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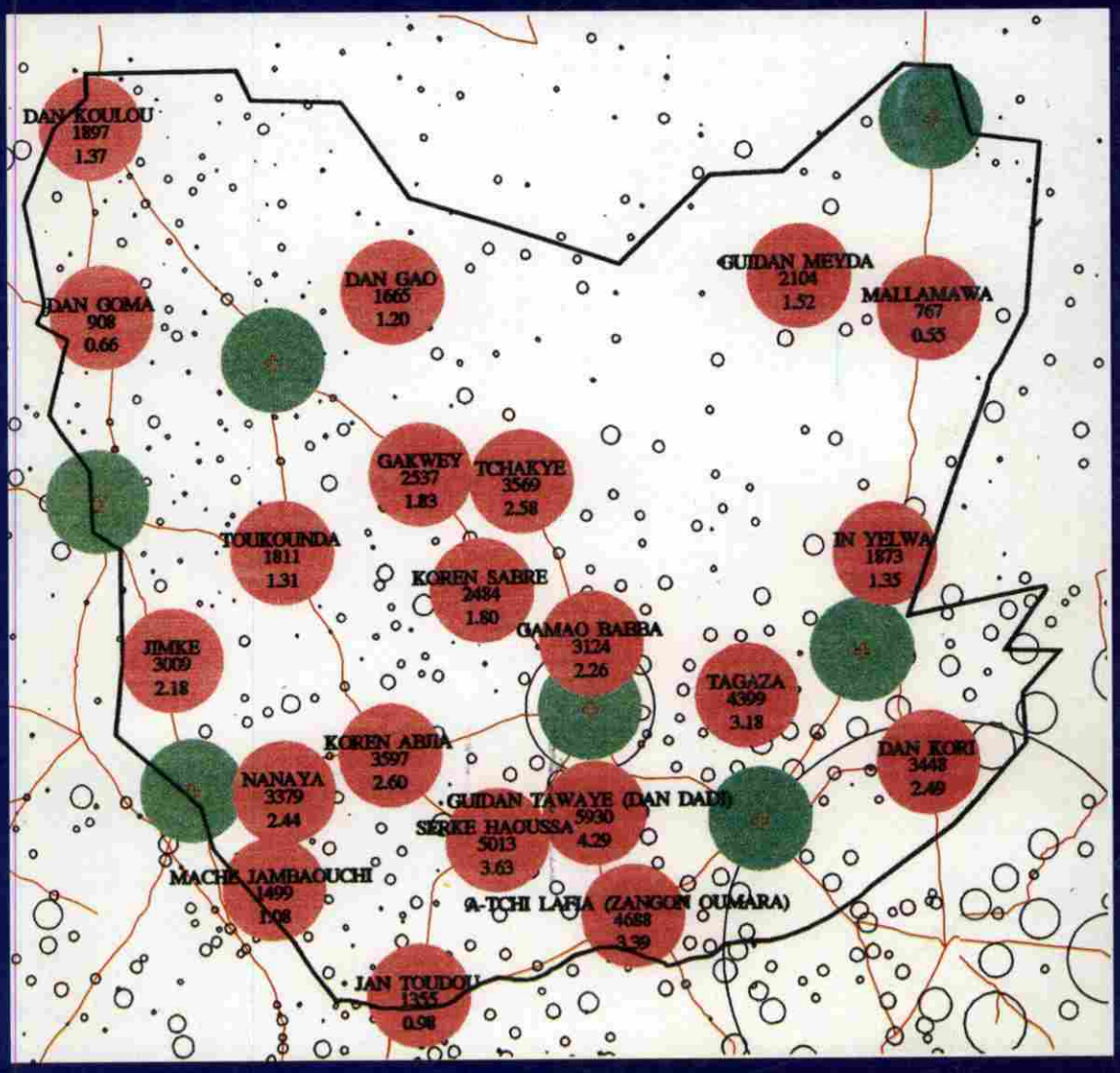
GOVERNMENT OF NIGER

CILSS

AGRHYMET CERPOD/INSAH

POPULATION, HEALTH AND ENVIRONMENT IN NIGER

A GEOGRAPHIC INFORMATION SYSTEM (GIS) PERSPECTIVE



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EXECUTIVE SUMMARY

*"**Population, Health and Environment in Niger**" was a USAID-financed project executed during 1994 by the Government of Niger and two CILSS (Inter-State Committee for Drought Control in the Sahel) institutions: AGRHYMET, the Center for Agricultural, Hydrologic and Meteorologic Research, and CERPOD, the Center for Applied Research in Population and Development. The goal of this project was to develop a GIS-based presentation showing multisectoral relationships using Niger data from the 1988 Census, the National Health Information System, and the environmental sector. The work completed for this project was presented at the International Conference on Population and Development, held in September, 1994, in Cairo, Egypt.*

The project had five principal goals:

i) To assess the suitability of currently available data to GIS uses, both in terms of content and quality;
ii) To assess the applicability of current GIS technical efforts to ongoing government activities;
iii) To link available databases and perform multisectoral analysis based on these data;
iv) To present the potential of GIS-based methodology and analysis to a variety of international donors and government and non-governmental agencies;
v) To provide a foundation for long-term collaborative efforts between AGRHYMET and CERPOD and a variety of Nigerien institutions.

The project was a pilot effort in a number of ways. Not only did it provide the opportunity for an initial collaborative effort between AGRHYMET and CERPOD, but it was also the first comprehensive effort among CILSS institutions to link multisectoral data in a spatial context using GIS. It should be noted that the findings of the project were also of a preliminary nature: the primary goal of the project was to explore a methodology, and not necessarily to produce accurate analytical results through that methodology. Thus results presented in the pages and maps that follow should be considered as an initial foray into the practical applications of GIS technology to actual data.

INTRODUCTION

GIS (Geographic Information Systems) could serve as a valuable tool for the analysis and presentation of population, health and environmental sector-related data. The numerous potential applications of GIS-based analysis to governmental, non-governmental and donor-based projects as well as the uses of GIS technology in decision-making for multi-sectoral planning in areas such as reproductive health, nutrition, educational development, agricultural development, natural resource management and disease control projects were just beginning to be explored. These areas also constitute the main focus of formal Sahelian population policy, which, along with other international population conventions (including Action 21 of the 1992 Rio Summit), aim at closely linking population, resources and development in an effort to attain a sustainable way of life (*Pop Sahel* n° 20).

With the numerous possibilities of GIS-based technology in mind, two leading Sahelian research institutions have joined forces with a national government to create an unprecedented effort in collaboration and creative thinking. "Population, Health and Environment in Niger" was a USAID-financed project executed during 1994 by the Government of Niger and two CILSS (Inter-State Committee for Drought Control in the Sahel) institutions: AGRHYMET, the Center for Agricultural, Hydrologic and Meteorologic Research, and CERPOD, the Center for Applied Research in Population and Development. The goal of this project was to develop a GIS-based presentation showing multisectoral relationships using Niger data from the 1988 Census, the National Health Information System, and data from the environmental sector. The work completed by this project was presented at the International Conference on Population and Development, held in September, 1994, in Cairo, Egypt.

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NIGER[1]

POPULATION

Niger is a landlocked West African country bordered by Algeria, Libya, Benin, Nigeria, Burkina Faso, Mali and Chad. The 1988 Census of the Republic of Niger reported 7,248,000 inhabitants. Based on population projections, the population in 1993 was estimated at 8,615,044 persons. The majority of the population lives in the southern zone of the country where ecological conditions were the most favorable to agricultural activities, while the northern portion of the country remains sparsely inhabited. Due to this environmentally-influenced settlement pattern, three quarters of the population of Niger reside on only one quarter of the national territory. As a result of environmental constraints and the steadily increasing population (a population growth rate of 3.3% and a doubling time of only 21 years), population-related issues have assumed great importance in governmental policies, and a National Population Policy was adopted in 1992. The 1992 Demographic and Health Survey of Niger found a contraceptive prevalence rate of 2.3 percent for modern methods and an overall contraceptive rate (modern and traditional methods) of 4.4 percent.

HEALTH

The Ministry of Public Health is responsible for the administration of Niger's health services. The Ministry is comprised of 7 centralized departments, as well as decentralized service provision facilities made up of Departmental Health Directives (DDS), Medical Centers (CM), Medical Posts (PM), Rural Dispensaries (DR), Neighborhood Dispensaries (DQ), Departmental Hospital Centers (CHD), National Hospitals (HN), and specialized health centers and teaching establishments. Niger's health profile is characterized by the continued presencé of contagious and parasitic diseases such as malaria, tuberculosis, measles, leprosy, schistosomiasis and dracunculiasis (Guinea Worm). The infant mortality rate for the country is one of the highest in Africa at 123 deaths per 1000 live births. By combining this with the child mortality rate (1 - 4 years of age) of 223 deaths per 1000 live births, it is found that nearly one child out of three will die before its fifth birthday. Access to health services plays a critical role in the health of a population. In Niger at the present time, 32.1 percent of the population lives within 5 kilometers of a health facility, the standard which is used to measure access to health services. One of the principal goals of the government with regard to health is to increase the national health coverage rate from 32 percent to 45 percent before the year 2000. To reach this goal, the government hopes to update and improve 122 of the 314 existing health facilities and build and equip 181 new health facilities.

ENVIRONMENT

Niger is composed of three major climatic zones from south to north: the Sudanian region, the Sahelian region and the Saharan region. The Sudanian region, located in the southern part of the country, receives the most rainfall of any area in Niger. Average rainfall in this area varies from 800 mm per year in the southwest to 600 mm towards the 15° latitude line. The majority of the country's agricultural production, in particular the cultivation of rice, millet and sorghum, takes place in this zone. The Sahelian region receives between 200 and 500 mm of rain annually, with rainfall diminishing towards the East and the North. This region supports the majority of Niger's livestock production. The Saharan region, located in the northern part of the country, contains scrub vegetation and grasses which disappear towards the country's northern border. The average temperature in this zone is 28° C, with extremely hot days and cold nights.

1 Adapted from the *Plan du Développement sanitaire 1994-2000, tome I*
République du Niger, Ministère de la Santé Publique, Niamey, Mars 1994

METHODOLOGY

GIS SOFTWARE

A number of types of GIS software with a variety of functions and features were currently available on the market. This project used ARC/INFO and ARC/VIEW, both of which were manufactured and distributed by Environmental Systems Research Institute (ESRI). The ARC/INFO system, which is regularly used by AGRHYMET for map-making and geographical analysis purposes, was the logical choice of software as it has the technical capacity necessary for the project work and is well established in the GIS community. There were many benefits to using ARC/INFO, including the ease of transfer of GIS data and products between users without data reformatting problems. For instance, ARC/INFO supports reformatting of files to and from several major GIS formats including ASCII text files. In addition, ARC/INFO is available for both the PC and workstation environments and thus supports a wide range of activities and user skills. In fact, a data viewing program called ARC/VIEW is available for viewing pre-formatted GIS products. It is easy to use and could be easily run by a GIS novice. The combination of ARC/INFO (for GIS creation and analysis) and ARC/VIEW (for the viewing and studying of products) was desirable given the existence of a central GIS lab, manned by experienced personnel, and from which products are sent out to managers for use as base data in the analysis and decision making process.

GIS OVERVIEW

The ability to perform spatial analysis and related computations gives GIS its emerging importance as a tool in the decision making process. For example, relationships between attributes such as health center location and population distribution can be visualized spatially. Famine relief center location can be visualized in relation to the distribution of population and their proximity to grain producing regions, health centers, and the transportation network. Models can be developed using current weather data and land productivity indicators in order to determine areas at risk, estimate expected food deficiency, and to determine the best possible sites for relief centers. Myriad analytical permutations are possible based on this manner of overlaying multisectoral data and the analyses presented in this project are but a few such examples.

Large databases are often used in population, health or environmental projects requiring the use of a database management system to manage the data. Existing database management programs allow routine input, storage, manipulation, analysis and reporting of tabular data for such projects. In such systems a basic limitation exists in not being able to visualize the results spatially. GIS is a type of information system that, like a database management system, is used for input, manipulation, storage and analysis of data. With GIS, however, the data attributes and their variations can be viewed in terms of their geographic relationship with one another. For instance, the distribution of medical centers across the landscape can be viewed, population density distribution can be analyzed in its geographical context, and medical case report summaries accessed.

A GIS does the work of a database manager for tabular data plus geographic analysis and management for the geographic component. A GIS can be used to improve the organization

of data from a wide range of data sources. It can also improve the presentation of data and the results of analysis. Cartographic tools in a GIS allow for efficient and effective visualization not available in traditional database management systems. In order to be used in a GIS, the data must first be geographically referenced, or linked to a geographic location such as a medical center, a village or an administrative district. The latitude and longitude coordinates of the location provide the geographic link to each particular type of data, known as an attribute.

The key element in the execution of a GIS-based study is the construction of a data base containing latitude/longitude coordinates for given locations or attributes and the linking of this database to selected tabular data. This type of organization allows the geographic distribution of data, for instance concerning population, to be included in an analysis. The best source of location data is often previously produced paper maps. In order to be used by the GIS, these paper maps must be computerized through a process known as digitization. In this process, maps are placed on an electronically sensitive table specially designed for digitizing which allows the tracing of lines and marking of points using a computer mouse. These lines and points were recorded digitally by the computer as latitude and longitude coordinates and stored in a GIS database. Once the digitizing process was finished, maps can be made showing village, or other, locations. A link was required, however, to tie selected data to the digitized point locations on the maps. Location name is often an attribute common to both tabular and map data. In the case of census data, for example, each village name contained in the census was accompanied by a unique code. This code was then duplicated for each village contained in the point attribute database, creating a link between the two databases. Thus the village-level data from the census database was matched to the village location coordinates contained in the point attribute database, and the census data for each village becomes directly available for use in the GIS for use in spatial analysis.

