Developing a Geo-spatial Information Framework to Facilitate National Identification System (NIS) in Ghana

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Abstract— The National Identification System (NIS), an initiative of the government to create a computerized database of Ghanaians and foreign nationals resident in Ghana using a biometric system of registration to captures the biodata of an individual and stores it in a database. The NIS is expected to provide some benefits such as d*evelopment planning based on sufficient accurate population data, delivery of social services such as health, retirement benefits and social administration; delivery of credit facilities; and identification of individuals for voting, insurance, licensing and general national security purposes* [8]. The NIS lacks a geospatial database and this could be a setback to the realization of the benefits of the NIS to the citizenry in Ghana. Literature reviewed shows that high quality geographic database is essential to having an effective citizenry identification system, to take care of the spatio-temporal dynamics which is key to the sustainability of such a system. Also this will aid policy makers, social scientist and government to geovisualise available citizenry data for research and decision making. This paper attempts to propose answers to the following questions: Can the NIS keep track of the spatial information pertaining to an individual or a group of people due to relocation? How can spatial information be validated during NIS registration? The paper first investigates novel geo-coding system that would be appropriate for providing spatial information of persons in Ghana. Secondly, the paper looks at the architectural framework for integrating a distributed geo-database into the NIS of Ghana. The paper then proposes a prototype system in the form of a Geo-demographic Information System for delivery of geographical data, demographic data, mapping capabilities and geo-information services. A system for validating location information within the NIS is discussed.

Keywords-architecturalframework,citizenry identification, decision making, distributed geo-database, Geo-demographic Information System, geovisualize, National Identification System (NIS).

I. INTRODUCTION

The National Identification System (NIS) is an initiative of the government of Ghana referred to in this paper as the Ghana NIS is a national database of Ghanaians and foreign nationals permanently resident in Ghana [9]. It is believed that this system would help the government to have a scientific basis for distributing resources, planning and proper management of socio-economic, cultural and political issues affecting the nation. This system captures the biometric details of applicants including the facial photograph and fingerprints individual and stores it in a national database. The national database is not linked to a corresponding geospatial database. The missing link between the national database and the corresponding spatial database could hamper the very benefits that the nation is supposed to derive from this all important initiative. A high quality geographic database is essential to having an effective citizenry identification system, to take care of the spatio-temporal aspects of the system which is key to the sustainability of such a system.

In this paper Geo-Information System and Science with an associated Spatial Data Infrastructure would be applied specifically to citizens' information and geo-demographics to support decision making at the local government level. Such a Geospatial Decision Infrastructure could compliment the Ghana NIS by contributing to location of persons with specific demographic characteristics, policy analysis and strategic modelling/planning. Internet and Web technologies have also made it possible to provide GIS functionalities and capabilities via servers, internet and the World Wide Web.

A number of important questions could be asked about the geospatial component of the NIS system, and it is the purpose of this research to investigate answers to some of these questions. The following is a partial list of some of such questions:

- *How quickly can the situ address of an individual or a group of people be accessed?*
- *How quickly can the geo-demographic characteristics of a location be found?*
- *How can the spatial information pertaining to an individual or a group of people be made current?*
- *How quickly can the information pertaining to location an individual or a group of people be validated during registration?*

The first objective would be to investigate a geo-coding and or dynamic segmentation system that would be appropriate for providing spatial (locational) information of persons with specific geo-demographic characteristics in

Ghana. The second objective looks at creating a distributed geo-database that could be integrated into the NIS of Ghana and to develop systems for updating the geo-data. The third objective highlights the design and implementation of a prototype Geo-demographic Data Infrastructure for delivery of geographical data, demographic data, mapping capabilities and Geo-Information services. The fourth objective is to investigate a system of checking the validity and currency of the location information provided by individuals or groups of persons.

This research would be appropriate to provide reliable, access and accurate geospatial information to support decision making pertaining to citizenry identification in Ghana. Section II of this paper takes a review of some literature, national *e-governance* initiatives of some developing countries including Ghana and the *Meldewesen* system of Germany, Austria and Switzerland. Section III discusses on the newly proposed methodology. Methodology for data acquisition is discussed in section IV. Section V highlights on the Expected outcome and further discussions. Finally, conclusions and future work is discussed in section VI.

II. Literature Survey/Review of Some National Identification Systems

Backus [1] highlighted that the *strategic objective* of e-governance is to support and simplify governance for all parties - government, citizens and businesses. Developing countries could take advantage of electronic means to speed up development. Some developing countries have embarked on initiatives geared towards promoting *e-governance*.

