population mapping in developing countries is evaluated. These criteria address not only population maps, but the census and base mapping activities that precede population mapping. The historical development of population mapping in Africa, Latin America, and Asia is traced, and some general problems shared by developing countries are identified. Population mapping is evaluated in greater detail in Jamaica, Guyana, Kenya, Sri Lanka, and Malaysia through interviews with governmental and academic officials involved in census and mapping activities and through an evaluation of sample population maps. Saudi Arabia was chosen as a case study of population mapping in a developing country, and its population data, censuses, and base maps are discussed in detail. Its current population mapping status is evaluated and its problems and opportunities for the future are examined. The study concludes that four major problems affect the availability and quality of population maps in developing countries. These are inaccurate or irregular acquisition of population data, scarcity or inadequacy of base maps, low level of cartographic skill, and inadequacy of production methods and facilities. General solutions are discussed and recommendations are made, including increased cooperation between academic units and governmental agencies, awareness and use of proper cartographic techniques, institution of on-going cartographic training programs, elimination of political influence in scientific activities, provision of sufficient funding for population mapping programs, and encouragement of the growth of graphic literacy.

بسم الله الرحمن الرحيم

"In the name of Allah,
the Beneficent,
the Merciful"

To my Father...To my Mother

To my Brothers...To my Sisters

To whom I owe much more than I can ever repay

For their prayers, love, encouragement, and support

while we were apart during the long years of my studies.

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CHAPTER I

INTRODUCTION

The Importance of Maps in Development

The role of mapping in national development is now recognized as essential for many purposes. Although it is impossible to list all the requirements for which maps are a key, Thackwell (1969) gave some indication of the universal nature of such requirements:

> Maps are required firstly to enable the general administration of the country to function for defense purposes, for communications, for education, for land revenue purposes, and lastly, but not least, for the development of the country both in the natural resources and for all other purposes. (p. 7)

There is hardly any development project that does not require maps in its planning or execution (Coker, 1973, p. 147). Recognizing that planned development of their countries demands reliable base maps, the governments of many developing countries are dedicating large sums of money to survey projects. Very few parts of the world today have not been surveyed and mapped to some degree. However, the scales and standards in these maps vary immensely. In some countries, high-quality maps may be available in many scales, while in others, base maps are considered inadequate even for basic administrative necessities of good government (Dickson, 1970, p. 150). The more developed a country is, the greater its need for maps. Moreover, the faster a country develops, the greater its need for more maps of different types and scales (Thackwell, 1969, p. 7).

The variety of maps required for development has its basis in accurate topographic surveys. The base maps derived from such surveys are required by a number of specialists involved in planning and development studies, such as foresters, geologists, soil surveyors, engineers, urban planners, and geographers. Geographers in particular require base maps to display different types of information on natural resources, economic variables, and population.

One of the necessities for development planning is an understanding of the spatial attributes ofpopulation, with maps used to transform large masses of population statistics into a visual form that is more easily understood. They allow readers to view complex spatial relationships between areas and different population variables, when such relationships may be very difficult to comprehend from statistical tables. As such, population maps are used both for displaying data and, perhaps more importantly, for analyzing spatial patterns.

Throughout history, there is little doubt about the practical value of population maps. In 1872, Gilman delivered an address on "Geographical Work in the United States During 1871," before the American Geographical Society. Describing a population map showing the distribution of "Africans" in the state of Alabama, Gilman stated,

> Now, it would take a long time to discover from a column of figures the fact which you see here at a glance; . . . No alphabetic list of counties would suggest that fact, or enable us to surmise the reason. (Mood, 1946, p. 218)

In 1934, Fawcett observed:

> The population map has become more important with every advance in the study of human geography and its application to problems of social organization and administration; for the distribution

> of human population over the land, and its arrangement in various types of settlement, is the chief resultant effect of the whole complex of geographical, economic, historical, and social conditions in which the people have developed. It is important that we should have the best possible maps representing the distribution and arrangement of the population at any given time. (p. 140)

Continuing theoretical and technical advances in geography and the social sciences make Fawcett's statement even more applicable today. Particularly in developing countries, population mapping can be considered a starting point for any planned organization of a region or community. Planning for political, social, and economic development requires knowledge of the location of various groups in the population; their patterns of distribution as well as a great many of their characteristics can be effectively portrayed on maps.

Thus, population maps have a variety of applications. Robertson and Wood (1966) showed the value of population distribution maps of Scotland in 1961, explaining that they provide "information of use to the planner, economist, national and local government officer, market research organizer, and private businessman, as well as to the geographer" (p. 54). These are some of the specialists who can use population maps and who can do comparative work on the basis of the population map. However, different kinds of population maps have different values in different disciplines.

Large-scale population maps have proven to be useful for a number of studies and projects. Haaland and Heath (1974) listed some of the uses of population density maps for small areas and concluded that they are

> useful for selection of sites for industries, public buildings and power plants. In addition, they provide guidance for

> planning of evacuation from areas of potential disaster, either natural or man-made, and also indicate areas of greatest population risk in the event of nuclear war. Furthermore, when density maps are available for a given area for two or more different periods in time, they provide direct graphic information on population movements. (p. 321)

Large-scale population maps are also important in studies of social structures of towns and overcrowding in cities.

Another form of population map is the socioeconomic map which presents such population characteristics as occupation, level of education, income, and so on. The widespread use of this kind of map testifies to its usefulness in the overall economic and political development of countries (Klawe, 1973, p. 45).

The creation of population maps followed the introduction of statistical censuses; however, population maps did not become numerous until the nineteenth century (Klawe, 1973, p. 44). Since that time, several methods of mapping have been employed that portray population data accurately and effectively, particularly in more developed countries. For example, the Census Bureau of the United States began to use maps to represent population data in 1870. A series of maps was published showing the population density of the settled areas of the United States for each census period from 1740 to 1870 (Klove, 1967, p. 191). The number of maps produced by the Census Bureau has increased each decade, and current map products portray a wide variety of population and socioeconomic characteristics, such as age, race, and income. Production methods are becoming increasingly sophisticated, and many Census Bureau maps are now computer produced, often in color.

In contrast to the United States and other developed countries with a long tradition of population mapping, many developing countries may lack population maps, while some may not possess the data required to construct them. Since spatial knowledge of population characteristics is a crucial step in the development of a region or country, it follows that those areas of the world that are in the process of "developing" are most in need of population mapping.[1]

Researchers on population maps and mapping in developing countries is sparse and, in particular, problems of mapping have not been addressed in the literature in a systematic manner or studied with the aim of identifying the reason behind them. A survey of studies on population mapping in developing countries indicates that only a few articles (Prothero, 1960; Barbour, 1961; Hilton, 1961; Langlands, 1971; Thomas, 1971) addressed these problems in specific countries. Only one (Prothero, 1963) dealt with African population maps, no studies have been found that examined population mapping in Latin America, and only two (Das Gupta, 1960; Withington, 1965) dealt with Asian developing countries.

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[1]"Developing" and "underdeveloped" are Western definitions, and no clear-cut division exists between the terms. The term "developing countries" is used with referene to those poorer countries of the world that generally are growing economically at a slow or intermittent rate and cannot depend on their economic growth as a continual or self-generating process, but whose population is expanding rapidly (Clarke, 1977, p. 3). They have relatively low per capita income, widespread poverty and illiteracy, and a historical experience that involved their colonial domination by various countries (Mabogunje, 1975, p. 288). The term "Third World" emerged as an alternative for countries that are not part of the two major blocs, capitalist and socialist, and represents a group of primarily independent countries struggling for geopolitical recognition in the world system (McGee, 1978, p. 94). It is the author's experience, after visiting a number of countries, that the term "Third World" is not always looked upon favorably; therefore, the term "developing countries" is used throughout this study.

Scope and Methodology

The major purpose of this study was to investigate population mapping in developing countries. To accomplish this, the following objectives were pursued:

1. Review and discussion of existing cartographic techniques for population mapping, including the historical development of map types and symbology. This area of cartography, which has become increasingly specialized, has seldom been addressed in comprehensive terms or general treatment in the literature.

2. A survey of the status of population mapping in selected developing countries in Africa, Asia, and Latin America, and identification of general mapping problems shared by those developing countries.

3. An assessment of the current level of conventional and computer-assisted technology available both for the creation of suitable base maps and for the collection, manipulation, and display of data; and an evaluation of population census data and their suitability for mapping, as well as base map (topographic and administrative) quality and suitability. In the selected countries, the cartographic technique used in mapping population was also examined and evaluated.

4. Presentation of Saudi Arabia as a case study of the general and unique mapping problems facing developing countries. Current population maps were examined and evaluated in terms of accuracy, effectiveness, technique, and design.

5. Suggestions for methods of portrayal that might be appropriate for developing countries. The study also addressed whether or not computer methods could be effectively introduced if they were not already in use.

This study is a qualitative study based on three distinct approaches: (1) a review of current population mapping and its origins in developed countries; (2) a survey of population mapping in selected developing countries; and (3) an in-depth analysis of population mapping in Saudi Arabia.

The first phase of the research relied on interviews and literature and map reviews using the U.S. Bureau of the Census and the Japanese Bureau of Statistics as "models" of well-developed population mapping agencies. In addition, literature and maps were reviewed at a number of major libraries including the Map Division of the Library of Congress, the American Geographical Society Library, and the Newberry Library (Chicago).

The second phase involved a survey in several developing countries during seven months of 1981. The countries visited were Jamaica in the Caribbean, Guyana and Brazil in South America, Kenya in East Africa, Egypt in North Africa, and Saudi Arabia, Sri Lanka, and Malaysia in Asia. These countries were chosen for several reasons: (1) they used English or Arabic in their censuses and maps; (2) they represented a worldwide coverage of developing countries; (3) they were amenable to discussion concerning the status of population mapping; and (4) they provided a wide range of experience in enumerating and mapping their populations. Before visiting any country, letters were sent to the national Census Department in order to determine the possibility of a visit. For the countries that did not reply such as Nigeria, visits were cancelled.

The main concerns of this phase of the research were large-scale population maps produced by government agencies or universities, including both the population data and base maps upon which they were based. Thus, within each country visited, it was necessary to assess both data collection and mapping capabilities. With regard to population data, information was acquired as to method of collection and processing, and some conclusions were drawn as to its accuracy. Visits to statistical or census offices, and interviews with those responsible for the collection of census or population, were arranged. With regard to maps, a survey of their availability and adequacy was conducted. The cartographic units of the census department, if any, were visited. When population maps were found to be produced by other sources within the country--such as universities or survey departments--these places were visited in order to draw conclusions about the country's technical cartographic capabilities. In the course of this survey, samples of the population mapping products of each country were acquired for evaluation. Survey results of the developing countries were summarized and analyzed from a cartographic point of view.

In some of these countries one of the problems confronted is that census or mapping departments are often security-conscious, and their data are considered confidential. In other countries, the lack of population data and cartographic production equipment appears to be a source of embarrassment. Therefore, some questions were sometimes ignored or incompletely answered, such as those regarding accuracy of the data or maps, the number of cartographers, or the kinds of mapping facilities available. Most officials interviewed were cooperative and helpful, although a few declined to be identified.

The third part of the research focused on Saudi Arabia as a case study. Analysis included several topics: availability and quality of data for population mapping; appropriateness of data manipulation for cartographic presentation; current use and acceptable alternative methods of data symbolization; technological capabilities for map production; and application of cartographic principles to mapping problems unique to the country.

The following chapters are organized as follows: Chapter II provides a discussion of the historical development of population maps in developed countries, particularly the United States. The growth of various types of population mapping techniques is followed by a discussion of population mapping at the U.S. Bureau of the Census. The next three chapters (III, IV, and V) are devoted to population mapping in developing countries. Chapter III reviews historical development of population maps in developing countries and considers general problems of population mapping in these areas. Chapter IV delineates problems of population mapping in the specific countries visited. In Chapter V, Saudi Arabian population mapping is examined and analyzed in detail as a case study. Chapter VI offers a summary, conclusions, and recommendations.

CHAPTER II

POPULATION MAPPING IN DEVELOPED COUNTRIES

Historically Significant Population Maps

Most writers agree that population mapping is a comparatively recent development. It apparently was not until the first half of the nineteenth century that the attention of thematic map-makers showed a marked shift toward mapping population and other socioeconomic factors (Robinson, 1967, p. 100; Klawe, 1973, p. 44; Hodgkiss, 1981, p. 154). Thematic mapping in general and population mapping specifically have been undergone considerable change and innovation since that time.

Population maps first appeared in Europe in the late 1700s. A map of Europe done by A. F. W. Crowe in 1785 is considered the earliest population map (Kosinski, 1970, p. 5). In this map, population was represented by superimposed squares of different sizes in proportion to each country's area (Klawe, 1973, p. 44). Another early population map was produced as part of an atlas, Administrative-Statisticher Atlas von Preussischen Staate, which appeared in 1828. The map was a hand-colored choropleth map of population density of Prussia by an unknown author. It is considered the first choropleth population map to show density of population, with the exception of Ritter's (1806) simple map, which shows density numbers and is actually an "areal table" (Robinson, 1982, p. 113).

Yet another early population map is that of France, done by A. Frère de Montizon in 1830 (Kormoss & Kosinski, 1973, p. 5). This map (Figure 1), now in the Bibliothéque Nationale in Paris, used a dot method, one dot representing 100,000 people (Klawe, 1973, p. 44).

Two of the earliest world maps that contain population data were the James Wyld Map (1815) and the George Poulett Scrape Map (1833). The first shows prevailing religion, number of inhabitants, and civilization of each country through a combination of colors and arabic numerals. It is an example of the practice of putting population numbers on maps, a method used before the development of population symbols. This technique is useful, but does not show geographically the character of the distribution or density effectively. On the technical aspect of this map, Jarcha (1973) wrote,

> In Wyld's maps, information is conveyed by means of symbols and also be means of ancillary comments inscribed on the chart. The an early state in the development of thematic cartography. Symbolic representation of data had not yet attained maturity and was not yet adequate for intricate presentations. The methods were to undergo a long course of evaluation before attaining the intricacy--and the beauty--of the methods available today. (p. 844)

The Scrape world-population map (Figure 2) is a density map published in London in 1833. It uses a dasymetric technique by delimiting "natural regions" rather than "political units." Some writers have mistakenly called this the choropleth method (Klawe, 1973, p. 44). Scrape's aim was to show three classes of population density using a simple system of horizontal ruling with thick lines to represent the "fully peopled surfaces averaging more than 200

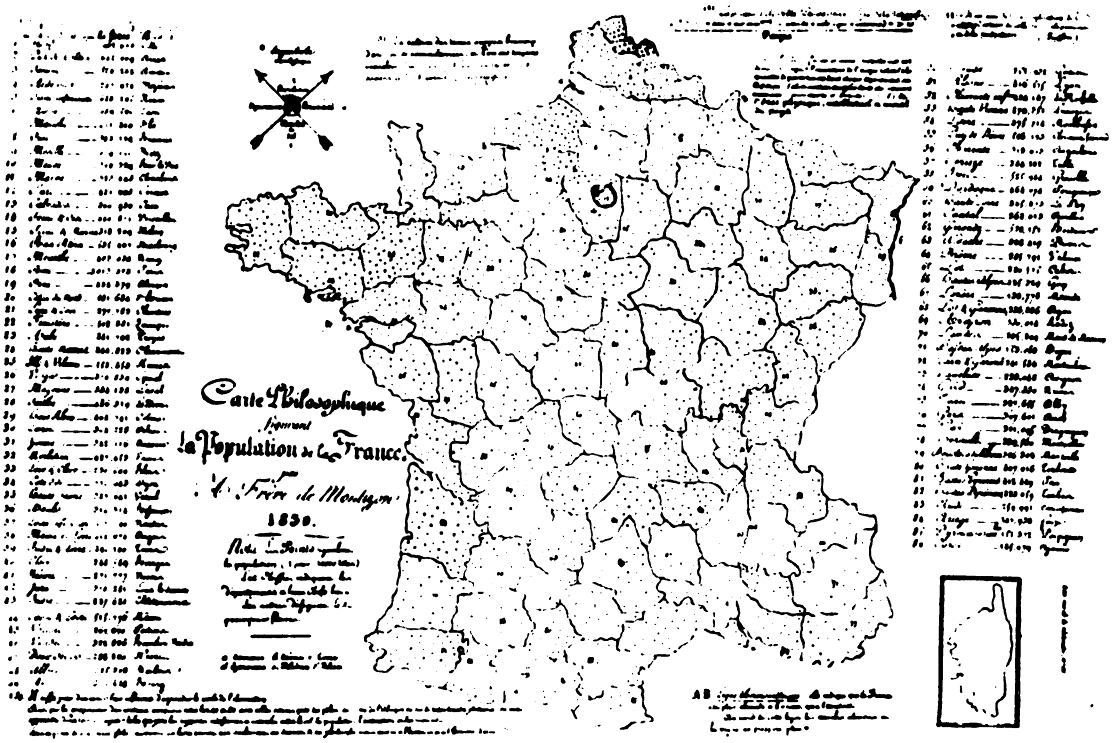

Figure 1. Frère de Montizon's map of population in France dated 1830 and entitled "Carte Philosophique Figurant de la Population de la France--1830." The first map to use a dot symbology. (From Robinson, 1982, Fig. 49, p. 112.)

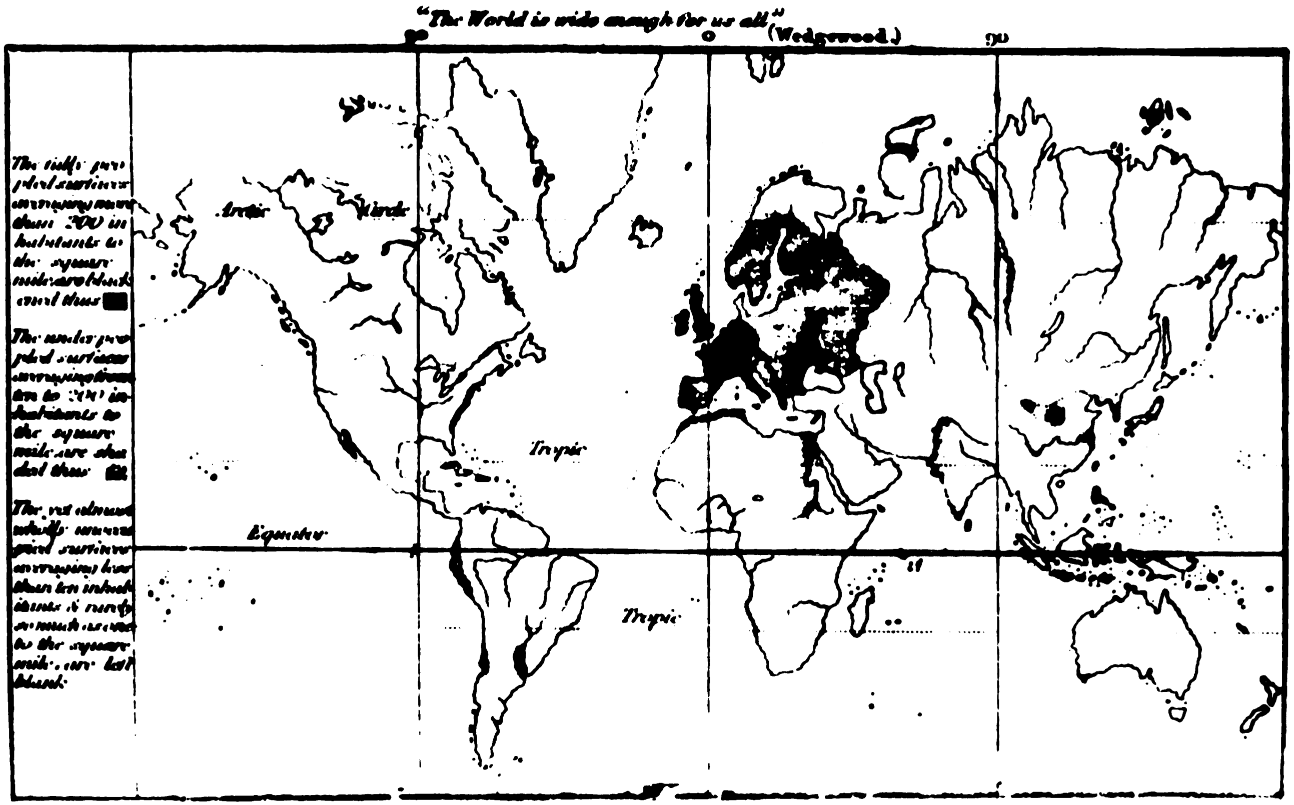

Figure 2. World population map by George Poulett Scrape published in 1833 and entitled "Map Exhibiting the Comparative Extent of the Fully-Peopled, the Under-peopled, and the Yet Unpeopled Parts of the Earth." (From Jarcho, 1973, Fig. 1, p. 838.)

inhabitants to the square mile." He employed finer lines to show the second class, "underpeopled surfaces averaging from 10 to 200 inhabitants to the square mile" and blank areas to show the third class, "the yet almost wholly unoccupied surfaces averaging less than 10 inhabitants and rarely so much as one to the square mile" (Andrews, 1966, p. 447). This map is considered to be the oldest and earliest dealing exclusively with population (Andrews, 1966, p. 448; Jarcho, 1973, p. 847; Klawe, 1973, p. 44).

The maps discussed thus far exemplify an early stage in the development of population mapping. They were crude in appearance and used a very simple symbology. However, they were a novelty and also advantageous for most of their contemporary readers.

A major innovation in cartographic representation in general, and in population cartography in particular, was represented in three maps by Henry Drury Harness in 1837. Two of these maps were concerned with population directly, and the third presented information concerning the movement of goods. On all three maps, base data contain county boundaries and named principal towns and cities represented by shaded graduated circles (Robinson, 1955, p. 442). In Harness's population map (Figure 3), boundaries of the classes are located where densities are assumed to change. Such a technique is known today as "dasymetric." Rural population is shown by aquatint shading, the darkest area being the most densely populated. In addition to shading, the map also includes approximately 100 population-density figures scattered over the map. In Harness's era,

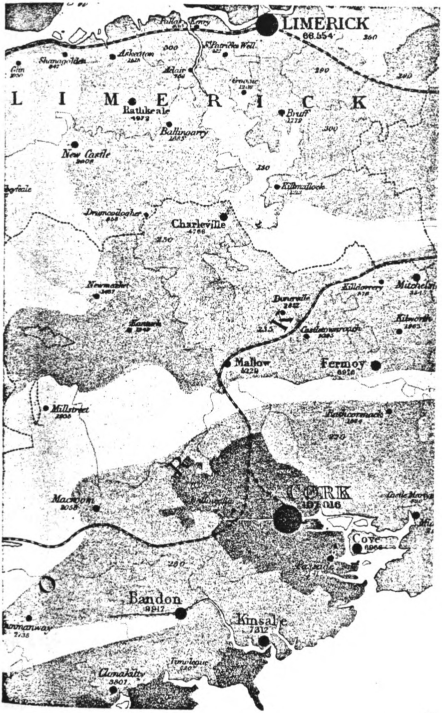

Figure 3. Part of Harness's Map of Population of Ireland prepared in 1837. Scale 1:633,600. (From Fawcett, 1934, p. 145.)

these maps were considered very sophisticated, and Robinson (1955, p. 441) believed that they (among others that Harness produced) very likely influenced the work of later cartographers.

The first map of population density to be part of a government census appeared in Ireland in 1843. This census map, which accompanied the 1841 Census of Ireland, was a choropleth map using the census enumeration district as an areal unit (Robinson, 1982, p. 120).

In 1849, two population maps appeared in England, one by Joseph Fletcher, a statistician, and the other by August Petermann, a cartographer-geographer. Fletcher's map (Figure 4) shows the density of population by proportion of inhabitants per 100 acres below and above the average for all England and Wales. Seven classes were represented, symbolized by cross-hatching light to dark shades. Robinson (1982, p. 121) characterized these class limits as "unusual," but no information was given on how they were established. Fletcher used the classes to assign each county a rank number, based on population density, representing an innovation in population mapping.

In Petermann's map, density of the rural population was shown by shading, whereas the towns were shown by dots and circles in five size categories. In addition, figures of population density per square mile by county were printed on the map. This map gives some indication that Petermann almost certainly copied Harness's techniques (Robinson, 1955, p. 448; Kormoss & Kosinski, 1973, p. 268) and indicates elaborate and detailed construction. This is partially because Petermann, unlike many of the early mapmakers, was a

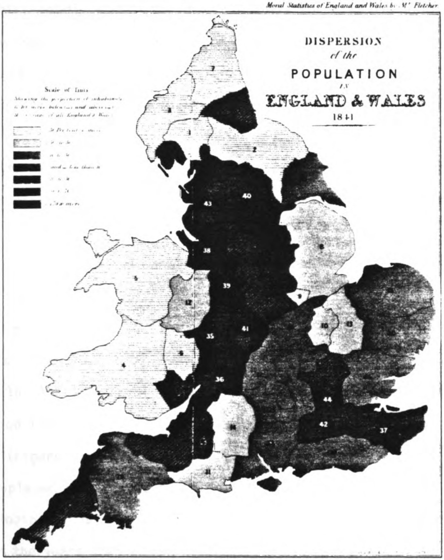

Figure 4. Fletcher's census population map entitled "Dispersion of the Population in England and Wales" and published in 1849. (From Robinson, 1982, Fig. 55, p. 122.)

cartographer-geographer, educated and trained in the field. Considering the practice of Petermann and others to employ numbers with symbols used to show distribution, it seems that early thematic mapmakers were very eager to provide more detailed informtion than they felt their symbols would portray. Fletcher, for example, wanted to give the reader information about the density ranking of counties symbolized by the same tint.

Petermann produced several other population maps. One made for the National Society's atlas depicted the population of every town "with more than 3,000 inhabitants" by a dot proportional to its population size. Petermann's two maps that were published in 1852 as part of the 1851 census report were described as highly sophisticated portrayals of very complex distributions (Robinson, 1982, p. 128). In these two maps he combined the variable shading used in his 1849 map and the dots for the towns he used on the National Society's Atlas map.

In 1857, the first application of isolines to the mapping of population was represented in two isopleth maps of the population of Denmark (Figure 5). The maps were the work of Niles F. Ravn and were completed as an assignment from the Statistical Bureau in Copenhagen (Robinson, 1971, p. 52). They portray rural-population densities for the years 1845 and 1855 with isopleths. The maps also show urban population with circles scaled in proportion to the population. In addition, areas of lowest and highest density are depicted by yellow and red colors (Kormoss & Kosinski, 1973, p. 269).

Figure 5. An isoline population map of a portion of Denmark by Niles F. Ravn entitled "Populations Kaart over Det Danske Monarki 1845" and published in 1857. (From Robinson, 1971, Fig. 2, p. 52.)

An atlas entitled Der Boden und die Landwirtschaftlichen Verhaeltnisse des Preussischen Staates by August Meitzen was published in Berlin in 1871 and comprises 20 plates in color. Two of the plates are concerned with population--Plate 6, which shows the density of population in Prussia (Germany) in 11 classes according to districts, and Plate 7, which shows different religious and linguistic groups of Prussia in terms of their areal distribution and density (Mood, 1946, p. 215). The maps in this atlas were later used as a model by the U.S. Bureau of the Census to illustrate the results of the 1870 census.

Most of these maps, which can be considered milestones in the development of population mapping, were produced by people who worked for their governments and were published as part of official reports or national censuses. The thematic cartographers of this period (the late eighteenth century and the first half of the nineteenth century), particularly in Denmark, England, France, Germany, and Ireland, introduced and used in their work all the standard techniques of statistical presentation used by today's cartographers. Robinson (1955) considered this period, and in particular the 20 years from 1835 to 1855, to be very important in the history of population mapping since it

> . . . witnessed one of the more remarkable "spurts" in development that has occurred in recent cartographic history. During this twenty-year period, almost every technique now known for representing population numbers, distribution, density, and movements seems to have come into being. (p. 438)

It was also during the first half of the nineteenth century that most current methods of symbolization used in thematic mapping were developed (MacEachren, 1979, p. 18).

The Development of Population Map Symbols

Population maps can be classified in various ways. One way is to distinguish between two major categories: qualitative and quantitative. The first includes all maps on which population data are differentiated nominally. An example is a map of the distribution of ethnic groups in a specific area. One of the main functions of qualitative maps is to display the relative location of population phenomen without consideration of variation in quantity or density of the distribution. Quantitative maps employ numerical measures, whether they are based on absolute numbers or on summaries, such as averages. In these maps, the major objective is to show spatial variations in amounts. Population distribution maps or population density maps are examples.

Population maps may also be classified as to the cartographic methods used to construct them. Klawe (1973, p. 46) defined eight methods of producing population maps: (1) cartodiagram, (2) choropleth or cartogram, (3) dasymetric, (4) dot mapping, (5) symbol maps (pictorial, geometrical, etc.), (6) areal method or map of extent, (7) chorochromatic method, and (8) isoline mapping.

The classification used in the present study organizes population maps in terms of the graphic devices or symbols used. These are:

1. Point symbols

    a. dot maps
    b. graduated-symbol maps

2. Line symbols

    a. isopleth maps
    b. flow-line maps

3. Areal symbols

    a. choropleth maps
    b. dasymetric maps

4. Other symbols

    a. cartograms
    b. maps with graphic forms superimposed
    c. three-dimensional maps
    d. computer symbol maps

<u>Point-Symbol Population Maps</u>

Point symbols are dots, circles, or other geometrical figures that locate elements of a population at certain points on the map. They may indicate only quantitative differences in distribution or density, or simultaneously they may indicate qualitative differences, as in maps of different ethnic groups. The use of qualitative point symbols to illustrate variations over space preceded that of quantitative point symbols (MacEachren, 1979, p. 23).

Dot maps are the simplest distribution maps of those that use point symbols. In such maps, a dot of uniform size and shape represents a stated number of individuals, and dots are distributed or placed as nearly as possible at the geographical location of the population.

The earliest application of dot symbols on population maps was Frère de Montizon's 1830 map of France, mentioned earlier (Figure

1). Two other maps, published in 1863 and 1898, also have been claimed to be the first to use the dot technique to show population distribution.[1] However, even though Frère de Montizon's map probably represents the earliest known use of the dot technique, for some reason no one referred to this cartographic innovation until well into the twentieth century. This simple, logical idea "had to wait some thirty years to be reinvented and much longer than that to become generally known" (Robinson, 1982, p. 113). It was not until 1859 that another true dot map appeared, authored by Alexander von Mentzer, showing the distribution of population in the Scandinavian Peninsula. There seem to have been no other dot population maps until near the end of the nineteenth century (Robinson, 1982, p. 201).