GIS FOR "POPULATION, HEALTH AND ENVIRONMENT IN NIGER"

POPULATION AND HEALTH DATA

For the purposes of this project, computer programs were developed using dBase IV that would link village level data from the 1988 census with the health infrastructure database, as well as linking the census data with map generating information. Each village record in the 1988 census database contains a unique 10 digit identification code. The first step was to add a field to the health infrastructure database, and then look up and input the correct census village identification code into that field. Using this identification code as the key field, the health clinics could then be linked with the census data. One hundred percent of the health clinics were thus linked.

The next step was to link the point attribute file used by ARC-INFO to generate maps with the census database and health infrastructure database. Fields were added to the point attribute database to contain census information, and identifiers for the various types of health infrastructures (rural dispensaries, medical centers, maternities, medical posts and department hospitals). A field was also added to include whether the village had a school (although this field was not included in the final project presentation). After the databases were linked, relevant information was transferred to the point attribute database, which was used to generate the desired maps through ARC/INFO. These maps included displays of population density by department; clinic location and type at the arrondissement, department and national levels; average health coverage rates throughout the country; and clinic location in relation to village population within the arrondissement of Mayahi.

Finally, an interactive mapping program was written using ARC/INFO to calculate the population living within 5 kilometers of a health clinic (the standard measure of the *health coverage* rate). The program ranks villages as potential clinic sites in order of the number of persons served within 5 km of the site. It also draws circles representing the 5 km catchment area surrounding a clinic site in order to minimize geographic overlap between areas served. If expanded to the department or national levels, this program could be used as a planning tool to determine the placement of new health clinics that would serve the largest proportion of the currently unserved population of the arrondissement.

ENVIRONMENTAL DATA

The environmental data used in this project came from pre-existing digital databases. The crop-use intensity map was interpreted from 1987 LANDSAT MSS satellite imagery by South Dakota State University. The soils map was a digital form of the ORSTOM soil map of Niger printed in 1967 at a scale of 1:500,000. The soil classes were grouped into 5 general classes by the authors for use in this study. Rainfall data was collected from the Meteo National of Niger, the ASECNA, and ORSTOM records for the years 1961 to 1990. Each weather station had a latitude/longitude position coordinate in the attribute table, so geo-referencing already existed. To establish the isohyets (lines of equal rainfall) the rainfall data was averaged over the 30 year period and the lines between weather stations interpolated to depict lines of equal rainfall. Veg-

ANALYSIS AND RESULTS

The two themes explored in the project were the relationship between population distribution and access to health services; and the relationship between population distribution and natural resources and land use in areas experiencing environmental stress. The arrondissement of Mayahi was selected as the main focus of project activities because its health coverage rate of 12 percent was the lowest of any arrondissement in the country and its environmental profile contained a variety of climatic, agricultural and hydrologic conditions.

POPULATION AND HEALTH

POPULATION DISTRIBUTION IN NIGER

The first set of maps in the "Population and Health" Section shows the distribution of population throughout Niger. In each of these thematic maps, the average population densities of the given administrative level (department, arrondissement or canton) was shaded according an established scale. The comparison of the three maps demonstrates the changes in population density distribution according to scale: as the level of aggregation becomes more dense, the picture of population density distribution becomes more evident. For example, on the departmental level map, the department of Tahoua was shown to have a population density of 10-24 persons per square kilometer, but when the administrative level was disaggregated to the arrondissement, it became clear that the majority of the population of Tahoua was located in the southern portion of the department in the arrondissements of Illela, Keita, Bouza, Madoua, and Birni N'Konni. The remaining arrondissements of Tahoua and Tchin-Tabaraden, located in the northern part of the department and making up approximately half of its land area, have fewer than 10 persons per square kilometer. This type of comparison clearly demonstrates the potential for error and the inappropriateness of the use of national-level data for local level decision-making.

The problem of how to effectively map the department of Niamey, its three arrondissements (Communes I, II and III) and the arrondissements of Zinder and Maradi became apparent during the development of the first set of maps. At the present time these areas appear in the AGRHYMET geographic database as single points. This fact complicated efforts to show population densities within any of these areas as their map representations were too small to allow for this level of detail. Thus in order to integrate the effect of these cities' sizable populations on the calculation of average population densities, it was necessary to combine the population figures of each city with its surrounding area. Thus Niamey arrondissement and department population data were combined with data for the department and arrondissement of Kollo; Maradi arrondissement data were combined with the arrondissement of Madarounfa data; and Zinder arrondissement data were combined with Mirria arrondissement data.

Map A1.1 : Population Density by Department

This thematic map portrays the entire country, with line boundaries separating the individual departments of Niger. Population density appears according to an established scale. The departments of Maradi and Dosso are the most densely populated departments, with 50-69 persons per square kilometer. Tahoua and Tillaberi are populated with 10-24 persons per square

kilometer, and Agadez, Zinder and Diffa have an average of fewer than 10 persons per square kilometer. As noted above, Niamey department population data were combined with data for the department of Kollo.

Map A1.2 : Population Density by Arrondissement

This thematic map portrays the entire country, with line boundaries separating the arrondissements of Niger. Population density appears according to an established scale. Population density appears most concentrated in the southern Sudan zone of the country, the area of the country receiving the most rainfall and where most agricultural production occurs. Mirroring the increasingly harsh climatic conditions of the countryside, population density diminishes towards the northern and eastern borders of the country. As previously noted, Niamey arrondissement population data were combined with data for the arrondissement of Kollo; Maradi arrondissement data were combined with the arrondissement of Madarounfa data; and Zinder arrondissement data were combined with Mirria arrondissement data.

Map A1.3 : Population Density by Canton

This thematic map portrays the entire country, with line boundaries separating the cantons of Niger. Population density appears according to a fixed scale. Population density appears most concentrated in the southern central portion of Niger's Sudanian zone and the diminishes steadily from this central area towards the western, northern and eastern borders of the country. It should be noted that here again Niamey population data were combined with data for Kollo; Maradi data were combined with Madarounfa data; and Zinder data were combined with Mirria data.

HEALTH SERVICE DISTRIBUTION IN NIGER

The second set of maps portrays the distribution of health services at the national, departmental and arrondissement levels. The progression of these maps demonstrates the ability of the GIS to focus on consecutive levels of land area according to defined boundary limits. Unlike the previous set of maps, in which the entire country was shown in each map, these maps show only the specific area with which this pilot study was concerned, be it the country as a whole, or a particular department or arrondissement.

Map A2.1 : Location of Health Services

This map shows the distribution of health services (maternities, medical centers, medical posts, and rural dispensaries) throughout the country. Health services are represented by a red cross and major cities shown with a black dot. A problem similar to that posed in the first set of maps was also encountered here. At this scale, it was not possible to clearly show each type of health service in a given area, as a city or village containing several different types of services would only appear as a single point on the map. Thus to avoid "overloading" the map, the same symbol was used for each type of health service.

Map A2.2 : Location and Type of Health Services, Department of Maradi

This map shows the location and type of health service in the department of Maradi. Five types of health service are shown: Maternities (Mat), Medical Centers (CM), Medical Posts (PM), Rural Dispensaries (DR), and the Departmental Hospital (CHD). The map also shows the boundaries

of the arrondissements located within the department. Even at this level it was difficult to clearly represent different types of services located in a given location, as the symbols tend to cancel each other out. The picture was more clear at this scale of mapping, however, and by using different symbols to represent each type of service, and by changing the size and coloration of the symbols, it becomes possible to discern the different types of services.

Map A2.3 : Location of Health Services, Arrondissement of Mayahi

This map represents the arrondissement of Mayahi, in the department of Maradi. As seen in the previous map, this map also depicts the distribution of selected health services, however in addition, other important attributes such as village and road location are also shown. Villages in the arrondissement and within a 15 km radius of the arrondissement borders are represented by circles sized according to the relative population of each village. The arrondissement's six medical centers and single *maternité* are each represented by a cross symbol. The names of towns where these medical facilities are located have been printed next to each cross symbol. Roads are represented by red lines.

ARRONDISSEMENT LEVEL HEALTH COVERAGE

The next set of maps presents two different perspectives of health coverage rates for the arrondissement level. The first map in the series shows the average health coverage rates for the country by arrondissement, based on SNIS arrondissement level coverage estimates for 1991. Subsequent maps show health coverage estimates for existing as well as hypothetical services in the arrondissement of Mayahi, based on 1988 Census data. Health coverage was estimated as the percentage of the population of a given area living within a five kilometer radius ("walking distance") of a health service facility.

Map A3.1 : Health Coverage by Arrondissement

This map shows average rates of health coverage throughout the country by arrondissement, based on 1991 SNIS arrondissement level coverage estimates. Only two arrondissements, N'Guigmi and Kollo, have average health coverage rates of more than 60 percent. The importance of population distribution and mapping scale should be remembered when considering these arrondissements. The average health coverage rate for the arrondissement of Kollo was skewed upwards because it includes data for the city of Niamey, which contains the majority of the area's population and where the health coverage rate was close to 98 percent. In N'Guigmi, the majority of the population was centered in the town of N'Guigmi itself, and thus the population health coverage rate was high in this one location and not spread throughout the arrondissement as it appears to be on the map. On the other end of the coverage scale, the arrondissement of Mayahi appears as the only arrondissement with health coverage for less than 12 percent of the population.

Map A3.2 : Existing Health Service Location and Coverage, Arrondissement of Mayahi

The existing health coverage situation for the arrondissement of Mayahi is represented on this map. The name of each town containing a health service facility is shown, along with the number of persons living within a five kilometer radius of the facility (the "health coverage rate") and the percentage of the population of the arrondissement represented by this figure (See Annex B). According to the 1988 census the total population of the arrondissement was estimated at 226,245 persons. The population estimates used in this study, however, were based on 87% of the 1988 arrondissement population due to constraints detailed above in section III.D. The sum of the 7 facility coverage rates, 11.47%, provides the total health coverage rate for the arrondissement.

Map A3.3: Strategic Placement of New Health Centers, Arrondissement of Mayahi

This map provides an example of the uses of GIS for strategic decision-making. The design of the map was based on the hypothesis that resources have been provided for the building of three new health facilities in the Mayahi arrondissement, and that sites must be determined which would provide health coverage to the highest possible proportion of the currently unserved population. The three proposed facility locations and their respective catchment areas are shown in pink, while existing centers are shown in green.

An interactive mapping program was written using ARC/INFO to calculate the population living within 5 kilometers of a health clinic. The program ranks villages as potential clinic sites in order of the number of persons living within 5 km of the site. It also draws circles representing the 5 km catchment area surrounding a clinic site in order to minimize geographic overlap between areas served. If expanded to the department or national levels, this program could be used as a planning tool to determine the placement of new health clinics that would serve the largest proportion of the currently unserved population of the arrondissement.

Map A3.4: Health Infrastructure Necessary to Obtain 45% Health Coverage Rate, Arrondissement of Mayahi

This map was produced using the interactive program noted above and took as its basis the national goal of an average health coverage rate of 45%. It was calculated that in order to reach this rate of health coverage in the arrondissement of Mayahi, 21 new health facility sites would have to be constructed. It should be remembered, however, that this national goal is an average and is not necessarily realistic for Mayahi, the arrondissement with the lowest health coverage rate in the nation. Despite this qualifier, however, the exercise was useful to demonstrate the practical considerations which should be taken into account during the determination of policy target figures.

DISCUSSION

The population figures used in the maps in the "Population and Health" section were taken from the 1988 Census of Niger. They were therefore accurate for 1988, however population projections would be necessary to update them to 1994 levels. In contrast, the Système National d'Information Sanitaire (SNIS) of the Republic of Niger updates the population figures it uses as

denominators, based on 1988 Census figures. It should be noted, however, that these figures are estimates, produced for the arrondissement level, and do not reflect movements of population nor aberrations in population growth. The five kilometer radius coverage area employed in this project was based on the World Health Organization guidelines, and was the standard currently employed by the SNIS at the ***formation sanitaire*** level.

Upon closer scrutiny, a discrepancy becomes apparent between the population coverage figures employed by the SNIS and those used in the project maps. The SNIS figures are higher than the map figures in every case but one. This inconsistency can be explained by three primary observations: a 10-13% difference was expected due to the 87% population coverage matching rate achieved during the mapping process (assuming a random distribution of the unmatched population and villages); the SNIS estimates, which take into account population growth between 1988 and 1993, can be expected to be higher than the map figures, which do not; and the data currently employed by the SNIS are estimate projections, and could be expected to contain occasional inaccuracies. Rather than negating the importance of this portion of the project's findings, these discrepancies add to its importance by underscoring the need for the standardization and regular updating of the population figures and projections used in research and applied work.

Clinic *type*	Population < 5km (SNIS data)	Health Coverage Rate	Population < 5 km (Map data)	Health Coverage Rate
Mayahi *medical center*	10213	4.48	7298	3.70
Kanembakache *dispensary*	8150	3.57	3706	1.88
Issa Wane *dispensary*	5740	2.52	3869	1.96
Serkin Arewa *dispensary*	2877	1.26	1274	0.65
Guidan Amoumane *dispensary*	3266	1.43	1512	0.77
Guidan Wari *dispensary*	1713	.75	1710	0.87
Dan Mairo *dispensary*	2367	1.04	3242	1.64
Total	**34326**	**15.07**	**22611**	**11.47**

POPULATION AND ENVIRONMENT

Major constraints to the health of a given population are in great part based on the nature and structure of household and individual income generation, whether this income be cash or in-kind. In sub-Saharan Africa, where economic output is based primarily in the agricultural and rural sectors, the nature of economic output is greatly determined by the natural resources available to the population and the manner in which these resources are managed and/or impinged upon by the population. In particular, the effects of population growth and resource management exert strong influences on the environment, often resulting in the degradation of the natural resource base. At the global level, many Sahelian countries have been affected by the synergy of these influences and consequently are suffering from degraded or insufficient natural resources. The most basic natural resources affecting the cash and in-kind economic output of Sahelian countries are soil, water and forestry resources. Of these, soil and water are the most important and constitute the primary parameters influencing agricultural production.