The following *e-governance* initiatives in some developing countries as outlined in [1] were reviewed: *Ghana - National Clearinghouse Ghana*, *Tanzania – ICT for Improved District Governance, Kenya – Busting Corruption Using the Internet*. None of these initiatives considers geo-data as a key component. However the success of each of these initiatives, just mentioned, primarily depended on a suitable geo-information system. This reveals that Geo-Information System has not been an integral part of the national agenda to promote good governance in some developing countries including Ghana.

The government of Ghana in recent times has been pursuing an agenda to accelerate development in the country through the ubiquitous information and communications technology (ICT). In this regard there has been some initiatives this agenda. One of such key initiatives is the *e-Government Interoperability Framework (e-GIF)*. This initiative seeks to basically create a framework and a platform for data and information to be shared among the ministries, departments and agencies of the state. One of the core areas considered by the *e-GIF* is geospatial information [4]. However, this initiative has not been fully implemented and therefore access to digital geospatial information is still (in 2010) a major problem in Ghana and therefore any attempt to disseminate geospatial information, which is one of the key issue in this research, would be significantly falling in line with *the e-GIF*.

Nerbert Douglas [7] acknowledges that geographic information is vital to make sound decisions at the local, regional, and global levels. Furthermore crime management, business development, flood mitigation, environmental restoration, land administration, public administration, disaster recovery are examples of areas in which decision-makers are benefitting from geographic information, together with the associated Spatial Data Infrastructure (SDI) that supports information discovery, access, and use of this information [7]. Reference [6], agree to the fact that local governments use Geo-Information System (GIS) in unique ways and because governments are responsible for long term health, safety, and welfare of citizens, wider issues need to be considered, including incorporating public values in decision making, delivering services in fair and equitable manner, and representing the views of citizens by working with elected officials.

Geographic Information a powerful but underused tool, if used in conjunction with local knowledge and good quality data, is key to understanding the geographies of place, community, economies and environments that are crucial if public policy interventions are to respond to the needs of citizens and the circumstances of their lives [16].

Kuntu-Mensah [5] proposed a *Ghana Office of Geographic Information Systems (GhOGIS)* which will serve the people of Ghana and the government to build a multi-user, multipurpose GIS database for the country. Though this has not been materialized, this research would further promote *e-governance* in the area of citizen identification using geographical information system as the means to achieving this objective.

A. Some Limitations of the Ghana NIS

NIA [8] highlights that the NIS when fully implemented is expected to facilitate national development. For the Ghana NIS to deliver its intended benefits there is the need to look critically at a number of issues. It is clear that the NIS focuses primarily on creating a demographic database. However, until this database could be linked to the residential (situ) address in a geo-database, decision making will be ineffective. At the same time it will be difficult to use such a system (NIS) to facilitate, credit facilities, planning and identification of individuals for general security purposes without a credible geo-database. This is because there is no means of validating the residential/home address of an individual at the time of registration. It means therefore that people could give wrong addresses during registration.

Assuming that the situ addresses of individuals in the NIS are valid, it may still be difficult to locate these addresses in Ghana due to the fact that most of the metropolis, cities, towns and villages are developed in a rather sporadic manner without proper spatial planning and house address systems. Most existing streets are not named

with the exception few in the urban areas. These make it difficult to have a systematic house numbering system as pertain in some developed countries.

Another issue has to do with individuals who may relocate, thereby changing their residential address. There is no system which ensures that citizens and foreign residents in the country register their residence. In this case, it would be very difficult to track changes in the situ address of individuals. The purpose of this research is to investigate these geo-spatial inadequacies associated with the NIS in Ghana in order to provide access to accurate and timely information which is a critical pre-requisite for national development. Policy-makers, planners, researchers, investors depend on reliable information for planning and decision-making.

B. *Lessons from the "Meldewesen" of Germany, Switzerland and Austria*

Switzerland, Germany and Austria employ a truly unique, brilliant practice known as the "*Meldewesen"* or registration system, by which each community, large and small, keeps track of the movements of its residents. All inhabitants of a community, of whatever nationality, are required by law to report their coming and going to the local community office and the police.

