

Health for All in New Millennium – Is This Possible Without GIS Applications?

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INTRODUCTION

Application of Geographical Information System (GIS) in health is relatively a new concept. Since mapping is an excellent means of communicating a message clearly even to those who are not necessarily familiar with the methodology, GIS can be used effectively with leadership at various levels – panchayats, nagarpalika, districts, states and national administration to convey the priorities, the problems and provide an analysis and evidence based menu of options for programme implementation. Such maps can help in discussion, assessment, analysis and decision making. These maps when posted in public places and if updated provide a mirror for review and continuous updating of decisions at the community level. An attempt has been made to develop a health GIS for leprosy and TB mapping in the state of M.P., Orissa and Tamil Nadu (Peters et al., 2000) and mapping of malaria has been done for Gujrat and A&N Island. The National Atlas of India also contains two maps one on Map – India Health and other on Map India Disease. Hence, GIS can be used as a management support tool through integrated data base management to prepare combined maps for state, districts or maps down to block / village levels.

CONCEPT OF GIS

GIS stands for Geographical Information Systems which is a powerful computerized system of hardware, software and procedures designed for input, storage, retrieval at will, manipulation, analysis and display of spatial data (Aronoff, 1989). Spatial data refers to data containing measured or observed values, termed attributes, associated with specific locations (Sabins, 1987). There are many definitions of GIS. The definitions of GIS given by various authors are as follows: a *spatial data handling system*; a *computer – assisted system for the capture, storage retrieval, analysis and display of spatial data, within a particular organisation*; a *powerful set of tools for collecting, storing,*

retrieving at will, transforming and displaying spatial data from the real world; an internally referenced, automated, spatial information system; a *system which uses a spatial data base to provide answers to queries of a geographical nature*.

Each piece of information is related in the system through specific geographical coordinates (e.g. latitude and longitude) to a geographical context (Nuttall et al., 1995). This can be a health facility, a laboratory, a village, a road, a hospital, a block, a district, a region, a country or a group of countries. The information can be displayed & represented in the form of graphs, charts and maps. In a sense, GIS is a special purpose digital database in which a common spatial coordinate system is the primary means of reference. GIS have the ability to perform numerous tasks utilizing both spatial & aspatial information stored within them.

COMPONENTS OF GIS

Geographical Information Systems (GIS) have 3 important components.

1. *Computer Hardware*: The general hardware component of a GIS consists of a digital computer and other devices such as a digitiser, plotter etc. The computer or central processing unit (CPU) is linked to a disk storage unit, which provide space for storing data and programs.
2. *GIS Software Modules*: The software package for a GIS consists of 5 basic technical modules. These basic modules are sub-systems for: (a) Data input and verification (b) Data storage and database management (c) Data output and presentation (d) Data transformation (e) Interaction with the user
3. *The Organizational Aspect of GIS*: The GIS needs to be placed in an appropriate organizational context. It is simply not sufficient for an organization to purchase a computer and some software and to hire or retain one or two enthusiastic individuals and then to expect instant success. Just as in all organizations dealing with complex products, as in

manufacturing industry, new tools can only be used effectively if they are properly integrated into the whole work process and not tackled on as an afterthought. To do this properly requires not only the necessary investment in hardware and software, but also in the retaining of personnel and managers to use the new technology in the proper organization context.

GEOGRAPHICAL DATA

1. *Spatial Data*: All geographical data can be reduced to three basic geographical phenomenon can in principle be represented by a point, line or area plus a label saying what it is. So location of an well or a Sub-centre or a PHC or a CHC or a hospital or a canal/ body could be represented by a point entity consisting of a X, Y coordinate; a road could be represented by a series of X, Y coordinates; a floodplain could be represented by an area entity covering a set of X- Y coordinates plus the label 'floodplain'. The labels could be the actual names as given here, or they could be special symbols.
2. *Non-spatial/ Aspatial Data*: Non-spatial data include information about the features (Sloggett, 1986) viz. name of roads, schools, forests, population or census data, number of vehicles, number of patients, number of Sub-centres, number of *anganwadi* in a village or block or district, number of PHCs, number of CHCs number of hospitals etc.

DATA REPRESENTATION AND STRUCTURE

1. *Raster Method*: The simplest raster data structures consists of an array of grid cells (Scholten, 1991). Each grid cell is referenced by a row and column number and it contains a number representing the type or value of the attribute being mapped. In raster structures a point is represented by a single grid cell; a line by a number of neighbouring cells strung out in given direction and an area by an agglomeration of neighbouring cells. The advantages of raster methods include simple data structure, overlay and combination of mapped data with remotely sensed data is easy, various kinds of spatial analysis are easy and technology is cheap. Main disadvantages include less beautiful maps,

network linkages are difficult to establish, there can be a serious loss of information and projection transformation are time consuming unless spatial algorithms or hardware are used.