In Niger, arable land represent less than 12 % of the country's total area, however, at the same time, only 44% of cultivated lands are found in arable areas. The surface area of cultivated land has doubled since the early 1960s and consists mostly of fragile, low mineral or heavy soils. In addition, less than 25% of cultivated land receives more than 300 mm of rainfall annually and only approximately 565,000 hectares, representing only 4% of the cultivable land area, is potentially irrigable (see Niger, 1994). Hydric renewable (2,5 billion cubic-meters) and non-renewable resources (200 billion cubic-meters) have been under-exploited due to the high cost of their mobilization and as a result they account for less than 20% of the renewable resource base (see *International Journal of Remote Sensing*, Volume 7, No. 11, November, 1986).

RAINFALL AND SOIL SUITABILITY

Rainfall data was collected from the Metéo National of Niger, ASECNA and ORSTOM records. The average of data from 1961-1990 was used for this analysis. Only 1988 census data, however, was used in the location of population and population densities. Rainfall was noted in millimeters with values indicated by isohyets (lines of equal rainfall) where the information has been interpolated between data collection stations.

Map B.1.1 : Average Annual Rainfall (1961-1990), Niger

Typically, the pluviometric progression in the Sahel is from south to north and follows the annual latitudinal northward progression of the International Tropical Convergence Zone (ITCZ). In Niger, annual rainfall varies from 600 mm in the far southern corner of the country to 140 mm on the edge of the Sahara in the north. Accordingly, isohyet lines become more widely spaced along the progression from south to north.

Map B.1.2 : Average Annual Rainfall (1961-1990), Arrondissement of Mayahi

This map shows rainfall isohyets and relative village populations for the arrondissement of Mayahi. Due to the arrondissement's location in the south of the country, relatively high levels of rainfall were noted, varying from 460 mm annually in the area between Mayahi and Tessoua to 290 mm near Serkin Arewa in the northeast corner. In contrast to the trend noted above concerning the progression of rainfall from south to north throughout the Sahel, we see here that the highest levels of rainfall (430 - 460 mm) are noted in the south eastern part of the arrondissement.

Perhaps the most striking relationship between environment and population is observed between rainfall levels and population distribution. Located in an area of relatively high rainfall (approximately 400-410 mm annually), the town of Mayahi is the most densely populated area of the arrondissement. It should be noted, however, that the town of Mayahi is located next to, but not in, the area receiving the highest average amount of annual rainfall. In the neighboring arrondissement of Tessaoua, a similar population/rainfall configuration is noted. The town of Tessoua, located just outside the southeastern boundary of the Mayahi arrondissement, is also situated next to, but not in, the area receiving the highest annual rainfall, approximately 410 mm.

Map B.1.3. : Average Annual Rainfall, Soil Suitability, Arrondissement of Mayahi

For the purpose of this project, it was decided that a map showing the quality of the available soils, rather than a more conventional map showing scientific soil descriptions, would be of potentially greater use to decision makers and planners. Soil quality was defined in terms of its suitability to agricultural use and the map based on the ORSTOM soil map of Niger (1967; 1:500,000). Like the ORSTOM map, soil quality has been categorized into five classes: unusable, very poor, poor, mediocre and good.

In accordance with the soil types determined by the authors, no "good" quality soils were found in the arrondissement of Mayahi. Soils here tend to be very sandy with little or no organic matter and very few clay minerals. Over half of the arrondissement was made up of mediocre quality soils, approximately 25% by poor soils (especially in the north and east), and less than 20% by very poor soils, located primarily in the north. The rest of the arrondissement's area was covered by unusable soils. These soils were located in valley areas such as Gulbi N'Kaba, where flooding during the growing season precludes agricultural use, as well as in the north of the arrondissement where a tendency towards superficial laterites occurs, resulting in water retention insufficient for crop production given the area's limited rainfall.

Some very clear relationships between population distribution and soil quality can be noted:

- no villages appear in the large valley flood plain of the Gulbi N'Kaba;
- the extended flood plains southeast of Mayahi and 10 km west of Tessoua also have limited populations;
- areas containing very poor soil south of Serkin Arewa and 15 km north east of Guindan Amoudou have limited populations located in widely spaced villages;
- areas with poor soil quality have varying population sizes. Among other factors this variability might be attributed to intra-area differences in rainfall or to recent migration;
- the highest population densities are located in the central and southern part of the arrondissement, where the best soils ("mediocre" quality) are found.

Despite the seemingly clear correlation between population distribution, rainfall and soil suitability, other elements such as market, historical and socio-political factors must be taken into consideration before valid conclusions may be drawn. On the whole, relationships between these variables tend to be highly dynamic and susceptible to reversal. According to recent research, variations in rural population density are more dependent on market factors, or "market attractiveness", than on soil suitability or climatic factors. It is hypothesized by some, however, that environmental factors such as these might assume an increasingly prominent role as rural population settlement and market attractiveness increase (OECD, ADB, 1993).

LAND USE INTENSITY

Maps showing crop use intensity (areas under cultivation) were derived from an interpretation of 1987-88 Landsat Imagery conducted by SDSU for the Eros Data Center under contract to USAID and AGRHYMET in 1991 and 1992. The original mapping interpretation was conducted at a scale of 1:200,000. The mapping and interpretation procedures follow methodologies developed by the USDA called an Area Sample Frame. Areas interpreted as agricultural lands include fallow ground. Land units were mapped as large composite entities with similar intensity of cultivation. The results of this mapping were partially verified by field checking (1993) and video overflight (Trip Report by K. Dalsted, 1994, AGRHYMET). An estimated 70% degree of correlation was found between the crop land use intensity totals and ministry/FAO estimates.

Map B.2. : Average Annual Rainfall, Land Use by Agriculture, Arrondissement of Mayahi.

This map displays the link between the intensity of land use for agriculture and the corresponding rainfall levels within the arrondissement. A strong correlation between these elements appears in the southern part of Mayahi, where the greatest amount of annual rainfall is received and the most cultivation takes place. A large portion of the arrondissement's population is also found in this area, in close proximity to their fields. In addition, a close correlation can be noted between the level of land use and the quality of the soil.

VEGETATION INDEX AND AGRICULTURE.

NOAA Satellite Data from Advanced Very High Resolution Radiometer (AVHRR) was received and processed by AGRHYMET to produce NDVI (Normalized Difference Vegetation Index) or "greenness" maps. The NDVI used by AGRHYMET is a relational method of evaluating the spectral response of plants and vegetation in general. The higher the index reading, the greener the vegetation. Lower index readings indicate less ground vegetation. These maps were made every 10 days during the growing season and the examination of these maps in chronological order reveals the increasing greenness of the landscape over the course of the growing season. Furthermore, the combination of NDVI data with data from other sectors provides early warning experts with advance information on crop status. For the purposes of this project, data from the third decade of August, 1993, have been used. These ten days constitute the period of time the most crucial to crop success during the growing season. NDVI readings of less than .16 during this decade were assumed to indicate ground conditions which would lead to an insufficient crop yield (Tucker, Prince and Justice, 1986).

The vegetation index was collected at two spatial levels: general area coverage data (GAC) representing pixels of 7 km² and local area coverage (LAC) representing 1 km². AGRHYMET uses LAC data in order to provide more detailed information for early warning. The monitoring of LAC data through time was also important to evaluate the degradation of land areas and to establish environmental trends, however only the last five years of sequential historical data for Niger exists in LAC format.

Map B.3.1. : Vegetation Index, LAC, 3rd Decade August 1993, > 30% Land Use by Agriculture

This map shows NDVI levels throughout the arrondissement as well as crop land use intensity and village population and location. Areas with both high and low NDVI ratings appear on the map, with high NDVI ratings shown in dark green and low NDVI ratings appearing in gray to

yellow tones. The potential quality of crop yields can be estimated according to this color scheme. The southeastern area of the arrondissement appears in dark green shades, indicating healthy vegetation and crops and an average or above average yield. On the other hand, the northwestern corner of the arrondissement appears in yellow shades indicating poor crop growth and potentially insufficient crop yields and low levels of biomass or forage.

Map B.3.2. : Vegetation Index > 0.16, 3rd Decade August 1993, > 30% Land Use by Agriculture

This map shows areas with NDVI ratings greater than 0.16. These areas, located primarily in the southern and eastern portions of the arrondissement, are areas in which the adequate levels of greenness indicate a potentially successful crop yield.

Map B.3.3. : Vegetation Index < 0.16, 3rd Decade August 1993, > 30% Land Use by Agriculture.

This map shows areas with NDVI ratings less than 0.16. These areas, located primarily in the northwest corner of the arrondissement, contain inadequate levels of greenness indicating the potential for deficient crop yield. According to field checks and other reports, this area as well as neighboring Dakoro and Tanout arrondissements did indeed have poor harvests in 1993.

DISCUSSION

It should be noted that the vegetation data used in this analysis was only *assumed* to correspond to certain levels of average harvest yield. In future applied situations the relationship between the vegetation index and field check figures must be clearly defined before calculations are made.

With this caveat in mind, a variety of projections and estimations could be made based on this type of NDVI data. For example, if we considered an NDVI reading of less than 0.16 as an indicator of insufficient crop yield, we could predict that the northwest corner of the arrondissement is at risk of a poor harvest. By combining NDVI and census data it would then become possible to estimate that there were 63,620 people living in these low crop yield areas, or approximately 32 % of the arrondissement's population. Assuming that the population of this at-risk-area consumes locally grown food for subsistence and that their land is primarily used for agricultural production, it would then become possible to predict that this population would be at risk of insufficient food production during the 1993-94 dry season. The total caloric deficit could also be estimated for the three zones, and in order to facilitate practical application of this information to food aid planning, the figures could then be translated into equivalent numbers of metric tons of millet (Niger's staple food). Given the proper application of formulae and methodology, calculations such as this demonstrate both the sophistication and power of GIS as a tool for use during the identification of areas-at-risk and the design of action plans.

CONCLUSIONS AND RECOMMENDATIONS

"Population, Health and Environment in Niger" was an attempt to explore the ways in which GIS can serve as a tool for the analysis and presentation of population, health and environmental sector data. With the myriad possibilities in mind, AGRHYMET and CERPOD undertook a collaboration with the government of Niger to create a GIS-based presentation showing multisectoral relationships using Niger data from the 1988 Census, the National Health Information System, and data from the environmental sector. In keeping with the interests and specializations of the collaborating institutions, the project's five principal goals,

- i) to assess the suitability of currently available data to GIS uses;
- ii) to assess the applicability of current GIS technical efforts to ongoing government activities;
- iii) to link available databases and perform multisectoral analysis based on these data;
- iv) to present possibilities of GIS-based methodology and analysis to a variety of institutions; and
- v) to provide a foundation for long-term collaborative efforts between the participating structures; were identified and pursued.

Over the life of the project significant achievements were noted, based primarily in terms of valuable lessons learned during the project's execution and the commentary received following the presentation of the project's final results. Specifically, during the execution of activities the project's pilot nature contributed flexibility to the work approach and permitted participants to focus on the exploration of the methodology, rather than the production of statistically precise results. As a result, the project's greatest contribution can be considered the identification of the strengths and weaknesses of GIS-based analysis of multi-sectoral data.

In addition, the ground-breaking nature of this multi-institutional and government collaboration should not be forgotten and every effort must be taken to build upon its example. The value of the input from the different sectors (environmental, health and demographic) and institutional bodies (both governmental and inter-governmental), cannot be underestimated. The richness of the experience gained during project activities as well as the positive reception of the maps and analysis produced by the project have been in large part due to the wide range of contributors and viewpoints taken into consideration during project execution.

RECOMMENDATIONS

In addition to the general conclusions outlined above, general and specific recommendations can be made in each area of interest as well as in terms of the methodological approach.

General

The presentation developed for the International Conference on Population and Development was a first step in the development of a geographic information system for Niger linking data from the sectors of health, population and the environment. Areas concerning data quality, the spatialization of census data and the development of collaborative mechanisms are recommended for further attention. There is still a considerable amount of data cleaning and verification required in both the SNIS and the 1988 Census which could prove time consuming. For example,

in the arrondissement of Mayahi, 87 percent of the population could be linked with villages in the point attribute file, but nationally, only 64 percent of the 1988 census population could be represented on the maps generated at AGRHYMET. An effort should be made to ensure the highest possible proportion of matching between the census and point attribute databases. In addition, the AGRHYMET census database should be expanded to include the wealth of information available in the 1988 Census that has yet to be analyzed, including areas such as ethnic distribution, size of household and infrastructural amenities.

Technical assistance for the implementation of the next census (1998) should be developed and executed to permit the possibility of spatial analysis as an integral element in the exploitation of census data. In order to accomplish this goal, census tract maps could be developed by AGRHYMET for use by census data collectors. In turn, these data collectors could be given and trained to use GPS (geo-positioning) devices in order to facilitate the spatialization of the census data. In this way the latitude and longitude of villages could be correctly determined, and census information more accurately represented.

Every effort should be made to continue the collaboration between AGRHYMET and CERPOD, two CILSS institutions which, despite similar mandates, have had little opportunity to collaborate in the past. With such future activities in mind, CERPOD and AGRHYMET have planned a comprehensive long term project which would allow for their continued participation in and contribution to GIS efforts within the CILSS member countries and throughout Africa. The combination of AGRHYMET's resources in biophysical and meteorological data and GIS equipment and training with CERPOD's wealth of knowledge and data relating to socio-demographic and health issues presents a valuable new resource for the Sahel.

Population and Health

An effort should be made to systematically integrate spatial considerations into health sector planning through the use of GIS. Many areas of integration are possible. For example, the implementation of the proposed increase in the national average health coverage rate from 32 to 45% provides a prime opportunity to use GIS in the decision-making process. Use of the interactive program developed by the project would allow planners to determine the best placement of a new clinic based on geographical access and applications of this program could be developed in order to include all the arrondissements of Niger. In this manner the Ministry of Health could use this program as an effective planning tool, and following its positive reception, the program could be adapted for use in other sectors.

In order to facilitate the use of the program in this manner the AGRHYMET maps must be modified to meet the specific needs of the Ministry of Health. For instance, the cities of Niamey, Zinder and Maradi currently appear as single points on the AGRHYMET maps, however the Ministry of Health considers Zinder and Maradi as arrondissements, and Niamey as a department containing three arrondissements. To resolve the problem presented by this type of representation, AGRHYMET could modify their map file, using insets for the zones in question and thus allow the spatial presentation of data from these areas.