The "*Meldewesen"*, maintained at great cost [15] and often great personal inconvenience, is used by the officials for many purposes. It is the local community office that notifies the tax board of new arrivals subject to taxation; it informs the school board of children who should be in school under the compulsory system of education; it informs medical authorities of unlicensed practitioners; it makes up lists of children to be vaccinated under the compulsory vaccination law; it compiles the election lists and furnishes information for the purpose of the state insurance act; it works in close co-operation with the post office and has charge of making up the annual city directory.

The authors are of the view that as it may be challenging to implement the same registration system in Ghana but one of the obvious reasons why the "*Meldewesen"* is working in these countries is their situ addressing (proper geo-coding system) which makes it easier for a building(home or office) to be easily located.

III. PROPOSED METHODOLOGY

This paper attempts to adopt and modify a methodology developed by Hugh Calkins [10]. The reason being that Calkins methodology is user centred. Promoting local governance would mean that public participation is integrated into systems that are developed for the benefit of the ordinary citizen. Figure 1 shows the functional diagram of the methodology that this research seeks to propose.

A. *Requirements Analysis with Ethnographic Studies*

The proposed methodology starts with requirements analysis. This requirement analysis would involve basically an investigation and assessment of the needs of the entire system. This would involve an analysis the German, Austrian and the Swiss *Meldewesen* (citizen identification/registration system), geocoding and situs address systems. Assessment of data and user needs would also be undertaken at this stage in the research. As shown is figure 2, a key factor of the requirements analysis would be an ethnographic study of the above mentioned systems from Germany, Switzerland, Austria. This aspect of the research would take a critical look at how some countries have successfully run their identification system viz-a-viz geo-coding and geo-registration. The geo-coding system of some selected countries like Germany, Switzerland and Austria would be studied. Lessons learnt from these countries together with the peculiar situation in Ghana would be the basis for conceptualizing a geo-coding system for Ghana.

A geo-coding (postcode) and situs address system would be conceptualised, modelled and tested in a Geo-Information System. Another issue that would be investigated is a way to integrate a kind of a residential registration system that would facilitate individuals to register their addresses even when they relocate. The kind of residence registration in Germany, Austria and Switzerland the "*Meldewesen"* system would be of great interest. One of the benefits that this research is that it would create a model of geo-coding and geo-registration system for developing countries where spatial planning has not been successful.

After the requirements analysis, this methodology then divides into two paths: one pursues issues of data, and the other pursues the issue of conceptual definition for functional and non functional requirement specification. This is important in the sense that by dividing the methodology in such a way, a stronger emphasis is placed on the data requirements and needs since in a geographic information system the data is as important as, if not more important than, the hardware and software [10].

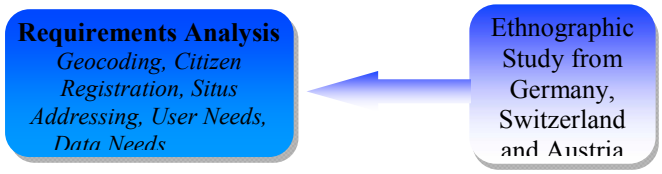

Figure 2: Requirements Analysis with input from ethnographic studies

B. *Conceptual definition pathway: Functional and non functional specifications*

Functional requirements for the system would be specified and described at this stage. The functional requirements for this system would basically describe what the system would do. These requirements would be expressed in terms of the system hardware and software requirements and acquisition. According to [14], the functional requirements specifications of a system should be both complete and consistent. That is to say that the all the services required are defined without contradictions. Since

this research looks at developing a socio-technical system, the non functional requirements specifications would deal with the ethical and legal aspects of developing such a system. It is important to state at this stage, that this research is basically investigating the technical issues not the legalities.

C. *Data Acquisition Pathway: Identification and Collection*

The second pathway deals primarily with data acquisition planning. Based on the requirements analysis, data acquisition plan would be drawn out. The plan would map out the necessary data and metadata that would be needed to set up the system. This research seeks to set up a pilot system in one of the districts in the Central region of Ghana. This region is chosen because at the time of writing this proposal, the National Identification Authority has captured data for the proposed National Identification System (NIS). However, by the time this research starts if NIS data for the Greater Accra region is available, a district in the Accra Metropolis would be selected for the pilot system. The proposed data for this project would be discussed under Methodology for Data Collection in section IV of this paper. Before the data is integrated into the system, the data would be synthesized and tested.