The dot method was popularized by Sten de Geer (Kormoss & Kosinski, 1973, p. 5), who claimed that the dot method for population mapping originated in his research in 1906 with an unpublished map of the density of habitations on Gottland (de Geer, 1922, p. 73). Although his claim is unfounded, de Geer's work on the improvement and consideration of different problems of this method is well known (Huntington, 1920, p. 360). Subsequently, he applied the dot method to his 1917 population map of Sweden at a scale of 1:500,000 (Figure 6).

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[1]The first one, published in 1863 in New Zeland, was not titled and the author was not identified. This map was included in "Memorandum on Roads and Military Settlements in the Northern Island of New Zealand," published in the Appendix to the Journal--House of Representatives, 1863. The New Zealand map shows the distribution of native Maoris by crosses; each cross represents 100 Maoris (Hargreaves, 1961, p. 38). The other map, published in 1898 by A. G. Kihlman, shows the distribution of population in a limited area on Finland's west coast.

Figure 6. Population map of part of Sweden using dots arranged to simulate spheres. Published by Sten de Geer in 1917 in 12 sheets. (From de Geer, 1977, Fig.2, p. 77.)

Following Sten de Geer maps, several others used the dot method to portray population distribution. Among them was Wesley Coulter (1926), who produced a population distribution map of Japan. With dots he also used open proportional circles to represent the larger cities. Another individual to use the dot method was Clarence Batschelet (1927), who created a map of the distribution of population in Pennsylvania. In his map, larger cities were represented by irregular symbols (shaded municipal boundaries).

Other well-known maps in which the dot method was used are the series of population maps of Ohio and of Wisconsin at different dates by Dr. Guy-Harold Smith (1928a, 1928b). In his maps of the population of Ohio for 1920 (Figure 7), Smith used a sphere-like symbol to show, in his words, "not only the distribution but the concentration of people in compact communities" (Smith, 1928a, p. 422). Smith borrowed this device from Sten de Geer, but he modified it in his map. Whereas Sten de Geer used dots to show both the distribution of the rural inhabitants and the locations of the small urban communities (distinguishing the urban communities by a symmetrical arrangement of the dots), Smith used dots only for rural inhabitants.

A satisfactory, effective population dot map depends on three important considerations: (1) dot size, (2) the value represented by each dot, and (3) the dot location. Many writers have discussed these considerations (de Geer, 1922; Fawcett, 1935; Wright, 1938; MacKay, 1949; Hilton, 1961; Birch, 1964; Hodgkiss, 1970; Monkhouse & Wilkinson, 1976; Robinson, Sale, & Morrison, 1978). Two of the more important

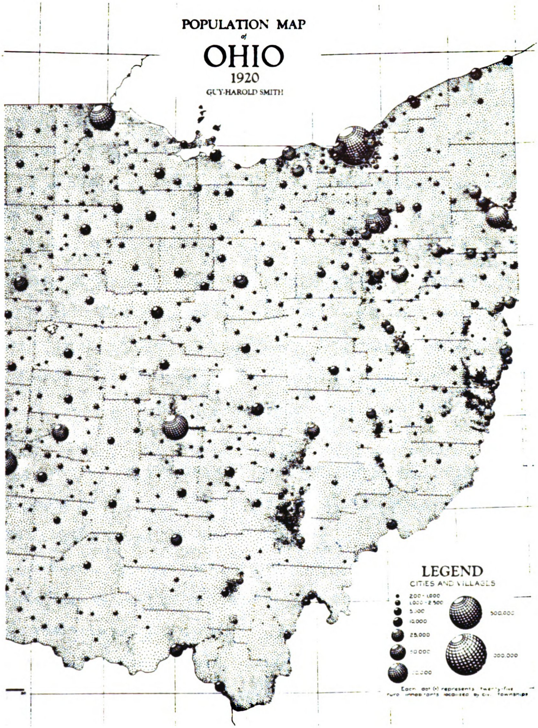

Figure 7. Guy-Harold Smith's map of Ohio using graduated spheres for urban population and dots for rural inhabitants. (From Smith, 1928, p. 427.)

studies on this subject were conducted by MacKay and Olson. MacKay (1949) believed that dot maps, which are often drawn to show distributional data such as dispersed rural population, are often disappointing and fail to achieve their purpose. He attributed this to a lack of balance between the combination of dot size and number of dots. MacKay developed a nomograph to aid in determining appropriate dot size and dot value. By varying the two, the cartographer can reach a compromise that is best suited to his map. MacKay's nomograph is still in use, and Robinson et al. (1978) included it in the latest edition of their textbook, adding to it a metric scale. Olson (1977) approached the construction of dot maps using psychophysical scaling research developed primarily in studies of graduated point symbols. She offered several formulae with which cartographers could "correct" readers' perceptions of dot maps for recognition of patterns or numerousness of dots.

The dot map was developed to accommodate a wide range of uses and applications in addition to basic distribution. MacKay (1953) differentiated between the common or quantitative dot map and the percentage dot map. In percentage dot maps, each dot represents a percentage of the total value of the distribution. The map itself has a round number of dots, either 100 or some simple multiple of it. MacKay believed that this kind of map is superior to the common dot map for some mapping purposes. He listed several advantages of percentage dot maps, including the comparison of areal relationships and the analysis of accordant and discordant patterns. (Accordant patterns occur when two phenomena or variables occupy the same or very nearly the same area; when this is not true, discordant patterns result.) The disadvantage of this method is that its dots seldom present a round number of the distribution except by chance, and it is troublesome to sum absolute values of the distribution.

Another kind of population dot map is the multi-color dot map where distributions of several phenomena are depicted (e.g., ethnographic distributions). Such a map combines the advantage of accurate detail viewed closely and broad areal patterns viewed more generally (Monkhouse & Wilkinson, 1976, p. 29). Although some writers feel that these maps give faulty visual impressions because of the use of more than one color, Thomas (1955, p. 8) indicated that such faulty impressions occur when three requirements necessary to maintain the proper relationships between the colors are not fulfilled. These requirements are (1) that each color must be distinctive, (2) that each color must have equal contrast with the background, and (3) that each color must be equally vivid. Rogers and Groop (1981) found that color dot maps are at least as effective as several single black and white dot maps in portraying regions. They suggested that cartographers should consider their use when overlapping regions and transitional boundaries are to be portrayed because color dot maps can illustrate several distributions simultaneously.

A dot map is generally considered best for showing population patterns, but difficulties arise when on one map the cartographer attempts to place both rural and urban populations. When one attempts to show large cities with dots at the same scale used for small rural areas the dots representing the city will spread out and cover adjacent rural areas (Fawcett, 1935, p. 143). This aspect of population distribution has resulted in the combined use of the dot method with graduated-point symbols, such as circles, spheres, or other geometrical figures. Of all the geometrical figures, graduated circles are most commonly used in population maps.

Graduated circles are considered one of the earliest quantitative symbols used to represent population statistics. William Playfair first used graduated circles in 1801 to display statistical data (Funkhouser, 1937, p. 283), although he used them in graphs rather than in maps. The first to use graduated circles on maps was Harness in 1837 (MacEachren, 1979, p. 24). He represented the population of cities by shaded circles ("dark spots" as he called them) whose size was proportional to the population. Petermann early realized their utility as a cartographic symbol and used them extensively after 1851. Since that time, cartographers have found that graduated circles are particularly useful symbols for representing urban population data. Since circle area is made proportional to the population value, they are appropriate in cases in which a large value has to be represented in a small space.

The sizes and values of graduated circles, and their perception by map readers, have been one of the most important research concerns of cartographers. Several empirical studies have been conducted to test individuals' perceptions of circles. Psychophysical research has revealed that, in general, human visual responses to cartographic stimuli are nonlinear in character and that readers tend to underestimate the population sizes represented in graduated circle maps. Flannery (1971) devised an often-used method to compensate for underestimation by scaling the circles to reflect the amount of expected underestimation. Because map readers cannot visually perceive small variations in circle sizes, Meihoefer (1969) suggested that the traditionally popular method of comparing and presenting quantitative data by using graduated circles should be modified. Through experimentation, he developed the method known as range-graded circles in which each circle represents a range of values rather than a specific value. He believed that this method was more useful and effective than the traditional method.

Line-Symbol Population Maps

Two kinds of line-symbol maps can be used to portray population data: isopleth maps, which can be used to display static population distribution, and flow line maps, which can be used to depict population movement. The isopleth is a specific form of the generic concept of the isoline (or isorhythm), which is, in general, a line connecting places or points of equal value. Population data can be mapped using this method by assuming values (such as density) to be at the centers of the mapping units and drawing lines connecting points of equal value.

The first individual to conceive of using the isoline in population maps was Lanne in 1845 (MacEachren, 1979, p. 27). He stressed the usefulness and importance of employing the concept with population and economic data. Nevertheless, the first published isopleth maps did not appear until 12 years later, in 1857. In an article on the state of mapping in 1858, Emil von Sydow, a German, suggested that as the lines of equal height were called "isohypses," the lines of equal population quantity might be called "isopleths." Robinson (1971) cited this as evidence of the internal character of ideas, saying that "the isopleth was conceived in France, born in Denmark, and named in Germany" (p. 53).

Isopleths are usually used for continuous distributions, such as temperature and rainfall. However, they are used for population mapping as well, with the distribution of population regarded as a continuous variable (Raisz, 1962, p. 200). On an isopleth surface the isopleths themselves (and not the mapping unit or area boundaries, as in choropleth maps) define the direction, gradient, and form of spatial variation. They are best suited to illustrate distributions where changes are relatively gradual, rather than distributions that are patchy or uneven (Monkhouse & Wilkinson, 1976, p. 45). They show gradual transitions better than abrupt changes in densities. On some isopleth maps, the areas between the lines are shaded or colored so that the higher the value, the darker the shade or color. This is why this method is sometimes regarded as areal symbol mapping. The most commonly used isopleth population map is the population-density map. However, the technique can also be used effectively in other population mapping, such as the plotting of potential of population or ethnographic distribution (Monkhouse & Wilkinson, 1976, p. 361).

The process of isopleth mapping is not simple and straightforward. In fact, it is subject to some problems. Schmid and MacCannell (1955) identified five major problems of isopleth mapping: (1) the influence that the sizes of base areas have on isopleths; (2) how the "control" point" for each areal unit is located; (3) class intervals for isopleths; (4) the interpolation technique; and (5) the rationale of isopleth technique in statistical theory. There have been several important contributions to the literature on these problems of isopleth mapping of populations, and attempts have been made to evaluate quantitatively certain sources of error arising from mapping procedures or the data themselves.[1]

Another form of line symbol population map is the flow line map, which can be used to depict population movement. In this kind of map, the line width, which is made proportional to the population value, is the important factor. The direction of the line indicates the direction of flow and flow lines may be colored or shaded to represent different characteristics of the quantity depicted. When aggregation of values cannot easly be represented, classed line widths can be adopted (Dickinson, 1973, p. 66).

Harness, in his 1837 series, first used a proportional line to show movement of people. In one of these maps, the flow lines are shaded and the width is proportional to the numbers that appear along the lines. The flow lines in general are drawn directly between connecting points and do not show the actual route followed. Robinson (1955) described this map as having a remarkably modern appearance.

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[1]For a general discussion of such problems, see MacKay, 1951, 1953b; Blumenstock, 1953; Schmid & MacCannell, 1955; Hsu & Robinson, 1970; Morrison, 1971; Dickinson, 1973; Robinson et al., 1978.

It was not until the 1840s that two other engineers, Belpaire of Belgium and Minard of France, employed flow lines to portray the movement of goods and passengers (Robinson, 1982, p. 208). Minard, who is considered the popularizer of this aspect of "dynamic" thematic cartography, produced numerous flow-line maps between 1845 and 1869 including the flow of emigrants (Robinson, 1982, p. 209). Permanent, seasonal, or daily migration can be effectively portrayed by flow lines (Kormoss & Kosinski, 1973, p. 9).

Areal Symbol Population Maps

Three mapping techniques are available that use areal symbols such as gray tones (sometimes referred to as shading) or color to show areal extent and magnitude of population or population characteristics. They include choropleth and dasymetric techniques, and shaded isolines, mentioned earlier.

These area symbols were first used to map a population characteristic in 1826, when Charles Dupin mapped the distribution of illiteracy in France by shading the number of male school population by each department of the country. This map was considered the first "true" choropleth map (MacEachren, 1979, p. 29; Robinson, 1982, p. 156). The earliest choropleth map to show density of population appeared in 1828 and was followed by several highly generalized combination choropleth/dasymetric portrayals of population in various parts of Europe.

The choropleth population map, also called a "shading map" or a "density map," is considered the most commonly used to present quantitative population data. Monkhouse and Wilkinson (1976) stated, "If the isopleth is the chief tool of the climatologist, the choropleth may be said to be the chief tool of the human geographer in his quantitative treatment of the distributional aspects of population" (p. 332). Mapping areas are normally administrative and political units used by the census bureaus to enumerate population. In this method, population values are represented by a graded series of shadings or colors with darker shades representing higher values. Although the most common choropleth population map shows density of population, the technique is important in the mapping of other population characteristics such as population change; birth and death rates; age, sex, or race variables; or socioeconomic characteristics such as percentage of unemployed, college graduates, population density, or per-capita income (Monkhouse & Wilkinson, 1976, p. 341; Schmid & Schmid, 1979, p. 177). Clearly, many kinds of population data can be mapped by this technique. However, one important consideration is that absolute numbers should not be presented in a choropleth map. The effect on quantities caused by the varying sizes of the mapping units must be avoided by expressing quantities by unit area (density) or as a percentage, ratio, or per-capita figure that is independent of area (Dickinson, 1973, p. 53; Williams, 1976, p. 213).

Although the choropleth map is a valuable method for presenting population data, it has some disadvantages. Boundaries of the mapping unit (statistical or administrative area) may have no necessary relationship to the distribution of the population in the unit. Thus it is possible that uniform shading, although showing the average density concept correctly, may imply uniformity of distribution over the entire statistical or administrative area, regardless of the great differences that may exist within the area (Birch, 1964, p. 170; Hodgkiss, 1970, p. 136; Dickinson, 1973, p. 55; Schmid & Schmid, 1979, p. 180). This depends primarily on the actual mapping area chosen, which depends on the scale and the desired detail of the map. Choropleth maps based on large geographical units, such as states or counties, produce a general and often erroneous picture of population density, whereas maps based on smaller statistical areas, such as census blocks or enumeration districts, can produce a detailed picture of population distribution if the base-map scale is large enough (Bradhurst, 1972, p. 14). Another disadvantage of choropleth maps stems from map readers' tendency to judge large geographical areas as being more important than smaller ones. Thus choropleth maps are more effective when mapping areas are fairly uniform in size and shape (Williams, 1976, p. 216).

In spite of these disadvantages, many population maps are made by the choropleth method because suitable data are readily available. In addition, because of the ease of automation of this type of map, it is commonly used by academicians and public agencies such as the Bureau of Census (Jensen, 1978, p. 127). The choropleth map is also recommended when one undertakes an initial look at a population distribution (Peuker, 1972, p. 33; Robinson et al., 1978, p. 246).

Selecting class intervals is one of the important problems mapmakers face when population data must be depicted by the choropleth technique. The number and variability of class intervals greatly affect the accuracy, usability, legibility, and attractiveness of maps (MacKay, 1955, p. 71). Much has been written about the methods available for selecting class intervals. These include traditional arbitrary classes of even-numbered boundaries (i.e., 10, 20, etc.); quantiles; and arithmetic or geometric progressions. Data also can be classified by using graphic aids such as frequency and cumulative graphs to select "natural breaks"; or by more sophisticated statistical techniques such as a minimum-variance procedure (Jenks, 1977). Whatever classing method is selected, it is important to create a map distribution that is suitable for further interpretation, analysis, and study.

Once class intervals have been established, the cartographer confronts the problem of portraying them graphically by using a suitable range of gray tones or colors. It is not a simple procedure to select shading patterns for choropleth maps. Jenks and Knos (1961) stated that

> The selection of area symbols that combine to give clarity and unity to a map is especially difficult. The cartographer must consider how the area shadings are to be used, what reduction and reproduction problems are involved, and what style and texture of pattern is best suited to a particular problem. He must also concern himself with the visual contrast between patterns, and, if patterns are to be used in sequences, what values give the best visual representation of a scale ranging from light to dark. (p. 316)

Psychologists, psychophysicists, and cartographers have studied shading values extensively. Various factors affecting the perception of shading, including optical responses and esthetics, have resulted in several gray-tone "curves," but much work remains to be done (Schmid & Schmid, 1979, p. 178). A relatively new technique is referred to as "unquantized" choropleth maps in which every tone is made proportional to a value. Computer technology allows the creation of an unlimited number of tones, and although some cartographers dispute their value, they are becoming more common (Muller, 1979).

The dasymetric population map is a modification or a refinement of the choropleth technique in that local knowledge about the population density, its distribution, and its nature is used when mapping to obtain more accurate distribution. The dasymetric population map may be used when the area within the boundaries of each statistical or administrative unit can be differentiated into recognizable subunits of different population densities with reasonably well-defined boundaries (Dixon, 1972, p. 24). This type of map focuses interest on value and location of areas having relative homogeneity in population density, regardless of the boundaries of the administrative or statistical unit. Although "controlled guesswork" is often involved (Wright, 1936, p. 104), the dasymetric technique gives a realistic and relatively detailed picture of the areal patterns of population density. It also shows abrupt changes of population density from one place to another (Bradhurst, 1972, p. 14).

Other Population Symbols

Statistical information on the size and characteristics of a population can be cartographically illustrated by methods other than the conventional ones discussed above. One technique, a cartogram, is sometimes called a "proportional map" or a "distorted map" (Schmid & Schmid, 1979, p. 212), a topological map (Monkhouse & Wilkinson, 1976, p. 85), or a value-by-area cartogram (Haro, 1968, p. 452). In a cartogram, mapping areas or units of the map are made directly proportional to the numerical or quantitative value of the population, while the shape and location of the mapping units or areas represented are preserved insofar as possible. This technique is believed to overcome one of the problems of choropleth mapping, namely, the tendency to judge the importance of areal units by the size of geographical areas, regardless of their number of cases or numerical values. Cartogram mapping is an attempt "to develop a rational adjustment to the problem of portraying areas on the basis of the numerical values they represent rather than on the arbitrary basis of geographical size" (Schmid & Schmid, 1979, p. 213).

Raisz (1934) is considered to be one of the earlier proponents of cartograms (Dent, 1972, p. 393). He portrayed the geographical divisions of the census and the states of the United States with rectangles proportional in size to their populations. He suggested that the rectangles be located at the relative locations of the regions they represent. Hunter and Young (1968) produced somewhat different cartograms based on the 1961 census population of England and Wales. In their cartograms, they took special care to preserve the shape of and contiguity between counties as far as possible. They suggested that authors present socioeconomic data on the cartogram or "demographic base map" to relate it to population while simultaneously displaying the same data, with the same symbols, in conventional choropleth style to show correct location and permit comparisons.

The idea of preserving the true shapes of the mapping units in a cartogram was first suggested by Tobler in 1963 (Dent, 1972, p. 393). This concept was then examined by Dent, who suggested that mapmakers should provide at least those points along state outlines that are proven to be the cues for shape identification. Another kind of cartogram in which the mapping units stay in more or less their correct location and maintain correct shape is the "noncontiguous cartogram" (Olson, 1976, p. 371). Here empty areas between mapping units are meaningful representations of discrepancies of values, and all the discrete units for which data are available are preserved, as are the shapes of the mapping units, so that their recognition by the map reader is relatively uncomplicated (Olson, 1976, p. 379).

A second technique uses a combination of graphs to present the value of a population characteristic that occurs at a number of points. Various graphic forms such as bars, curves, half-circles, or pie graphs can be superimposed on base maps to make possible simple comparisons. For example, pie graphs are often used to illustrate features of the population structure: the area of each circle is made proportionate to the total population of the mapping unit (such as a county), and the two segments of the circle represent the rural and urban populations. This method can be used to show the ethnic, racial, occupational, industrial, and age structure of the population (Monkhouse & Wilkinson, 1976, p. 361).

The amount of information one can display with this method is almost unlimited. However, the important question is how much of the information the map reader will be able to extract (Robinson et al., 1978, p. 216).

Three-dimensional maps are perspective representations of obliquely viewed statistical or topographic surfaces (Jenks & Brown, 1966, p. 1). One of the most influential developments in cartography has been the definition of a geographical "volume" described by a statistical surface. The "statistical surface" concept permits researchers to treat inherently discrete data, such as population data, as continuous and differentiable for purposes of analysis (Muehrcke, 1973, p. 63). In mapping statistical surfaces, the mapping units can be visualized as a series of numbers, each of which has an W,Y location and a Z characteristic. A three-dimensional surface is the one that represents the height of the Z values above the plane of the map. Three-dimensional population maps are frequently used to show variations in population density or rates of growth, or variations in other population characteristics.

Three-dimensional surface variations can be represented by either a stepped surface map or a smooth surface map. In a stepped surface population density map, each of the mapping units (states, counties, or any administrative division) is raised above the base level of the map to a height proportionate to its average density. Stepped surface maps suffer the same limitations as choropleth maps: (1) abrupt value changes at unit boundaries, (2) the misleading impression of a uniform distribution within the unit, and (3) the effect of unit size or area on the judgment of unit value or importance (Cuff, 1973, p. 45; Muehrcke, 1980, p. 67). Smooth surface population density maps overcome some of these problems by eliminating interior-unit boundaries and generating a smooth rather than a stepped transition from one unit to another. High data values become "peaks" rather than elevated flat surfaces, and low data values become "valleys."

Computer-Assisted Population Mapping

Computer-assisted cartography for large quantities of statistical information has developed rapidly over the last two decades. It has become possible, in theory if not in practice, to program all mapping methods and symbology used in population mapping. The introduction of the computer to statistical mapping in general has enhanced the maps' value by decreasing their production time and by facilitating the reproduction of the resulting outputs quickly and accurately (Morehouse & Nisen, 1980, p. 82). Major benefits of using a computer-assisted mapping system to map population data in particular include the following:

First, when a vast quantity of population data is available, tremendous reductions in data-handling time, costs, and errors can be realized, particularly if the data are already in machine-readable form. For example, a savings of up to 90 percent in compilation time can be realized in producing population dot-distribution maps of Australia through a program that merges computer files containing the census data and geographic descriptions of the collection areas (Fryer, Smith, & MacLeod, 1974, p. 122). Another benefit of using computer-assisted cartography for population mapping lies in the creation of maps of a kind that are extremely difficult or impossible to produce by hand, for example, three-dimensional maps such as stereo population maps (Rhind, 1977, p. 78). For areas where the U.S. Bureau of Census now makes available machine-readable information by latitude and longitude coordinates, one could calculate the spatial rate of change of the population density (the gradient) and produce a map of the results (Tobler, 1965, p. 34). The computer's speed in revising and updating maps represents another benefit of computer-assisted cartography. Because of the dynamics of growth and change characteristics of population information, a quickly updated graphic representation is of interest to many people, including planners, legislators, administrators, and researchers.

Computer-assisted mapping also has some disadvantages. The speed with which automated cartographic systems can be installed and brought into production has frequently been underestimated. Moreover, the speed of technological improvement makes the selection of both hardware and software especially difficult(Rhind, 1977). Other disadvantages are apparent. Accepting computerized methods and acquiring equipment and staff make any subsequent return to manual methods next to impossible. And, since computer specialists are often better paid than traditional cartographers, administrative and social problems may arise.

Population maps produced by computer depend on the equipment available to the user and the program used. There are two basic types of computer hard-copy output equipment: line printers and digital plotters. Typically, the graphic quality of plotter maps exceeds that of line printers and more closely approaches the appearance of manually produced maps. In general, computer-produced maps seldom equal conventional cartographic quality, but as the technology grows, visual appearance will undoubtedly improve.

The development of a variety of thematic mapping methods and their symbologies over the past century and a half, coupled with production techniques and materials perfected over the past 50 years, has resulted in conventionally produced maps of high quality. Within the last two decades, this capability has converged with rapid advancements in computer technology in the census bureaus of some of the developed countries, notably Canada, Japan, and the United States, resulting in extremely sophisticated statistical and population mapping agencies.

Population Mapping at the U.S. Bureau of the Census

The use of statistical cartography in the United States began as early as 1815. There is ample evidence that some agencies of the federal government (other than the Census Bureau) were well aware of these techniques (Friis, 1974, p. 131). However, most statistical cartography encompassed only physical maps (topographic maps, meteorological maps, and so on). The first significant statistical cartography that included population maps was initiated in 1870 by the Census Bureau, resulting in the first statistical atlas of the United States. Published in 1874 under the direction of Francis A. Walker (Klove, 1967, p. 191) and modelled after Meitzen (Mood, 1946, p. 215), part II of U.S. Statistical Atlas (1870)[1] was titled "Population, Social and Industrial Statistics," and included maps depicting the: (1) distribution and density of the main immigrant groups; (2) distribution and density of the total foreign-born population--Irish, German, Swedish, etc.: (3) "colored" population; and (4) 1870 distribution of the general population of the United States. The atlas also included a series of maps showing the population density of the U.S. settled area at each census from 1790 to 1870. These were based on county and smaller area data using the dasymetric method and various shades of one color. This series of maps has been cited as a primary source of information for an important historical analysis of early American settlement.

In 1890 the Bureau of the Census produced maps based on the 1890 census that were more sophisticated in their conception and execution than their predecessors (Klove, 1975, p. 175). Many new population maps were presented in the 1890 atlas; among them were maps showing increases and decreases in population and maps of occupations and mortality.

After 1870, it became the practice for the Census Bureau to publish an atlas after each census. This practice continued only

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[1]Statistical atlases were published by the U.S. Bureau of the Census following the census of 1850, 1870, 1890, 1900, 1910, and 1920. Copies of these atlases may be examined at the Census Bureau Library.

through the 1920 census. Durland (interview, January 1982) gave two reasons for the discontinuation of these atlases. The first involved a cost consideration because by 1930 the nation had entered the Great Depression. The second reason concerned the staff of the Bureau in 1940, which Durland characterized as keenly professional in the administrative and statistical operation of the census but lacking in cartographic interest.

The preparation of series of outline base maps at different scales and with different degrees of detail has been one of the primary useful by the Census Bureau. Maps of the United States showing the boundaries and names of all counties were published at a scale of approximately 1:5,000,000 for the 1920 and 1930 censuses. Also, for the 1930 census, large-scale maps of each state were prepared to show the boundaries and names of all counties and their minor civil divisions, including incorporated cities, boroughs, towns, and villages (Klove, 1967, p. 191). These outline base maps, and other more detailed maps such as outline maps locating and identifying small statistical areas (blocks and census tracts), have become regular parts of census mapping since that time. The availability of such maps is very important for population mapping, and it has undoubtedly increased the value of the data themselves for other persons interested in producing statistical maps from census data.

Although early statistical atlases included color maps, from the 1920s through the 1950s, most maps were in black and white. Population maps in color were once again included in the summary volume of the 1960 census of population. Since the 1960 census, the

Bureau has begun three series of color maps that differ in scale, topic, and cartographic technique. They are known as the GE-50, GE-70, and GE-80 urban atlas map series.

GE-50 map series: The series began in 1963 with 1960 census data (although most maps in the series are now based on 1970 data). These maps are at a scale of 1:5,000,000 and depict distribution in one of three categories: (1) people and their economic characteristics; (2) socioeconomic measures, such as percentage of population in poverty; or (3) are boundaries of major interest, such as Congressional districts (Meyer, Broomer, & Schweitzer, 1975, p. 101). Maps receive sequential numbers as they are added to the GE-50 series, which now includes 78 maps, most of these choropleth maps. Their subject matter includes population, race, housing, income, retail sales, employment, and Congressional districts, and other socioeconomic characteristics. Nine of these 74 maps deal with population distribution, density, change, and migration. The nine maps are identified in Appendix A.

GE-70 map series: Initiated in 1974, the GE-70 maps series is a specialized series of thematic maps at a smaller scale (1:7,500,000) than the GE-50 series (Meyer et al., 1975, p. 102). They employ various cartographic techniques and scales and have been described as experimental (Durland, interview, January 1982). The series consists of three single-sheet maps, two of which display population data. The first map (Figure 8), which "simulates the 1970 U.S. population distribution at night from a satellite," is considered to be one of the most popular maps produced by the Census Bureau (Kaplan &

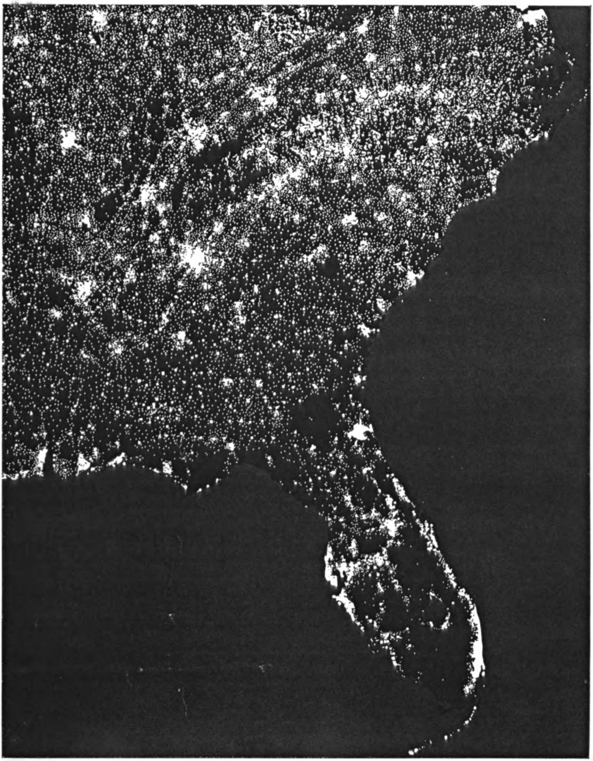

Figure 8. Population distribution, urban and rural, in the U.S.: 1971. (From Bureau of the Census, 1978: GE-70 Map Series, No. 1.)