Population and Environment

In the area of population and the environment, the primary result of this pilot project was the illustration of associations and simple correlations between climatic and soil characteristics, population density and land use, and population density and vegetation cover. The project undertook

to illustrate these associations on a case-by-case basis rather than to seek out cause and effect relationships between these variables, however, taking into account the critical issues raised during the project's first phase, the identification and quantification of these causal relationships could be the next step in continuing research.

An avenue of such exploration could be the dynamization of the parameters of the various relationships. For example, cross sectional soil quality data, NDVI data and historical data on the evolution of the cultivated land areas (from AGRHYMET's *Diagnostic Permanent Program* database) could be combined with information concerning policy change (for example, extension service availability and producer pricing policy) to examine the relationship between these factors and their impact on changes in land use patterns. Another issue of primary importance to the dynamization of the model is that of migration. This issue could be considered using, for instance, data from the Network Survey on Migration and Urbanization in West Africa (NESMUWA). Coordinated by CERPOD, this survey was conducted in 1992 in Burkina Faso, Guinea, Côte d'Ivoire, Mali, Mauritania, Niger, Nigeria and Senegal. The data is now being analyzed in each of the countries and the first national descriptive report will be available in 1995. An example of useful analysis would be an examination of the migratory flows during the 15 year period (1978-1992) preceding the survey. However, as the use of this data by GIS was not considered before or during its collection, it would have to be carefully examined in order to establish the viability of its application to a GIS-based analysis.

These are but a few examples of the types of comprehensive analysis which could be undertaken to better understand the interactions between population dynamics, climate, changes in land use and vegetation cover and the evolution of public policy. These relationships are the topic of AGRHYMET's ongoing research as well as the focus of CERPOD's regional research project detailed in its Three-Year Plan for 1995-1997.

APPENDIX A - LIST OF MAPS

Population and Health

Map A1.1: Population Density by Department, Republic of Niger
Map A1.2: Population Density by Arrondissement, Republic of Niger
Map A1.3: Population Density by Canton, Republic of Niger
Map A2.1: Health Center Placement, Republic of Niger
Map A2.2: Health Center Types, Department of Maradi
Map A2.3: Health Center Placement, Arrondissement of Mayahi
Map A3.1: Health Center Coverage by Arrondissement, Republic of Niger
Map A3.2: Health Center Placement and Coverage, Arrondissement of Mayahi
Map A3.3: Placement of New Health Centers, Arrondissement of Mayahi
Map A3.4: 45% Health Coverage Rate, Arrondissement of Mayahi

Population and Environment

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Map B.1.2: Average Annual Rainfall (1961-1990), Arrondissement of Mayahi
Map B.1.3. Average Annual Rainfall, Soil Suitability, Arrondissement of Mayahi
Map B.2. Average Annual Rainfall, % Land Use by Agriculture, Arrondissement of Mayahi.
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Map B.3.2. Vegetation Index > 0.16, 3rd Decade August 1993, > 30% Land Use by Agriculture, Arrondissement of Mayahi
Map B.3.3. Vegetation Index < 0.16, 3rd Decade August 1993, > 30% Land Use by Agriculture, Arrondissement of Mayahi

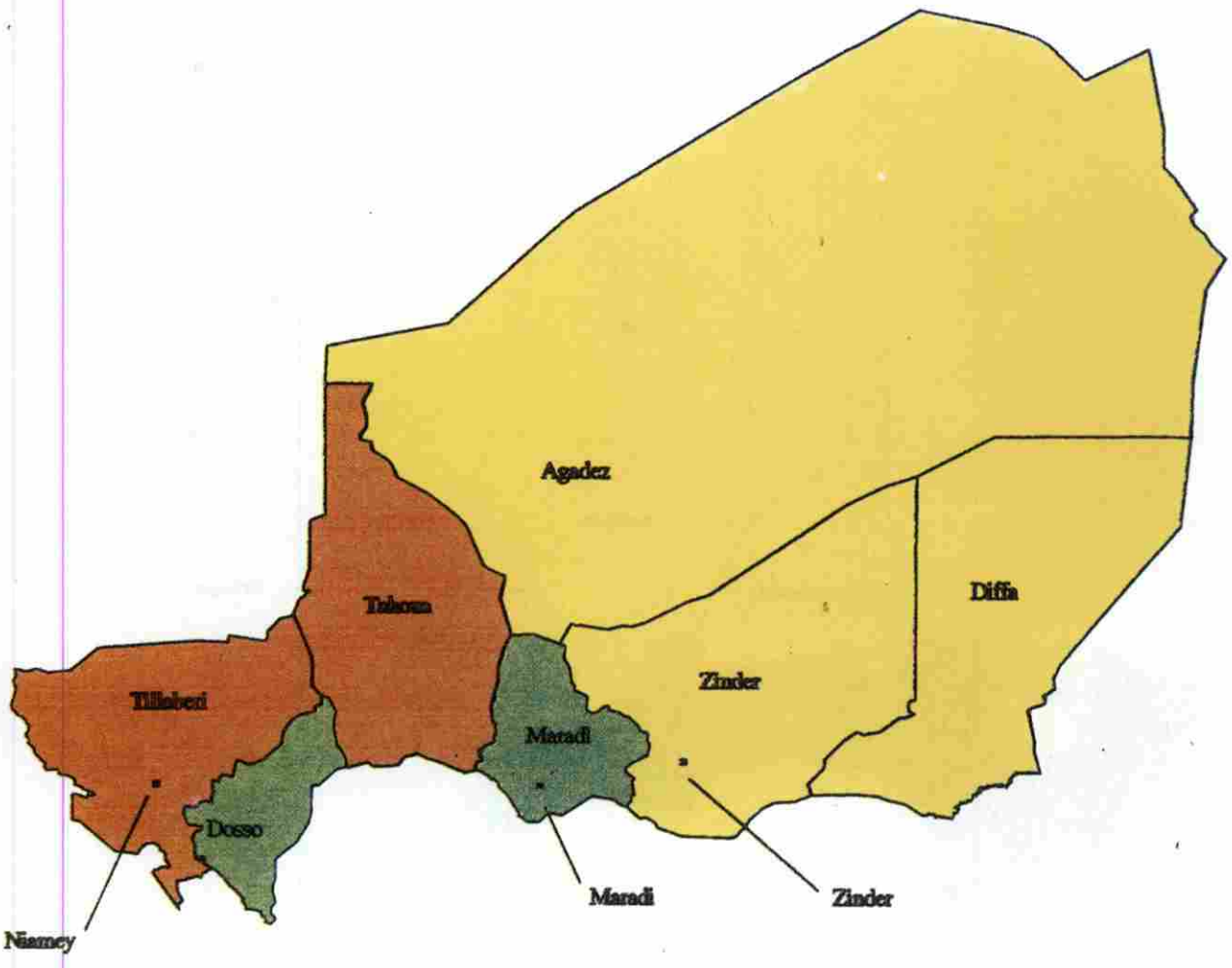
ANNEXES

(Cartes)

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID



Population Sector Analysis
Republic of Niger

Population Density by Department

Population / km²
- < 10
- 10 - 24
- 25 - 49
- 50 - 69
- > 69

Population Centers
- Niamey, 392169
- Zinder, 119838
- Maradi, 109386

_ Arrondissement Boundary

N

0 100 200 300 km

Projection: Universal Transverse Mercator
UTM zone 32

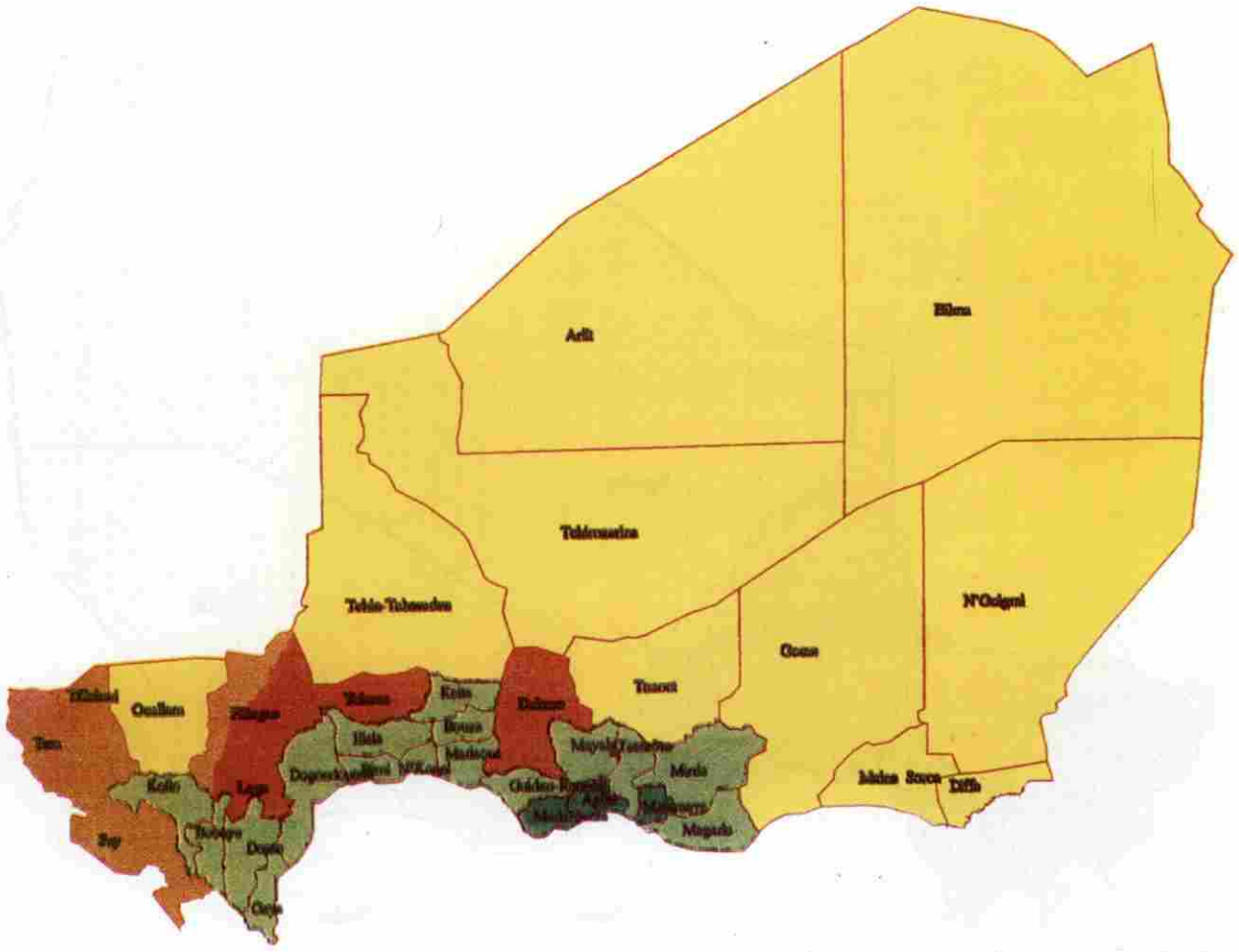
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Figure A1.1

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID



Population Sector Analysis
Population Density by Arrondissement

Republic of Niger

Population / Km²
- < 10
- 10 - 24
- 25 - 49
- 50 - 69
- > 69
- Arrondissement Boundary

km
0 100 200 300

Projection: Universal Transverse Mercator
UTM zone 32

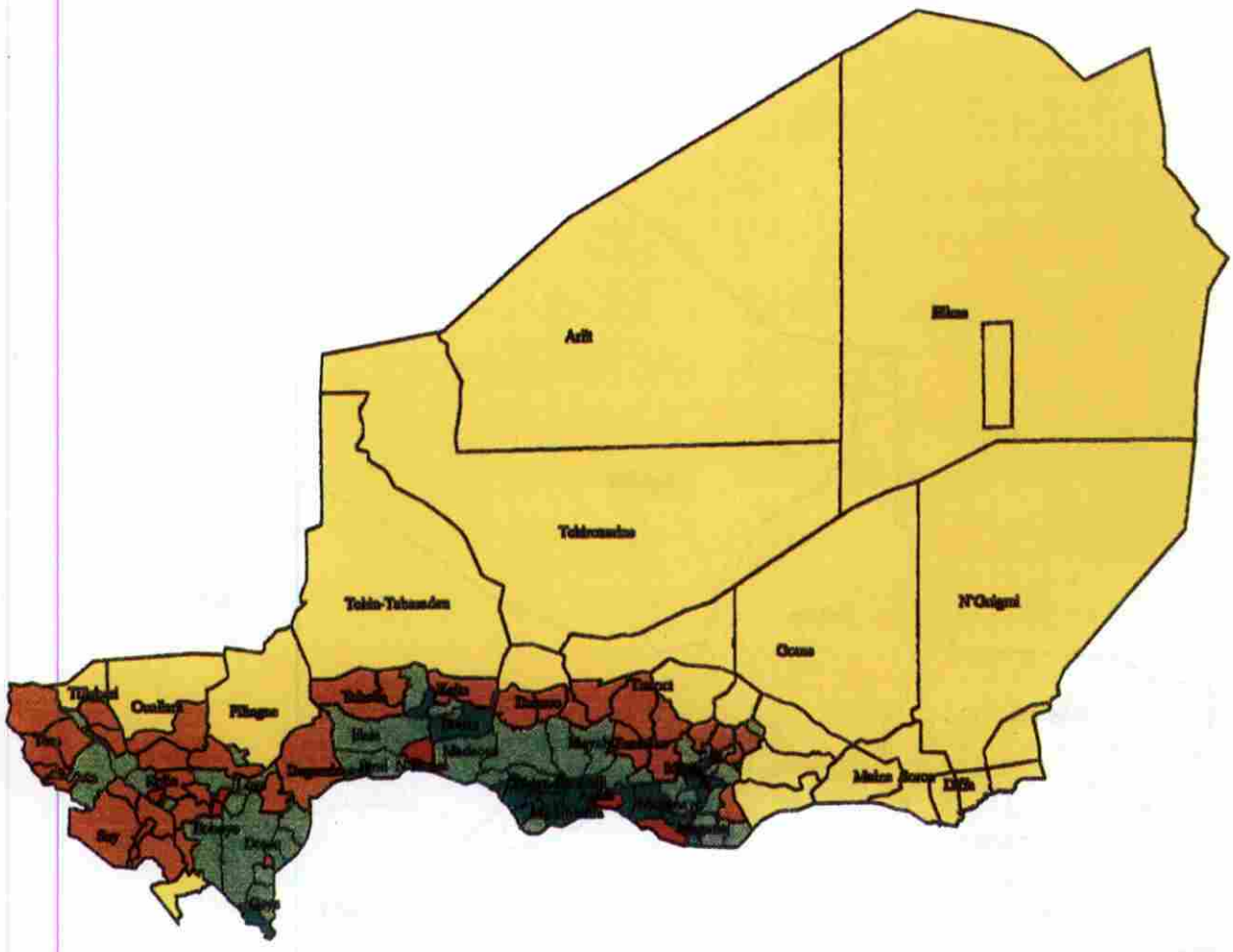
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Figure A1.2