D. *Geo-coding Reference Database (Postcodes/Situ Addressing)*

Geo-coding refers to the process of assigning spatial locations to data that are in tabular format but have fields that describe their locations. Address geo-coding also known as address matching, which plots street addresses as point features on a map requires basically two sets of data [3]. The first data set contains individual street addresses in a table (one record per address). The second, a reference database that consists of a street map and attributes for each street segment such as the street name, address ranges, and ZIP codes. Address geo-coding seeks to interpolate the location of a street address by comparing it with data in the reference data. Based on the proposed geo-coding system, a prototype geo-coding reference database in the likes of the U.S. Census Bureau TIGER (Topologically Integrated Geographic Encoding and Referencing) database would be developed and implemented.

According to Chang in [3], many GIS users in the United States derive a geo-coding reference database from the TIGER/Line files. The proposed geo-coding reference database prototype is needed to facilitate geo-coding in this proposed Citizen Geo-demographic Information System.

E. *Pilot System Development*

The two paths later converge into the development and testing of a pilot citizen identification system. The pilot system would be a citizen information/geo-demographic system which could be accessible via the internet/Web with a front-end graphical user interface with analytical and visualization tools for professionals and the citizenry alike. The proposed pilot system (as shown in Figure 3) is a client-server socio-technical system [14]. Each integrator object is linked to a Core Database.

The Core Database (Core DB) contains reliable non-redundant collection of citizen demographic data, spatial data, geo-coding reference data, residential registration data (in the likes of *Meldewesen*) ,temporal data as well as metadata, parts of which are made available for queries through data marts designed for specific purposes and groups of users (professionals and citizens). A Citizen Geo-demographic information objects would interact with data marts to produce internet/Web interface with analytical and visualisations capabilities or "front counter" systems for highly trained professionals or citizens. This pilot system would provide tools for inventory applications, policy analysis, management and policy-making applications.

Sommerville [14] specifies that the distributed object architecture is appropriate for a data mining system that looks for relationships between the data that is stored in a number of databases (as in Figure 3). One of the reasons why distributed object approach is appropriate for this proposed system is that databases could be added to the system without major disruptions [14]. The database objects could provide a simplified interface that controls access to the data. A distributed database will help the so-called NIS accredited agencies to access and share data. Another reason why this approach is appropriate is that new visualisation techniques could be integrated into the system by adding new data marts. The system could also provide an opportunity for data mining activities to take place.

During the operation and maintenance phase, final evaluation is done with a feedback mechanism to the requirement analysis. This feedback mechanism is a deviation from Calkins methodology which has no feedback loops. Although not illustrated in figure 1, at each step of the process the system would be evaluated by the users and minor changes can be made before the final evaluation since Calkins methodology encourages continual user input throughout the process.