Van Valey, 1980, p. 345). It is a dot-map printed in negative form where population data are white on a black background representing land area. The second map is titled "Distribution of Older Americans in 1970 Related to Year of Maximum Population." Through this map the Census Bureau wished to examine an alternative mapmaking technique, known as two-variable or multivariate mapping. This consists of two choropleth maps of different variables, which are "crossed" with different color combinations. The two-variable color map is intended to show the spatial distribution of two variables and to reveal information concerning the relationship between the variables. Bureau staff believes that it will aid the reader in locating areas of special interest in relationship to the total picture (Meyer et al., 1975, p. 104). A study by Olsen (1975) underscored the complexity of such maps, both in their conception and in their execution, and recognized the present lack of research data on reader perception and understanding of such maps.

<u>GE-80 urban atlas series</u>: This series displays, in atlas format, population data and selected socioeconomic characteristics from the 1970 census by census tract. Atlases are included in this series for the 65 largest SMSA's that were in existence at the time of the 1970 census (Urban Atlas, 1974). Whereas most of the statistical maps of the other series illustrate topics on a national basis, the color urban atlases were produced for specific regions; their greater detail and thus their usefulness made some of them very popular at the local and regional levels. Some are now out of print, and this series will not be repeated as a part of the 1980 census program.

Statistical cartography at the U.S. Census Bureau not only concerns the examination of alternative map-making techniques, but also the improvement of production technology. At first, the computer was used to analyze data, arrive at class intervals, and plot county codes. Then in the late 1960s, the Bureau developed an approach called the "micrographics mapping system" (Broom, 1974, p. 1), which uses both automation and conventional techniques in a total system, significantly reducing both the cost and the time needed to prepare the statistical maps. The micrographics mapping system is used only in producing maps of areas for which both the data and the boundary-description information exist in machine-readable forms.

The Census Bureau has digital descriptions of the census-tract boundaries for the 287 SMSA's but not for the whole country. When information for this study was being collected at the Census Bureau, the Bureau's executive staff was discussing the possibility of preparing base maps for the entire country in digital form. Ultimately, such maps will permit the efficient collection and tabulation of population statistics down to the block level or its equivalent nationwide. Such maps would also seem to be valuable for statistical mapping, including the rapid production of population maps. The task is so enormous that the staff does not anticipate its completion by the 1990 census. Suggestions have been made for the mapping of certain types of areas first--generally those more densely populated areas that have not already been mapped. This plan has now been given an operational framework with a deadline and cost estimate, but its prospect for implementation is indefinite because of the Bureau's limited budget.

It seems logical to expect that, with the advent of computer cartography, the Census Bureau will produce more population and statistical maps in the future. Durland (interview, 1982) said that under good budgetary circumstances, this is inevitable. He pointed out, however, that the Bureau had not experienced such constraints in its programs since 1930; thus it is difficult to predict the future of mapping in the Census Bureau, regardless of its desire to expand its map-producing capabilities.

Population Mapping at the Japanese Bureau of Statistics

Japan is another developed country having an advanced population mapping program. The country has rich statistical data and a very detailed population census which covers all important variables. Their first enumeration of the total population was made in 1872 and the first population census was taken in 1920. Since then, a large-scale census has been taken decennially, and a simple census quinquennially with the exception of 1945 (Bureau of Business Research, 1966, p. 19-1). Population census data are provided for small statistical areas and census results are tabulated for each enumeration district. In 1965, the Bureau of Statistics started to tabulate population census results on grid square units; statistics so collected are called "mesh statistics," and the area of each grid square is about 1 Km^2 (Matsumura, interview, August 1981). Grid square statistics are believed to be advantageous in that statistics are recorded on the basis of unchanging areal units which are smaller than municipal administrative divisions, and in that the data of various kinds of surveys may be used if they are based on a common unit area. This method is also advantageous in time-series analysis, because enumeration district boundaries change in every census.

In Japan, there are many kinds of large-scale maps. Topographical maps for the whole country are produced at several scales by the Geographical Survey Institute, in the Ministry of Construction, and by the Geographical Survey Institute. Other kinds of maps, such as those of cities, towns and villages are produced by each municipal government. From such a broad array of large-scale maps, each municipal government produces census maps. For the 1975 population census, 30,491 sheets of the original enumeration district map were produced.

Various kinds of population maps based on small municipal administrative divisions (e.g., Shi, Ku, Machi, and Mura) have been published as a part of the population census reports by the Statistics Bureau since the 1950 census. Three large-scale population maps accompanied both the 1950 and the 1955 censuses; six accompanied both the 1960 and 1965 censuses; and 24 and 23 large-scale population maps accompanied the 1970 and 1975 censuses, respectively (Matsumura, interview, August 1981). All 23 population maps of the 1975 census (listed in Appendix B) are color maps; four of the maps are at a scale of 1:1,000,000, and consist of three sheets each; 18 of the maps are at a scale of 1:1,500,000, and consist of one sheet each; and one of the maps is in atlas form at a scale of 1:500,000, and consists of 29 sheets.

An example of the 1975 population maps of Japan is shown in Figure 9, which is part of the 1:1,000,000 population distribution dot map. The population distribution is presented by dots, each of which represents 500 persons, and by graduated circles proportional to urban population; the shapes of the urban areas were also represented by pink shading. The dots in these maps were distributed with reference to the location of settlements on topographical maps of scales of 1:200,000 or 1:50,000 which are prepared by the Geographical Survey Institute (Inami, interview, August 1981).

The Bureau of Statistics will probably publish at least the same number of population maps for the 1980 population census as were published in 1975. Mr. Shozo Inami, of the General Affairs Division, and Mr. Michio Matsumura, of the population Census Division, both a part of the Statistics Bureau, indicated that demand from policy-makers, regional planners, companies, and researchers in general for population maps is very strong. In fact, to satisfy the demand, the Statistics Bureau published three population maps in 1981 based on the Preliminary Counts of the population of the 1980 Population Census of Japan. Figure 10 is part of the 1980 population density map. The density per square kilometer for each shi, ka, machi, and mura was shown in color in nine class intervals. An important factor in the growth of population mapping in Japan has been the provision of adequate funding and the integration of planning for both the census and its population maps.

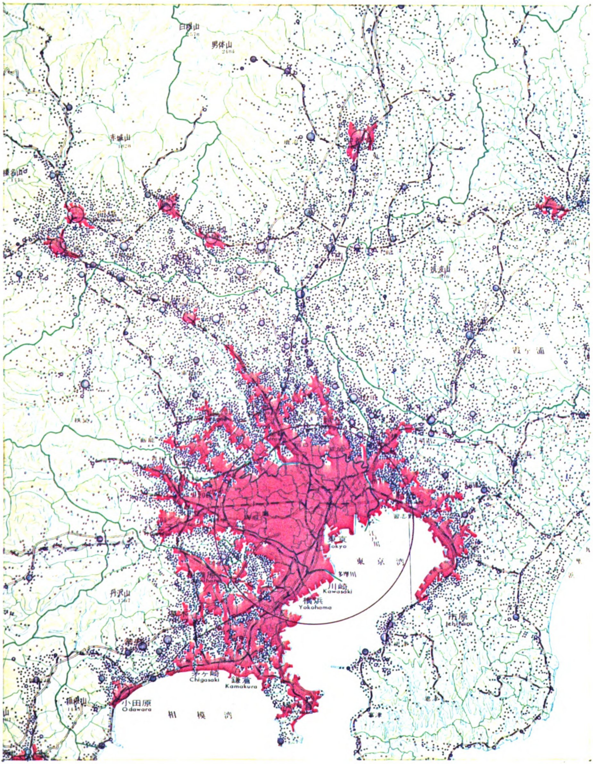

Figure 9. 1975 population distribution dot map of Japan, No. 1 (1:1,000,000). (From Bureau of Statistics, Office of the Prime Minister.)

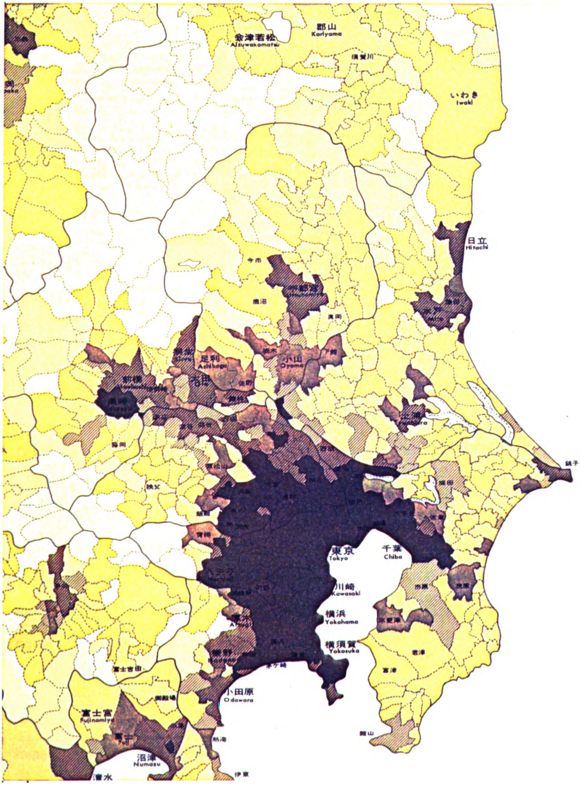

Figure 10. 1980 population density map of Japan (1:1,500,000). (From Statistics Bureau, Prime Minister's Office.)

Summary

The population mapping activities of the United States and Japan indicate several of the characteristics of a good population mapping program: population data are of high quality and have high geographical resolution. Efficient vital registration also provides information on other population characteristics, such as migration, fertility and mortaltiy, for mapping. Accurate, large-scale reference maps--topographic, road, administrative, and city maps--are abundant, and maps are available which show the smallest statistical units for which population census data are collected. Government agencies attract and retain highly qualified geographers and cartographers who stimulate and encourage research and experimentation. These persons are often drawn from the universities and private organizations which are also active in producing population maps. Modern production facilities and techniques are widespread and include the rapid introduction of computer-assisted methods which, by reducing the time and cost of manipulating data and producing maps, are increasing the agencies' production capability. The market for population maps in these developed countries is high, as indicated by a demand for numerous maps and publications which has exceeded supply. Finally, budgetary support for mapping agencies has been great.

Criteria for Population Mapping in Developing Countries

Developing countries do not necessarily need all of the capabilities of the developed countries in order to accomplish satisfactory population mapping, but certain minimum criteria must be met.

The 11 criteria that follow are crucial:

1. Accuracy of population data. Included is the use of census maps during the enumeration; the use of literate census enumerators; the inclusion of key geographic and demographic characteristics; absence of political influence; and a statement of census difficulties or shortcomings which bear on data reliability.

2. Resolution of population data. This includes the acquisition and publication of population data at relatively small levels (corresponding at least to U.S. county levels); and the inclusion of the population values of towns and major villages in addition to statistical area totals. Such high resolution is of great benefit for statistical analysis and population mapping.

3. Availability of large-scale base maps. This encompasses the existence of an inclusive base map series whose circulation is not restricted to official government use.

4. Accuracy of large-scale base maps. This includes naming and correctly locating settlements, villages, towns, and cities as well as other man-made and physical features; and appropriate revisions and updating. This is important not only for the compilation and construction of census maps but for subsequent mapping of the population. For example, the correct placement of dots on a population distribution map is very much dependent on the accuracy of such base maps.

5. Availability of administrative and statistical boundaries maps. This includes the existence of maps depicting all units for

which data are collected and presented, whether administrative or statistical; unit boundaries are authoritative.

6. Resolution of administrative and statistical boundaries maps. The resolution of such maps corresponds to the lowest level for which population data are collected. As areal unit size decreases, the ability to detect small-scale spatial variations in the data increases.

7. Adequacy of geographic and cartographic skills in the census departments. This includes the presence of trained geographers and cartographers within the census departments, at least at supervisory levels. This level of staffing will give each department population mapping capability.

8. Adequacy of production facilities. This includes the equipping of cartographic facilities capable of producing census maps and the subsequent displays of census data in a timely fashion and in a cartographically professional manner.

9. Appropriate scale and acceptable quality of population maps. One complete, large-scale population map series accompanies or soon follows the publication of each census. The maps demonstrate the consistent application of good cartographic theory and design as well as technical competence.

10. Suitable level of graphic literacy. The level of graphic literacy is sufficient to promote the use of and demand for maps, at least among educated persons in general and policy makers in particular.

11. Sufficiency of funding for population mapping. The government provides sufficient funds to support a regular program of population mapping following each census. These funds are considered an integral part of population census support.

These criteria are considered minimum requirements for sound population mapping. The following two chapters evaluate deevloping countries in light of these minimum criteria.

CHAPTER III

POPULATION MAPPING IN DEVELOPING COUNTRIES

Most current methods for population cartography came into being and were first used in developed countries during the first half of the nineteenth century. The mapping of population phenomena in the United States and Europe has been aided since then by the availability of information about populations which has been collected regularly by censuses and is kept current by registration systems for births and deaths. The development and availability of base maps and large-scale topographical maps has aided this effort. Population mapping may be more important for developing countries than for developed countries since it provides information about the location of basic population characteristics. Thus it can be considered a starting point for political, social, educational, or economic development of a community, region, or country.

Population mapping in developing countries, however, has faced many problems and has often failed to meet minimum criteria for an adequate program. Population data for most countries have been incomplete and inaccurate; base maps have either been nonexistent or inadequate; and the absence of practicing geographers and of people trained to approach problems geographically and to appreciate maps and their usefulness has contributed to the neglect of population mapping.

This chapter discusses the historical development of population mapping in some developing countries in three geographic areas: Africa, Latin America, and Asia. The latter part of the chapter deals with general population problems in developing countries. Specific problems in the countries visited are addressed in the following chapter.

Historical Development

All too frequently, population in developing countries is thought of only in terms of demographic indices. The facts and implications of the detailed patterns of population distribution and density are ignored (Prothero, 1960, p. 1). Frequently, detailed maps of population distribution and density which are a basic requirement for such studies are difficult to find. Some areas of the developing world have been covered by these maps, while other areas may have none. A search for literature on population maps revealed unequal amounts of this material published in English on the three geographical areas (Africa, Latin America, and Asia). Latin America and Asia have very little, while some countries in Africa have a number of studies on this subject.

Population Maps in Africa

Before the Second World War, there were few population maps of African territories other than those that covered very large areas on very small scales. These maps were valuable for their general representation of population patterns, although the inevitable generalization at these scales has tended to produce errors and misconceptions that are repeated and that are only gradually being eliminated. Population densities in the Eastern Region of Nigeria, for example, frequently have been understated as a result of inadequate mapping. While the highest figure is quoted as "over 300 persons per square mile," recent large-scale mapping of the region has shown that almost one-half of the total area has average densities of over 500 persons per square mile (Prothero, 1961).

One of the population maps of this pre-war era was of Tanganyika Territory published by Gillman in 1936. He considered this map, which depicted with "reasonable precision" the distribution of the native population in Tanganyika Territory, to be essential for the better understanding of regional problems. The map used a dot method to show the distribution of the native population. Because census data alone were inadequate and other sources of data were needed, and since detailed maps were scarce, Gillman collected the basic data of population distribution by asking district administrative officers to provide the most accurate data possible, whether from the most recent census or from tax assessment rolls. They were also asked to provide district maps with the positions of the head villages of the units along with the approximate boundaries of the units. Gillman's personal knowledge of much of the country and of the settlement types helped to lend reality to the pattern (Gillman, 1936). This map was considered an important pioneer effort because there was nothing comparable to it for many parts of Africa at that time (Prothero, 1961).

In 1948, Steel indicated that the published census figures for tropical countries in Africa were quite inadequate for geographic purposes. They were often incomplete and inaccurate, and one needed other sources in order to produce an acceptable map. In a discussion of one popular population map of Ashanti (Ghana) and the whole of the Gold Coast which appears in numerous official publications, Steel stated that the map

> appears to give a surprisingly detailed picture of population distribution, but on analysis, it proves to be a cartographic representation not of the census statistics, but of the impressions of officials and travellers of that date. The roads and railways of 1921 have been superimposed on the official map to suggest the method of compilation. Changes in density do not coincide with administrative (or any other) boundaries, but with a diminution in the knowledge of the officials of the day. Administrative officers were able to estimate probably fairly accurately the density of population in the districts with which they were familiar, that is, the areas within 10 or 12 miles of the roads and tracks that they normally followed, and within 15 miles or so of their headquarters. Beyond, information was lacking and it was safer to state "less than 10 per square mile." (Steel, 1948, p. 67)

Steel described the map (Figure 11) as "somewhat bogus," but because of the serious inaccuracy of the data at that time (with discrepancies possibly as high as 50 percent), the method used to produce the density may be considered an improvement over a conventional choropleth map made with faulty statistics.

To overcome the limitations of poor enumerations, another population map was compiled by Boody in which features of demographic significance have been traced from the Gold Coast survey 1:125,000 maps. The resulting dot map was reproduced at a scale of one to a million. The sheets traced varied in date, and it is impossible to say precisely what each dot on the map represents (the dot may

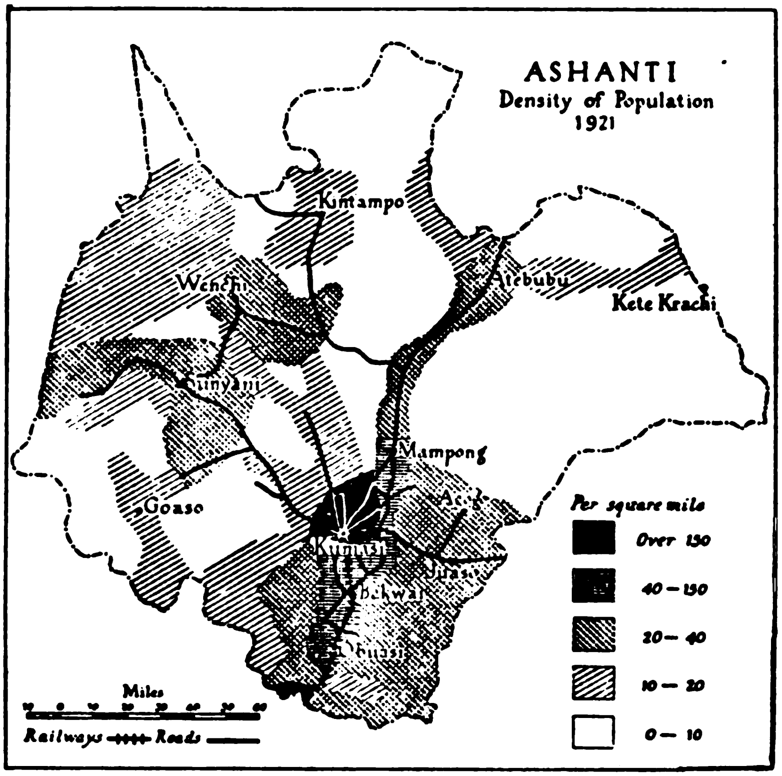

Figure 11. Population map. Section of the map of the Gold Coast--Ashanti (Ghana), 1921. (From Steel, 1948, Fig 2., p. 68.)

represent an isolated farm camp or 20 or more buildings in a town), but Steel (1948) claimed that, despite these drawbacks, it gives a far more realistic picture of population distribution than any of the maps so far published.

Since the end of the Second World War, there has been improvement in the population mapping of Africa. In a summary of post-war population maps in Africa south of the Sahara, Prothero (1961) stated that about 50 percent of the countries have maps, with the majority on a scale of 1:1,000,000 or larger. Prothero (1963) provided an inventory of population maps produced between 1945 and 1962 that included nine large-scale maps of individual countries, 13 maps of parts of countries, as well as two small-scale maps covering west and tropical Africa. He also indicated that as of mid-1963 nine African nations were actively engaged in population mapping.

Trewartha and Zelinsky (1954) mapped the distribution of population in tropical Africa which they believed is more poorly known and understood than any other equally extensively inhabited portion of the world. They excluded a part of Africa in their maps--the Somaliland colonies, Southwest Africa, Bechuanaland, Ethiopia, and the Anglo-Egypt-Sudan--generally because of the inadequacy of their statistics or the almost total absence of population data for some of those countries. There are two maps included in their article. One is a choropleth map that involves the entire population, rural and urban, African and non-African. The second is a dot map of rural African population only. The maps were produced at a very small scale and give only a general, rather broad outline of the distribution.

In Nigeria, the only population map available in 1952 was at a scale of 1:3,000,000 and showed density of population throughout the country based on the 1931 census. The map, published by the Nigerian Survey Department in 1949, is very generalized, and other survey department records do not indicate how it was compiled.

In 1953, Prothero attempted to make a detailed map of Nigerian population distribution and density. He produced a dot population map in which the towns with populations of over 10,000 were represented by proportional spheres, those from 5,000 to 10,000 by range-graded circles, and the remainder of the population by dots; each dot represented 200 persons. The map was completed at a scale of 1:100,000, though the author acknowledged problems of missing and inaccurate data and inaccurate base maps. After compilation of the dot map, which was carried out irregularly over a period of two and a half years, Prothero developed a method for converting a dot distribution map to a population density map (Figure 12). The density map was prepared by superimposing a grid on the dot distribution map, counting the dots in each square, and entering the density per square mile. The size of the dots had been chosen so that it was possible to count them even in the areas of densest population concentration (Prothero, 1960, p. 6). This method was used to overcome the disadvantages of making a choropleth map in the large districts as mapping units. Prothero's method was described as "ingenious" by Monkhouse and Wilkinson (1976, p. 333).

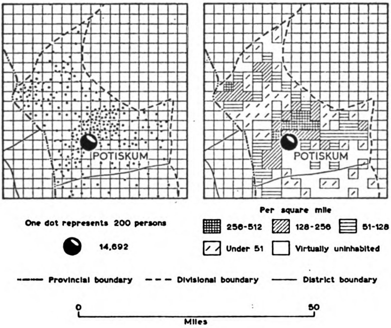

Figure 12. Prothero's technique for converting a dot distribution map to a population density map. (From Monkhouse & Wilkinson, 1976, Fig. 144, p. 335.)

For Ghana, Hilton (1961) described a project consisting of the preparation of maps of population distribution in the country in 1931 and 1948 and of provisional maps of population density for 1948 using the 1931 and 1948 census reports. He discussed the difficulties with census figures and base maps when mapping the population in Ghana. However, it was believed that the quality and reliability of the published base maps were better than most of the West African territories, including Nigeria. In a population distribution map, a dot and circle method was employed. A dot value of 200 was chosen for rural population, and proportional circles were used to represent settlements of more than 500 persons. For the three settlements which were very much larger than all others, squares of proportional area were used. The maps were prepared for publication at a 1:1,500,000 scale.

Two types of density maps were prepared. The first consisted of six choropleth maps, one showing densities in the 1948 districts and the other five tracing densities and annual percentage rates of increase or decrease from 1921 to 1948 in the subdivisions identifiable for 1931. Such maps

> are valuable in giving preliminary impressions and in suggesting possible lines of enquiry, but their "checkerboard" pattern conceals many density variations and may obscure the essential homogeneity of areas of uniform population density which lie across the administrative boundaries used.

The second type was a dasymetric map at a scale of 1:1,000,000 that ignored administrative boundaries and showed density variations based on the 1948 census. These maps are published in the Atlas of the Population of Ghana (Hilton, 1961).

In the Sudan, the University College of Khartoum published several population maps that accompanied the first census conducted in the winter of 1955/56 (Barbour, 1961b). The purpose was to illustrate the findings of the census reports, and they constitute a considerable advance in the geographic knowledge of the Sudan. Barbour believed that several of these maps

> could not be compiled directly from the published figures on maps of administrative or other boundaries. They represent rather the result of an investigation carried out at the same time as the census, into the distribution of the population within the known administrative areas, and into the most suitable manner of representing the patterns thus revealed on a series of maps. (Barbour, 1961b, p. 99)

The types of maps that were produced depended on two factors: the items included in the questionnaire, and the size and number of areas for which information was to be produced. For rural territory, only large areas about 10,000 square miles were employed; however, for towns that were enumerated fully, a smaller unit, or "ward," was used. The population distribution and density maps were produced at a scale of 1:2,000,000 on three sheets and accompanied the final report of the census. They were also produced at a scale of 1:4,000,000 as a single sheet and were published earlier with the summary of the census results. The maps were printed in both English and Arabic. By the end of 1960, additional maps were added showing tribes in Sudan, languages, population centers, West Africans, Arabic speakers, birth rate, death rate, and census areas, all at a scale of 1:8,000,000.

Uganda provides a different example of population mapping because maps were made after each official population estimate or census, despite weaknesses of the data and the inadequacy of the base maps. The first population map of Uganda was drawn in small scale in 1902, even before the first official population estimates. It was a choropleth map at the scale of 1:4,000 000, with nine shadings representing densities, but much of the information is considered highly speculative. The next two maps to appear were derived from the 1921 and 1931 official estimates. The first, in 1930, shows population distribution by dots, with each dot representing 500 persons. The second, printed by the Survey Department, in black with red dots, was considered an improvement over the first (Langlands, 1971, p. 114).

Several population maps of Uganda were produced using the 1948 census. Some of these maps were included in East African population maps which were done in association with the Royal Commission Report of 1953-1955. Several dot maps for all of East Africa used a scale of 1:3,000,000, with each dot representing 5,000 persons. Uganda occupies an area of approximately eight inches square on this map. A population map accompanying the western Uganda railway extension report in 1951 was a "valueless and peculiar map" (Langlands, 1971, p. 115). It was a choropleth map entitled "Population Density," but with shadings varying according to total numbers of people without regard to any unit area. Another population map accompanied the Northern Uganda railway extension report in 1954. It was a dot map based partly on 1948 census statistics and partly on chiefs' returns, in an attempt to bring the data up-to-date for 1954.

In 1958, a population distribution map independent of census data was presented by McMaster using the number of taxpayers in 1958. Although it gave a suitable indication of the approximate distribution of the population to fill the gap since 1948, it also had a certain amount of distortion (Langlands, 1971, p. 116).

The 1959 Uganda census was accompanied for the first time by an official map showing subcountry boundary divisions. This made possible the mapping of population densities, and in 1960 a map was published by the Lands and Survey Department at a scale of 1:1,250,000. Later, the same map was reproduced for the Atlas of Uganda at the slightly reduced scale of 1:1,500,000. Langlands (1971) indicated some problems on these maps, including the selection of density classes, which exaggerates the number of overpopulated areas.

There were no dot maps published using 1959 census data; however, two population projection maps were published. One by Porter gave data projected to 1962 (the 1959 figures were increased at the rate of 2.5 percent per annum, a national average figure). Langlands described the map as "not easy to read," because Porter used three different sizes of dots to represent population. Urban units were shown by larger circles, and the distribution of African, Asian, and European communities is shown in different colors. A second dot map by Pike projected the 1959 census data to mid-1968. This map shows rural population by dots representing 5,000 people and towns by circles of varying sizes.

Other types of population maps also appeared after the 1959 census depicting other aspects of Uganda's population, such as ethnic origin and migration. Langlands (1971) prepared five small-scale dot maps to illustrate population distribution for census years 1959-1948, 1931, 1921, and 1911. He believed that these maps were crude, but that they gave some general indicators of the nature of population distribution in Uganda.

In a study of population in the Southern Highlands of Tanzania, Thomas (1971) provided three population maps using the post-war census for Tanganyika and base maps at 1:500,000 based on aerial photographs. On one map, he delineated settled areas using a one-square-kilometer grid and recorded whether it contained settlements or not. The symbols for settlement on the map were not used in any quantitative way. A second map, a conventional dot population map, was prepared using the territorial census area map published in 1966 and his own settled-areas map. At a scale of 1:500,000 and a dot value of 200 persons, it provided a detailed representation of distribution. A third map showed population density and used the dot map as a base. Thomas adopted Prothero's technique (mapping population densisty from a dot map with the aid of a grid framework) and eliminated the otherwise obtrusive effect of administrative and census boundaries (Figure 13). Thomas believed that this method satisfactorily represented the rapid changes in density over short distances, characteristic of much of Tanzania, and that is also facilitated comparison of population density for different time periods.

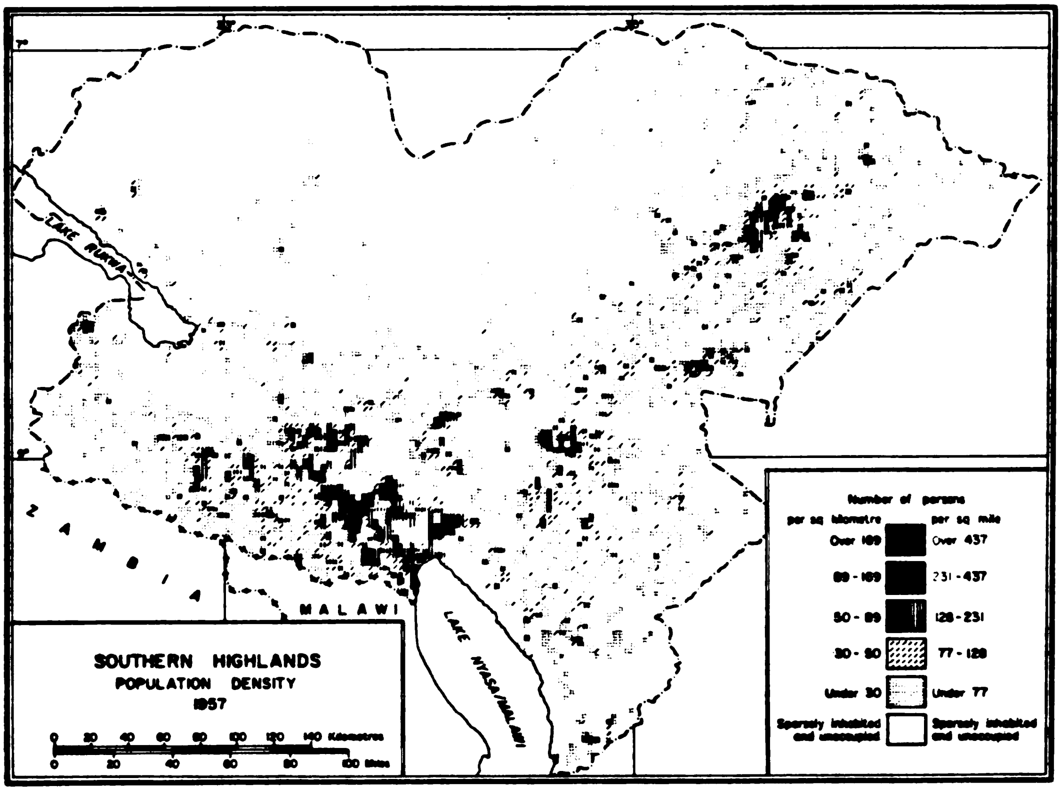

Figure 13. Thomas's map of the Southern Highlands: population density, 1957, adopting Prothero's technique. (From Thomas, 1971, Fig. 19.4, p. 244.)