2. *Vector Method*: The vector representation of an object is an attempt to represent the object as exactly as possible. The co-ordinate space is assumed to be continuous, not quantised as with the raster space, allowing all positions, lengths, and dimensions to be defined precisely. The advantages of vector methods include good representation of phenomenological data structure, compact data structure, accurate graphics, topology can be completely described with network linkages, retrieval, updating and generalisation of graphics and attributes are possible. Main disadvantages include complex data structures (Twigg, 1990), combination of several vector polygon maps or polygon and raster maps through overlay creates difficulties, display and plotting can be expensive, spatial analysis and filtering within polygons are impossible.

GIS APPLICATIONS

GIS applications include data input, data storage and management, data manipulation and analysis and data output. In data collection, a GIS provides an excellent means of collecting, updating (Yadav, 1997) and managing epidemiological surveillance and related information management and analysis. In data management, a GIS serves as a common platform for convergence of multi-disease surveillance activities. Standardized georeferencing of epidemiological data facilities standardized approaches to data management. As such, a GIS can serve as an entry point for integrating disease surveillance activities where appropriate. A GIS facilitates the convergence of multisectoral data, including epidemiological surveillance information, population information, environmental information and health and other resources into a common platform for analysis. In data analysis, a GIS provides an excellent means of visualizing and analysis epidemiological data, thus revealing trends, dependencies and inter-relationships that would be more difficult to discover in other formats.

In functioning, a GIS can help answer

specific questions and perform the following functions: generate thematic maps (ranged color maps or proportional symbol maps to denote the intensity of a mapped variable); allowing for overlaying of different pieces of information (WHO, 1999); create buffer areas around selected features, for example a radius of 2 Km. around a stagnated water body where *Anopheles* can breed, a radius of 10 Km. around a health centre to denote a catchment area etc.; carry out specific calculations, for example the proportion of the population falling within a certain radius of a health facility, school etc.; calculate distances e.g. the distance of a community to a health facility; permit a dynamic link between databases and maps so that updates are automatically reflected on the maps; permit interactive queries of information contained within the map, table or graph; process images such as aerial or satellite images to allow information such as temperature, rainfall, soil type and landuse to be easily integrated, and spatial correlations between potential risk factors and the occurrence of diseases to be determined; provide a range of extrapolation techniques e.g. extrapolating sentinel site surveillance to unsampled areas and so on.

Thus, GIS could be extremely useful in public health for determining geographical distribution & variation of diseases (prevalence, incidence); analysing spatial and longitudinal trends; mapping population at risk; stratifying risk factors; assessing resource allocation like health services, schools and water points; planning (Yadav, 2001) and targeting interventions; forecasting epidemics; monitoring diseases (Yadav et al., 1999) and interventions over time and in many other aspect.

CONCLUSION

There are many questions that GIS can help resolve with their spatial analysis tools. Maps and final outputs produced by a GIS can be used by health officials as a monitoring and evaluation tool for better planning, showing the spatial distribution and differential evolution of diseases, thereby reducing the monitoring and implementation costs of the health sector programmes. GIS techniques through over laying, buffering, rationing give an output which helps in indicating longitudinal trends, mapping population at risk, stratifying risk factors, planning

and targeting interventions, forecasting epidemics, monitoring diseases and interventions over time, determining geographical distribution and variation of diseases (prevalence & incidence).

KEYWORDS GIS. Spatial Analysis. Mapping. Health Management,

ABSTRACT There will be many challenges in effective health care delivery system in the new millennium. A health administrator can implement & use Geographical Information System (GIS)- a powerful computer based technology for evaluation, planning, assessment and management due to the options and capabilities for data maintenance and manipulation through add/ delete/ change, move/ rotate, stretch/ rectify, transform projection and scale, zoom/ window, clip and modifications, 3-D projection and display and data retrieval and reporting etc. of any feature or entity. Management and handling of large data base of spatial and aspatial nature in context of communicable and non-communicable diseases, reproductive and child health (RCH), environmental health, health sector reforms, decentralization and role of various institutions, role of various agencies and Government etc for analysis and solutions of complex and difficult problems is simple, time and cost effective by GIS. Non-spatial data (viz. number of vehicles, well, schools, HIV infected persons, name of roads, forests, population or census data, number of patients, number of *anganwadi* in a village or block or district, number of SCs, number of PHCs, number of CHCs number of hospitals etc.) directly and spatial data (viz. location of a SC, PHC or a CHC or a hospital) through digitization can be entered in the GIS system. Non-spatial information can be represented as spatial information using GIS on a map or a monitor. GIS can generate maps in various combinations and permutations as initial and final output (ranged colour maps or proportional symbol maps to denote the intensity of a mapped variable) to depict various health and family welfare programmes for general monitoring, demographic, programme performance, health infrastructure, maternal & adolescent health, status of various methods used and position of various diseases etc. This technology provides overlay of different pieces of information in desired and required manner and can create a buffer zone/ area around any required parameter or object. All type of calculations & measurements are possible by interactive queries of information contained within the map, table or graph. It is helpful in determining geographical distribution and variation of diseases (prevalence and incidence) and various disease causing parameters/ agents, monitoring diseases, stratifying risk factors and mapping population at risk e.g. HIV prevalence in a State or a Country. Wide ranges of extrapolation techniques are also possible in GIS. Final output can be in the form of maps, graphs and tables for future planning, course of action and management for better health.

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