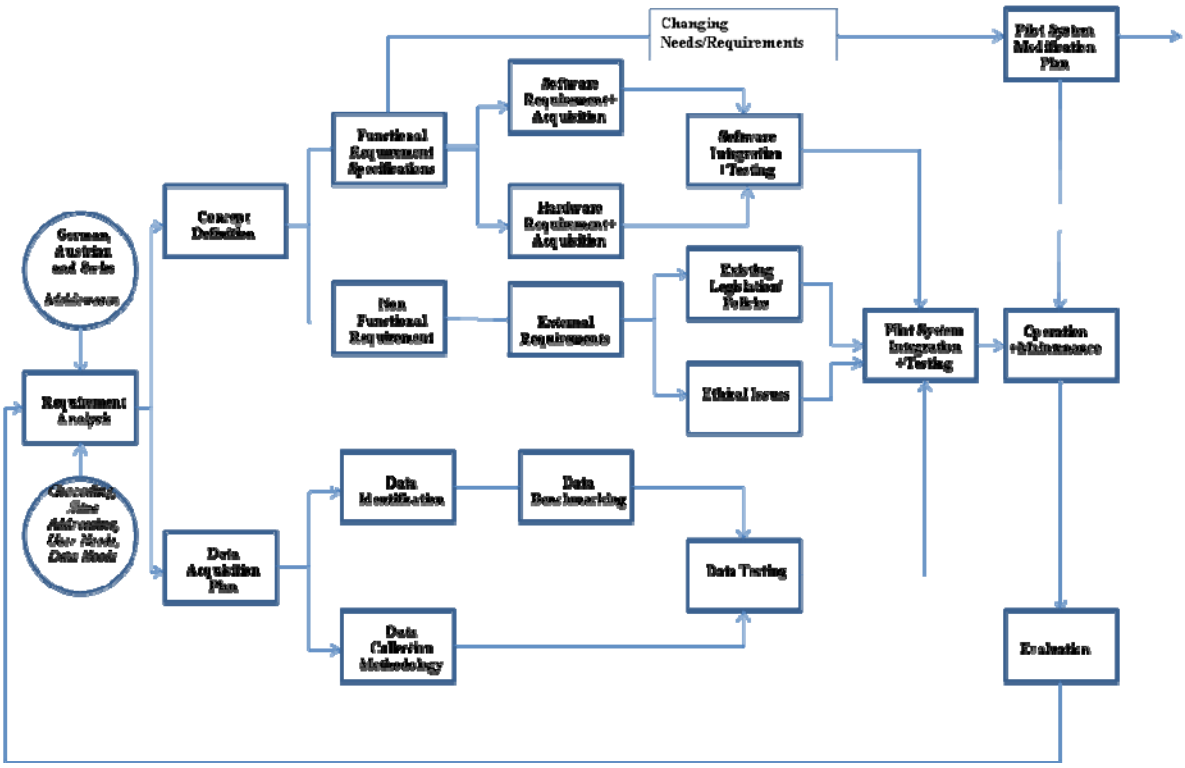

Figure 1: Functional diagram for proposed methodology

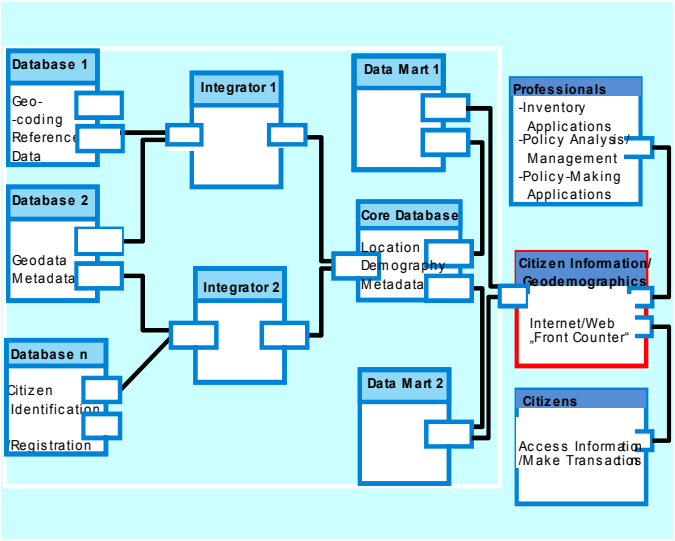

Figure 3: System architecture of proposed pilot citizen information system

IV. METHODOLOGY FOR DATA ACQUISITION

Data for this research is categorized mainly into citizen demographic data, locational (geospatial) data, temporal data and ethnographic study data. The latter shall be collected during the requirement analysis stage through the study of the *Meldewesen* system (of Germany, Austria and Switzerland). With the Core Database, a variety of databases will be integrated to generate a Citizen Geo-demographic Information System. As information on citizen identification results from a background of social, geospatial and temporal factors, this studies will encompass the use of data on the, geographic, demographic and temporal database which will be collected from existing sources in Ghana to cover the proposed study area for the Pilot System.

A. Geo-spatial Data and Metadata

The following geo-data (digital or paper) covering the area under study for the Pilot System would be collected from the municipal/district office of the Survey Department, Lands Commission, Land Title Registry, Town and Country Planning Department, Office of the administrator of Stool Lands, Lands Valuation Board.

1) **Base Map:** Large scale maps (1:2500) are available from the Survey Department.
2) **Zonal Plans:** Data on parcel inventory of zoning areas and land uses.
3) **Cadastral Data:** Data on land parcels will provide information on land ownership. This would include information on Land Title/Deed pertaining to parcels of land.
4) **Geo-code Areas Data:** Data on land parcels will provide information on land ownership. This would include information on Land Title/Deed pertaining to parcels of land.
5) **Utilities/Lines/Routes Data:** This will provide information on utility lines, roads and railroads. This

would be needed when creating geo-coding reference database.

Metadata which provide information about geo-spatial data will be an integral part of this geo-spatial database will be prepared during the data processing stage. Content standards for metadata shall be adhered to during the metadata development.