A large number of population maps has been produced for Rhodesia (Zimbabwe) by both academicians and government agencies, most appearing after the 1956 census. All of these maps mentioned by Prescott (1962) and Wheeler (1973) suffer from one or more problems. The map in Figure 14 is an example, having been constructed from 1956 census data which contained only estimates of African population. The same map is characterized by technical defects such as extremely uneven dot sizes and the delineation of forest and game reserves by dotted lines which can be confused with population dot symbols.

Two maps were published in 1963 and 1965, the first a dot distribution map of the African population of Rhodesia at a scale of 1:1,000,000 published by the Department of Federal Surveys and based on the 1962 census. It was described by Wheeler (1973) as having a weak appearance because of its "very pale colors" and badly placed dots with poorly chosen values and sizes. The second map, published in 1965 in Collins' Atlas of Rhodesia, was based on the 1961 European census and the 1962 African census. It was a dot map, with small red dots for every 100 Europeans and slightly larger black dots for every 1,000 Africans. Wheeler (1973) criticized it as a rather unrealistic placement of dots, since it was based on administrative district unit areas with little regard for actual population locations. Wheeler also cited two new population maps of Rhodesia published in 1971. These maps were compiled and drawn by the Geography Department at the University of Rhodesia at a scale of 1:1,250,000. One of these was a dot map on which each dot represented

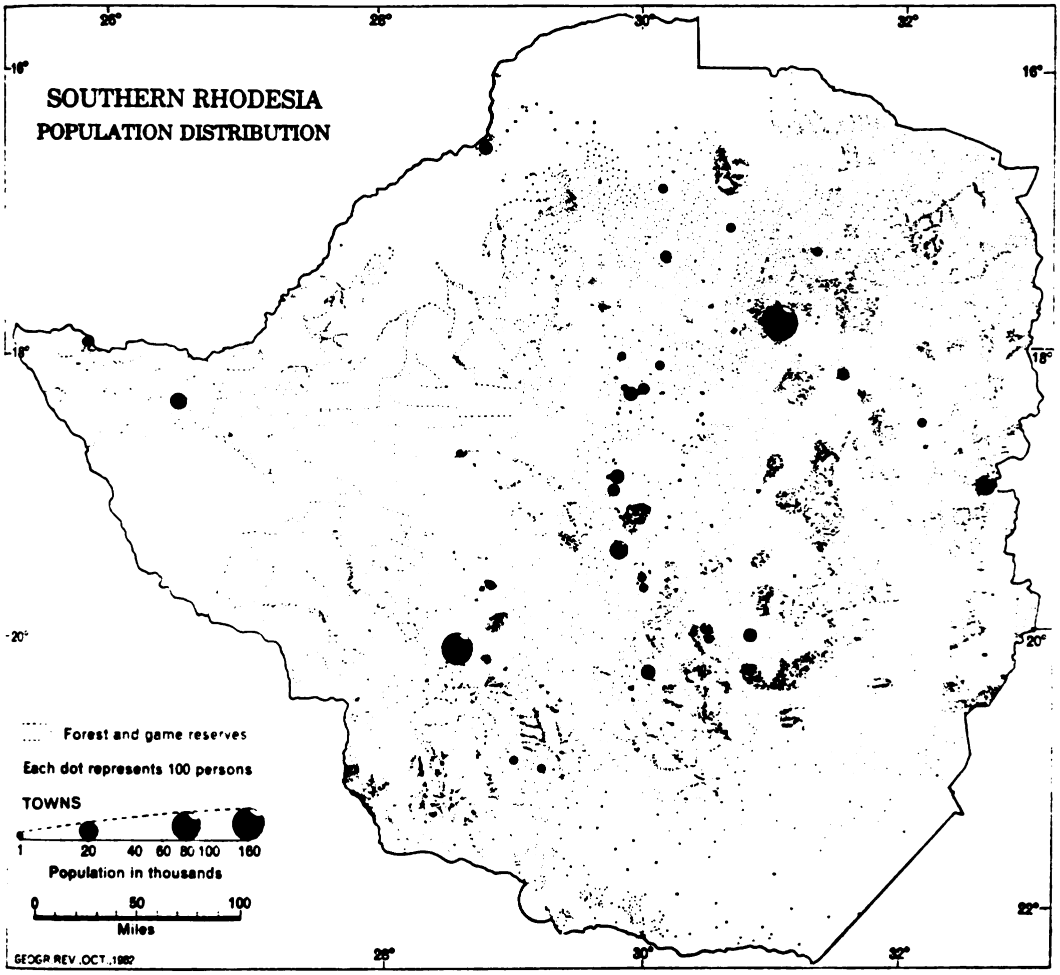

Figure 14. Prescott population map of Southern Rhodesia based on the 1956 census, published in 1962. (From Prescott, 1962, Fig. 1, p. 561.)

500 persons. Urban areas of 2,500 and more are represented by a red circle proportional to their population, and small townships (below 2,500 people) are identified by a black circle. Wheeler considered the map was the most realistic effect obtainable with the available data. Several problems were encountered including inconsistencies and varying standards in source mapping. The second map was a population density map derived from the dot map using Prothero's method. The resulting densities relate to rural people only, while urban areas of over 2,500 are represented by graduated circles.

Population maps reviewed and discussed for African countries generally have been prepared by individual geographers working in African universities or other institutions. Several maps have been produced by foreign academics interested in the field of population geography and mapping, such as Trewartha and Zelinsky. Most of the maps were prepared using the 1950 or 1960 censuses, and a few use the 1970 census. The majority of these maps suffer from one or more problems. Some suffer from the lack of reliable census data. This includes the collection of data for large administrative units which obscure significant detail, inconsistencies in data collection among the African and European populations, and for some areas the reliance upon estimates rather than counts for some areas. Problems with base maps are common. Only major administrative boundaries may be shown; these are generally approximate, unauthoritative, and involve large areas that strongly influence the geographic pattern. Map scales are small, ordinarily less than 1:1,000,000, making any detailed placement of symbols difficult. Finally, symbology is often crude, poorly executed, and inadequately referenced in legends.

Population Maps in Latin America

A review of population bibliographies on Latin America, a survey of studies in several professional geography journals, and two dicussions with professors who deal with population studies in Latin America[1] revealed no particular studies dealing with the population mapping of Latin America. The sole exception is an article by Browning, Robinson, and Miles (1976) that discusses cartographic problems that have been encountered in a project (the Joint Oxford-Syracuse Population Project) mapping population distribution in Colonial Spanish America. This deals, however, only with old, detailed census data that survived from the eighteenth-century Spanish overseas territory records.

The author is aware of large-scale population maps for Brazil, Mexico, and Peru. These are native-language maps that do not appear in English-langauge references, and, except for Brazil (which has been visited and whose population mapping situation will be discussed later), they could not be obtained outside their countries for evaluation.

In general, for the period before 1950, little was done in terms of population mapping and population studies. In a report that dealt with the basic geographic and cartographic work available in

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[1]Dr. Robert N. Thomas, Professor of Geography, Michigan State University, and Dr. Ernst C. Griffin, Professor of Geography, San Diego State University.

the Latin American Nations that could serve for the compilation of census maps for the 1950 census of America, Zarur (1948) stated that "At present, Latin America is 'terra incognita.' The mapping and geographic activities have not produced enough material suitable for use without considerable editorial work in the 1950 census" (p. 5). He added that probably not more than 10 percent of all Latin American areas are covered by acceptable large-scale maps. The cultural information on the existing maps is not periodically brought up-to-date, and undoubtedly this lack of map coverage has had repercussions in the standards of statistical and census work (Zarur, 1948, p. 5). In the 1960s, Bennett (1968) indicated that

> Until recently, neither cartography nor geographical studies were well developed within much of Latin America. A significant share of the published maps of all or parts of Latin America were [sic] being compiled and published by agencies outside of the Latin American region. Autochthonous geographical studies were relatively few and much of the work was done by visitors from countries outside the region. (p. 7)

The study of Latin America by geographers from the United States can be said to have started during the first decade of the twentieth century (James, 1971). However, an examination by Simkin (1971) of publications by geographical associations revealed little work in population for Latin America relative to other systematic fields of geographical inquiry.

A project to map population in South America is under consideration by Thomas and Griffen, but it has been slowed by the lack of standard base maps among the countries of South America, whose scales, projections, and years of publication vary. The census data themselves are often unavailable at the municipal level, and the years in which censuses are taken vary by country (Griffen, 1982, interview).

Some of the population geography studies published in English about Latin American countries occasionally include population maps (Pearson, 1963; Morrison, 1963). For example, Pearson (1963), realizing the importance of population maps, stated, "Shifts in population are not always apparent, nor readily understood. . . . From examination of statistical tables the geographer frequently resorts to cartographic devices for the study of demographic phenomena." In his discussion of population changes in Argentina he included several small-scale population maps. Two of these are choropleth maps showing by minor civil divisions the population density in 1947 and in 1960. Two other choropleth maps show population increase and decrease (1947-1960) by percentages for the minor civil divisions. Another two graduated circle maps show population increase and decrease by numbers for minor civil divisions. Morrison (1963) included three maps in his study of population changes in Mexico (1950-1960). One is a bar graph map of Mexico's population distribution, 1950-1960. The other two are choropleth maps of population percentage increase for 1940-1950 and for 1950-1960. None of these maps includes any discusssion of how they were constructed nor the difficulties faced when constructing them. There is also no mention of any pre-existing population maps, and all maps are small-scale.

Population Maps in Asia

Only a few of the developing countries in Asia have been mentioned in the literature as having large-scale population maps.

William-Olsson's progress report (1963) of population mapping, taken from the correspondence of the Commission of World Population Mapping, reveals that India, Nepal, Cambodia (Kampuchea), and Turkey are reported to have population maps. Although other countries such as Pakistan, South Vietnam, and Indonesia were planning to produce population maps at the time of the report, no reviews of these maps have been found.

In India, the National Atlas Organization (NAO) mapped the population at a scale of 1:1,000,000. The NAO used very detailed "village-size" information published in District Census Handbooks in 1951 and large-scale maps of both the Survey of India and of state governments in order to identify and locate villages (Das Gupta, 1960). Because India is such a large and populous country, having great varieties in population density, a symbology of graduated dots known as the "coin system" was adopted to construct the map. Das Gupta believed that in this way the extremes of population density could be better portrayed, and rural population could be shown in greater detail.

Coins of three fixed "denominations"--for 100, 500, and 1,000 people--were used to show India's rural population, and proportional circles were adopted to show towns. The coins and the proportional circles were colored on the basis of the occupational data in the census tables. Coins were colored green for agricultural populations and red for nonagricultural populations, while towns were classified into four functional types: industrial, commercial, service, and agricultural. Each was represented by a circle of a distinctive color. Das Gupta (1960) stated in his concluding remarks that

> the coin method is being successfully utilized for mapping the teeming millions of India. No other agency in any country is known to have attempted such a gigantic programme of population mapping on so elaborate a scale. . . . Thus the I/M population map of India for the National Atlas, drawn by the coin method, forms a great landmark in the history of Indian cartography. (p. 43)

Another map prepared by the National Atlas Organization is called an Iso-choropleth Map, a combination of the principles of both choropleth and isopleth mapping. The NAO divided India

> into some 50,000 tiny grids of 5-minute squares, each measuring 70 sq. km on an average. Population of each grid is found by taking into consideration all the villages falling in them. Then the density of each grid is worked out. (Das Gupta, 1964, p. 38)

The final map was published at a scale of 1:2,00,000. This method is similar to that used by Prothero in 1953 in mapping the population density of Northern Nigeria.

Taiwan's population was mapped by Hsu and published as a map supplement to the <u>Annals of the American Association of Geographers</u>. The map (Figure 15) was described by Thrower (1969) as a depiction of the population with sufficient accuracy relative to actual residential locations, and as distinguishing settlement types in various regions of the island. Four supplementary inset maps were included in order to show the density of population, the average growth rate in a five-year period, the employment structure, and the location of administrative subdivisions.

Some population geography studies have been done for other developing countries in Asia and include small-scale population

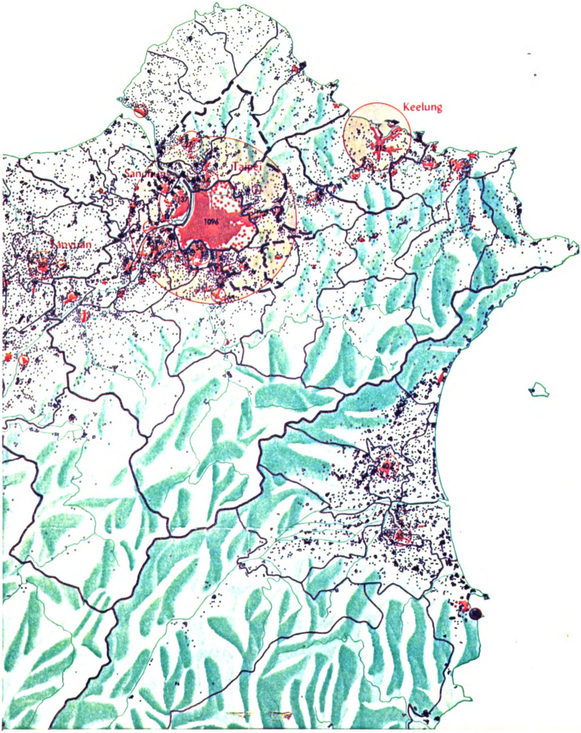

Figure 15. Part of Hsu's Taiwan population distribution, 1965, map. (From the annals of the American Association of Geographers, 1969, map supplement No. 11)

maps. As examples, population maps of Bengal (formerly East Pakistan) by Johnson (1962) and Patel (1966) were included with agricultural analyses of the country. These maps were prepared at small scales and suffer from poor symbology and inadequate data. Withington (1965) in his study of population density and the problems of mapping spatial variations in Southeast Asia included a population density map of this region. The map scale is very small.

Most of the early population maps for developing countries in Africa and Asia shared the problems of small scale and lack of detail in the display of population distribution and density. In recognition of this fact, as well as the dearth of population maps throughout the world, the International Geographical Union established a commission to promote the standardization of maps at large scale on a worldwide basis. A discussion of the Commission's work is included in Appendix C.

Problems of Population Mapping in Developing Countries

An historical examination of population mapping in developing countries has revealed difficulties stemming from an inability to meet the criteria outlined in Chapter II, including the unavailability and poor quality of population data, the scarcity and inaccuracy of base maps on which to plot population data, the use of collection units having only estimated boundaries, the production of maps by foreigners less familiar with the country, the lack of native theoretical mapping knowledge, and the scarcity of local production facilities. The same reasons may help explain what Prothero (1960, p. 1) has called "indifference" toward detailed population mapping in developing countries. Each of these problem areas is discussed in more detail below.

National Censuses in Developing Countries

There is a considerable variation in the availability of censuses in developing countries. There is also variation in terms of quality, character, and amount of population data collected by the census. While many of the developed countries started their censuses as early as the second half of the eighteenth century (Sweden in 1749, Finland in 1750, Austria in 1754, Norway and Denmark in 1769, and the U.S.A. in 1790), only a few developing countries have a long record of census taking in the first half of the nineteenth century. Censuses were held in Java in 1815, the Philippines in 1881, Algeria in 1865, Egypt in 1882, and in India, Pakistan, and Ceylon since 1871 (Clarke, 1977). As recently as 1970 there were still some developing countries that had not conducted a national census. These include Afghanistan, Lebanon, Qatar, Yemen, Southern Yemen, Oman, Laos, South Vietnam, Ethiopia, and Somalia (U.N., 1981). These countries have all recently completed census data collection; however, most of these censuses are either totally or partially sample surveys. Most developing countries do not conduct their censuses at regular intervals, adding to problems of accuracy and consistency.

Most developing countries lack census experience. As a result, their censuses are generally characterized as being poor, inaccurate, inadequate, or delayed in publication as compared to the censuses published in developing countries. This inaccuracy of population census data may discourage population mapping, i.e., the African countries of Nigeria and Sierra Leone. Nigeria had two censuses in two consecutive years (1962-1963). Both are criticized as being inaccurate due to an overcount of the population. Caldwell (1968) stated that the count in 1962, which was believed to have enumerated some millions more Nigerians than expected, became a center of political controversy and was declared void, without release of any figures. In 1963 another census was conducted, with greater expenditure than the first; however, it was also criticized as being an overcount before it was scaled down prior to release (Udo, 1968, p. 102). In Sierra Leone, the 1963 census was accused of undercounting, which produced consternation among politicians because of the unexpectedly low population figures and the questions it raised about ethnic balance (Clarke, 1968, p. 271).

In developing countries, census data are usually tabulated or published for large geographical units, and only seldom at the level of detail found in developed countries. This results in an inadequate data base for the type of detailed population mapping necessary. In Taiwan, for example, Hsu (Thrower, 1969) indicated that one of the reasons for the lack of a large-scale population map was the level of administrative subdivisions used in published demographic data. The same has been said about Southeast Asia in general, where the size of census divisions is very large for mapping population (Withington, 1965). In Uganda, Langlands (1971, p. 113) noted that the smallest units for which population data were published in 1948 and 1959 were subcounties, some as large as 1,000 square miles. In Saudi Arabia, population figures from the 1974 census provided data only on the large emirate level; no census data are provided at the subemirate, town, or village levels.

A population census project requires a major preparation for its many and varied operations. Many of the developing countries--particularly those carrying out population censuses for the first time--encounter difficulties in such planning. Preparing and adopting a realistic budget for carrying out the census is a major problem. For example, Brass (1968) believed that "no African country at the present time can afford more than a fraction of the expense which would be needed to establish an efficient and comprehensive system for the provision of demographic statistics" (p. 34). Preparation of the census schedule, questionnaires, collection routines, and data recording requires trained specialists, but few are found in developing countries. Census maps of appropriate size and detail are needed to assure complete coverage without any omission or duplication.

In Africa, a U.N. report stated that "the lack of a department responsible for cartographic operations in some countries was felt with particular force, as a result of difficulties arising from the inaccuracy of the geographical framework on which the census was based" (U.N., 1977, p. 15). Several countries in Africa attempted their censuses with inadequate base maps in 1970, resulting in major inaccuracies and delays (U.N., 1977, p. 6). For example, the undercounts of the 1963 Sierra Leone first census were related in part to the poor quality of enumeration area maps.

Although some 2,000 maps were prepared for the census, their source was outdated and inaccurate (Clarke, 1968, p. 272).

Widespread illiteracy affects the overall accuracy of census figures, since there are some errors in the reporting of various data. For example, illiteracy was given as the reason for excluding some important questions relating to economic characteristics, household situation, and social data in the 1952/1953 census of Nigeria (Lury, 1968, p. 71).

Problems of geographic isolation may cause inaccuracy in censuses because of the omission of more inaccessible areas. For example, Duru (1968) stated that poor access in Nigeria militated against a complete count in 1952-1953 since it took two weeks to reach settlement sites within selected enumeration areas, while other small settlement sites--notably fishing hamlets--were completely omitted.

Publication of data is considered one of the main problems with the census in developing countries. In Africa, Caldwell (1968) believed that "not all information gathered is being published, and some that is published appears in a corrected form that makes further analysis hazardous" (p. 6). In some cases, census statistics are not published until they are history.

All these difficulties affect the accuracy and completeness of census figures and often make censuses in these developing countries open to question. This may discourage specialists and researchers in population--of which there are few in these countries--from attempting to make population maps, especially at a large scale. However, data collection is improving, and census methodology, concepts, and statistical output are becoming more standardized, probably as a consequence of U.N. recommendations and improved collaboration among census offices (Hakim, 1979, p. 343).

Base Maps in Developing Countries

Difficulties experienced by developing countries in preparing population maps can be attributed not only to problems in gathering and manipulating data, but to the inadequacy or scarcity of suitable base maps on which to plot the data. Gerlach (1964) observed that "the thematic or special subject cartographer can build a solid structure only upon valid base maps which result from field surveys or air photo interpretation" (p. 39). Yet Hsu (Thrower, 1969) noted, with regard to Taiwan, that those topographic maps, aerial photos, and base maps "are often difficult, if not impossible, to obtain for research purposes" (p. 611). Available materials may remain unused because, as in the case of Latin America, "index materials of existing aerial photography and map coverage . . . either do not exist or are not easily obtained" (Freeman et al., 1963, p. 8). But the principal problem remains a lack of large-scale base maps. Brandenberger (1976, p. 72) reported that only 44 percent of the world's land area was covered by mapping at scales of 1:100,000 or larger in 1974. After making an assumption that nearly half of the maps available before 1968 were obsolete, he estimated an annual progress rate for world mapping of considerably less than 1.3 percent.

Many reasons for a scarcity of base maps may be cited. One is a country's failure to adequately define basic boundaries or divisions. This is clearly the case in Saudi Arabia, where the first preliminary official map showing administrative boundaries was not published until after the 1974 census. Even then, the map is not considered authoritative. The boundaries between _omodias_ in the Sudan were not recorded by the survey department or by the administrative district headquarters. Memory was regarded largely as "a perfectly adequate repository of tradition in such matters and it was not felt necessary to record on paper what everyone concerned knew perfectly well" (Barbour, 1961, p. 103). In other developing countries, internal divisions and boundaries may be sensitive for political reasons, and fixing them in a publication might provoke strife.

Political considerations may also underlie the scarcity of base maps. Withington (1965, p. 22) pointed out the difficulties of carrying out and publishing censuses in the face of political instability, and the same may be said for base mapping. On the other hand, "in many countries maps exist but few see them because their use is restricted for security reasons" (Thackwell, 1969, p. 7).

Existing maps may be inaccurate in that they contain simple errors or omissions. In Ghana, for example, only 129 of 254 place names listed in the census for one area appeared on the available maps (Hilton, 1961, p. 84). The spellings of some village names in India varied widely from that on topographic sheets and _mujmuli_ (administrative district) maps (Padhye, 1961, p. 51). Some villages in Nigeria on which 1952 census figures were based could not be located on topographic maps (Barbour, 1961, p. 76). Existing maps may not be useful as population mapping bases. While topographic maps have been extolled for their value in development planning and as bases for specialized mapping, Fry (1975, p. 344) cautioned that it is not possible to provide a single base map for all thematic map requirements. Spiess (1970) acknowledged the suitability of a topographic map as a base for a natural resource inventory, but he observed that administrative boundaries often are only fully shown on other maps. He concluded that "the complete topographic map is unsuitable [for thematic mapping] as its content is too great" (p. 11).

The general problems of data and base map accuracy and availability affect, to some extent, all developing countries. However, further difficulties, mentioned above, arise that are specific to individual countries. These problems, along with the current status of population mapping in selected countries, are addressed in the next chapter.

CHAPTER IV

SPECIFIC PROBLEMS OF POPULATION MAPPING IN SELECTED DEVELOPING COUNTRIES

Problems of population mapping vary greatly from one developing country to another. Each country is different and is experiencing its own unique successes and difficulties. The purpose of this chapter is not to provide an exhaustive accounting of population mapping activities in the entire developing world but rather a survey of _selected_ countries that illustrates the range of problems and mapping developments. Since countries surveyed excluded non-English-language areas, bias has probably been introduced. British colonial governments generally fostered census-taking, base map surveys, and other requirements for population mapping. Therefore, countries included here are probably more advanced than developing areas formerly controlled by other colonial powers. In this chapter, the population mapping activities and programs of five countries--Jamaica, Guyana, Kenya, Sri Lanka, and Malaysia--are evaluated according to the 11 criteria established in Chapter II.

Jamaica

Jamaica began a population census very early in comparison with other developing countries. Their first census was in 1844 at the request of Britain and the island's plantation owners, who were worried about the status of the labor force. After a lapse of 17 years, censuses were taken at ten-year intervals from 1861 to 1921 and again in 1943 and 1953. The 1943 census was conducted by the Central Bureau of Statistics and, for the first time, was a de jure and canvassed census mechanically tabulated. The 1953 census was only a sample tabulation (Goyer & Domschke, 1983, p. 226). The first modern census, held in 1960, was especially important because it was the first time that Jamaica participated in a statistical operation of a regional nature. In the Caribbean area, two centers were established to carry out the operations. The Eastern subregion was headquartered in Port-of-Spain, Trinidad, and the Western subregion was headquartered in Kingston, Jamaica. In 1960, the two subregions operated largely as autonomous units, although considerable collaboration and contact was maintained throughout the entire exercise (Rose, 1974, p. 294). The 1970 census of all 15 Caribbean countries, including Jamaica, was coordinated, computer-tabulated, and printed through the Census Research Program at the University of West Indies in Jamaica. However, national censuses were conducted through the statistical office of each country (Goyer & Domschke, 1983, p. 108).

The tenth (1970) census of Jamaica is the most recent and was conducted by the Department of Statistics. The preliminary report was published in 1971 with subsequent reports appearing from 1973 to 1976. The census provided counts of population with a breakdown by selected characteristics including age, sex, marital status, race, religion, educational status, and economic activity.

The results are presented on a de jure basis; that is, each individual was counted at his usual place of residence. The final report was published in six volumes: (1) Administrative Report, (2) Subject Reports, (3) Enumeration District Reports (tables), (4) Parish Reports (tables), (5) Parish Reports (maps and descriptions of areas), and (6) a Demographic Atlas of urban areas. Tables present characteristics of the population at various administrative and geographical levels, with enumeration districts as the smallest. The census also provided maps and verbal descriptions of boundaries for the Enumeration Districts (Department of Statistics, 1976).

The Department of Statistics has produced other materials that are useful for mapping population characteristics, namely, the series of demographic statistic reports, which present information on the population and its vital events--births, deaths, marriages, and divorces. It also includes information on external migration and family planning services provided by the government through its family planning clinics (Department of Statistics, 1977).

Topographic maps were used to construct the census maps and were provided by the Survey Department in Jamaica. The topographic maps ranged in scale from 1:5,000 and 1:10,000 for metropolitan areas to 1:50,000 for rural areas. There is also a map at a scale of 1:250,000 which shows the entire country on one sheet (Blackwood, interview, April 1981). From these topographic maps, census maps were constructed. Jamaica is divided into 14 parishes, subdivided into 60 Constituencies, and further subdivided into Enumeration Districts. There are no base maps below the constituency level for the country; however, a volume published with the census presents the census area maps and descriptions.

Using these base maps and data from the 1970 census, the Department of Statistics and the Department of Town and Country Planning in Jamaica have produced several population maps, including a publication of the Department of Statistics, Demographic Atlas of Urban Areas. This black-and-white atlas was intended to be published in several parts, but the series was not completed. Part 1 of Volume 6, the Demographic Atlas of Kingston Metropolitan Area, presents 31 maps at a scale of 1:54,000, and corresponding analysis on urban patterns, land use, population, housing characteristics, economic activity, fertility and union (marital) status, educational and occupational training, and socioeconomic status. The census divisions used in these maps range from Enumeration Districts (E.D.s), to "neighborhood area" or "special area" as defined by the Department of Statistics. Approximately one-half of the maps are choropleth while the remainder use graphic forms superimposed on the base maps. One dot map depicts the distribution of population in Kingston and a wide range of social and economic characteristics (Figures 16 and 17).

The atlas maps have a number of cartographic shortcomings. The choropleth maps have deficiencies in construction and symbol choice. For example, in Figure 16, areal patterns are difficult to distinguish, particularly in the two highest density categories. Poor application of patterns is apparent, and there are overall design problems. In maps that used graphic forms superimposed, two used three-dimensional cubes (or blocks) and six used pie graphs. These

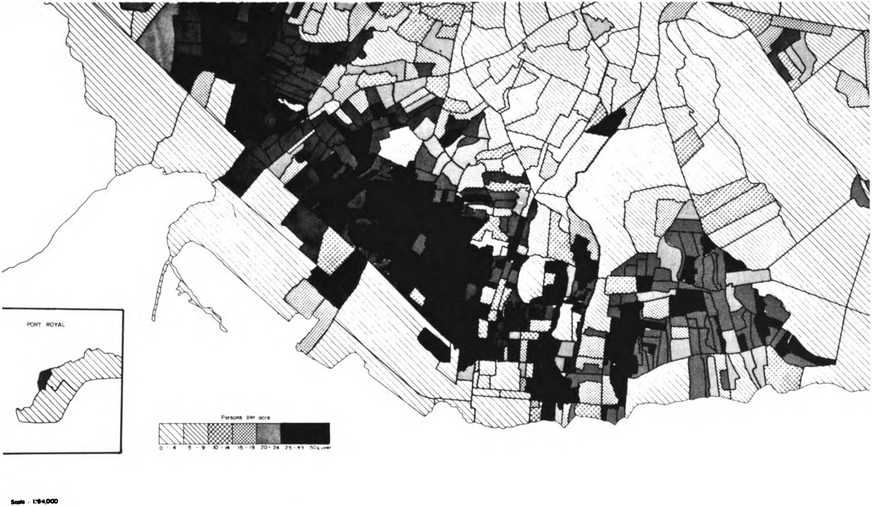

Figure 16. Density of population (Map 8) from Volume 6 (Kingston Metropolitan Area) of the <u>Demographic Atlas of Urban Areas</u>, 1977.

Figure 17. A dot map of population in Kingston (Map 7) from Volume 6 (Kingston Metropolitan Area) of the Demographic Atlas of Urban Areas, 1977.

maps revealed the deficiencies of the technique when applied to real data containing small quantities, especially since shading on the symbols was not well chosen. The dot map of population distribution (Figure 15) uses suitable value and size, but the dot pattern was affected by the shape of the Enumeration Districts.

A second major cartographic product from the Department of Statistics in 1975 was a series of population-change maps from 1960 to 1970. Sheet A covered Western Jamaica, Sheet B, Eastern Jamaica, and Sheet C mapped the Kingston Urban Area. All maps were published at a scale of 1:250,000. The maps were constructed with overlays of Zipatone dot patterns used to prepare printing plates for black, red, and blue colors. Four class intervals were selected with red representing growth and three shades of blue representing population decrease (Figure 18).

In general, these maps have two flaws: selected rural areas in the 14 parishes are divided into constituencies while others are not. It would be more accurate and appropriate if all were divided into constituencies because in choropleth mapping, statistical units should be of the same level. The other defect is in the cartographic design where the shading pattern was not well applied; in several places the orientation of the same area symbol varies widely.