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID



Population Sector Analysis

Population Density by Canton

Republic of Niger

Population / km²

- < 10
- 10 - 24
- 25 - 49
- 50 - 69
- > 69

_ Canton Boundary

km
0 100 200 300

Projection: Universal Transverse Mercator
UTM zone 32

Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Figure A1.3

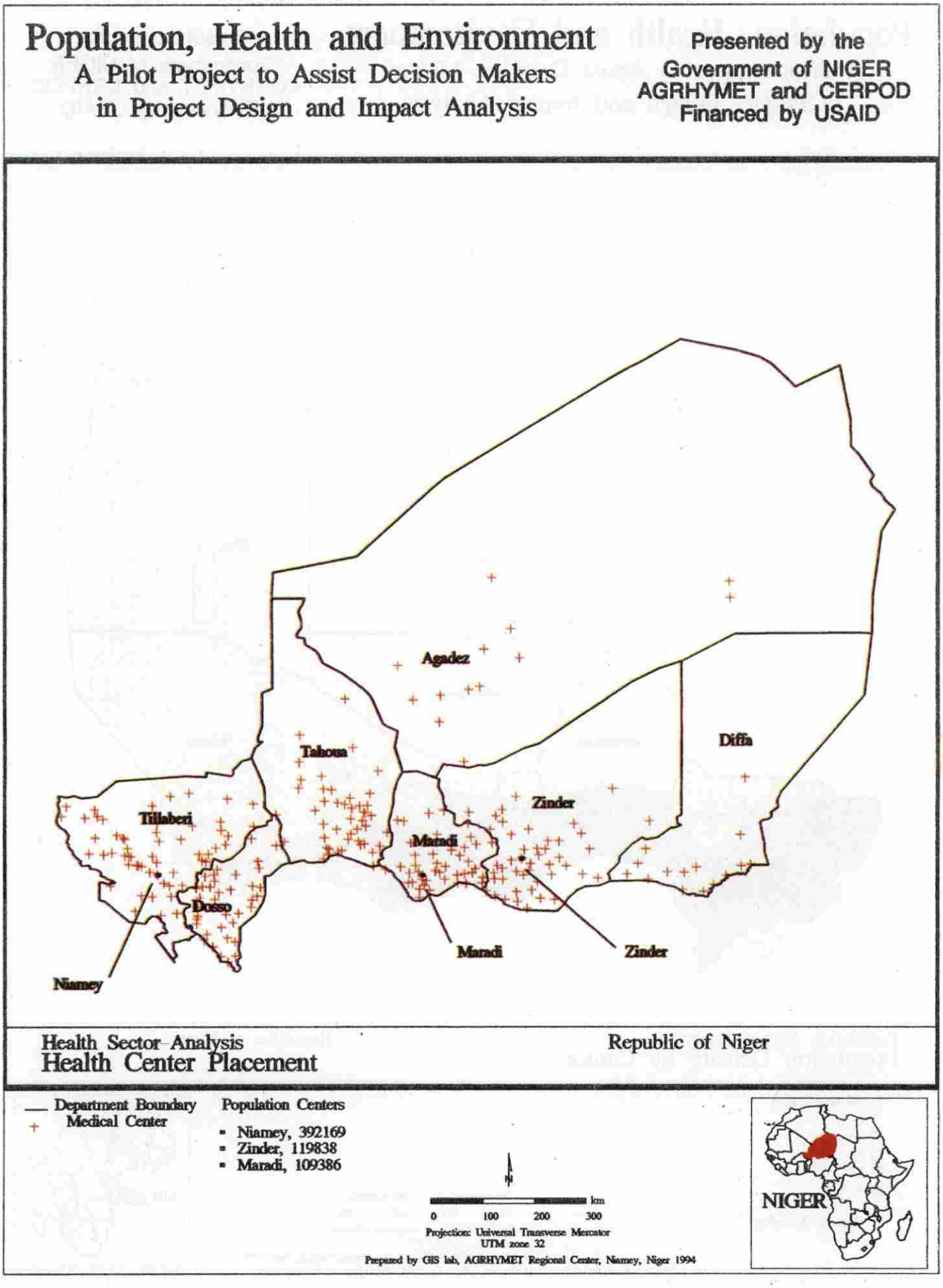
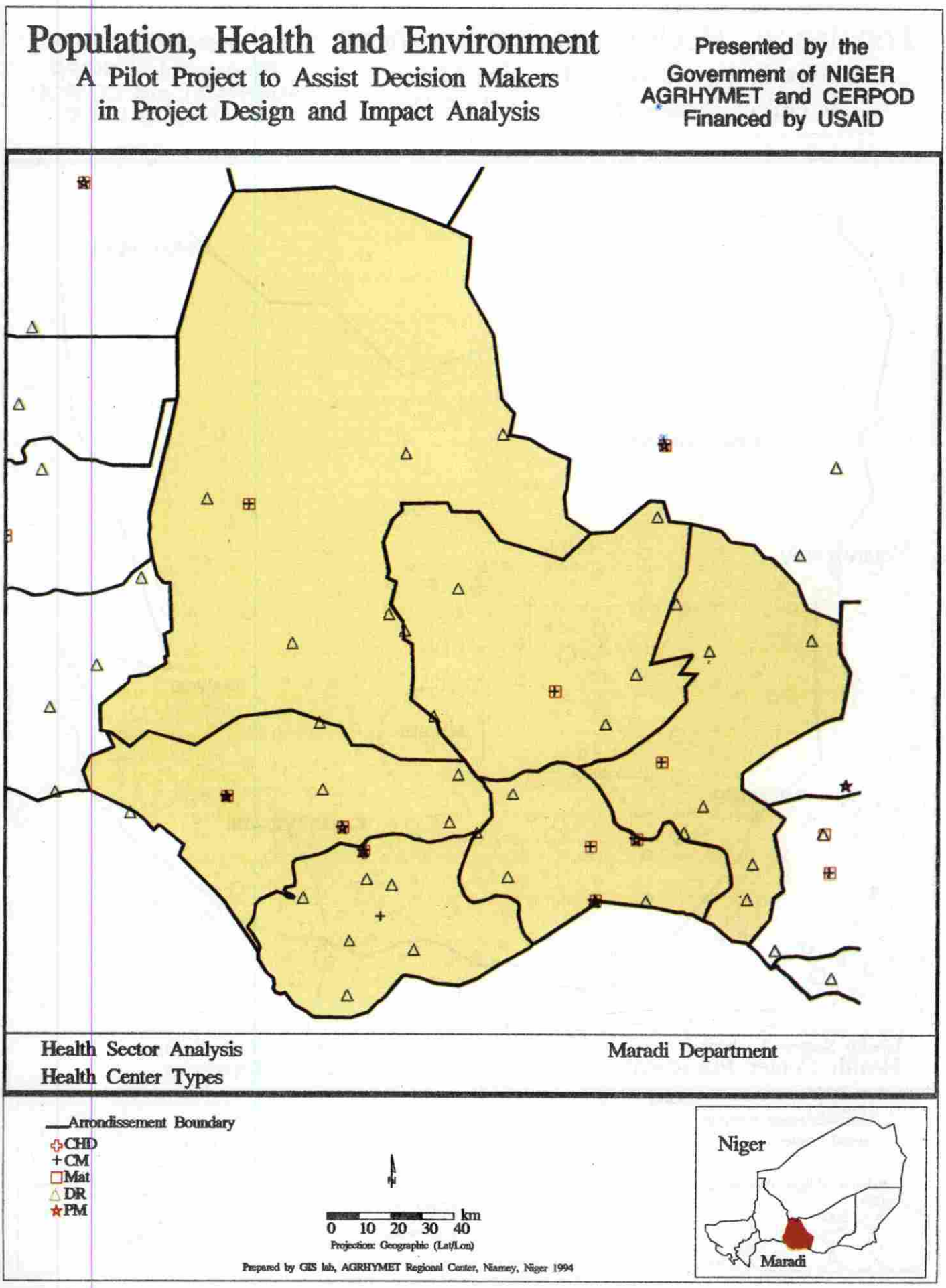

Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID
Agadez
Tahoua
Diffa
Zinder
Tillaberi
Maradi
Dosso
Niamey
Maradi
Zinder
Health Sector Analysis
Health Center Placement
Republic of Niger
Department Boundary
Medical Center
Population Centers
Niamey, 392169
Zinder, 119838
Maradi, 109386
km
0
100
200
300
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
NIGER

Figure A2.1


Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
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Health Sector Analysis
Health Center Types
Maradi Department
Arrondissement Boundary
CHD
CM
Mat
DR
PM
km
0 10 20 30 40
Projection: Geographic (Lat/Lon)
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
Niger
Maradi

Figure A2.2

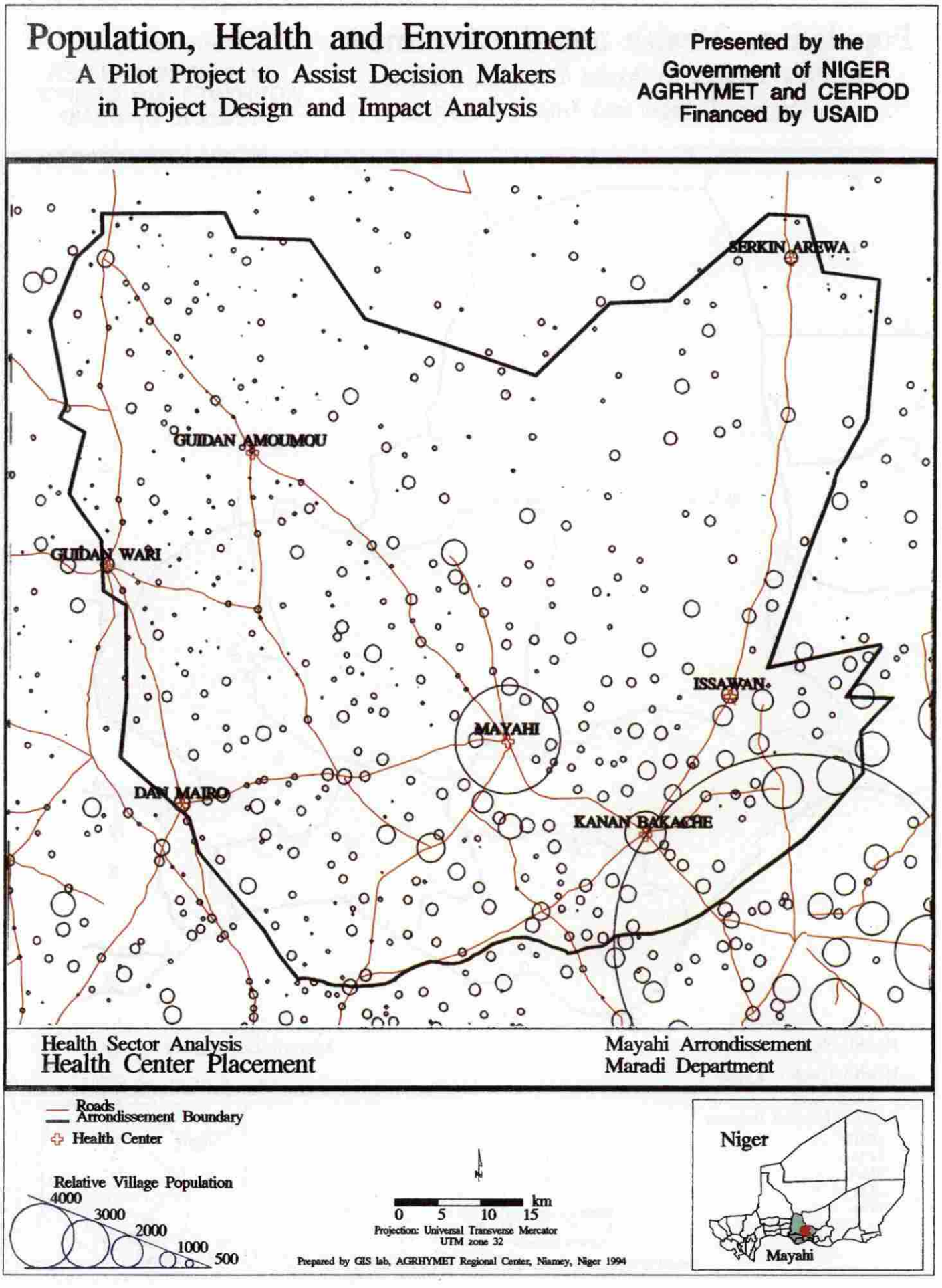
Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID
SERKIN AREWA
GUIDAN AMOUMOU
GUIDAN WARI
ISSAWAN
MAYAHI
DAN MAIRO
KANAN BAKAGHE
Health Sector Analysis
Health Center Placement
Mayahi Arrondissement
Maradi Department
Roads
Arrondissement Boundary
Health Center
Relative Village Population
4000
3000
2000
1000
500
0 5 10 15 km
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
Niger
Mayahi

