GIS for rural health and sustainable development in India, with special reference to vector-borne diseases

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Environmental degradation, socio-economic decline, and extreme weather patterns are contributing to changing pattern of morbidity and mortality and posing serious challenge to public health. The problems of health are increasing in both spatial and temporal dimension to many newer places, especially in the rural areas due to increased risk of disease transmission fuelled by developmental activities, demographic changes and introduction of newer products. However, with advanced knowledge on the principles underlying the disease transmission dynamics, prediction of occurrence of diseases is possible based on environmental factors and satellite-based remote sensing data. Limited physical access to primary health care is also a major factor contributing to the poor health of rural populations in India. Modern tools like remote sensing and Geographical Information Systems (GIS) have now come in handy to address the issues on the disease surveillance, control, monitoring and evaluation. Our responsibility in the immediate future should be to provide technical information on these, facilitate formulation of policy statement, preparation of strategic plan, ease advocacy steps at different stages and foster effective linkages with all partners. The rural health care information system envisaged on GIS domain in this article explains how it eventually facilitates utilization of resources, preventing disease and promoting health care, working towards the overall rural development and thereby ensure sustenance of the programme at all levels.

EVER increasing population and lack of adequate health care facilities, particularly for the rural masses are a matter of concern for India. While on one side the country is proud of major achievements in science and technology, including space and our march towards a knowledge society, it is true on the other side that a large proportion of our population has no access to even safe drinking water, to cite one of the major problems facing the country. The continued practice of open drainage system, indiscriminate disposal of water and industrial effluents into water bodies, and added to this, the increased migration from rural areas have resulted in large slums in our urban centres creating an environment unsuitable for healthy living and thus aggravating the spread of water-borne diseases like cholera, typhoid, tuberculosis, dysentery and gastroenteritis.

Yet another area of concern to the country is the spread of vector-borne diseases (VBDs) such as malaria, filariasis, Japanese encephalitis and dengue to newer areas with mosquitoes, the vectors carrying these diseases, breeding in water bodies. The World Health Organization (WHO) and other international bodies highlight the threat posed by these VBDs to the world's population in general and to India in particular[1]. It is said that in India alone, over two million cases of malaria are reported every year[2]. VBDs are spreading to newer areas due to increased risk of transmission fuelled by developmental activities, demographic changes and introduction of new chemicals to name a few possible causes.

Health care for our rural populace has become a nightmare with no facilities nearby, thereby forcing the rural poor to travel long distances for medical help. While specialist medical practitioners are particularly scarce in rural areas, even the few who chose to serve in rural areas suffer from lack of availability of infrastructure facilities, besides missing out the technological advances as well as essential day-to-day professional interactions. Globally, tele-health is becoming a viable technological option and for a country like India, it could be a boon if appropriately planned and executed. It is in this context that there is an urgency to launch a nation-wide mission for rural health care integrating the modern tools. The following paragraphs dwell on the utility/role of GIS in the rural health scenario and possible means of controlling/preventing diseases which could form part of a national mission, with participation by the concerned institutions/departments/non-governmental organizations.

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The Health Information System

In the past, information systems for disease control were designed for use centrally with little or no feedback to the source of information and with no impact on local activities. The information systems are a vital element for strengthening the national and local capacities for assessing the situations, for selecting appropriate control measures, and for adapting activities to changes in the situation. It was seen that information systems should therefore be reoriented to deal with specific disease and decentralized in such a way that information is available to be used by those who need it. The occurrence of malaria for instance, is influenced by a number of factors outside the habitual framework of health systems (including population movements, environmental changes, and health practices); the information system should be able to incorporate and use these different types of information. Each of these different types of data and information have a spatial basis, and therefore, should be able to deal with geographic aspects of information.

Necessary capabilities

The system chosen should be able to:

- Use the existing databases of the disease control programme.
- Be open to the future incorporation of data from other sources.
- Deal with the spatial aspects of this information.
- Produce routine epidemiological evaluations.
- Stratify areas based on a set of rules.
- Automate maps.
- Produce feedback to the peripheral level.
- Produce feedback to the general public.

Rural health management

It is evident that many questions concerning the provision of health care are related to space. People are not evenly distributed in villages. Health problems vary in space and so do the needs of the people. Where should health care centres be situated and what services should they offer to answer efficiently the needs of populations varying in numbers, densities and health problems? These are problems that the Geographical Information Systems (GIS) can help resolve with its spatial analysis tools.