The Department of Town and Country Planning has produced a number of population maps for various planning purposes. One is a dot map of Jamaica at a scale of 1:50,000 using data from the 1960 census (Figure 19). Dots were printed in red on a base map not suitable for this kind of technique. The base map includes information on

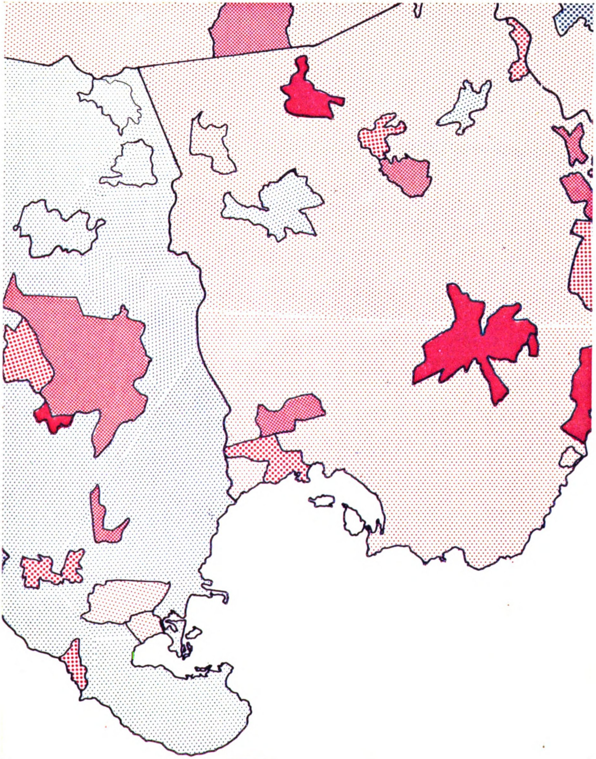

Figure 18. Map of population growth in Jamaica. (From the Department of Statistics, Jamaica, 1975, Sheet B.)

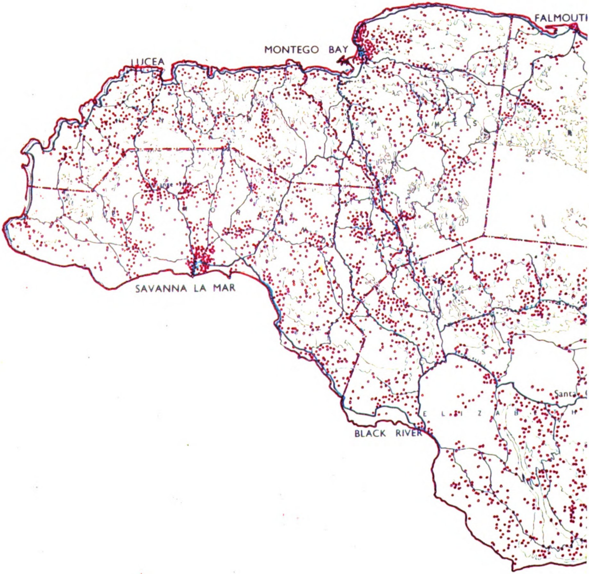

Figure 19. Population distribution map (1960 census). (From the Department of Town and Country Planning, Jamaica.)

principal roads, secondary roads, contour lines, and names of parish capitals, main towns, and names and boundaries of parishes. Although the department printed this information in gray instead of black, it adds confusion to the map and is cartographically incorrect. In addition to these problems, the parish boundaries and the coastal line are both printed in red, similar to the dots. The Department of Town and Country Planning also produced some Development Plan reports for the main towns, including Kingston, Montego Bay, and others. These, too, contain population maps.

In summary, Jamaica has only a few published large-scale population maps, despite the fact that it has relatively rich statistical data base and good topographic map coverage at various scales.

Interviews were conducted with several census and mapping officials in Jamaica in April 1981 including Mr. Vernon James, the Deputy Director of the Department of Statistics, and Mrs. Jacqueline Blackwood, who is in charge of the cartographic section in the statistical department. These discussions revealed the problems facing Jamaica in developing its population mapping programs.

Although Jamaica was to conduct a census in 1980, Mr. James stated that it was impossible due to the financial plight of the government. On the other hand, Dr. George Roberts, a Jamaican working as a director of Demographic Training and Research Units in Sri Lanka, stated that there are several problems, including political ones (interview, August 1981). An election was announced for 1980, and the decision was yet to be made whether the new administration would hold the census in 1981. Mr. James believed that it was very unlikely that the census would be held in 1982; it was more likely to be scheduled for 1983.

The 1970 census was used to map the population, and its accuracy is considered good by Mr. James. Some problems were encountered, however, including difficulty in enumeration of particularly sensitive areas because of threats of violence. The Department of Statistics had to select special census takers from the area itself and provide special training, or two or three people worked together during data-gathering interviews. Further problems arose when some census takers strayed beyond the boundaries of the census maps. The department used its regular field staff and others to check on the paths taken by the census takers.

Deficient resources cause the Department of Statistics to do cartographic work with the most limited laboratory facilities. Only a few tables and pens were available, and the simplest task of reducing or enlarging maps required considerable time. There are drafts of many population and population-characteristic maps which are parts of proposed atlases of parishes' capitals, but they have not been completed because of funding problems.

The lack of skilled or trained cartographers probably is shared by almost all developing countries. The statistical department in Jamaica has several draftsmen but only four of them have training in drafting and cartography, having attended short courses run by the College of Arts, and Science and Technology. For financial reasons, draftsmen seldom stay in the department for long. The statistical department cannot pay more than the government's wage scales, so movement is to either private enterprise, which pays more, or government agencies which have posts at higher levels.

The future of population mapping in Jamaica is predicted to improve. The Department of Statistics is hoping to get an IBM computer system, including a printer and a plotter, through external funding. However, with computerization, an even greater need is created for skilled, trained cartographers and geographers.

Guyana

Guyana has a long history of census-taking, similar to Jamaica's, dating from 1841 when the country was under British rule. Decennial censuses were taken through 1931 with the first of the closely coordinated Caribbean censuses conducted by the registrar's General Office occurring in 1946. In 1960 the second coordinated Caribbean census was conducted. This marked the first time that Guyana attempted to enumerate Amerindians (Goyer & Domschke, 1983, p. 205).

The third coordinated Caribbean census was conducted in 1970 through the direction of the University of the West Indies, Census Research Programme, in Jamaica. The Guyana portion of the census was performed by the Statistical Bureau, Ministry of Economic Planning and Finance, using the general set of questionnaires prepared for the Caribbean territories. Guyana's 1970 census, with the exception of one report, was produced as part of the report for all the countries in the Caribbean; the exception was the population enumeration, which was a separate publication on Guyana. A volume that was supposed to contain Enumeration District maps of Guyana has never been published. In general, although some population data were available at Enumeration District levels, the 1970 census was not very useful for population mapping because there were no published outline maps that showed statistical census units.

The Statistical Bureau's cartographic unit is using updated topographic maps and aerial photography to prepare Enumeration District maps for the 1970 census; these have not yet been published. There are several major problems with this mapping project that are related to the governmental administrative units of the country. The Statistical Bureau has divided the country into 13 major areas and some minor and special areas as well. These were then subdivided into Enumeration Districts, the smallest units used for the census enumeration. These divisions are not coincidental with other administrative divisions of the country. Some Enumeration District boundaries straddle administrative divisions, limiting the usefulness of the data collected. There are no published maps showing the statistical divisions or aerial units used by the population census at any level for the entire country. The cartographic unit is presently preparing these kinds of maps for the 1970 census and, at the same time, working to complete the maps for the 1980 census.

Unlike Jamaica, which has had fixed administrative divisions since 1943, Guyana has tried several different division systems. Currently the country is divided into ten regions and numerous subregions; however, maps of these regions are not used by the Statistical Bureau for its work since they have not been circulated through the government. The Administrative Map of Guyana, obtained from the

Land Survey Department, shows the ten regions and subregions at a 1:1,125,000 scale. As noted earlier, boundaries on the map bear little relationship to census collection units.

There are no population maps for Guyana published by any of its government departments. In interviews with Mr. Bertram Bowman, the chief statistician of the Statistical Bureau; Mr. Lennox Bruce, head of the Cartographic Unit; and Mr. Hubert Baker, executive chairman of the Regional Census Coordinating Committee, in April 1981, several reasons were put forth.

At the time of the author's visit to Guyana, the 1980 census had been conducted and the Statistical Bureau was preparing to ship the census documents to Barbados. The 1980 census will be processed, tabulated, and published there, using the government's computer. Some of the major problems that faced Guyana during this census included the following: The government did not provide funds until a year before the due date of the census; therefore, the work schedule was rushed. Furthermore, enumeration people recruited were either politically aligned or unemployed. Those people came through the regional offices--the political arm--and had to be accepted. Mr. Bowman, with his experience, believed they were not adequate for the job. In addition, the census was done just prior to an election, and some individuals did not cooperate in giving complete information. These points may give an idea about the quality of the 1980 census data. In general, Mr. Bowman believed that the accuracy of the 1980 census enumeration was poorer than that of the 1970 census because it was affected by politics. Aside from that, the Statistical Bureau tried to correct one of the major problems of the 1970 census. They adjusted the enumeration districts in 1980 to conform with the small towns and the villages, thereby enabling one to extract from the census report data relating to that particular town or village; this was not possible with the 1970 census.

Financial resources are far too limited, especially for cartographic work. Many government agencies do not appreciate the importance of maps or cartography and refuse to allocate monies for such graphics. Staffing is another problem: although the University of Guyana has a geography department offering elementary cartography, its graduates are not anxious to work in the Statistical Department because of its low pay. Also, the Cartographic Unit provides little opportunity for advancement. Only six draftsmen and cartographers are employed in the Cartographic Unit, and employee turnover is high. The Cartographic Unit is limited by its equipment to minimum cartographic work. For example, to enlarge or reduce a map, they must use facilities in the Department of Geography at Guyana University. In general, a lack of coordination and communication seems to exist between government departments and the Statistical Bureau in Guyana, especially in coordinating census data and base map usage.

Guyana could be considered the poorest country in population mapping in relation to the other developing countries studied. Its present situation may be compared to Saudi Arabia's before 1974 when there were no base maps showing statistical units or administrative boundaries. In general, unless the attitude of the government authorities changes toward the importance of cartographic work and financial support is provided to such cartographic offices in government departments, and unless academic geographers and cartographers initiate and support such change, the present situation will continue.

Kenya

Kenya did not begin a comprehensive population census until 1948. Previous counts in 1921, 1926, and 1931 enumerated only non-African population, and even in 1948 only partial tabulation results were published for Black Africans (Statistics Division, 1966, p. 1). The second census was conducted in 1962, and it had several problems, including sample counts, de facto population in some provinces, and outdated provincial and district boundaries (Statistics Division, 1964, p. 2).

The 1969 census was the first conducted by Kenya as an independent country and consisted of four volumes. Volume I contained data on administrative areas and districts (tribe, nationality, sex, and age); Volume II, urban population; Volume III, data on education, marital status, birthplace, and relationship characteristics; and Volume IV, an analysis of the social and demographic character of the country. The first volume contained a dot population map as a supplement. This census was considered an improvement over the 1962 census in that, for the first time, an attempt was made to enumerate the population on a _de facto_ basis for the entire country, and a sample census of 10 percent of the rural population was carried out simultaneously in order to secure more detailed data. This was also the first census in which the enumeration areas were clearly delineated by maps. Although the 1969 census was reasonably complete, some parts of the country were not enumerated because of political disturbances, and some variables were not considered dependable, particularly age categories (Gichobi, interview, May 1981).

The 1979 census was the second taken in Kenya following independence and is believed to be an improvement over all those preceding counts (Gichobi, interview, May 1981). The 1979 census was preceded by a pilot census, which provided valuable experience, by the establishment (in 1976) of a cartographic unit within the Central Bureau of Statistics, and by widespread publicity. The census itself was better-funded, and more information was collected than in 1969. The first reports appeared in 1980 and 1981 and contained data by district on population density, sex, age, tribe, and education. The Central Bureau of Statistics intends to publish additional volumes on sex, age, and education by districts, interdistrict migration, and conduct an analysis of the data.

Several large-scale base maps are available for Kenya. While the South and Southwest parts of the country, which are the most populous, are covered by topographic maps at 1:50,000, the rest of the country is covered by 1:100,000 scale maps. There are also topographic maps at 1:1,000,000 which cover the entire country. Administrative maps to show provincial and district boundaries are available in different scales; however, maps showing the location and sublocation boundaries are only available for a small part of the country.

With the availability of population census data and base maps, several population maps of relatively high quality have been produced for Kenya. The earliest medium-scale map of Kenya found containing population information was published in 1954. This map, entitled "KENYA, Boundaries, Land Units Population, Tsetse Fly and Rainfall," was drawn by the Directorate of Colonial Surveys at a scale of 1:2,000,000. A second version of the map with only the population distribution appeared in the 1959 Atlas of Kenya. The map has some cartographic shortcomings, including its representation of rural and urban populations with the same dot value, which results in a depiction of the cities and towns with less than their actual population.

In 1966, the Department of Geography at University College, Nairobi, published two population maps at a scale of 1:1,000,000 based on the 1962 census. The first was a dot map, and the second was a colored choropleth map of population density. Although the dot map suffered somewhat from excessive base information, which obscured the dots, as well as from the omission of a scale for its graduated circles, in general, the maps are of good quality and involved a collaborative effort of many government departments. The density map shared the problem of cluttered base data, and the sizes of the statistical units used varied greatly. Two similar maps were produced for the 1969 census by the same department and represented an improvement over the 1962 maps (Figure 20).

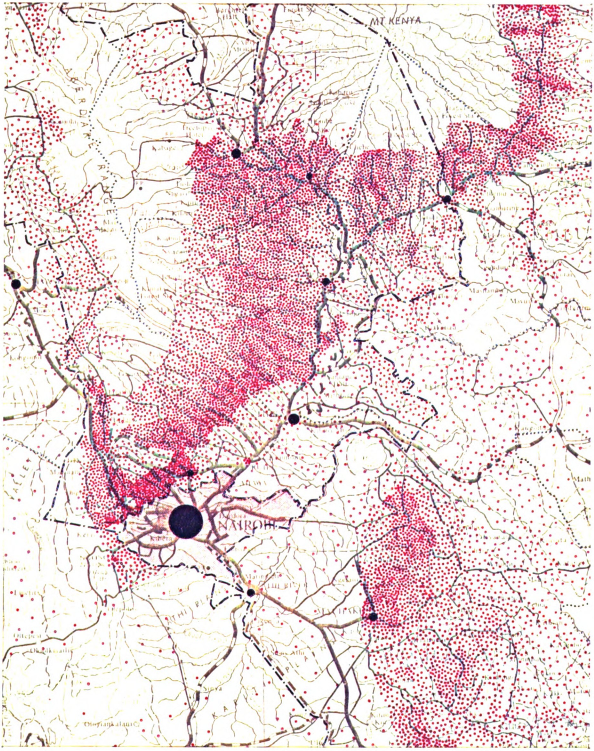

Figure 20. Kenya population distributioh map, 1969, published by Survey of Kenya (1:1,000,000).

Three other population maps based on the 1962 census were published by the Survey of Kenya at a scale of 1:3,000,000. The first was a color map showing rainfall and population distribution. A second population map (part of the 1970 National Atlas of Kenya) was a choropleth map showing population density and was based on the earlier University College maps. The third was a map of ethnic groups using colored segmented wedges to symbolize ethnic types.

Kenya apparently has some advantages that have fostered population mapping. It met almost all the minimum criteria established in this study for a good population mapping program. First, population data and base maps are adequate. Second, funding for population mapping after each census has been available. Third, skilled, trained cartographers--both foreign and Kenyans--are available in some government offices such as the Survey of Kenya and, more recently, in the Central Bureau of Statistics. The Department of Geography employs population geographers with cartographic training who have been instrumental in producing population maps for the country with the cooperation of government agencies (Ominde, interview, May 1981). The Survey of Kenya has a very-well-equipped cartographic unit which has published many maps including the 1969 population map, the three national Atlases of Kenya, and other thematic maps. Recently, the Central Bureau of Statistics office established a cartographic unit headed by a European professional cartographer and provides overseas training for its cartographers. Finally, there is considerable cooperation among government agencies collecting population data and university personnel with the expertise to map those data.

Among the countries studied, Kenya ranks as one of the best in the quality and availability of population maps. It has demonstrated leadership as one of the few developing countries to respond to the IGU's worldwide appeal for production of large-scale (1:1,000,000) population distribution maps, and represents an example of cooperation among academic geographers, cartographers and government agencies.

Sri Lanka

Decennial censuses of Sri Lanka were taken between 1871 and 1931, while the country was under British rule. Interrupted by World War Two, censuses continued in 1946, 1953, 1963, 1971, and 1981 (Department of Census and Statistics, 1974a, p. 4).

Census information in Sri Lanka is reasonably complete and accurate, particularly those data collected in 1971 and 1981 (Nadarajan, interview, August 1981). Basic data on sex, age, school attendance, etc., are collected along with information concerning employment, wages, and other economic variables. Censuses are preceded by a careful selection of variables and questions and by a pretest of census schedules carried out in the field to determine suitability.

Sri Lanka's success at census-taking results from several factors: (1) long experience inherited from British colonial rule, (2) relatively good communication and transportation in this small island country, (3) foreign training of a few census officers, and (4) a reasonably stable system of administrative divisions. The country is divided into districts (29 in 1981), subdivided into AGAs (assistant government agent divisions), and further subdivided into "grama sevakas" or village groups. There were about 5,000 of these in 1981.

Even though Sri Lanka has an extensive census and administrative district divisions and subdivisions are well established on base maps, the Department of Census and Statistics does not have or use census maps when conducting the census; instead, they use a list of houses prepared by the grama sevaka officers prior to the enumeration.

Base maps of Sri Lanka are available at a fairly detailed level. The most detailed series is at a scale of 1:63,360 (1 inch = 1 mile). These are contoured topographic maps and contain considerable land detail. The maps published by the Survey Department also indicate the boundaries of provinces, districts, AGA divisions, and grama sevaka divisions. The series is somewhat dated with irregular revisions from 1950 to 1971 (Nadarajan, interview, August 1981). Another series at a scale of 1:253,440 consists of four sheets and shows province, district, and AGA division boundaries. They were drawn and printed by the Survey Department of Ceylon in 1969.

Sri Lanka, like Jamaica and Saudi Arabia, has few published small-scale maps. There are two old medium-scale population maps published for Ceylon. One is a dot map entitled "Distribution of Rural and Urban Population--1946," at a scale of 1:1,750,000, published by the Surveyor General, Ceylon, in 1953. The other, published by Ceylon Survey Department, 1963, in black and white, at a scale of 1:1,500,000, is a choropleth map entitled "Population Distribution by

Revenue Districts 1953." The maps were out of print and presently not available. However, there are small-scale population maps published in three different atlases, and one population map published with the 1981 census Preliminary Release No. 1.

A population map appeared in A Concise Atlas Geography of Ceylon published in 1971. In this map, the author used manually produced line patterns of various widths to show density of population in six class intervals (Figure 21). The map also included density values and total number of persons in the center of each district, which adds further disturbance to the already annoying line patterns.

Another more recent atlas project was undertaken by the Demographic Training and Research Unit financed by the United Nations Fund for Population Activities.[1] It includes 29 population maps at a scale of 1:1,520,640 "covering mainly growth and distribution of the population, its fertility and mortality" (Demographic Atlas of Sri Lanka, 1980, p. v). The data used for mapping were from the 1971 census and from vital registrations. The majority are choropleth maps shaded with Zipatone patterns and printed in orange and appear to have been carefully compiled. There are a few maps that use superimposed graphics such as pie graphs and age pyramids.

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[1]The Demographic Training and Research Unit was started in 1973 on an agreement between the United Nations and the government of Sri Lanka. It was designed to promote teaching and research in the field of population. It was located in the University of Colombo, and initially two United Nations experts were assigned to it, with local personnel drawn from the University of Colombo and from other universities (Roberts, interview, August 1981).

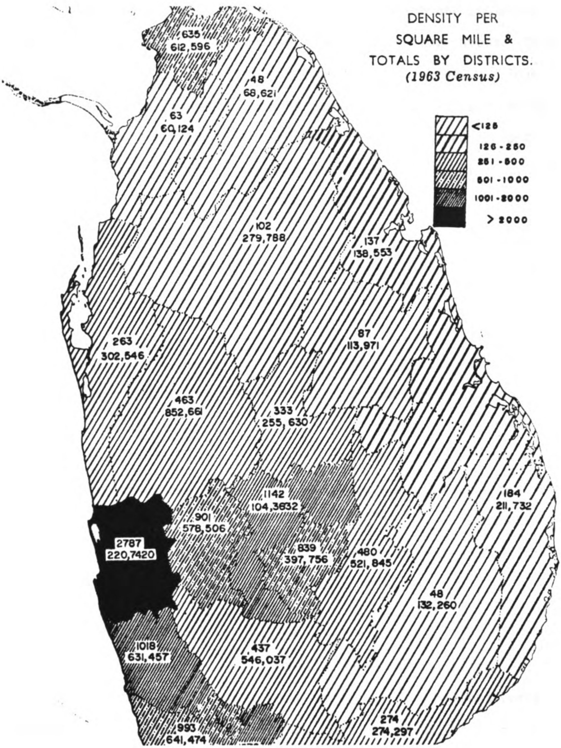

Figure 21. Population density map of Sri Lanka (1963 census). (From A Concise Atlas Geography of Ceylon, 1971, p. 26.)

An economic atlas was prepared by the Department of Census and Statistics, the main statistical agency of the government. This is an updating of the first issue, which appeared in 1969. Four choropleth maps of population used district divisions as statistical units (Figures 22 and 23). The maps exhibit numerous cartographic problems including a lack of progression in both black-and-white and color maps, ambiguous or overlapping class intervals, and disturbing patterns.

Two general observations can be made concerning population mapping in Sri Lanka. First, Sri Lanka appears to have the necessary ingredients for a strong mapping program: it is a small country with a long history of census taking with data provided at detailed administrative levels; and base maps showing administrative divisions at levels suitable for mapping are available, though somewhat dated. Second, despite these advantages, the small-scale population maps published in various atlases are of low quality and indicate that they were produced by people with limited cartographic or geographic background. Taken together, these two factors make the Sri Lankan population mapping situation unique.

Malaysia

Previous censuses in the territories now encompassing Malaysia were carried out by colonial officials in different years: Sarawak was enumerated in 1871, 1909, 1947, and 1960; Sabah in 1891, 1901, 1911, 1921, 1931, 1951, and 1960; and the Federated Malay States in 1901, 1911, 1921, 1931, 1947, and 1957 (Bureau of Business Research, 1966, p. 27). The 1970 population and housing census of

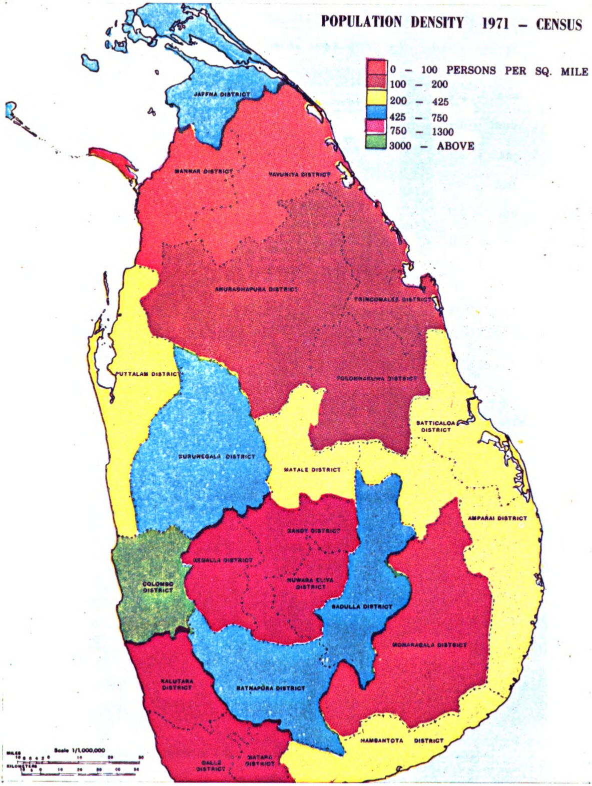

Figure 22. Population density map of Sri Lanka (1971 census). (From Sri Lanka Economic Atlas, 1980, published in 1981; no page or map number.)

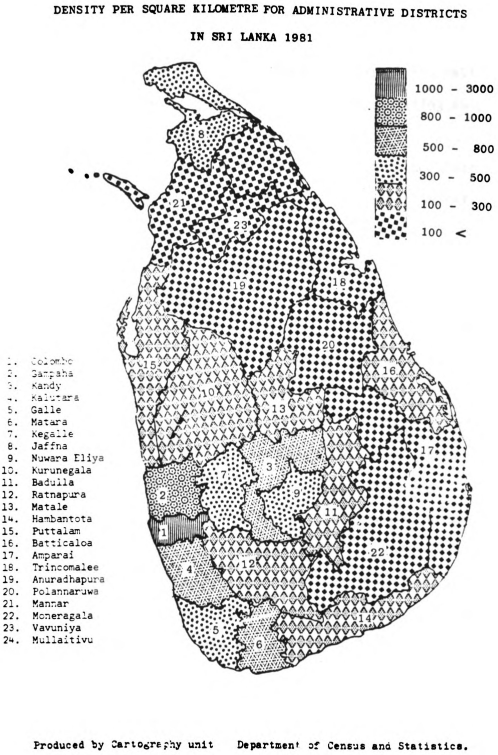

Figure 23. Density map of Sri Lanka, 1981. (From Sri Lanka Economic Atlas, 1980, published in 1981; no page or map number.)

Malaysia was the first carried out since the formation of Malaysia in 1963. The 1970 census led to the publication of about 50 volumes and special reports that contained data analysis at the national and state levels. There were also special reports analyzing selected key topics (Department of Statistics, 1977, p. v).

The 1980 population census does not contain complete national coverage for several reasons. First, transportation is difficult, particularly in East Malaysia, resulting in some areas of incomplete enumeration. Second, local languages are numerous, requiring translators during interviews by census takers. Third, boundaries are not clearly observed by the population, resulting in the "sudden birth or death of localities." In several instances, names of places change because when a "head man" dies, the name will change accordingly. Finally, because of political instability, some areas cannot be visited by enumerators (Kit Yee Van and Tee Ko Hock, interviews, August 1981). For these reasons, the quality of the data for peninsular Malaysia is believed to be better than that for Sarawak and Sabah.

Population census data are provided at several administrative levels: the town, village, and locality. Malaysia is divided into 14 states, including Sarawak and Sabah. In peninsular Malaysia, the 12 states are divided into districts and subdistricts and each district is further divided into Mukims. In East Malaysia, the two states of Sarawak and Sabah have slightly different aerial administrative organizations. They are divided into residencies in Sabah and divisions in Sarawak. These are further divided into districts and subdistricts for which census data are collected. Topographic maps are insufficient for census purposes because their scale is small. Other sources are used to make enumeration area sketches. These include the 1977 agricultural sample sketch maps which were checked in the field by enumerators during the agricultural census; anti-malaria maps prepared by the Ministry of Health; and census-taker sketch maps (Van, interview, August 1981).

Population mapping has been included with the censuses since 1947. A color dot and graduated circle map was published in 1947 at a scale of 1:1,013,760 (Figure 24). Black dots represented rural population and shaded graduated circles were used to show urban population. Three colors represented the major ethnic groups within each census district. The map is well executed and its color reproduction is good. A map showing towns of 10,000 or more population appeared with the 1957 census, but it is little more than a location map (Figure 25).

Several large-scale population distribution maps were prepared and published by the Department of Statistics, some of which were published as part of the 1970 census reports (Figures 26 and 27). These are dot and circle maps at a scale of 1:760,000 for peninsular Malaysia, with some states mapped individually. Although these maps were prepared with similar cartographic methods, they are not comparable because map scale and dot size vary from map to map. In addition, different-sized graduated circles are used to represent classes of the same value on different map sheets.

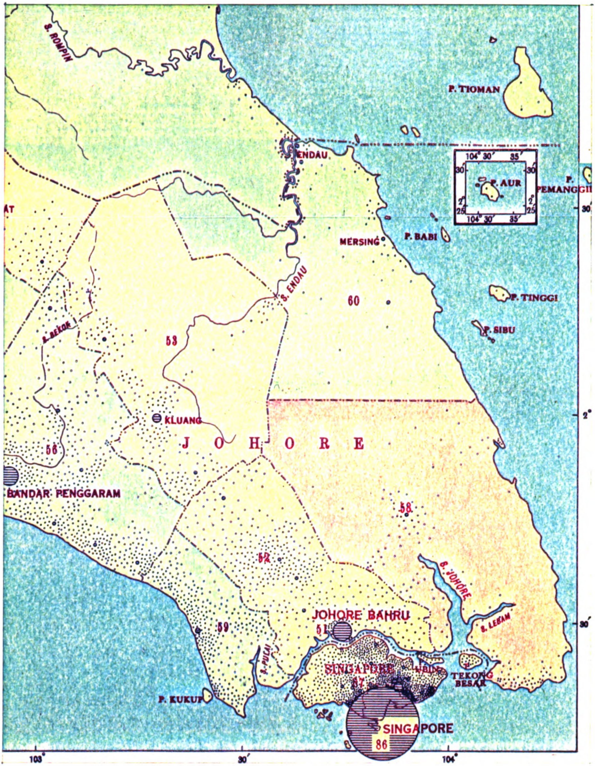

Figure 24. Distribution of population map of Malaysia. (From A Report on the 1947 Census of Population, 1949; map facing p. 37.)