Figure A2.3

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

Presented by the
Government of NIGER
AGRHYMET and CERPOD
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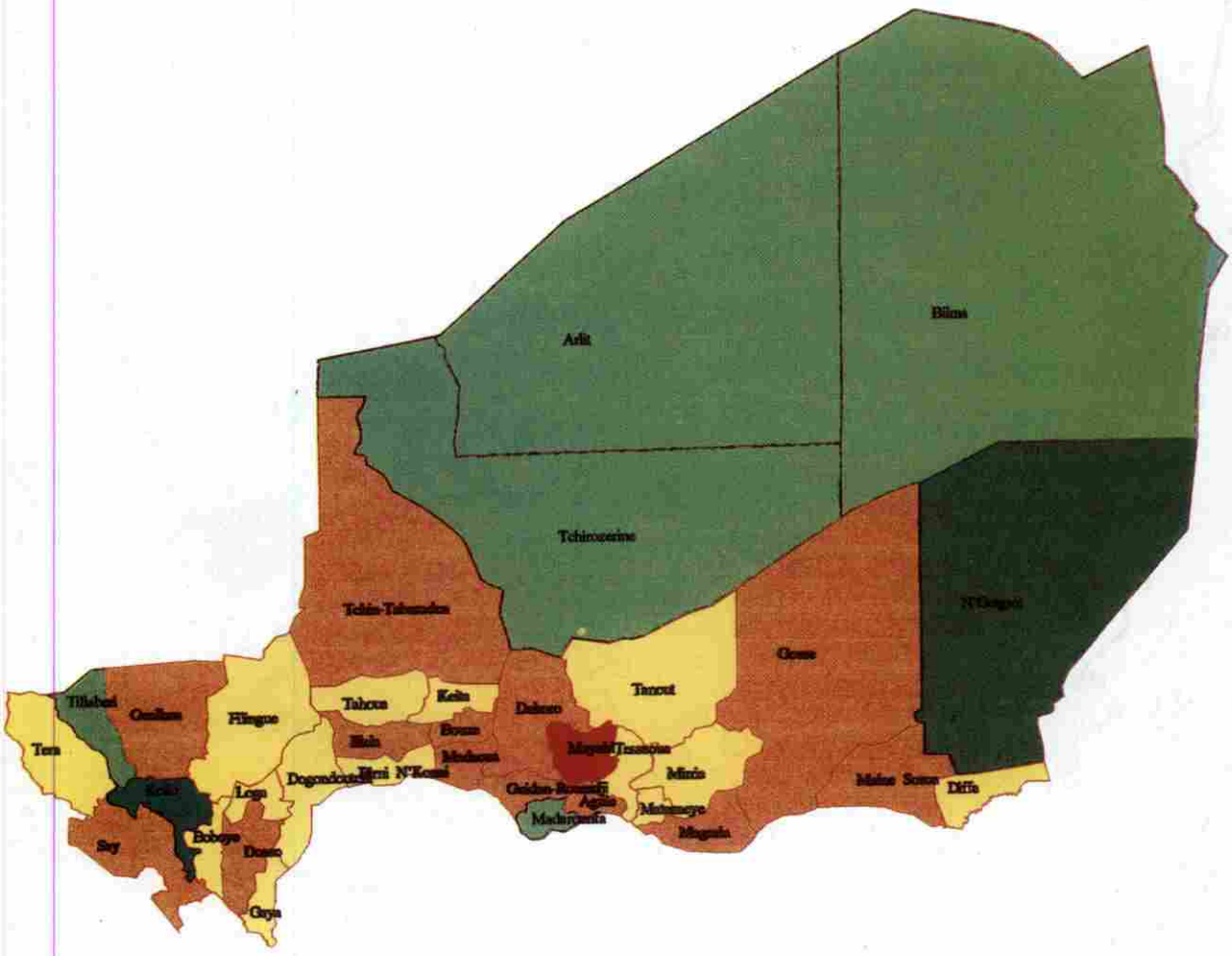

Health Sector Analysis
Health Center Coverage by Arrondissement

Republic of Niger

Health Center Coverage (%)
- < 12%
- 12 - 24
- 24 - 36
- 36 - 48
- 48 - 60
- > 60
- Arrondissement Boundary

N

0 100 200 300 km

Projection: Universal Transverse Mercator
UTM zone 32

Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Figure A3.1

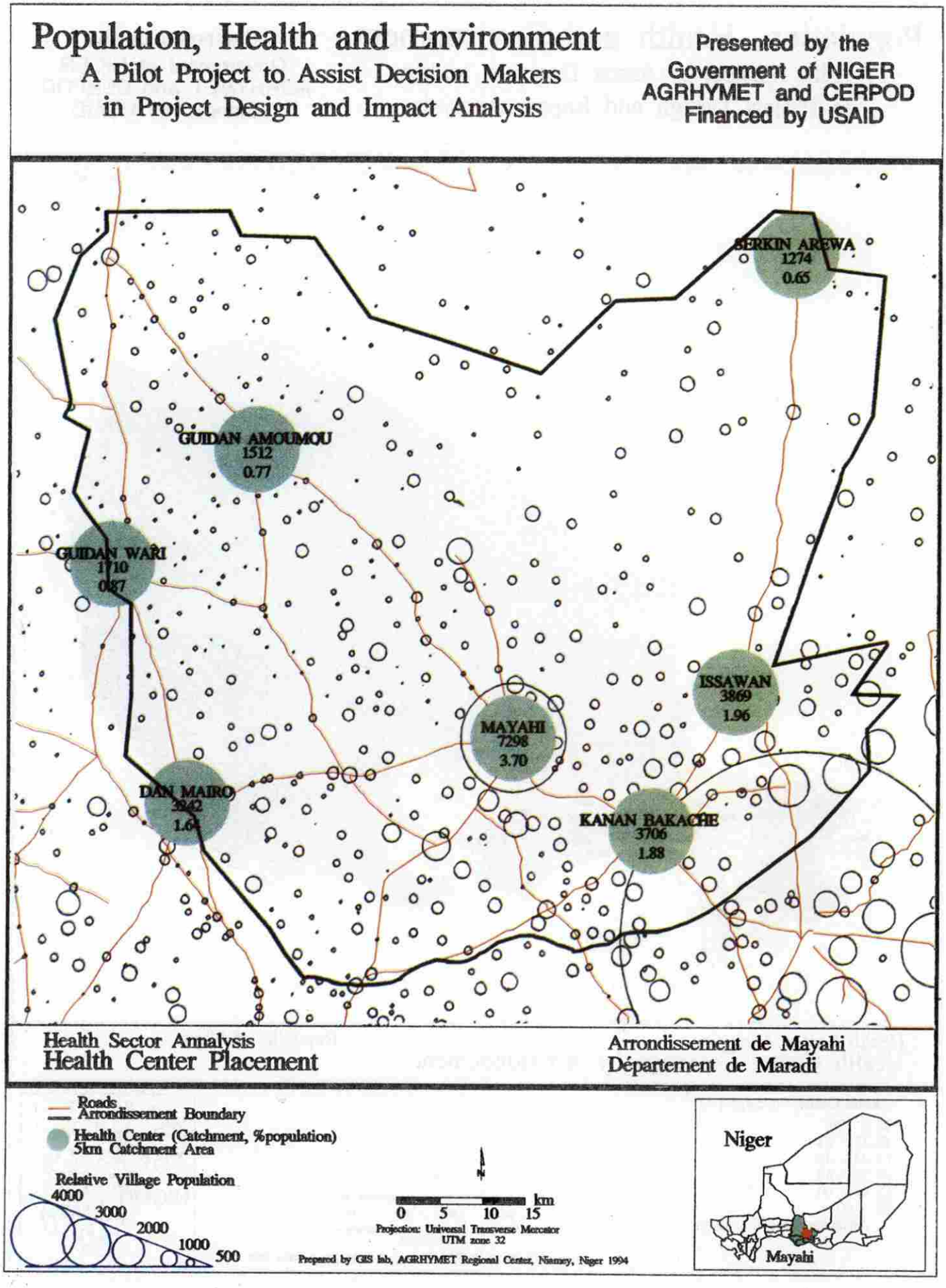
Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID
SERKIN AREWA
1274
0.65
GUIDAN AMOUMOU
1512
0.77
GUIDAN WARI
1710
0.87
ISSAWAN
3869
1.96
MAYAHI
7298
3.70
DAN MAIRO
3842
1.64
KANAN BAKACHE
3706
1.88
Health Sector Annalysis
Health Center Placement
Arrondissement de Mayahi
Département de Maradi
Roads
Arrondissement Boundary
Health Center (Catchment, %population)
5km Catchment Area
Relative Village Population
4000
3000
2000
1000
500
km
0 5 10 15
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
Niger
Mayahi

Figure A3.2

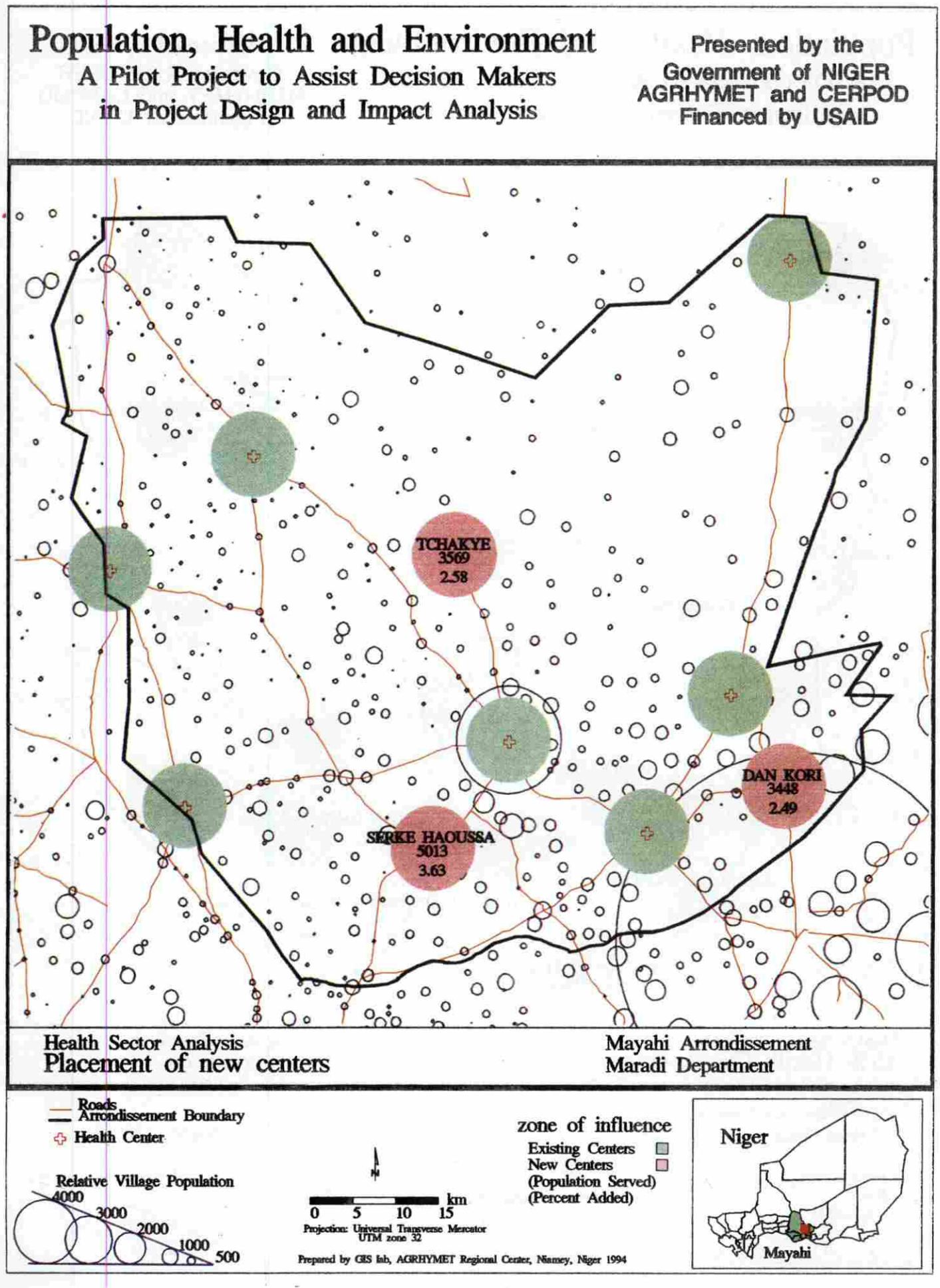
Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID
TCHAKYE
3569
2.58
DAN KORI
3448
2.49
SERKE HAOUSSA
5013
3.63
Health Sector Analysis
Placement of new centers
Mayahi Arrondissement
Maradi Department
Roads
Arrondissement Boundary
Health Center
Relative Village Population
4000
3000
2000
1000
500
km
0 5 10 15
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
zone of influence
Existing Centers
New Centers
(Population Served)
(Percent Added)
Niger
Mayahi