Health officials can also use maps produced by GIS, as a monitoring and evaluation tool, showing the spatial distribution and differential evolution of diseases. Monitoring and evaluation are an essential part of the health programme, as well as other programmes related to development. Monitoring is defined as the periodic review of the implementation of an activity which seeks to establish the extent to which input deliveries, work schedules, other required actions and targetted outputs are proceeding according to plan, so that timely action can be taken to correct the deficiencies detected. Closely linked to monitoring is evaluation. This is a process by which programme inputs, activities and results are analysed and judged explicitly against stated norms. These two aspects are usually an integral part of every programme, including rural health management.

By giving the managers, planners and policy-makers access to information on coverage, functioning and utilization of the facilities/resources, operation and maintenance, monitoring as a tool guides them in taking important decisions. Similarly, worthwhile evaluation, as a result of effective monitoring, is necessary in ensuring rational utilization of resources allocated for the sector and thereby sustenance of achievements accomplished.

Tele-health for rural folks

In a vast country like India, one of the fundamental issues is to provide timely advice on the health status and diagnosis of diseases, particularly in rural and tribal areas. With the advent of computers, advances in software, imaging and high-speed communication technologies, there have been a lot of studies globally involving clinicians, health services, researchers, etc. making use of these advances in technologies towards providing health care solutions to the deprived lot, by overcoming what is commonly known as the 'last mile' problem. It is here that the terms such as tele-health and telemedicine are heard more often in the recent past. Tele-health is a more generic term, wherein telecommunication technology is used for the purpose of providing telemedicine, medical education, and other health education services over long distance. Here, one can cite the example of Project SHARE (Satellites in Health And Rural Education), launched by INTELSAT and the International Institute of Communication[3]. On the other hand, telemedicine is a subset of tele-health, providing medical and health care, enhancing diagnoses, expediting research and improving treatment of illness over a distance.

In India, health care delivery has been largely the responsibility of hospitals run by the Government (both State and Central), by trusts, the private sector, and private practitioners. The Government has been responsible in bringing primary health care to the semi-urban and rural areas in an effective manner. However, due to sheer magnitude of the task and the limited resources, the health care delivery systems have not grown beyond the primary medicare level, resulting in large gaps in the availability of secondary and tertiary levels, particularly in rural areas. Further, the inclination of the medical community to serve largely in the metros has also deprived the rural community of

advanced medical care. It is also the case with the northeastern part of India, Andaman and Nicobar and Lakshadweep islands. Particularly in the case of islands, it has become a nightmare both for the administration and the affected populace to get medical aid in time, as often the patient(s) have to be flown to the nearby metros at prohibitive cost and time overruns. However, it does not mean that our urban communities are healthy and all medical facilities are available.

Basically, telemedicine is a mode of health delivery involving transfer of medical information (in audio, motion video, still images, graphics, text and other modalities) amongst distant locations with patients, physicians, other health care providers and medical institutions. It includes using telecommunications to link health care specialists with clinics, hospitals, primary physicians and patients in distant locations for diagnosis, treatment, consultation and continuing education. The case history of a patient as well as, records and reports are transferred miles across to seek a second opinion. A live operation could be conducted in the rural set-up under the vision and guidance of a mentor/surgeon, who would be viewing and providing consultation at the same time from a city. Application of tele-health/telemedicine offers advantages in terms of improved medical care to remote rural areas. Satellite-based communication provides the essential capability to reach inaccessible remote areas most effectively, wherein a priori limitation on the use of traditional or terrestrial telecommunications systems, which rely on physical links is overcome. Besides, the terrestrial systems need ground support and the cost of installing terrestrial systems and laying cables is prohibitively expensive. Satellites can reach any point and can be flexible in terms of required coverage and the traffic, and hence provide the ideal solution for the 'last mile' problem, the weakest link in any system. It is with the above in mind that the Indian Space Research Organization (ISRO) has launched, in the past few years, a series of socially relevant programmes under the Training and Development Communication and Channel, Jhabua Development Communications Project, and GRAMSAT Pilot Project using the INSAT Transponder system, a unique interactive satellite-based network concept providing 'one-way video and two-way audio' connectivity for specified users in various states such as Madhya Pradesh, Gujarat, Orissa, Karnataka, West Bengal and Rajasthan[4].