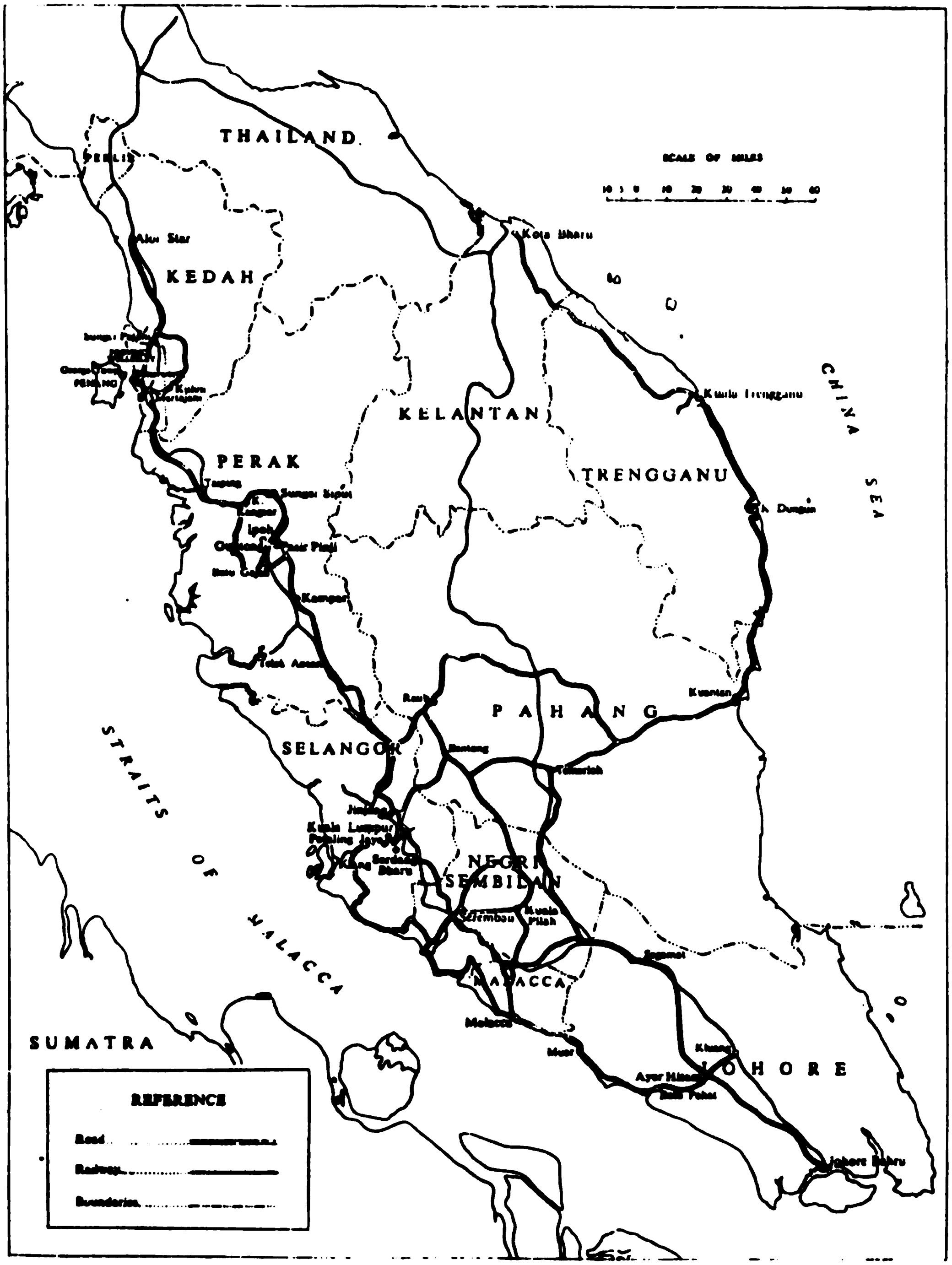

Figure 25. Malaysian map showing towns and villages with a population of 10,000 or more. (From Report 14 of the 1957 Census, 1958, p. 181.)

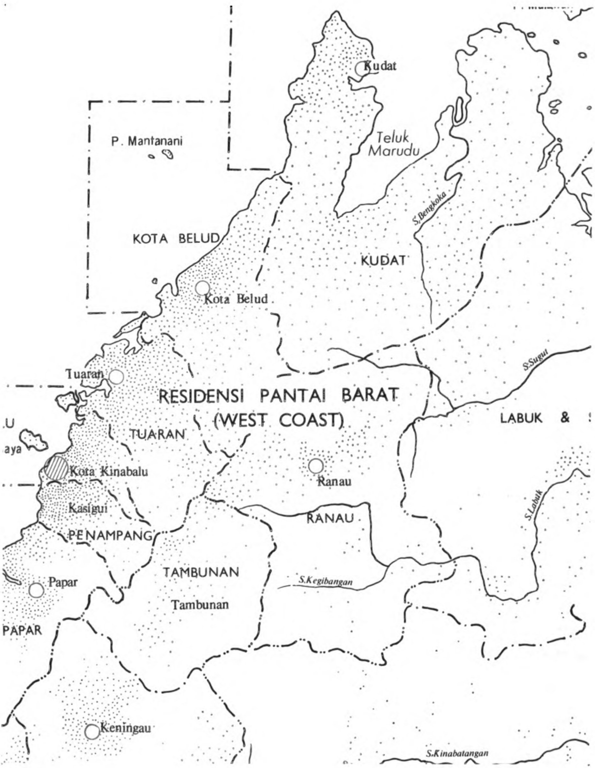

Figure 26. Map showing distribution of population, Subah State, Malaysia, 1970. (Published by the Department of Statistics, Malaysia, 1974.)

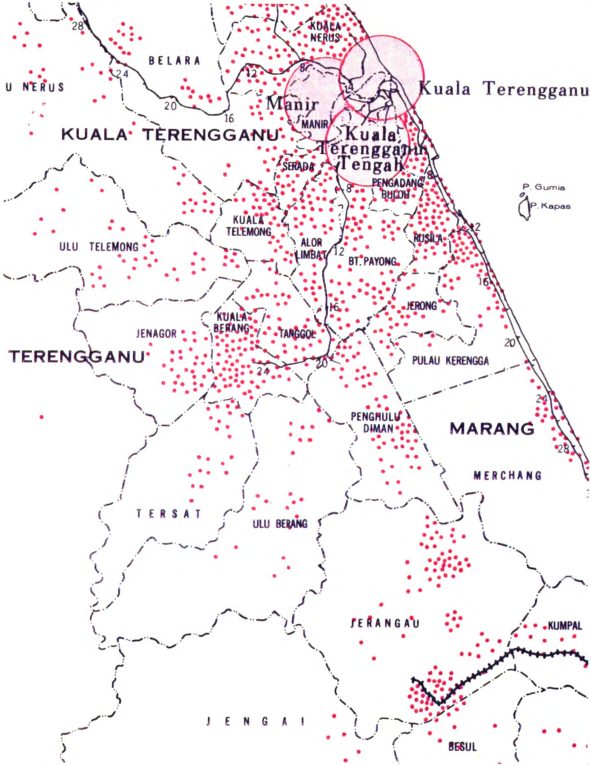

Figure 27. Map showing distribution of population, Terengganu State, Malaysia, 1970. (Published by the Department of Statistics, Malaysia, 1976.

Malaysia is one of the few developing countries that has large-scale population maps, and the quality of these is reasonably good. The attitude of authorities in the Department of Statistics toward the importance of such maps is very positive. Since the Department of Statistics does not have a cartographic unit, the maps were done with the cooperation of the Directorate of National Mapping. The Deprtment of Statistics is now working on a national atlas based on the 1980 census.

Application of Population Mapping Criteria

In Chapter II, 11 criteria for evaluating population mapping activities or programs of developing countries were discussed: (1) accuracy of population data, (2) resolution of population data, (3)availability of large-scale base maps, (4) accuracy of large-scale base maps, (5) availability of administrative and statistical boundaries maps, (6) resolution of administrative and statistical boundaries maps, (7) adequacy of geographic and cartographic skills in the census department, (8) adequacy of production facilities in the census department, (9) appropriate scale and acceptable quality of population maps, (10) suitable level of graphic literacy, and (11) sufficiency of funding for population mapping. These criteria were then applied to Jamaica, Guyana, Kenya, Sri Lanka, and Malaysia to summarize their evaluation in terms of population mapping performance.

The resources and activities of each country were evaluated, and an ordinal rating was assigned to it for each of the 11 criteria, as follows: Any country that fully met a criterion was given a "3" for that criterion. Any country that met a major portion of a criterion received a "2." Any country that met only a minor part of a criterion received a "1." Any country failing to meet all parts of a criterion received a "0." These ratings were then totalled to arrive at a composite score for each country, which is given in Table 1. The maximum score a country could receive is "33," and the minimum is "0." These scores are described in the following manner:

--A country receiving a rating from 23 to 33 is considered to have a good population mapping program.

--A country receiving a rating from 12 to 22 is considered to have an acceptable population mapping program.

--A country receiving a rating of 11 or less is considered to have a poor population mapping program.

Class breaks of 11, 22, and 33 represent the maximum score a country could receive if its individual ratings were uniform across all criteria.

The last row of Table 1 provides the score for each country. Guyana's score of 11 indicates that its population mapping resources and activities are poor. Jamaica, with a score of 21, and Sri Lanka, with 22, demonstrate acceptable population mapping activities. Malaysia and Kenya, with scores of 27 and 30, respectively, evidence a good population mapping program.

Throughout the countries sampled, the attitude of census officials toward population mapping is favorable. The desire to produce maps exists, but the cartographic expertise needed to carry out these programs varies widely. Mapping activities in Kenya and Malaysia enjoy substantial financial support. For the rest, funding frequently represents a problem that not only curtails current

Table 1.--Ratings assigned to the five countries sampled according to the 11 criteria for population mapping activities or programs.

Criterion	Country				
	Jamaica	Guyana	Kenya	Sri Lanka	Malaysia
Accuracy of population data	2	1	2	3	2
Resolution of population data	3	2	3	3	3
Availability of large-scale base maps	3	2	3	3	2
Accuracy of large-scale base maps	2	2	2	2	2
Availability of administrative and statistical boundaries maps	3	1	3	2	3
Resolution of administrative and statistical boundaries maps	2	0	2	3	2
Adequacy of geographic and cartographic skills in the census depts.	1	1	3	1	2
Adequacy of production facilities	1	1	3	1	2
Appropriate scale and acceptable quality of population maps	2	0	3	1	3
Suitable level of graphic literacy	1	1	3	2	3
Sufficiency of funds for population mapping	1	0	3	1	3
SCORE:	21	11	30	22	27

activities but restricts planning. Kenya is characterized both by skilled personnel and good map-production facilities. In the other countries discussed in this chapter, technological capability and availability of native staff range from poor to adequate.

Except for Guyana, all the countries examined in this chapter have produced thematic atlases and plan to continue such projects on a decennial basis. Kenya and Malaysia have produced large-scale population maps, but problems with skills, data, base maps, funding, and/or other resources are hindering the remainder of the countries, and the future of large-scale mapping depends on improvement in these areas, particularly in cartographic training and education.

CHAPTER V

SAUDI ARABIAN POPULATION MAPPING: A CASE STUDY

Saudi Arabia was chosen as a case study in population mapping because of the author's familiarity with its social and governmental structure, thereby providing insight into its lack of thematic maps in general and population maps in particular. Saudi Arabia was expected to provide a unique example in that, unlike other developing countries, financial support is not a problem, but it also turned out to be unique among the countries studied in having a short history of census taking and mapping of administrative regions. On the other hand, Saudi Arabia shares with the other countries studied a shortage of adequate base maps and often indefinite administrative boundaries.

Base Maps

Before 1910, maps of Arabia relied heavily on reports of individual travellers, most of whom visited the area for political, religious, or commercial reasons. Maps produced from such reports are poor and depend on estimation of distance and location of places (Leatherdale & Kennedy, 1975, p. 240).

Probably the first complete map of Arabia is one published in 1910 by the British War Office. It is a topographic map in four sheets at 32 miles to the inch (approximately 1:2,000,000) (Leatherdale & Kennedy, 1975, p. 240).

The discovery of oil in commercial quantities in 1938 in the Eastern province of Saudi Arabia marked the beginning of changes in the economy and structure of the nation (Aramco, 1959, p. 14). Topographical mapping became an urgent need in order to produce base maps for geological and geophysical surveys. Until 1954, mapping in Saudi Arabia was restricted to limited areas, mainly in the oil-concession zone, and was carried out by the Arabian American Oil Company (Aramco). However, after the establishment of the Directorate General of Petroleum and Mineral Affairs (now the Ministry of Petroleum and Mineral Resources) in 1954, projects of topographical and geological mapping were started for the entire country.

The first mapping project to publish 1:500,000 scale geographical and geological surface maps for all of Saudi Arabia was initiated in 1954 by the Arabian American Oil Company (Aramco) in cooperation with the United States Geological Survey, under the joint sponsorship of the Kingdom of Saudi Arabia and the United States Department of State (Ghalayini, 1961, p. 57). Four years later, in 1958, a preliminary edition of a geography map of the Arabian Peninsula was published at 1:2,000,000 scale, printed in both English and Arabic versions. This map, compiled for the Ministry of Petroleum and Mineral Resources by the U.S. Geological Survey and the Arabian American Oil Company, is a revision of U.S. Geological Survey Miscellaneous Geologic Investigation Map 1-270 B-1, 1958, and was prepared as a base for a geological map (Arabian Peninsula Map, 1963). A revised edition of this geographic map and a new geologic edition at the same scale were published in 1963. A 1:4,000,000 topographic map, compiled by the U.S. Geological Survey Saudi Arabian Project and distributed by the Ministry of Petroleum and Mineral Resources, was published in 1972. The map has topographic contour intervals of 100 and 200 meters and contains very few names of towns and villages. A 1:3,000,000 road map in color was published in 1981 by the Ministry of Communications with the cooperation of the Ministry of Petroleum and Mineral Resources, Aerial Survey Department. A series of city plans was compiled photogrammetrically by Asia Aero Survey Company of Seoul, Korea, from aerial photographs taken in 1978. This series does not cover the entire country, but does provide maps of all major cities at scales of 1:50,000, 1:10,000, and 1:2,500. Smaller villages have been mapped at larger scales of 1:2,500 and 1:1,000.

A number of large-scale base maps was prepared by various agencies for smaller areas of Saudi Arabia. This included the Hauta Quadrangle in 1956 (1:200,000), and a 1:100,000 photomap of the Najd area in 1967. Other small-scale maps have been compiled by foreign consultant companies and are concerned with specific, limited areas in which the consultants were working. They are often difficult to obtain since they are limited to official use and were prepared in small quantities as part of the companies' reports to various ministries.

From this survey of available base maps, it is obvious that large-scale maps are currently only available for small parts of the country. Saudi Arabia has only 15.6 percent of its total area covered in the scale range of 1:140,000 to 1:253,550 (1/4" to 1 mile) (United Nations, 1970). This is the least detailed of the four scale ranges used in the U.N. classification (United Nations, 1970, p. 18). However, the Ministry of Petroleum and Mineral Resources indicated that in the last few years, photographs at 1:60,000, 1:80,000, and 1:100,000 scales are being used to produce orthophoto and line maps at 1:50,000 and 1:100,000 scales. The systematic coverage of Saudi Arabia by maps at 1:50,000 scale except for some remote areas is progressing without any major technical problems (Al-Ribeash, interview, 1981). None of the topographic maps include administrative divisions at any level. The first map produced by a government office that shows the administrative regions and emirate boundaries was created at the time of the first census (1974) at a scale of 1:4,000,000 by the Central Department of Statistics (C.D.S.).

The 1:500,000 Geographic Map

Of all the topographic maps listed above, the geographical map at a scale of 1:500,000 is very often used as a base map in research and development planning because it is the largest-scale base map available for the entire country. This map is also used by population researchers, geographers, and cartographers for their research and mapping. The map series consists of 21 separate sheets, each covering an area of approximately three degrees by four degrees. The map, constructed on a Lambert Conformal Conic projection, is bilingual (Arabic and English). Hachures represent low topography in the sedimentary areas, while a shaded relief "air brush" method was used in the more rugged areas of crystalline rocks. Sand areas were shown by hand stippling in order to present trends and types of sand (Ghalayini, 1961, p. 57). The project to publish this map (and the geological map) was initiated in 1954, and the final publication of all map sheets was completed in 1962.

The accuracy and quality of topographic representation are believed to be suitable for planning and development of roads, towns, agricultural programs, and mineral exploration (Ghalayini, 1961, p. 59). However, there are problems that reduce its suitability as a good base map for population mapping. The map names only a fraction of the settlements in Saudi Arabia. While the 1974 census indicated the existence of a total of 21,020 settlements (including towns, villages, isolated farmsteads, and water resources with some populations), the 1:500,000 map locates and names 5,131 settlements and physical and cultural features (Abdo, 1983a). This means that, at the very most, only 24 percent of the settlements included in the 1974 census appear on the maps, and many of these are incorrectly located. Another problem involves the bilingual nature of the map. It appears that place names were originally compiled in English and then translated into Arabic and, because of differences in alphabets, resulting translations were sometimes incorrect. Finally, some settlements, although correctly located, carry names that are partially or totally incorrect. Dr. Assad Abdo (1983b) has determined that there are 1,316 names on the map different from authoritative Arabic geographic reference works.

Administrative Region Boundary Map

Even at a smaller scale, no official map of administrative regions existed. Several maps have been published with arbitrarily defined region boundaries, none of which coincide exactly (Figure 28). To prepare the first government map, prior to the census the C.D.S. listed all the settlement names (15,000 names before the beginning of the census), for use in preparing a map showing the administrative and emirate boundaries. Administrative provinces were asked to list all the settlement names under their jurisdiction, and staff from the Central Department of Statistics reconciled differing points of view. Three levels of administrative divisions were identified. (1) The 14 main administrative regions are Riyadh, Holy Makkah, Eastern Province, Asir, Al-Medina Al Munawarah, Jizan, Gasim, Hail, Tabuk, Al-Baha, Najran, Northern Frontier, Al Joef, and Al Burruyat. Each of these administrative regions is connected directly to the Ministry of the Interior. (2) Each of the 14 administrative regions is divided into a number of emirates (the total number of emirates is 342). Each emirate is connected directly with the prince of the administrative region in which it is located. (3) Some emirates are divided into subemirates, which are connected directly to the princes of the emirates. The total number of subemirates is 208. These divisions (except for the subemirate divisions) were then mapped; the resulting map was produced at a scale of 1:4,000,000 and is available to researchers on request. However, boundaries are approximate, and some disagreement still exists between some emirates over the administration of some settlements (Figure 29) (C.D.S., 1981). It is the base

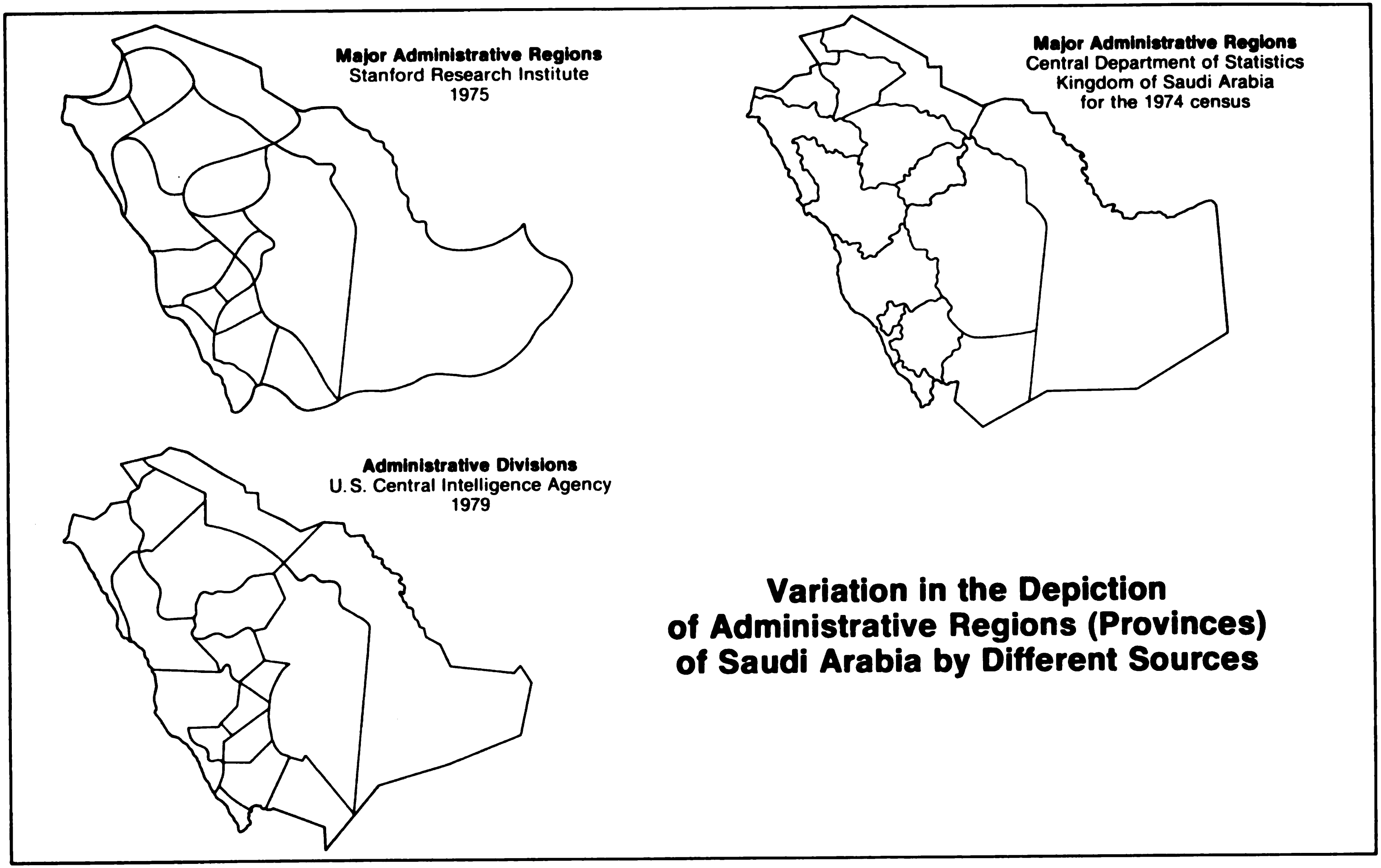

Figure 28. Administrative regions of Saudi Arabia as depicted by two different sources (A and B) and by the government (C).

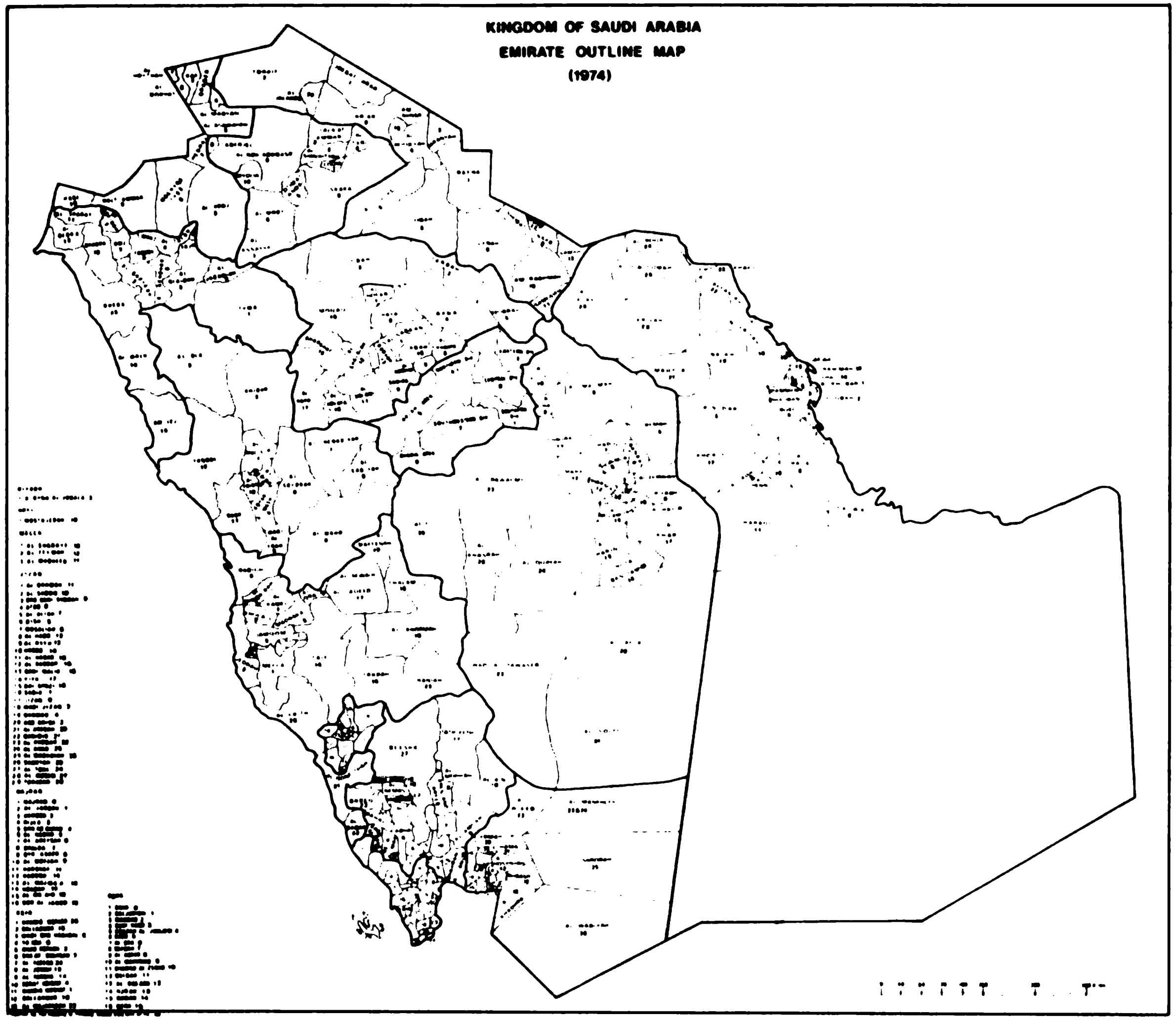

Figure 29. Reduced version of the Central Department of Statistics emirate outline map published after the 1974 census.

map used by the C.D.S. in collecting census data despite the fact that the boundaries are not authoritative.

Population Data

The main sources of population data before the 1974 census were estimates. Hamza (1933) gave what is believed to be the first estimation of the approximate number of settled and unsettled persons in the whole country by six geographic regions. His estimation depended on several sources: personal knowledge of the area, social relationship with government officials and heads of tribes, on official reports and lists of people receiving a sort of salary called "aotiat" from the government, on lists of the "mujahedin," or people in the National Guard, and the results of a preliminary census conducted by the towns of Hijaz region in 1932. Hamza's estimates were used by others in their writings, as in Geography of the Arabian Peninsula by Kahalah (1945) and Geography of the Arabian Peninsula by Abu-Alola (1972). In addition to being unreliable, these estimates were not detailed and gave only a general idea of population distribution. Therefore, no population mapping was done using them as a source of information.

There were other sources of early population data, however. Beginning in 1950, Saudi Arabia appears in the statistical table of population published by the United Nations (Rajab, 1978, p. 17). These numbers are estimates using a rate of natural increase applied to original estimates. Consultant companies working for various ministries (such as Sogreah, Parsons and Basil, and Doxiadis) provided general estimates for populations in areas they surveyed. The data in these reports have two main problems: (1) The areas of their estimates are only for regions defined by the ministry or the company. The boundaries of these regions differ from areas defined by other ministries or companies, and they are also different from the current boundaries of the administrative regions and emirates. As a result, some areas overlap and gaps exist among others. The lack of uniformity illustrated in Figure 30. Thus, data given by such companies cannot be compared. (2) Most consultant companies do not indicate methods used for their estimates or their sources. They depend primarily on personal estimation, which depends in turn on biased samples, unrepresentative of the total population (Rajab, 1978, p. 19). These early sources of population data, whether total numbers given by the United Nations or data provided by consultant companies for specific areas, cannot be considered adequate for mapping nor useful for spatial analysis.

The Saudi Arabian census, taken in 1962-63, may or may not be considered the first population enumeration in Saudi Arabia since it was not approved by the government and was not published. It was believed that the census contained numerous errors and underestimated the population. Furthermore, the Central Department of Statistics does not recognize this as an official census. Ali Al-Rashed (1981), the head of C.D.S., stated that while this effort was more than an estimate, it did not meet the official government requirements of a census. The enumeration of all people was not performed at one time; therefore, movement within the country was not controlled. Also, selected Bedouin areas were not included in the enumeration.

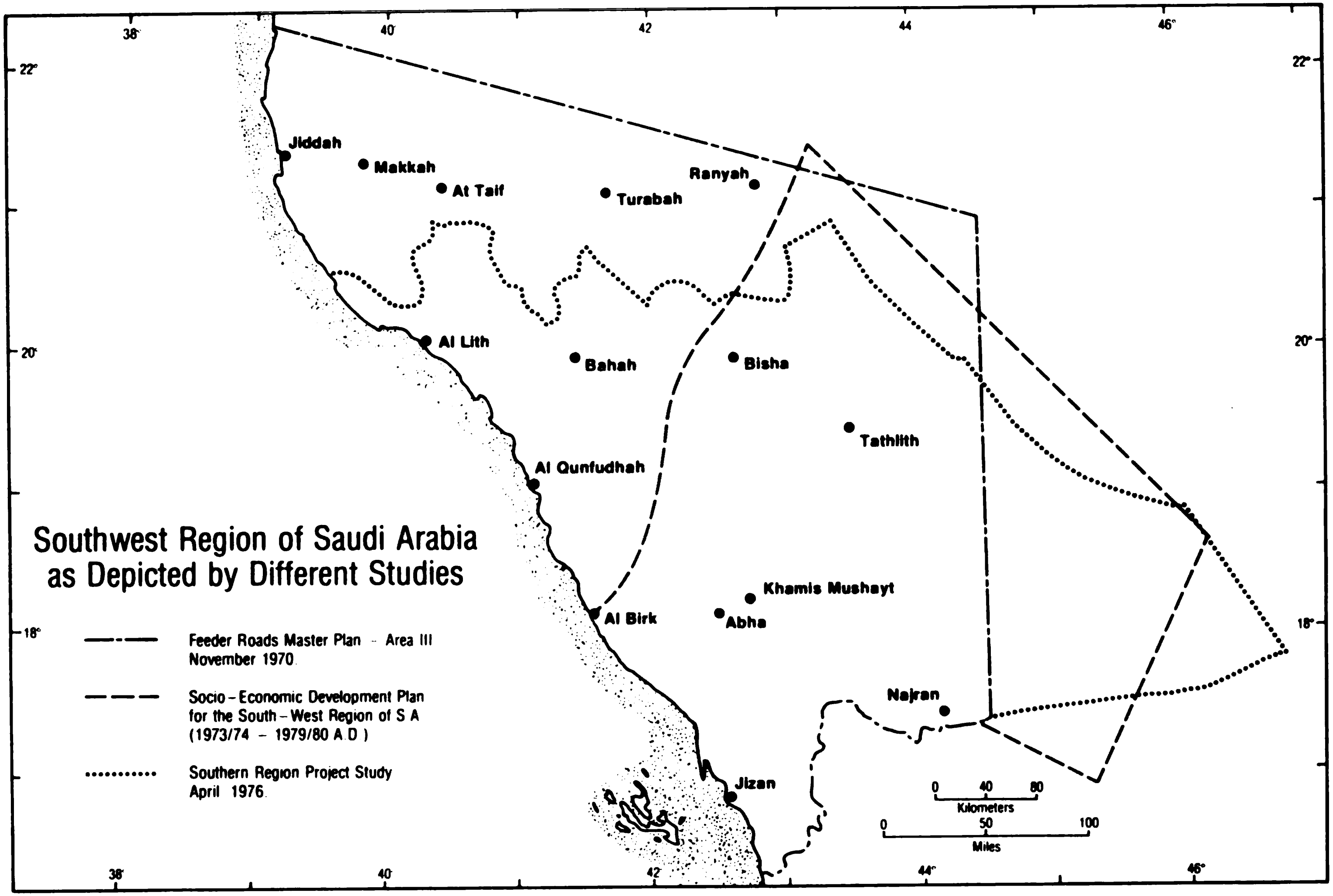

Figure 30. Lack of uniformity in the representation of the southwest region of Saudi Arabia as mapped by different sources.