Figure A3.3

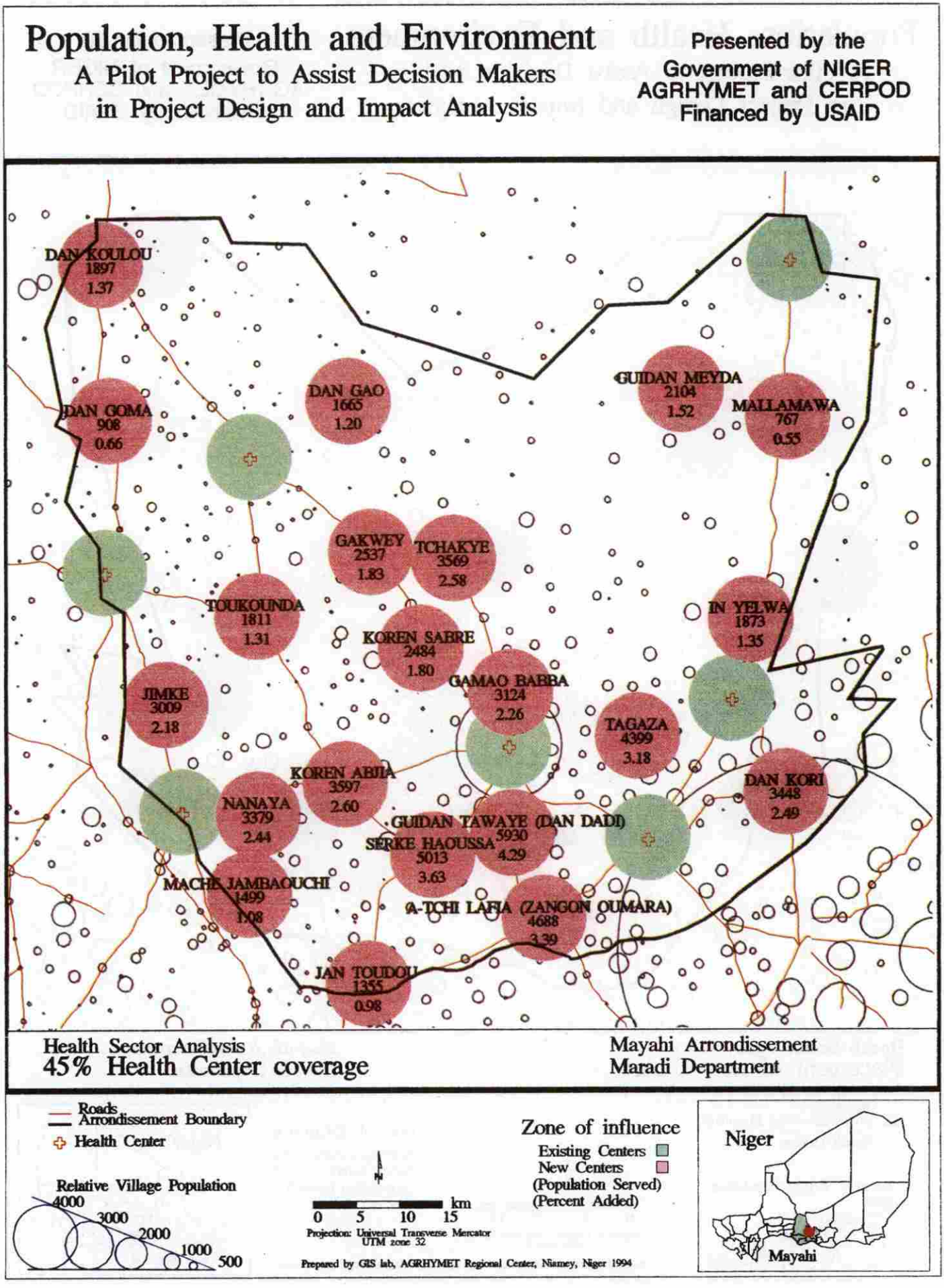
Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID
DAN KOULOU
1897
1.37
DAN GOMA
908
0.66
DAN GAO
1665
1.20
GUIDAN MEYDA
2104
1.52
MALLAMAWA
767
0.55
GAKWEY
2537
1.83
TCHAKYE
3569
2.58
TOUKOUNDA
1811
1.31
KOREN SABRE
2484
1.80
IN YELWA
1873
1.35
GAMAO BABBA
3124
2.26
JIMKE
3009
2.18
TAGAZA
4399
3.18
KOREN ABUA
3597
2.60
DAN KORI
3448
2.49
NANAYA
3379
2.44
GUIDAN TAWAYE (DAN DADI)
5930
4.29
SERKE HAOUSSA
5013
3.63
MACHE JAMBAOUCHI
1499
1.08
A-TCHI LAFIA (ZANGON OUMARA)
4688
3.39
JAN TOUDOU
1355
0.98
Health Sector Analysis
45% Health Center coverage
Mayahi Arrondissement
Maradi Department
Roads
Arrondissement Boundary
Health Center
Relative Village Population
4000
3000
2000
1000
500
km
0 5 10 15
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
Zone of influence
Existing Centers
New Centers
(Population Served)
(Percent Added)
Niger
Mayahi

Figure A3.4

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

Presented by the
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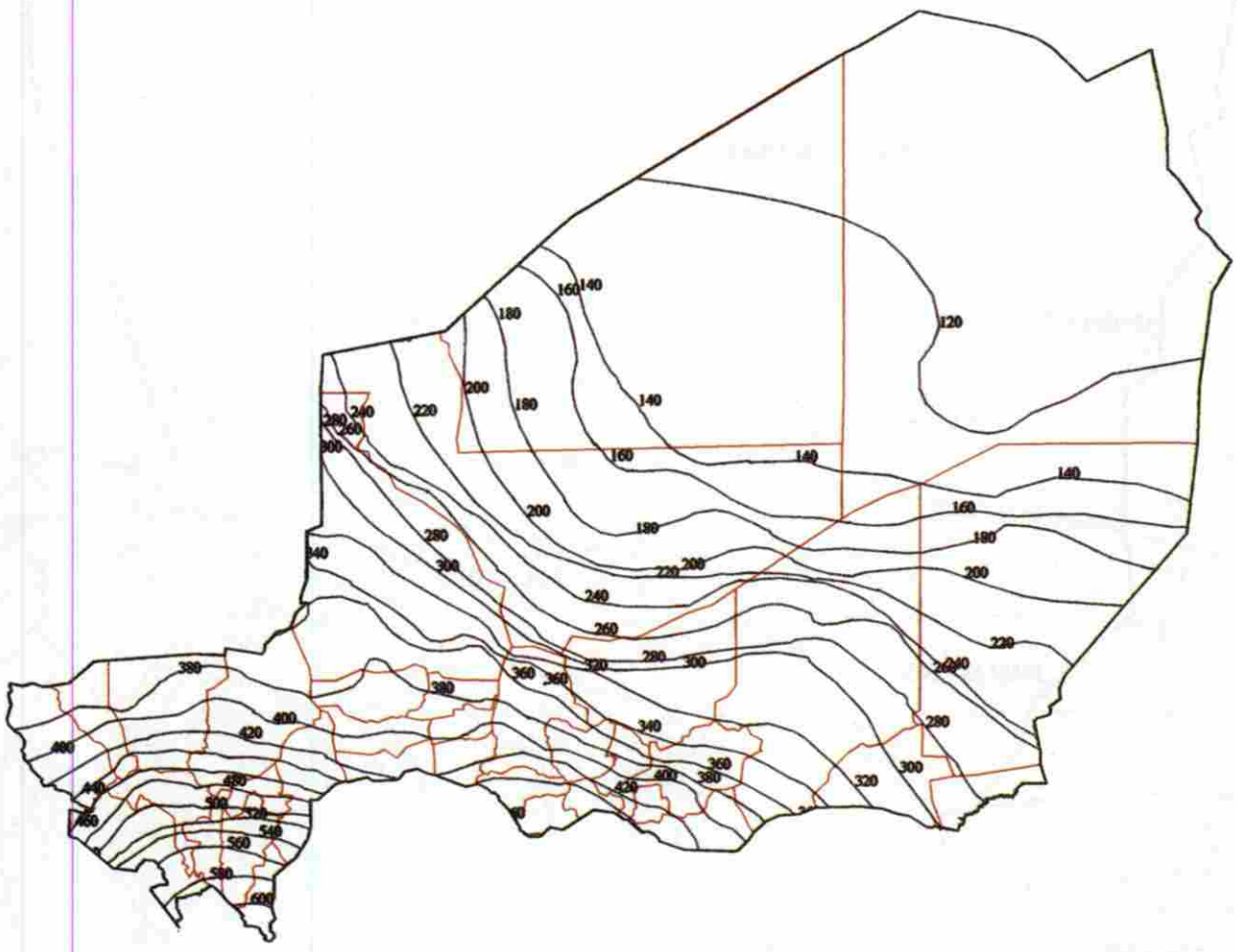

Environmental Sector Analysis

Average Annual Rainfall (1961-1990)

Republic of Niger

_ Average Annual Rainfall (1961 - 1990) in mm

_ Arrondissement Boundary

km
0 100 200 300

Projection: Universal Transverse Mercator
UTM zone 32

Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Figure B1.1

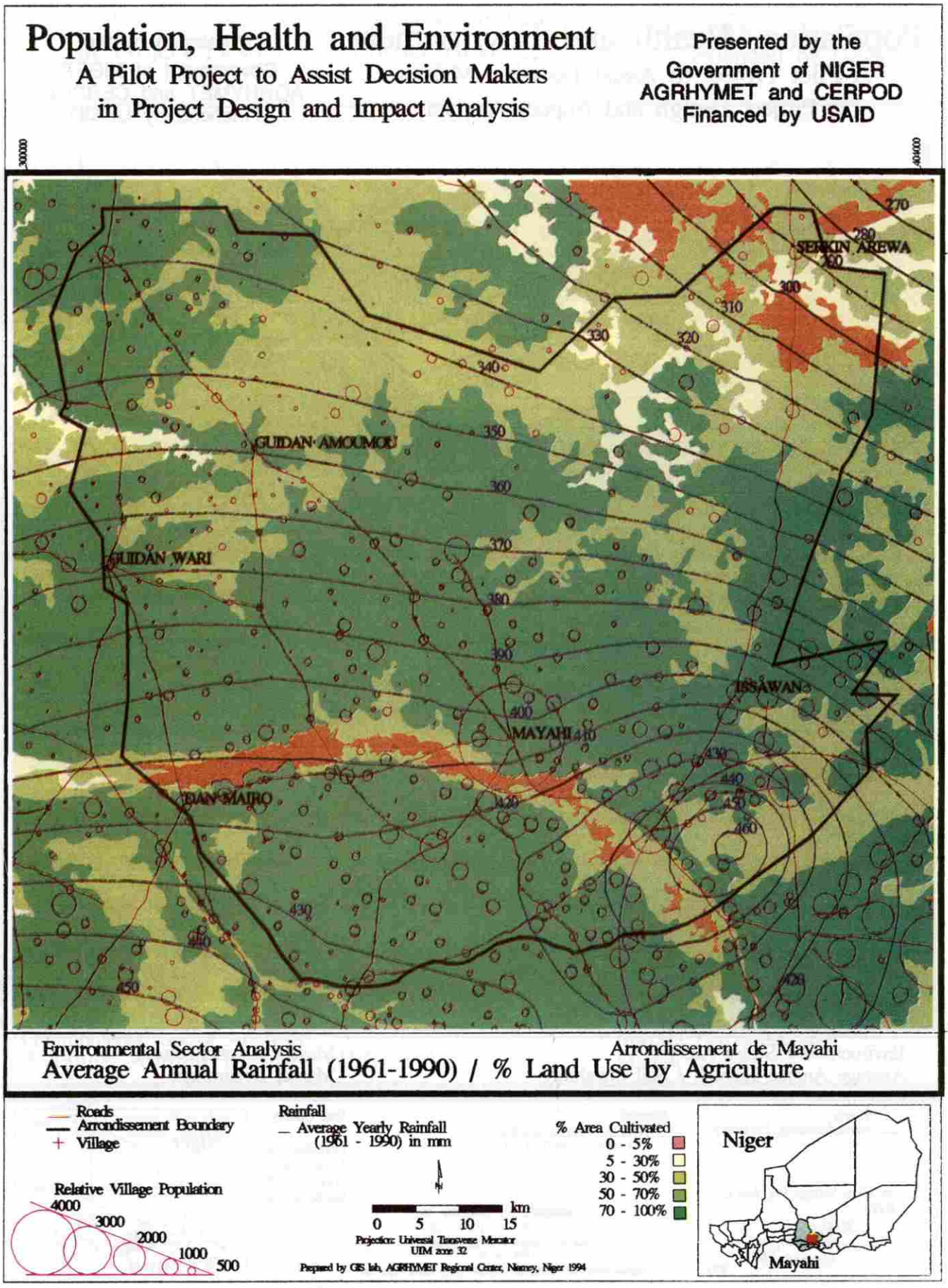
Population, Health and Environment
A Pilot Project to Assist Decision Makers
in Project Design and Impact Analysis
Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID
300000
404000
1600000
1510000
SERKIN AREWA
GUIDAN AMOUMOU
GUIDAN WARI
DAN MAIRO
MAYAHI
ISSAWANE
270
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
Environmental Sector Analysis
Arrondissement de Mayahi
Average Annual Rainfall (1961-1990) / % Land Use by Agriculture
Roads
Arrondissement Boundary
Village
Relative Village Population
4000
3000
2000
1000
500
Rainfall
Average Yearly Rainfall
(1961 - 1990) in mm
km
0 5 10 15
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
% Area Cultivated
0 - 5%
5 - 30%
30 - 50%
50 - 70%
70 - 100%
Niger
Mayahi