B. Geo-coding Reference Data

A proposed Ghana Topologically Integrated Geographic Encoding and Referencing (GhaTIGER) database would be generated by extracting information from the following data. The GhaTIGER will be a spatial extracts from the Census database, containing features such as roads, railroads, rivers, as well as legal and statistical geographic areas. The following data will be collected from the Ghana Statistical Service, Electoral Commission, Ministry of Roads and Transport, and the Ministry for Local Government Works and Housing respectively.

1) **Census Area Data:** Data on census for the study area will provide information on population and housing.
2) **Electoral Area Data:** This data will provide information on persons (18 years and above) with on electoral areas.
3) **Lines and Routes Data:** Data on lines and routes will provide information on streets, railways and roads.
4) **Property Data:** Inventory of housing stocks, age, condition, status (public, private, rental), durability and demographic. This would lead to the implementation of a property database.

B. Citizen Identification Data

The main demographic data for this project would be collected from the National Identification Authority, the Electoral Commission, Ghana Statistical Service, Rent Control Board, Birth and Death Registry. The demographic data is expected to be complete and current. The demographic profile of each person captured in the system shall be linked to the location (situ address).

V. Expected Outcome and Discussions

All data will be entered into a selected GIS base on a temporal/spatial basis. Visual display of the data and data analyses for interrelationships and changes will be conducted using the GIS. Because all data are being used including citizen information data have a location and time reference and this makes them suitable for spatial and temporal analysis. Geo-informatics or GIS provides a powerful tool for mapping, data analysis and temporal/spatial presentation of data.

One of the benefits that this research will produce is that it will provide a Geo-demographic Information System (GDIS) for the selected local authority and in the future for the entire nation of Ghana. The GDIS will be a geospatial-temporal database organized using Linux/ Windows XP (or Vista) and other GIS software in an integrated, user-friendly manner that can be updated as required. This will contain and organize all of the, geographic, demographic and temporal and other relational information. It will also be designed to facilitate statistical analysis and report generation.

A. GIS, Statistical Analysis

Geographic Information Systems have developed into a powerful modeling tool used for spatial analysis of various types of information. A GIS can be linked to a database in order to spatially relate, analyze and compare information. Traditional applications have involved natural resources and agriculture management, municipal and utilities infrastructure and organization, and international development. The GIS is a flexible spatial analysis framework that can be adapted to virtually any use.

In this research work, the GIS would initially be used to relate existing citizen identification, demographic and locational information related data into an organized structure. This structure would provide the basis for the identification of persons with specific demographic characteristics such as voting patterns, service usage and preferences, commuting routes, identification of ownership by land plot, spatial patterns and trends for in depth statistical analysis. Comparisons between persons and various demographic patterns could be tracked.

Based on these visual results, standard multivariate statistical analysis would be applied to test the likely relationships between citizens and demographic variables. Those with the highest residual or correlation coefficients, either as individual or multiple relationships would be tested further through geospatial GIS techniques or through *ground truthing* reviews to determine the conclusions which could lead to further research or new approaches to management of the citizen information and its related issues.

VI. Conclusion and Future Work

The proposed socio-technical research project is expected to provide the means for local authorities to manage citizen identification data in a distributed computing system. GIS software would be distributed in application servers to deliver GIS capabilities to a large number of users over networks. The system would be accessible via internet or WWW. Intuitive graphical user interface (GUI) would be incorporated to provide user friendly interaction within the system. The research would set the stage for the following applications in local governance:

1) **Voters Register:** Analysis of voting characteristics of particular areas. Modelling the effect of siting polling stations at particular locations.
2) **Socio-economic Development:** Geo-demographic data could be the basis for market area analysis. It could also provide a scientific basis for the equity distribution of the national resources.

3) **Crime Management:** Analysis of crime data could lead to the modelling of potential areas for specific crime activities.
4) **Law Enforcement:** Inventory of location of police stations, crimes, arrests, convicted perpetrators and victims; plotting police beats and patrol car routing; alarm and security system locations. Analysis of police visibility and presence; victim profiles in relation to residential populations.
5) **Health:** Location of persons with particular health problems. Analysis to pinpoint possible sources of disease.
6) **Emergency Management:** Modeling the effect of placing emergency facilities and response capacities in particular locations.
7) **Tax Mapping:** Analysis of tax revenues by land use within various distances from the city centre.
8) **Infrastructure Planning:** Analysis of infrastructure conditions by demographic variables such as income and population change.
9) **Human Services:** Facility siting, public transportation routing, program planning and place-based social intervention.

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