Some research based on the 1962-63 census was published (Rajab, 1978, p. 20). Although the data available from this "census" were general and not detailed, it at least gave geographers and demographers some sketchy data. During the period 1963-1974, when these were the only population data available, population maps were published in papers and books that showed density and distribution in a general form. For example, Clarke and Fisher (1972) used the 1962-63 data for maps of population density and town and city size, despite their recognition that "the government repudiated the results" (p. 224).

In 1971, a Royal Decree was issued mandating a complete census of the population in 1974, and the years from 1971 to 1974 were spent in preparation for the census. Several problems were encountered in this census. Detailed, large-scale maps suitable for census work did not exist, so the C.D.S., with the assistance of the Department of Aerial Survey in the Ministry of Petroleum and Mineral Resources produced 700 maps at scales appropriate to population density, locating all settlements and roads (C.D.S., n.d., p. 5). These maps are restricted to official use only. Relying on these maps, the administrative division maps necessary for census counts were produced. Other problems included the absence of previous estimates of population numbers or designation of places; the scarcity of statisticians in general and enumerators in particular; the low popular awareness of the value of a census, which required intensive publicity; the location and enumeration of Bedouins, who seldom stay in one place year around; and the sheer distances involved among settlements in Saudi Arabia (Rizk, interview, 1981).

In 1975, a preliminary report of the census was published by the Central Department of Statistics (C.D.S., 1975). This report contained (1) a table of the total population in Saudi Arabia by administrative regions (settled and unsettled population); (2) a table for all towns of 30,000 or more, showing their total population and number of families; and (3) a section for each of the 14 regions, showing by emirates and subemirates the total number of settlements, number of families, and total number of settled and unsettled persons. Thus, the report offered only one characteristic of the population--settled or unsettled persons. Other variables such as age composition, sex composition, and so on, were not included.

In 1977, detailed data of the 1974 census were published in 11 volumes, some of which included more than one region. Sketch maps of the administrative regions and their emirates were included in each volume, but these maps are crude (Figure 31). Each volume also included introductory pages, tables listing the names of emirates and their subemirates with the combined number of villages and water resources in each subemirate, and the total population by sex of each emirate and its capital.

For each administrative region, there are 36 different tables in Arabic and English. Twenty-six tables provide data at the administrative-region level only and ten provide data on the emirate

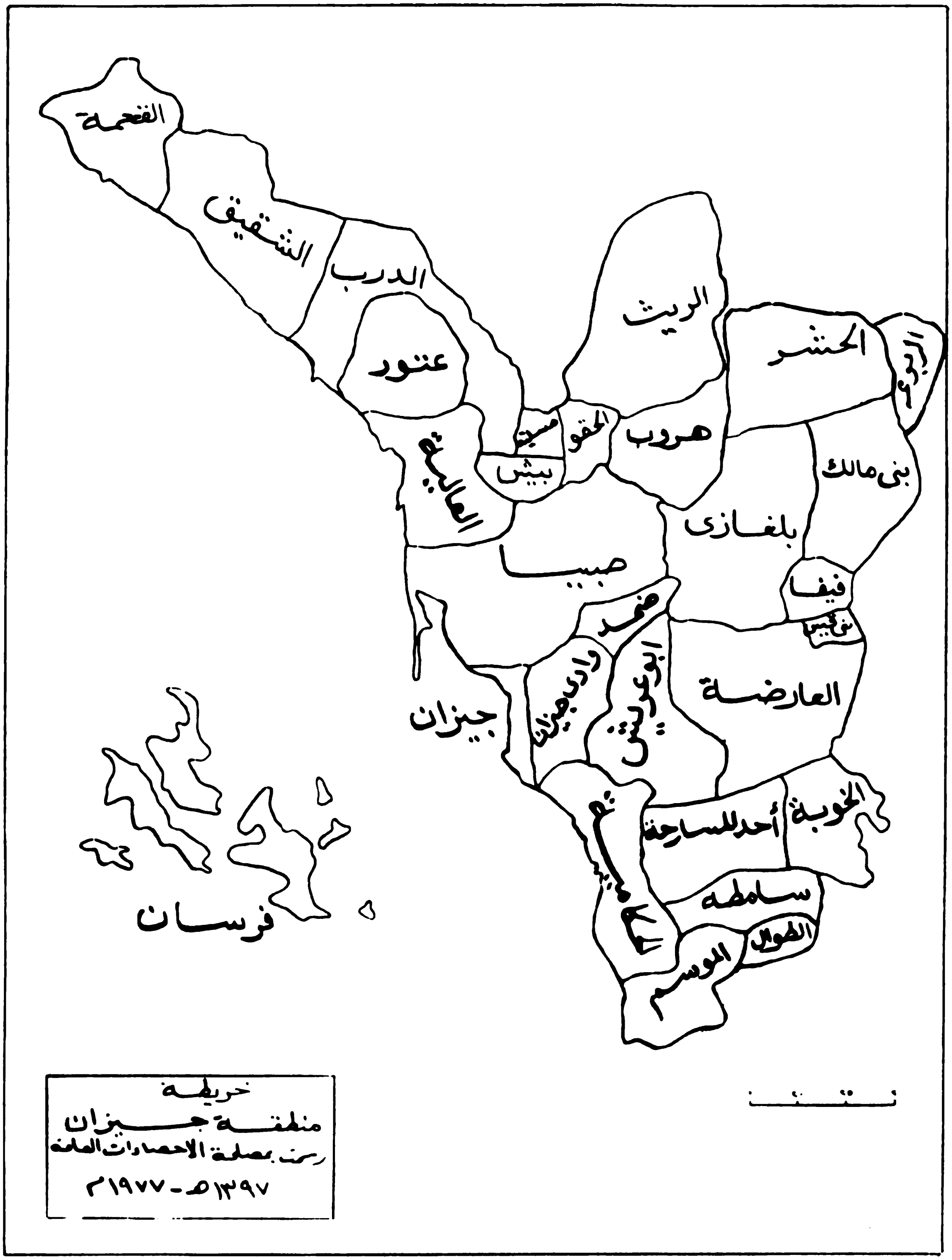

Figure 31. Reduced version of the census sketch map of the Jizan Region. This is one of 14 crudely drawn maps that exhibit problems such as gaps in boundaries, the absence of major towns, and labels that are misspelled or illegible in the Arabic.

level; no census data are provided at the subemirate, town, or village levels.

The Saudi Arabian 1974 census attempted to follow principles and recommendations of the United Nations for population censuses; however, the census failed to consider some of the recommendations (Tables 2 and 3). For geographic and migratory characteristics, only one variable, "place of enumeration," is used. This variable was used at the emirate level and divided into "emirate, villages, water points (or resources)." In terms of information about specific settlements, only emirate capitals are included. When an emirate contains several towns, only one of them (the capital) is shown; the others are included in the village category, which provides only one total number for all people living in villages in each emirate. For example, "Al-Mubaraz" town, which appears in the preliminary census with a total population of 54,325 and is the tenth largest town in the country, is not shown because it is not the capital of Al-Hasa Emirate. Its population is included in the general category "villages." Other geographical and migration characteristics recommended by the United Nations (1980) such as place of usual residence, place of birth, and duration of residence, which have great value for studies of internal and international migration, are not included.

The census does include, however, "age, sex, nationality, and marital status." "Sex" is cross-classified with all other characteristics of the population (see Tables 2 and 3). However, there are other important demographic characteristics not listed, including such variables that provide data on fertility and mortality, e.g.,

Table 2.--Contents of tables for the administrative-region level.

Census Table #	Population Category	Nationality	Age	Sex	Length Reside	Educ. Level	Marital Status	Employment Status	Economic Status	Occupation	Industry
58	Total	x	x	x							
59	Foreign	x		x	x						
60	Foreign		x	x	x						
62	10 yrs old and over		x	x		x					
63	10 yrs old and over	x		x		x					
64	10 yrs old and over	x		x		x					
65	12 yrs old and over	x		x			x				
66	12 yrs old and over		x	x			x				
67	12 yrs old and over			x		x	x				
68	12 yrs old and over		x	x				x			
69	12 yrs old and over	x		x				x			
70	12 yrs old and over			x		x		x			
71	12 yrs old and over	x		x					x		
72	12 yrs old and over		x	x					x		
73	12 yrs old and over			x		x			x		
74	12 yrs old and over			x					x	x	
75	12 yrs old and over			x					x		x
76	Working--12 yrs old and over		x	x						x	
77	12 yrs old and over	x		x						x	
78	Educational level of labor force			x						x	
80	12 yrs old and over			x						x	x
81	12 yrs old and over	x							x		x
82	12 yrs old and over			x						x	x
83	12 yrs old and over		x	x							x
84	12 yrs old and over	x		x							x
85	12 yrs old and over			x		x					x

Table 3.--Contents of tables for the emirates level.

Population Categories	Age	Sex	Place Enum.	Ed. Stat.	Nation-ality	School Attend	Ed. Cert.	Marital Stat.	Employ. Stat.	Econ. Stat.	Occup. Stat.	Indus. Stat.
57. Total	x	x	x									
61. 10 yrs and over		x	x	x								
87. Total		x			x							
88. 6-9 yrs		x	x			x						
89. 10 yrs and over	x	x					x					
90. 12 yrs and over		x						x				
91. 12 yrs and over		x	x						x			
92. 12 yrs and over		x	x							x		
93. 12 yrs and over		x									x	
94. 12 yrs and over		x										x

"children born alive," "children living," and "age at marriage." These data are particularly important in Saudi Arabia because of the lack of a timely and reliable system of vital statistics. Data about religion, language, and ethnic group are not included. The population data from the census are considered by C.D.S. officials to be accurate. However, for the purpose of population mapping and spatial analysis, the census is of a limited value since data were not provided for subemirate, town, or village levels. In fact, the administrative-region divisions used in the classification of the census data for the 26 tables are very large. The areas of the seven largest of the 14 administrative regions range from about 120,000 square kilometers in Hai to 780,000 square kilometers in Eastern Province. By comparison, the state of Michigan is 147,511 square kilometers, and Marquette, its largest county, is 4,718 square kilometers. Such large geographical units are considered undesirable for population mapping and spatial analysis because they obscure differences within the region. Use of the tables is complicated by the treatment of Al-Qusim region, which was tabulated by internal divisions not comparable with the other regions' emirates.

Population Mapping in Saudi Arabia

Before the informal census of 1963, there were no population maps published for the country. After the 1963 informal census, several maps appeared in books, dissertations, and articles. These small-scale maps were general, and the data were mapped within arbitrary geographic regions. Clark and Fisher (1972) included two population maps at a scale of 1:22,000,000 in their book. One is a town and city map using graduated circles, while the other uses the choropleth technique to show population density in Saudi Arabia in 1962/1963 (Figure 32). Because of the lack of an administrative-boundaries map, they used 18 geographical units or areas to show density; these were arbitrarily defined and named. There is no explanation in the map of the definition or source of these areas; in fact, the map mixes regions and emirates without distinguishing between them. Another example is a map by Beaumont et al. (1976), which uses an isopleth technique to show distribution and density of population in Southwest Asia in 1972 at a scale of 1:31,500,000 (Figure 33). The reliability of this map is questionable since no base maps of statistical units were available at the time, and one area, known to contain two towns of 10,000 persons each, is shown as "virtually uninhabited." The reports of foreign consultant companies sometimes included population maps, but these lacked detail and show only the areas in which the companies were working. Moreover, their boundaries do not follow any official administrative boundaries; thus it is difficult to compare them or use them in conjunction with maps from other sources (Figure 30).

The Atlas of the Kingdom of Saudi Arabia (1975) was the first published atlas for the country. Its 26 maps, drawn at a scale of 1:10,000,000 by undergradute students from the Department of Geography, Riyadh University, were compiled under the supervision of two faculty members at a scale of 1:10,000,000. Plate 12 is a population-density map using an isopleth technique. Very coarse line shadings with different arrangements and orientations have been used to show

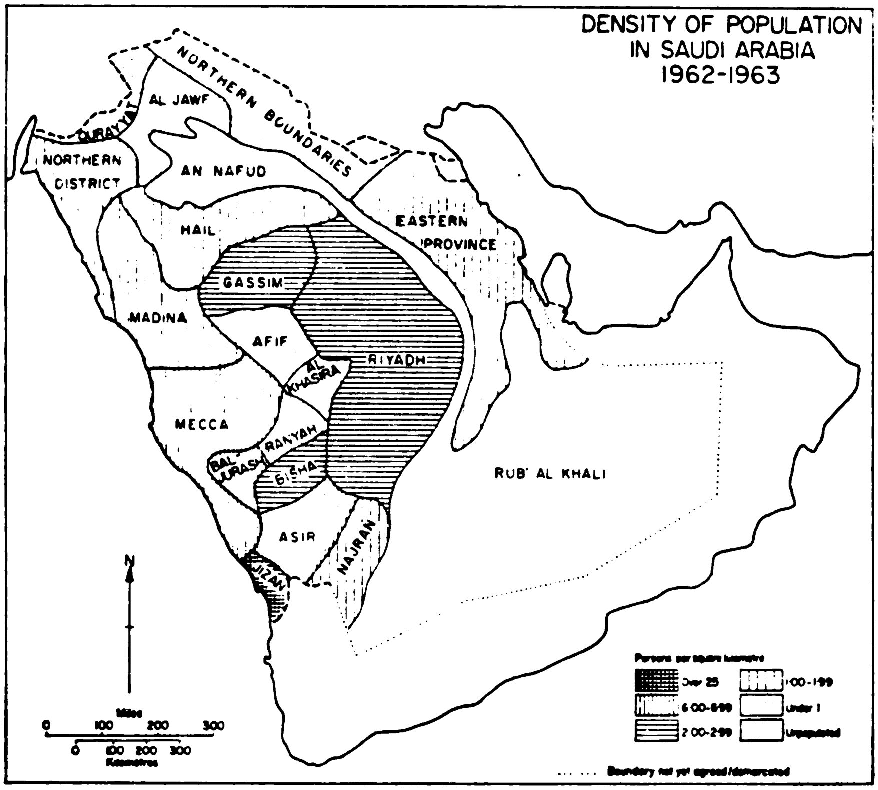

Figure 32. Clark and Fisher's choropleth map: Population density in Saudi Arabia. (From Clark and Fisher, 1972, Fig. 10.1, p. 226.)

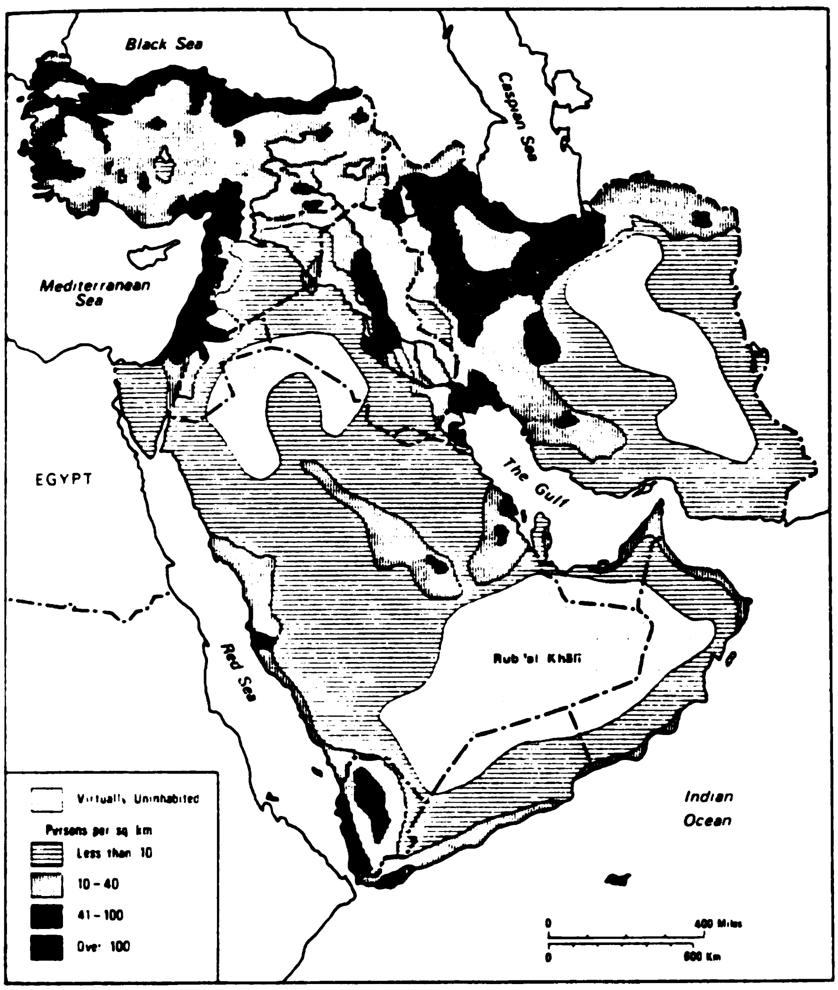

Figure 33. Beaumont et al.'s isopleth map: Density of population, Southwest Asia, 1972. (From Beaumont et al., 1976, Fig. 5.2, p. 185.)

four classes of density. There is no information concerning which year this map represents nor what kinds of data were used. Also, there is no explanation of how densities were calculated. This is of particular interest because the 1974 census of the country had not yet been published, and a source of density information such as the administrative-regions map did not officially exist. A second edition of the atlas appeared in 1977 and contains 36 plates, some of which are redrawn versions of the original 1975 maps. Seven of the maps deal with population. The first, titled "Settlement in Saudi Arabia," shows six classes of population centers, with graduated circles, some of which are difficult to distinguish. A second map used dots to symbolize distribution of population with one dot representing 100 persons (Figure 34). The dot value is too small, causing sparsely settled areas to appear densely populated. A third map shows density in six class intervals. Classes are discontinuous, and two pairs of class intervals overlap. The original density map in the first edition used isopleths, but in the second edition it has been changed to a choropleth map. Its cartographic shortcomings include a lack of pattern progression and discrepancies between some regional density values on the map and in the 1974 census. The fourth population map is meant to show the percentage of population in each administrative division in relation to the total population of the country. The map uses six class intervals, nearly all of which overlap. Figure 35 is a reduced version of the whole map, to illustrate the lack of progression in the pattern. Figure 36 is a portion of the map shown at actual size to show its coarse patterns. The fifth population map

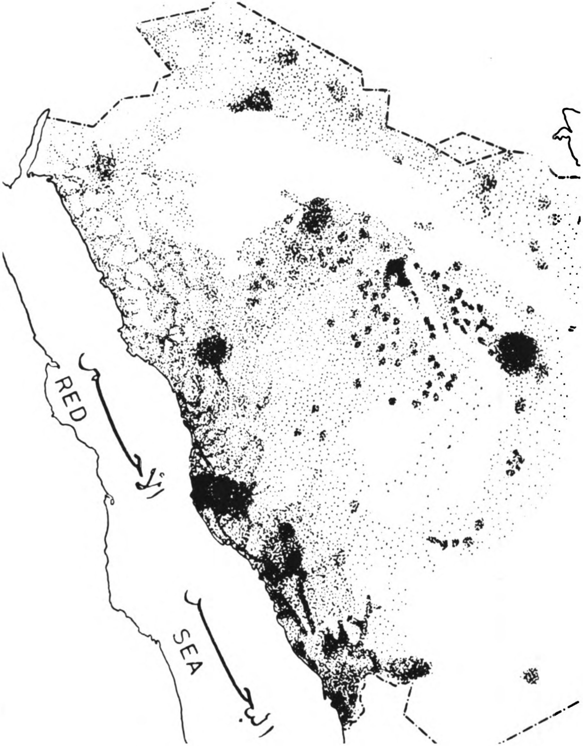

Figure 34. Population dot map of Saudi Arabia, with the dot value of 100 persons per dot. (From Atlas of the Kingdom of Saudi Arabia, 2nd ed., 1977, Plate 6.)

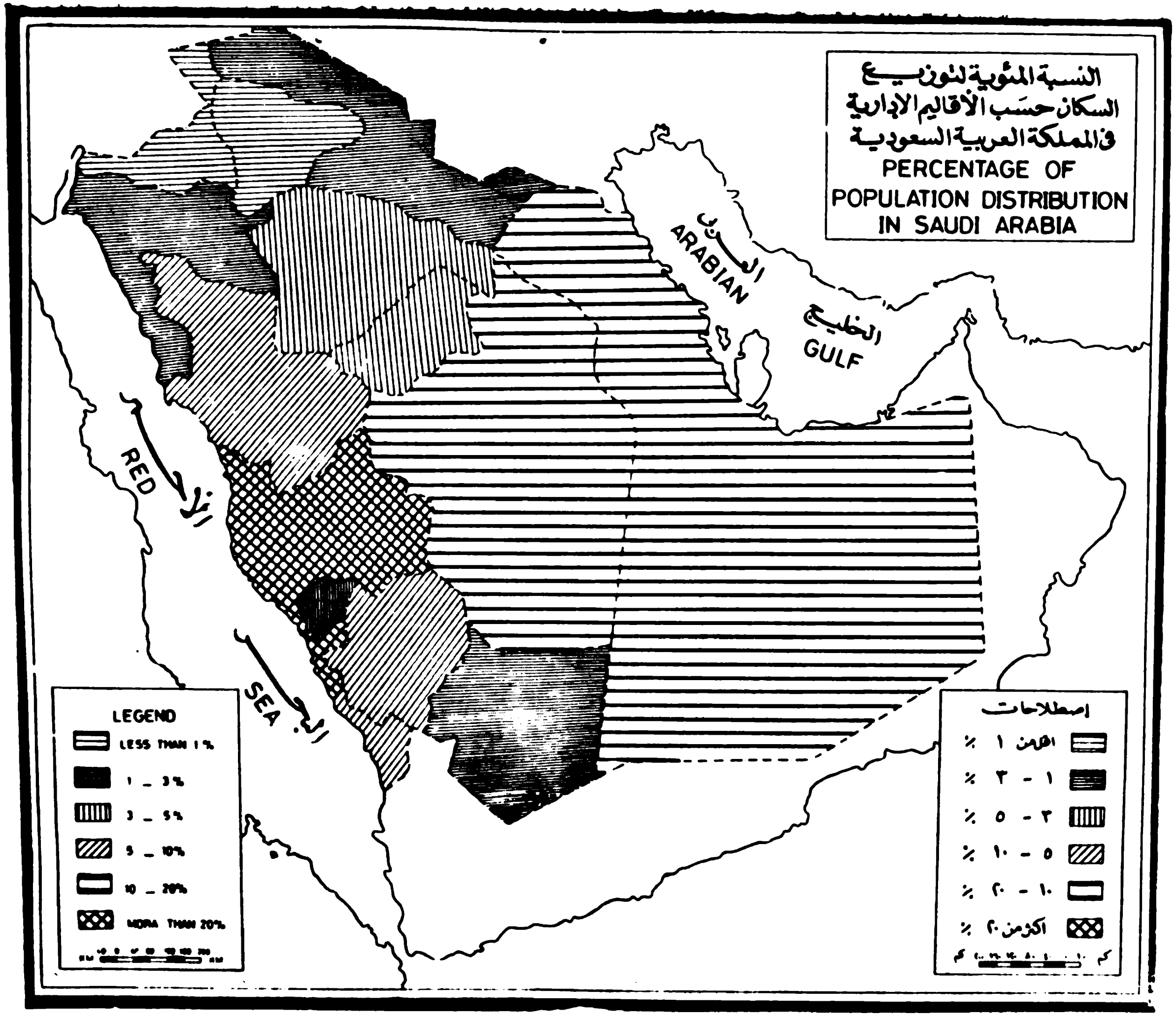

Figure 35. A reduced version of the fourth population map. (From Atlas of the Kingdom of Saudi Arabia, 2nd ed., 1977, Plate 8.)

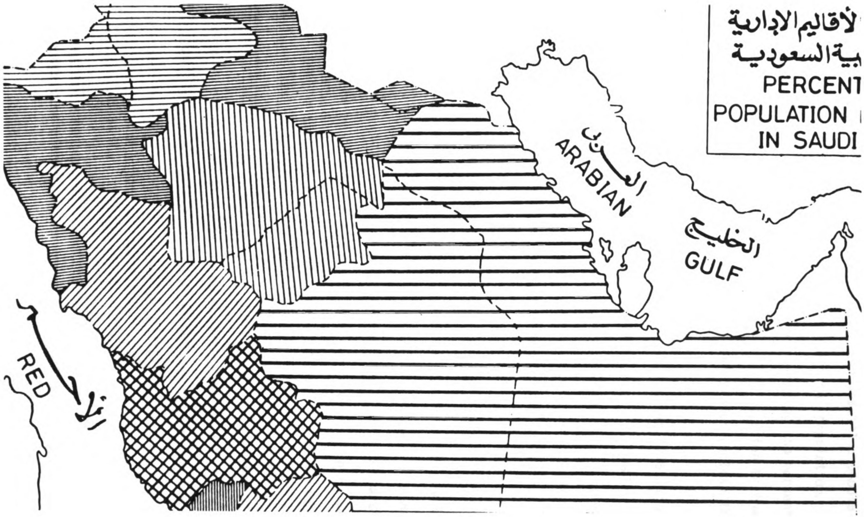

Figure 36. A portion of the fourth population map. (From Atlas of the Kingdom of Saudi Arabia, 2nd ed., 1977, Plate 8.)

uses graduated pie graphs to show settled and unsettled people in each administrative region and their relation to total population. The sixth and seventh maps are choropleths representing the percentage of settled and unsettled persons in each region in relation to the country's total population. Pattern progression is also unclear in these two maps.

A color version of the atlas was produced in 1978 and contains 61 figures which fall into three main groups: general maps, regional maps, and city maps. Six of the general maps concern population, and all have an approximate scale of 1:7,700,000. Four of these maps are identical to the maps in the black-and-white atlas published in 1977, except that they are in color. The other three maps differ slightly in data classification and presentation.

A Population Atlas of the Kingdom of Saudi Arabia, published in 1981, was prepared by the National Atlas Committee of the Department of Geography, University of Riyadh (now King Saud University). Final production was done by Esselte Map Service, Stockholm, Sweden. Data from the 1974 census were used to construct 13 maps of Saudi Arabia at the approximate scale of 1:8,300,000.

The atlas is a high-quality, full-color publication including a total of 14 maps and accompanying text. All the maps have an inset showing the boundaries of the administrative regions and their names. Maps are unnumbered and will be referred to in the order in which they appear.

Map 1 illustrates world population using dots and filled, graduated circles for population and six areal classes for population growth. Map 2 shows the boundaries of the 14 administrative regions, along with the names of the main cities and towns. Map 3 (Figure 37) uses dots to illustrate population and six areal classes for population density. Given the tabular data, seven of the 14 regions had too few dots and two had too many. One province was incorrectly classed for population density. Map 4 is one of three maps which combine choropleth patterns and graduated symbols. It shows by the choropleth hue the percentage of unsettled persons to the total population and, by segmented pie graph, the ratio of settled to unsettled persons in each region. The map appears to combine data from both the preliminary and final census reports to arrive at values for the percentage of unsettled persons, resulting in some minor incorrect percentages. Map 5 (Figure 38) illustrates urban population, using graduated, filled circles for cities and five choropleth hues for percentage of urban to total population in each region. The problem of using large geographic areas as choropleth units is clearly illustrated in the Eastern province, whose vast area is shown (in red color) to have an urban population of 50 percent or more despite the fact that 76 percent of its area consists of the Empty Quarter desert. Map 6, showing the percentage of rural people to the total population, combines dot and choropleth techniques. Again one province has been misclassed, and misregistration has moved some dots into adjacent regions. Population according to age and sex is shown by population pyramids in the seventh map, while population according to age and nationality appears in Map 8. The only simple choropleth map in the atlas, Map 9, displays average family size in five classes.

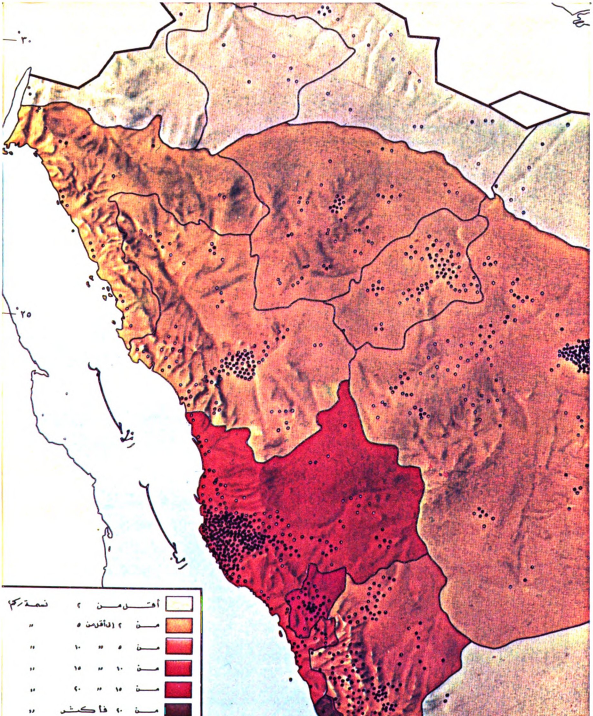

Figure 37. Population distribution and density map. (From Population Atlas of the Kingdom of Saudi Arabia, 1981, p. 10.)