Figure B2

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

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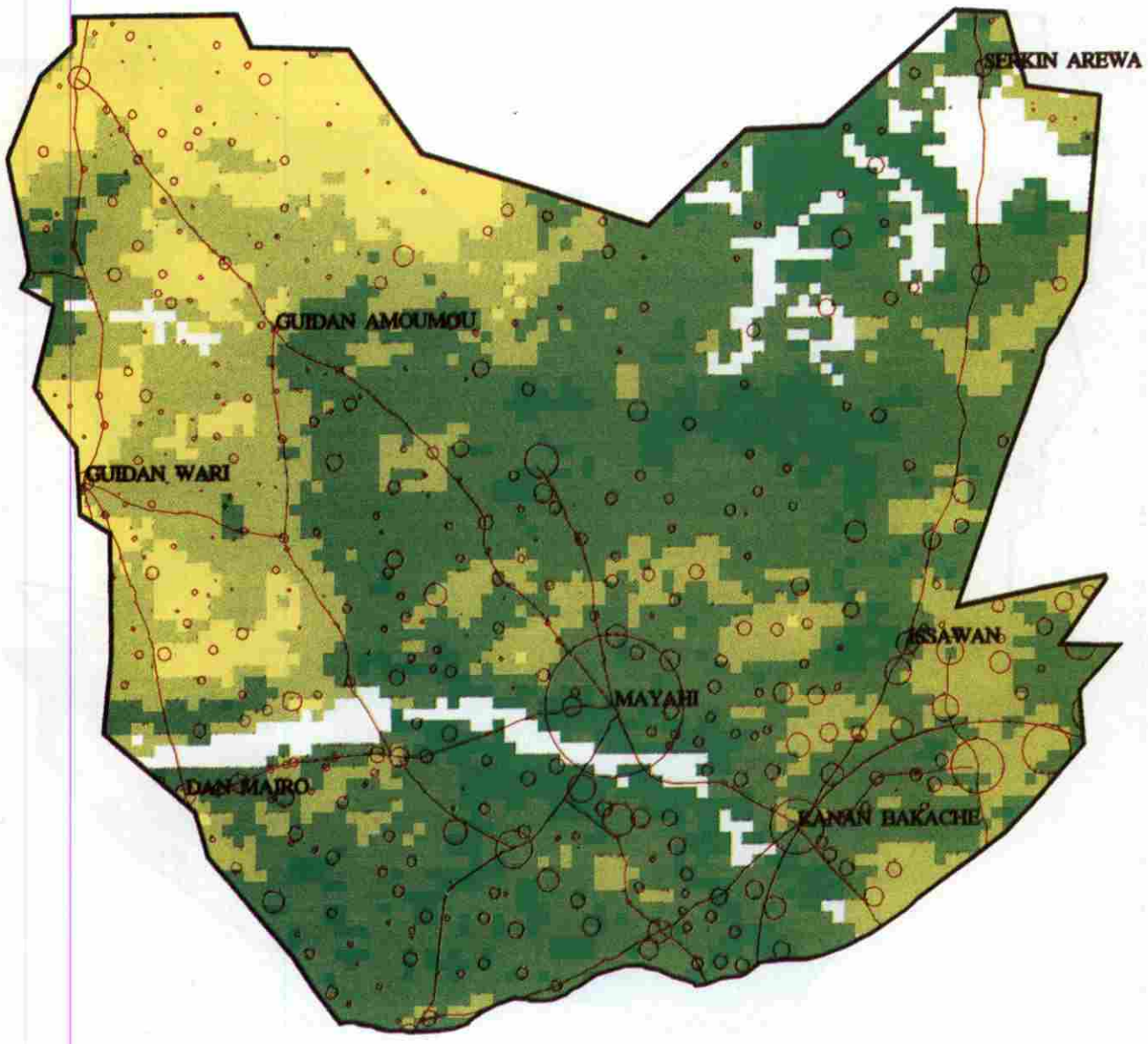


Environmental Sector Analysis — Mayahi Arrondissement

Vegetation Index, LAC, 3rd decade August 1993, > 30% Land Use by Agriculture

Roads
Arrondissement Boundary

Relative Village Population
4000
3000
2000
1000
500

km
0 5 10 15
Projection: Universal Transverse Mercator
UTM zone 32

Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Vegetation Index
< .05
0.05 - .1
0.1 - .15
0.15 - .2
0.2 - .25

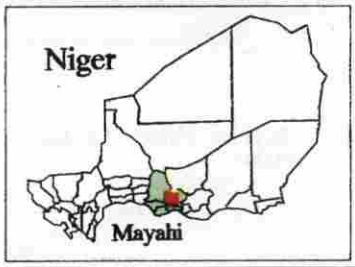
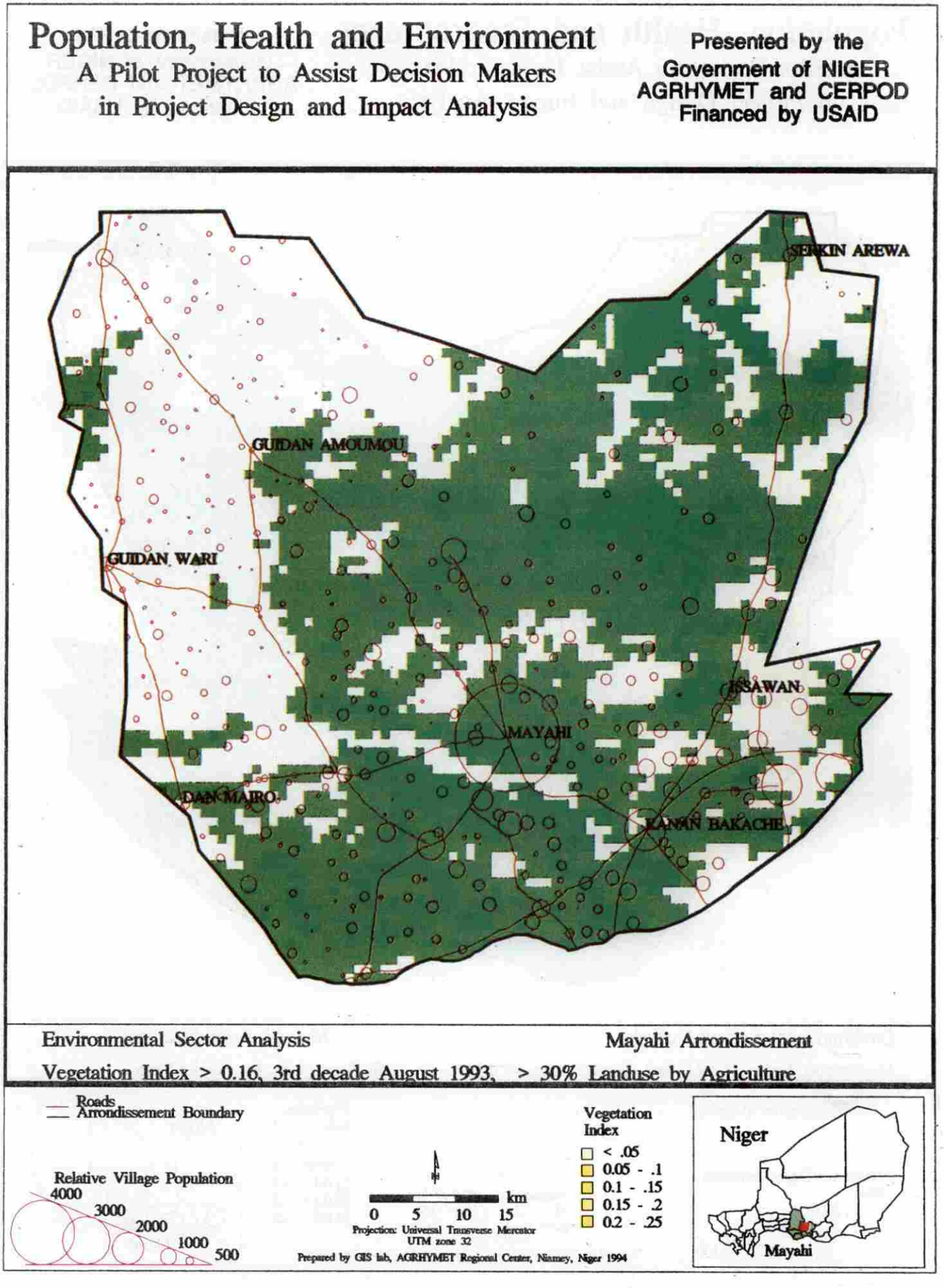


Figure B3.1


Population, Health and Environment
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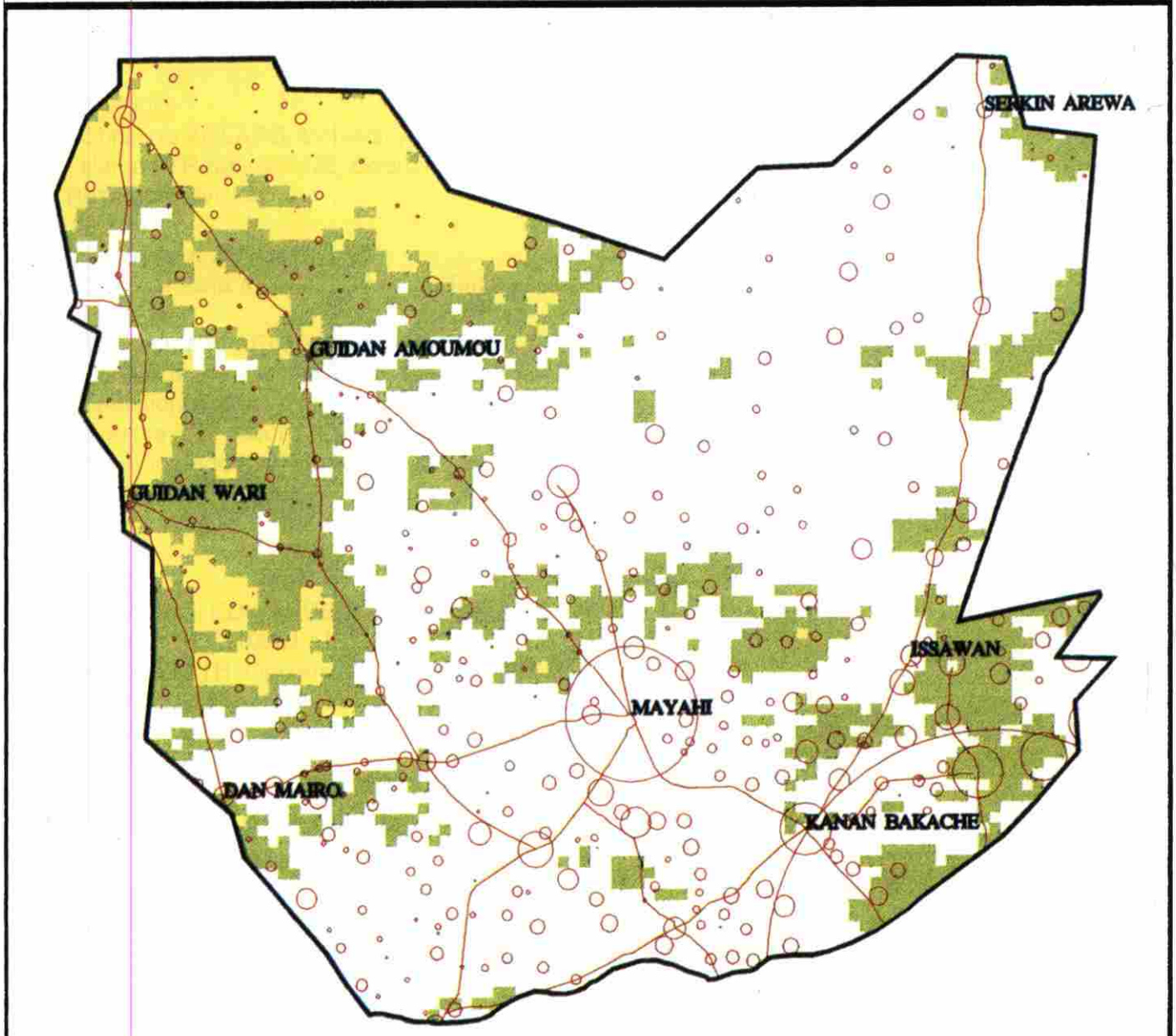
SERKIN AREWA
GUIDAN AMOUMOU
GUIDAN WARI
ISSAWAN
MAYAHI
DAN MAIRO
KANAN BAKACHE
Environmental Sector Analysis
Mayahi Arrondissement
Vegetation Index > 0.16, 3rd decade August 1993, > 30% Landuse by Agriculture
Roads
Arrondissement Boundary
Relative Village Population
4000
3000
2000
1000
500
km
0 5 10 15
Projection: Universal Transverse Mercator
UTM zone 32
Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994
Vegetation Index
< .05
0.05 - .1
0.1 - .15
0.15 - .2
0.2 - .25
Niger
Mayahi

Figure B3.2

Population, Health and Environment

A Pilot Project to Assist Decision Makers in Project Design and Impact Analysis

Presented by the
Government of NIGER
AGRHYMET and CERPOD
Financed by USAID



Environmental Sector Analysis — Mayahi Arrondissement

Vegetation Index < 0.16, 3rd decade August 1993, > 30% Landuse by Agriculture

Roads
Arrondissement Boundary

Relative Village Population
4000
3000
2000
1000
500

0 5 10 15 km

Projection: Universal Transverse Mercator
UTM zone 32

Prepared by GIS lab, AGRHYMET Regional Center, Niamey, Niger 1994

Vegetation Index
< .05
0.05 - .1
0.1 - .15
0.15 - .2
0.2 - .25

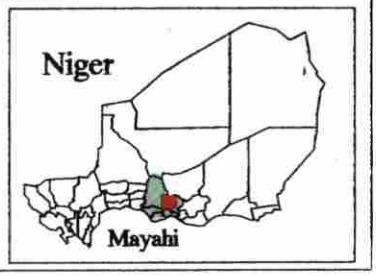


Figure B3.3

APPENDIX C
DEMOGRAPHIC DATA FOR MAYAHI ARRONDISSEMENT

Total Population (1988 Census)	226,245
Number of Households	30,801
Birth Rate	0.88%
Population Growth Rate	2.90%
Population Projection for 1994	269,219
Population Doubling Time	24 years
Population Density	34.7 km^2
Land Area	6519 km^2

Source: Fichier National des Localités, Ministry of Plan, 1988

Health Center Information for Mayahi Arrondissement

Number of Medical Centers	1
Number of Rural Dispensaries	6
Patient Beds	34
Infirmiers	18
Coverage by Dispensary	37,707/dispensary
Incidence of Measles (1993)	2.02/1000
Incidence of Malaria (1993)	2001000
Incidence of Pneumonia (1993)	120/1000
Contraceptive Prevalence (total Pop)	26%

Source: SNIS, 1993

Mayahi Health Center Information

Clinic	Population < 5km	CYP**	Contraceptive Prevalence***
Mayahi Medical Center	10,213	406	18.1
Kanembakache	8,150	55	3.0
Issa Wane	5,740	19	1.5
Serkin Arewa	2,877	40	6.3
Guidan Amoumane	3,266	7	1.0
Guidan Wari	1,713	27	7.2
Dan Mairo	2,367	36	6.9
Total	34,326	590	7.8

(Source: SNIS, 1993)
***(Source: DPF, 1993)*
****(calculations using DPF CYP data as a proximitive measure of number of users; SNIS coverage estimates used for denominator)*

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