Taking note of the above, a nation-wide mission involving concerned medical agencies/institutions, possibly coordinated by the Indian Council of Medical Research, and the Directorates of Health Services in states could be launched primarily to combat VBDs by integrating the requirements and pooling together the resources from the participating government departments/non-governmental agencies/other institutions. ISRO may be approached for its involvement in such a mission and provide necessary wherewithal in terms of satellite remote sensing and communication support.

Space technology inputs in vector surveillance

Vectors of malaria, filariasis, Japanese encephalitis and dengue thrive on water, vegetation and dwellings (with the availability of vertebrate host). Obviously, mosquito control requires the knowledge of the location of aquatic habitats suitable for mosquito larval growth. Study of mosquito population dynamics with the change of environmental variables will help in understanding the criticality of those variables and in the undertaking of appropriate control measures. Identification, location and monitoring of these environmental variables through conventional ground surveys are difficult, time-consuming and expensive. With the advent of satellite remote sensing, continuous monitoring of the environmental variables mentioned above has become feasible. It is appropriate to use satellite data for monitoring aquatic habitats, vegetation cover and human settlements, and relate them with changing mosquitogenic conditions. Globally, there are many studies proving applicability of remote sensing in vector habitat identification and for optimization of vector control operations[5,6].

Satellite remote sensing technique along with GIS enable surveillance of environmental conditions for vector development and disease transmission providing information on epidemiology of a region, viz. favourable ecological conditions, habitat types providing breeding sites and their characterization, prevailing disease, past history of epidemics and environment and social and economic factors associated with the epidemics. Major factors such as climate, landscape and developmental activities responsible for risky conditions can be studied with the help of remotely-sensed data analysis. Using satellite remote sensing data, identification and categorization of mosquito larval habitat associated with plant communities, wetlands and other aquatic locations as well as relationship between land use and land cover categories have also been reported[6]. The temporal multi-spectral remote sensing data provide a means for understanding varying degrees of VBD incidence with vegetation cover, moisture and waterlogged areas, and associated environmental factors, including social and economical factors.

Preventive approach – A positive proposition

Japanese encephalitis

Japanese encephalitis (JE) is one of the mosquito-borne arboviral diseases that mainly affect rural areas, where victims are mostly children. The lack of reporting system and poor diagnostic tools available for JE limit appropriate estimation of cases as on date. Further, there is no specific treatment on hand for JE. The use of vaccine is restricted to certain situations only, and no standard formulation is available yet. Creation of an advance warning system, and thereby preventing JE outbreak remains the only fea-

sible approach. 'Vector abundance' is the key element for disease outbreak, when the other transmission parameters are conducive[7]. Vegetation type and growth stage of paddy, along with the extent of water availability are reported to be the important factors determining vector abundance. It is impracticable to obtain the prevalence and density of the vector mosquitoes and also to monitor any sharp increase in the vector density by manual means, as their breeding habitats are enormous. However, there is a distinct possibility of utilizing remote sensing and GIS to predict JE mosquito vector(s) abundance through geo-environmental risk determinants[7]. If a spurt in vector density can be detected in advance, risk prediction will subsequently become possible, following the screening of amplifier hosts ('pigs') and the vector mosquito pools for virus activity. Similarly, for any other problem, the first option should be 'prevention' rather than 'cure'.

Conclusion

GIS is a relatively recent and complex technology, which explains why it has not been used to its full potential, especially in the health domain where it is extremely promising. We are now at a point where the possibilities are clearly seen. Hardware and software development has produced systems with functions and interfaces, which make them easier to use. GIS can be a tool of prime importance to rural health care deliveries, and in the surveillance and control of VBDs. It should be noted that GIS is not a tool designed to increase the quality of data. It is paramount to review all the steps in the information flow to guarantee quality and adequacy. Otherwise, the powerful tools of GIS can easily lead to misinformation and misinterpretation, particularly by someone unfamiliar with its use. Ecological fallacies, problems of scales, and propagation of error are frequent, and should be given serious consideration. Also, GIS is not a magical solution to all the difficulties regarding information in health care, but is a powerful tool capable of transforming the way with which information is dealt with.

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