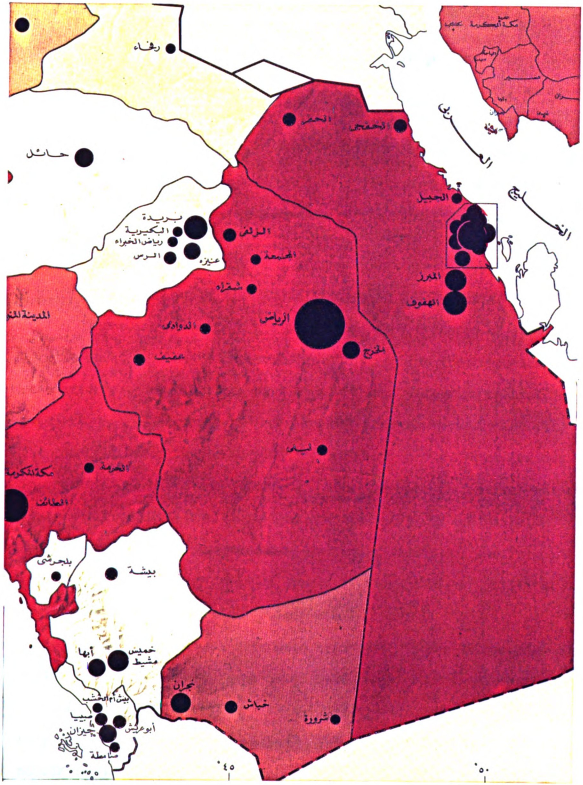

Figure 38. Urban population map. (From Population Atlas of the Kingdom of Saudi Arabia, 1981, p. 14.)

This is the third map containing a misclassed province. Map 10 illustrates marital status with superimposed bar graphs. Maps 11, 12, 13, and 14 all use segmented, graduated pie graphs to portray educational status and percentage of illiteracy, educational levels, economic activity and occupational structure, respectively. The maps are complex and require study, and the text illustrates the ambiguity that can arise when percentages of segments of the population, rather than the total, are discussed.

Evaluation of Population Mapping in Saudi Arabia

There are no large-scale population maps produced or published for the country. Two of the important requirements for large-scale population mapping--accurate base maps and data with high spatial resolution--are inadequate. There are no large-scale base maps for the country except the 1:5,000,000 series which suffers from few and incorrect place names and locations. Even the most fundamental map of administrative divisions, published only recently, is approximate, unofficial, lacks settlement names (including capitals), and is inconsistent in its depiction of levels of hierarchies of political divisions (regions, emirates, subemirates).

Most of the census data were tabulated (in the only census available--1974) on very large geographic units, or "administrative regions." Population mapping on such geographic units is considered very general and cannot show spatial differences. Only small-scale population maps found in thematic atlases published by individuals and academicians within Departments of Geography in universities are available. These suffer from many cartographic flaws caused by deficiencies in data and lack of good base maps. Other problems occur due to a lack of technical experience. Although gradual improvement in production quality has been observed, mistakes in reporting the data and errors in mapping the data occur often.

The population mapping activities of Saudi Arabia were evaluated according to the same 11 criteria applied to the five developing countries studied. The resulting score of 19 represents an acceptable level, a condition that is largely influenced by the adequacy of funding and facilities, though both factors are underused.

The Future of Population Mapping in Saudi Arabia

Population mapping in Saudi Arabia depends on several factors. The uncertainty of future population data collection and the lack of any officially sanctioned administrative or statistical units represent obstacles to population mapping. First, in terms of population data, only one census exists. The second population census for Saudi Arabia, originally projected for 1984, will not occur (C.D.S., interview, 1981), and future dates for census-taking have not been set. In any event, circulation of census information has typically been restricted. Projection of population for Saudi Arabia, if based on the available census (1974), will provide only general information that is unsuitable for population mapping. Second, there has been no governmental decision to make the administrative divisions (region, emirate, subemirate) official. The existing approximate boundaries are rapidly changing, and several small emirates have been absorbed by adjacent, larger ones. For example, Al-Ghotghout Emirate was added to

Almozahimiah Emirate, and Al Hair Emirate and Ergah Emirate were added to Al-Riyadh Emirate. Thus the only existing administrative boundary map in the country is outdated.

The growth of a body of trained professionals, the availability of funding for both facilities and equipment, and the on-going topographic coverage of the country represent beneficial factors for population mapping. First, departments involved in cartography are encouraging improvement of skills through scholarships for students and training programs for their staff, often involving travel overseas. In addition, introductory cartography courses are now offered in most Saudi Arabian universities. Second, departments and cartographic units in the universities and appropriate government agencies are unlikely to encounter problems funding improved facilities and equipment so long as their activities are perceived as beneficial to the country's development. Finally, although base maps are currently a problem, the on-going program of topographic mapping will provide an increasingly complete source of base maps which will, in turn, facilitate large-scale population mapping.

Given these facts, Saudi Arabia can undertake a number of steps to overcome its obstacles and capitalize on its advantages. Population censuses should be conducted at regular intervals. Problems associated with the 1974 census and discussed above, including missing variables and crude spatial resolution, should be remedied. Data should be disseminated not only for the regional and emirate levels but for the subemirates; town and village populations, which are not currently published, should be made available. A detailed, authoritative map of administrative boundaries should be compiled and published; this will contribute both to increased census accuracy and facilitate population mapping. Cooperation among the Central Department of Statistics, other government agencies, and the universities should be formally encouraged; and the C.D.S., given the detailed but restricted information it possesses, such as 700 maps containing most of the settlement names in the country, should have a mandate to provide assistance for any population mapping activity. Finally, current practice in government agencies fails to make the best use of skilled, trained personnel, whether they are natives who have studied abroad or foreign experts. In both cases, individuals are usually employed to perform a specific production function, when greater benefit would be derived by having these persons train additional native staff, thus enlarging the pool of cartographic expertise. In addition, geography departments in one or two of the universities should establish advanced cartographic programs to further develop local expertise.

Given a continuation of cartographic training and financial support for improved facilities, Saudi Arabia will be capable of producing a full range of modern cartographic products, from large-scale population maps to data models, three-dimensional graphics, and cartograms, whether in black and white or color, conventionally or with computer assistance.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

This study has investigated population mapping in developing countries: a review of its historical development, a critique of maps produced, and a survey of problems encountered. To facilitate the analysis and to obtain data and population maps, a survey was conducted in selected developing countries in Latin America, Africa, and Asia that represent a broad sample of the developing world. The survey revealed that most countries have some sort of population mapping and that those countries that have a long history of census activity and related mapping programs currently have the most successful population mapping programs.

Four major problems affect the availability and quality of population maps in developing countries. These are the inaccurate or irregular acquisition of population data, the scarcity or inadequacy of base maps, the low level of cartographic skill, and the inadequacy of production methods and facilities. The aim of the following discussion is to draw conclusions about the common features of such problems and to suggest general solutions.

Population Data

As of 1983, all developing countries in the world have had at least one census. The quality, character, and quantity of population data collected vary from one country to another according to their cultural characteristics, technical ability, experience in data collecting, and financial resources. Despite the importance of periodicity in census-taking, several developing countries will fail to meet census deadlines for the period 1980/1984 (United Nations, 1981). In this era of rapid and significant changes in the earth's demography, especially in developing countries, delay in conducting a census could have a serious effect on the rate of development.

Even when censuses are conducted, many problems are encountered that affect the accuracy and reliability of population data. Those problems include the lack of trained enumeration and skilled staff, inadequate census-taking experience, illiteracy of the population and distrust of censuses, enumeration by large statistical or administrative units, approximate or unstable unit boundaries, and political instability or influence. Even if the problems cannot be eliminated, it would be appropriate and useful to indicate such problems in the census volumes. Pretension to the accuracy of the census in all places and in every variable is not conducive to the country's development.

Despite these prevalent problems, developing countries are attempting to improve their census-data situation. Outside aid is being provided in the form of visiting experts and advisors, training abroad, and donations of equipment. Statistical departments in developing countries are beginning to use computers for tabulation and publication, and some for data storage. The computer process, assuming the availability of skilled programmers and technicians, should help solve two major limitations of present censuses. One is delay in compilation and publication of census data, and a second is the low level of geographical resolution of census tables. The computer can rapidly manipulate data at a much higher and, therefore, much more useful level of geographic resolution than otherwise possible.

Brazil is a good example of a developing country that has crossed this crucial threshold. Brazil's 1970 census was stored, tabulated, and published by computer. About 2,000 indicators/ variables from population, industrial, agricultural, and other census for each county, micro-region, state, and macro-region were stored in the data base. For population alone, there are approximately 150 indicators at the census-tract level. These data are available to demographers, analysts, and cartographers (Faissol, interview, April 1981).

Base Maps

Usually, large-scale topographical maps are used as the primary input for creating census base maps. They are also used by geographers and cartographers to insure accurate population mapping. During the period 1968 to 1974, the average annual progress rate in large-scale topographic mapping was around 1.3 percent. Brandenberger (1976) believed that due to the universal use of maps, it is reasonable to assume that map production and revision should progress as rapidly as population growth. U.N. figures depicting the percentage of map coverage and population growth index for the period 1960 to 1980 indicate that this assumption applies only for the developed countries, while topographic coverage in developing countries, though expanding, still lags behind population growth. By 1974, approximately 57 percent of the world's area was reported covered by large-scale topographic maps; most of the area not reported or uncovered is found in developing countries.

Population maps are also dependent on accurate location of census (statistical) or administrative unit boundaries. In most of the countries, the boundaries of such units are approximate, and their sizes are inappropriately large for data collection or data display. Boundaries may be approximate due to inadequate topographic survey or to political influence. Census departments in developing countries need to provide authoritative boundary or statistical unit maps for their censuses, if those countries' national mapping agencies do not do so. This could be carried out as an adjunct to their census work. However, such agencies normally can do no more than point out boundary discrepancies, and the decisions to rectify such situations are normally not within the scope of their delegated authority (Gordon, 1975, p. 4). Detailed administrative or statistical outline maps that show the smallest statistical units for which data are available should be put in each census volume. Additional maps should show the location and names of cities, major towns, and villages. Providing these base maps as a part of the census publication is extremely important in developing countries, where base maps frequently do not exist.

Some countries have inherited base mapping from colonial governments but cannot update or revise what they have locally because the governing power never intended to create an organization capable of operating without its support. Aid and training for developing countries should build local ability and control. Ideally, this is the motive behind the United Nations' programs in these countries. As Dickson (1970) stated, "technical cooperation in mapping is one of the most useful forms of assistance that can be given by developed countries" (p. 135).

Cartographic Skills

One of the important factors in the progress of population mapping is the close collaboration between population geographers and cartographers. Population geographers bring to mapping a knowledge of population distribution, composition, and growth as these factors relate to spatial variation in the nature of places (Clarke, 1972). Cartographers bring experience in techniques for effectively and accurately portraying data on maps and in the technical aspects of map production. Members of each group are often conversant in the other's methods, but their cooperation makes the best use of the expertise in both fields. The need for these two groups of specialists in developing countries is clear.

The study and evaluation of population maps for selected developing countries indicated that cartographic principles are frequently violated. The most common include incorrect choropleth classing and shading, the use of statistical units of different levels or of inappropriate sizes, poor dot-value selection and placement, excessive base information, and absence or inadequacy of legends.

In only two countries surveyed did geographers and cartographers play an active role in the publication of large-scale population maps, Kenya and Brazil. For example, Instituto Brasileiro de Geografía e Estadística (IBGE) was established in 1940, began operations in 1946, and has been an important factor in the development of thematic mapping. The Institute is a statistical and mapping agency that publishes reasonably high quality thematic maps. The Institute usually publishes two maps with each census, one on the status of the population and the other a population-change map. The IBGE follows the guidelines of the International Geographical Union (IGU) for publishing population-distribution maps at a scale of 1:1,000,000 (Figure 39). They have published 35 sheets out of a total of 45 required to cover the country. Moreover, IBGE has planned the production of three classes of atlases: a National Atlas published in 1979, regional atlases for five macro-regions, and state atlases for each of the 22 states, five of which have already been published.

The Geography Department of the IBGE has approximately 100 geographers and cartographers, while the group working on the national atlas employs 35 to 40 geographers and 20 cartographers, as well as people in auxiliary positions. The cartographic quality of their work is generally high in terms of technique used and color reproduction.

The IBGE is unique in having both the technological capability and skilled native staff to produce maps from the field-work stage through compilation, scribing, photography, platemaking,

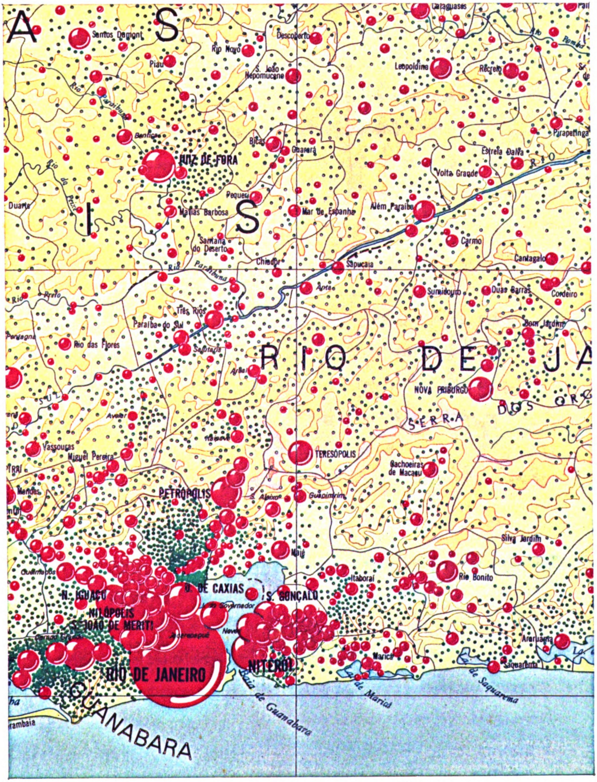

Figure 39. Brazilian population-distribution map at a scale of 1:1,000,000. (From the IBGE, Sheet No. SF-22/23/24, 1973.)

printing, and sales-distribution steps (Faissol, interview, April 1981). Brazil has no comparison among the other developing countries, a fact that is emphasized by the perfect score the country received according to the 11-criteria evaluative process.

The solution to such problems lies in cartographic education and training programs. Needed is a pool of cartographers able to do cartographic analyses and work for a variety of government agencies. Some developing countries, especially in Africa and Asia, bring in foreign cartographers to occupy permanent jobs and perform cartographic work. It would be more appropriate if thsoe foreign cartographers were used to train local technicians. Concurrently, additional specialists could receive training abroad where quality cartographic centers are located. At a later time, cartographic centers would be established within the developing country by those people who have received overseas training/education.

Production Methods and Facilities

In general, there are three map-production methods available to developing countries. The first is ink drafting with manually constructed symbols or preprinted symbols. The second is photomechanical construction using screen tints, peelcoats and other such techniques to produce maps. The third and most recent development is computer-assisted mapping. Among developing countries, cartographic offices lack essential materials and equipment needed to produce maps with modern techniques. Only Brazil's IBGE cartographic offices have modern scribing and photographic equipment, and in the last four years they have started mapping with computers. Almost all other developing countries lag behind the developed world in computer applications. Although some computer installations are found in Southeast Asia, Latin America, and Africa, they are employed for mostly clerical work and are obtained more as status symbols than for improving data manipulation, storage, and display (Nilsen, 1979, p. 517). Computers are a necessary tool for developing countries as a production method for population mapping because of the huge amount of data involved and the rapid change and shifts of population that often occur. Computers can also aid map production where drafting and basic skills are scarce; produce kinds of maps that are extremely difficult or impossible to produce by hand; and facilitate experimentation with differing geographical representations of the same data.

Brazil is one of the developing countries that uses computers in producing population maps in the offices of the IBGE. Using foreign training at Harvard, the IBGE acquired SYMAP and CALFORM. After digitizing the country, they began to use CALFORM and other programs in making thematic maps, including population maps (Figure 40). They are now working to digitize all counties in Brazil and census tracts for some cities (Magalhaes and Menezes, interviews, April 1981). The IBGE firmly believes that computer-assisted mapping is valuable in that it decreases cost and time. However, they have also found that computer-assisted mapping has some disadvantages. They estimate that map quality decreases 30 to 40 percent and that, because of this, the new national atlas of Brazil (based on the 1980 census) will include

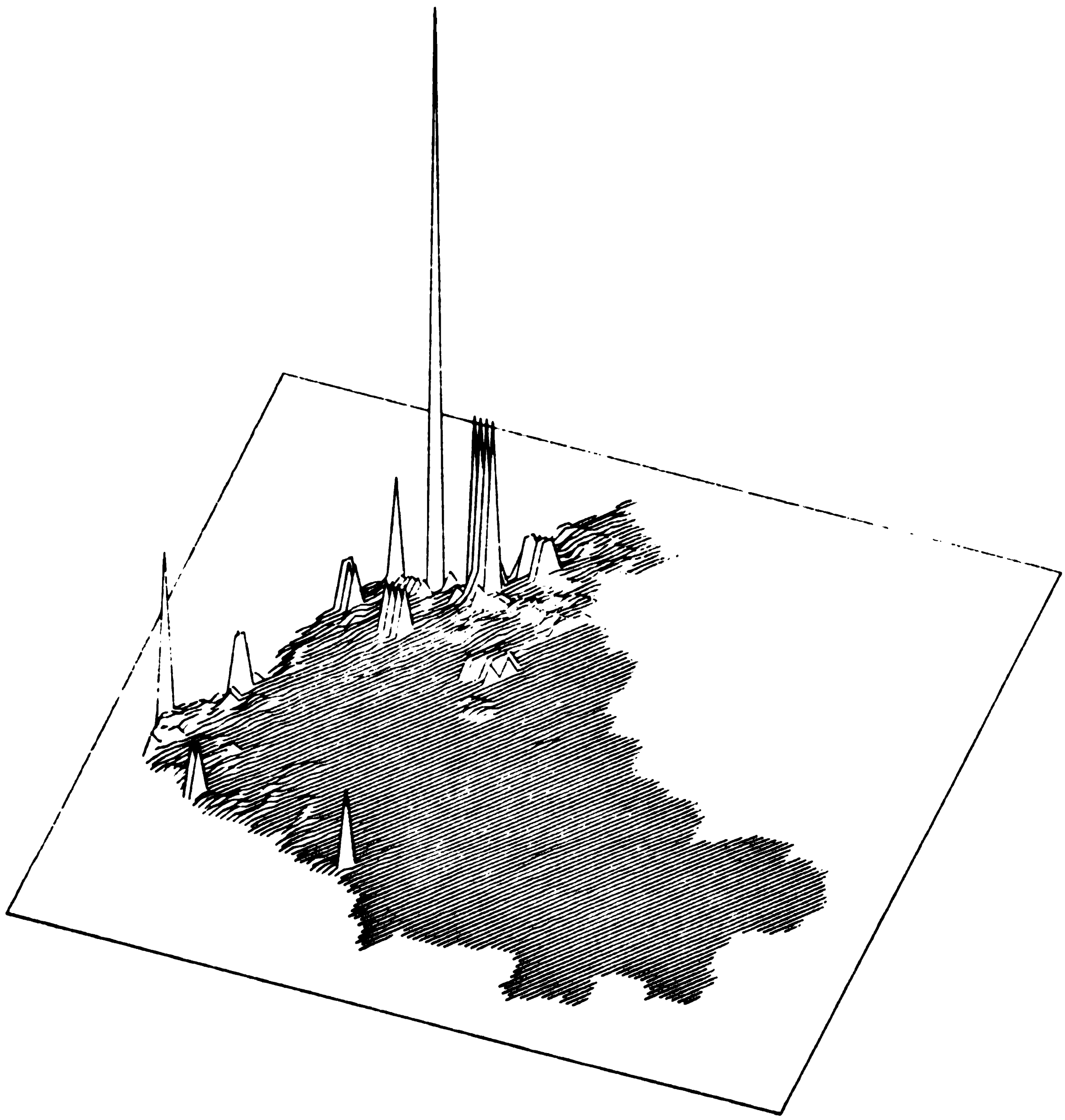

Figure 40. Brazilian population-density map of a microregion, produced using the SYMVU computer package. (From the IBGE.)

some computer-assisted mapping, but only those maps that cannot be easily produced by other methods (Faissol, interview, April 1981).

Recommendations

Developing countries can improve their population-mapping capability. The problems discussed in this study suggest that improvement could be effected by increasing cooperation between academic institutions and government agencies, developing an awareness in use of appropriate cartographic techniques, establishing a set of uniform mapping standards, instituting an on-going program of cartographic training, eliminating political influence on census collection and mapping, providing sufficient funding to maintain census and mapping programs, and encouraging the growth of graphic literacy in the population as a whole.

Academic geographers and cartographers must cooperate with census departments in developing countries. For example, in Sudan, geographers were given access to detailed data and detailed maps which were not published with the census, and conducted their own investigation of population distribution simultaneously with the census. As a result, several population maps were produced that could not have been compiled directly from the published figures (Barbour, 1961).

Responsibility for data and base map source validation could be delegated to an academic facility within regions because cartographers and geographers who live in those regions are more familiar with them. This work could be supervised by a national agency that would establish general guidelines and be responsible for map preparation. As an example, in Saudi Arabia there are six universities in six different regions of the country. Each university has a geography department which could assume responsibility for collecting data and preparing base maps for its area. Maps and data could then be organized by a central national committee. This committee would then be responsible for preparing and publishing final population maps.

There should be a more careful selection of cartographic techniques used to display data. For example, choropleth mapping should not be used without modification in countries that have only large geographical or administrative statistical units. Calculated population density or other population characteristics based on such large units are often misleading. Dasymetric techniques should not be used where boundaries are poorly defined. Prothero's technique could be employed where small collection units are absent. This list of cartographic improvements ranges from major design considerations to minute decisions on such items as choropleth class intervals. Whatever the level of expertise, considerable improvement in cartographic choice is strongly recommended.

Developing countries should establish uniform mapping standards for base map content, map scale, and geographic level of data display without limiting cartographic creativity and progress. In addition, up-to-date indices should be kept for all maps produced. This is particularly important for population maps because population growth, settlement patterns, and migratory patterns can be followed over the years and possibly projected into the future.

Developing countries need to establish a sound native cadre of individuals with cartographic expertise and skill capable not only of producing maps but who have the capability to train additional personnel, thus creating a self-sustaining, professional community. The first step may require training in cartographically advanced countries not only in production techniques but also in the theoretical basis of cartography. Those trained should be expected to train others when they return. Emphasis should be placed on keeping pace with current developments through professional societies, maintaining familiarity with the literature, and attending international proceedings such as those of the IGU and the ICA.

Population censuses, scientific research, and governmental mapping programs should not be hampered by political types. To do so results in an inaccurate picture of the country, not only externally but internally as well. For example, it is very hard to make accurate plans and projections of a country's future if the current information and data are incorrect, inadequate, or unavailable.

The governments of developing countries must be prepared to provide sufficient funding to train and support the necessary staff and to equip the facilities necessary to maintain a regular program of national census and population mapping.

The final recommendation concerns graphic literacy in general, not solely in regard to population maps. In developing countries, the awareness and general use of maps is very limited, perhaps since very few maps are available, and those that do exist are not well-circulated. This is related to the educational system in the schools and universities where maps are rarely used. In some developing countries, policy-makers often do not think in spatial formats, and they seldom use maps to complement their development planning programs. This problem should be approached from the most elementary level. Educational planners should ensure that students are exposed to maps so they will learn to comprehend and appreciate their role and value in today's world.

APPENDICES

APPENDIX A

THE NINE MAPS IN THE BUREAU OF CENSUS GE-50 SERIES DEALING WITH POPULATION DISTRIBUTION, DENSITY, CHANGE, AND MIGRATION

APPENDIX A

THE NINE MAPS IN THE BUREAU OF CENSUS GE-50 SERIES DEALING WITH POPULATION DISTRIBUTION, DENSITY, CHANGE, AND MIGRATION

No. 1 --Population Distribution, Urban and Rural, in U.S.: 1960

No. 37--Year of Maximum Population by Countries of U.S.: 1970

No. 38--Population Density by Counties of U.S.: 1970

No. 39--Percentage of Urban Population by Counties of U.S.: 1970

No. 41--Percentage Change in Population by Counties of the U.S.: 1960-1970

No. 42--Population Trends by Counties of the U.S.: 1940-1970

No. 43--1970 Population as a Percentage of Maximum Population by Counties of the U.S.

No. 44--Net Migration by Counties of the U.S.: 1960-1970

No. 45--Population Distribution, Urban and Rural, in the U.S.: 1970

APPENDIX B

POPULATION MAPS OF JAPAN: 1975 POPULATION CENSUS

APPENDIX B

POPULATION MAPS OF JAPAN: 1975 POPULATION CENSUS

No. 1 --Population Distribution; 1,000,000; 1978

No. 2 --Population Density; 1,500,000; 1977

No. 3 --Rate of Population Change; 1,500,000; 1977

No. 4 --Percent Working Age Population; 1,500,000; 1977

No. 5 --Ratio of Aged Population; 1,500,000; 1977

No. 6 --Ratio of Children and Aged Population; 1,500,000; 1977

No. 7 --Number of Persons Per Household; 1,500,000; 1977

No. 8 --Percent Family Nuclei; 1,500,000; 1977

No. 9 --Percent Employed Households; 1,500,000; 1977

No. 10--Number of Tatami per Household Member; 1,500,000; 1977

No. 11--Number and Change Rate of Workers Employed in Primary Industry; 1,000,000; 1978

No. 12--Number and Change Rate of Workers Employed in Secondary Industry; 1,000,000; 1978

No. 13--Number and Change Rate of Workers Employed in Tertiary Industry; 1,000,000; 1978

No. 14--Percent Workers Employed in Industries (3 sectors); 1,500,000; 1978

No. 15--Ratio of Workers in Clerical, Technical, Managerial Occupations and Workers in Production and Transport Occupations; 1,500,000; 1978

No. 16--Ratio of Day- and Night-Time Population; 1,500,000; 1978

No. 17--Workers and Students Commuting to Large Cities; 500,000; 1978

No. 18--Ratio of Immigrants; 1,500,000; 1979

No. 19--Percent Households With Old-Age Related Members; 1,500,000; 1979

No. 20--Persons Engaged in Retail Trade and Personal Services per 100 Population; 1,500,000; 1979

No. 21--Percent Workers Employed in Primary Industry by Place of Work; 1,500,000; 1979

No. 22--Percent Workers Employed in Secondary Industry by Place of Work; 1,500,000; 1979

NO. 23--Percent Workers Employed in Tertiary Industry by Place of Work; 1,500,000; 1979

APPENDIX C

WORLD POPULATION MAPPING AND THE INTERNATIONAL GEOGRAPHICAL UNION (IGU)

APPENDIX C

WORLD POPULATION MAPPING AND THE INTERNATIONAL GEOGRAPHICAL UNION (IGU)[1]

In 1933, Sten de Geer proposed that the International Geographical Union sponsor the production of a population map at the scale of 1:1,000,000 showing the geographical distribution of world population by the dot method. It would, he suggested, provide a basis for future discussions on the regional incidence of overpopulation and its underlying causes (William-Olsson, 1963a, p. 245). Furthermore, the work could be done in his geographical institute in Goteborg (Soderlund, 1937, p. 548). Several population maps had already been done there, including some by Sten de Geer mentioned in Chapter II.

In the following years, several notes on this project were presented to meetings of the IGU Congress. At its meeting in Rio de Janeiro in 1956, a special committee was appoined to formulate some guiding principles on population mapping. These would be used with the results of the 1960 population census. Through IGU National Committees, contacts were made with population geographers in most

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[1]The IGU was founded in 1923 "to encourage the study of geographic problems, to initiate and coordinate research requiring international cooperation, and to provide for their scientific discussion and publication, to provide for meetings of the International Geographical Congress, and to appoint commissions for the study of special matters during the intervals between Congresses" (Lock, 1976, p. 372). One of the commissions was the Commission of World Population Mapping, appointed in 1956.

parts of the world, and population maps from different countries were brought together. Thirty-one of these population maps were exhibited at the International Statistical Institute meeting in Stockholm in 1957 (William-Olsson, 1963a, p. 244).

A general rule adopted in Zurich in 1958 stated that each country is responsible for its own mapping and that the IGU only formulate guidelines. Since general agreement suggested that some kind of dot map would be the most appropriate form, the IGU Special Committee made that a part of its recommendations at a meeting in London in 1961. The recommendations were then sent to all the corresponding members.

At a meeting of the commission in Wiesbaden in 1962, it was decided to discontinue its functions and to wind up the program in which the commission was then involved (William-Olsson, 1963a). In 1964, at the IGU Congress meeting in London, another commission was established. This was the Commission on the Geography and Cartography of World Population, and its purpose was similar to that of the commission it had replaced.

At the Belgrade meeting in 1965, the new commission formulated a program that included two bibliographical projects, one a bibliography of population maps, the other a glossary of terms used in population geography (Lock, 1969, p. 448). However, an extensive search for this material has not led to any information about these two projects or other activity of the commission.

The Commission of World Population Mapping served two terms, from 1956 to 1964. One might agree that the commission "has not succeeded in accomplishing its aim to exhaust the topic" (William-Olsson, 1963b, p. 288). However, the cause was not lost entirely. The commission performed a valuable service for geographers and cartographers by conducting experiments to find the best types of symbols needed to present accurate representations on population, such as the Psychophysical Study of Cartographic Symbols by Ekman and others (1961). Through the interest generated and assistance provided, numerous countries produced population maps. Several developing countries mentioned in the literature as having published population maps (some for the first time) in accordance with the recommendations of the IGU include Kenya, Ghana, Uganda, Mexico, Turkey, India, and Cambodia. In general, however, the appeal of the IGU was accepted by geographers, mostly academic, in various countries, and especially in developing countries where encouragement and guidance were much needed. It would have been more helpful and productive if that guidance and encouragement had been accompanied by financial aid, something that did not exist at the IGU.

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