Transforming
public health with GIS

Good health and well-being are essential to sustainable development of our nation and is one of key priorities of 2030 Agenda. Over the last decade, India has undertaken major strides in the area of public health and its accessibility. The average life-expectancy has risen from 64 to 68; neonatal mortality rates have dropped on average from 57 to 37, per 100 live births; there has been a renewed focus on non-communicable diseases. Various government programs such as National Health Mission, Ayushman Bharat and Pradhan Mantri Jan Arogya Abhiyan (PM-JAY) are aimed towards making healthcare facilities available and accessible to the economically weaker segment of the population. Swachh Bharat Mission is another such initiative which aims at making India free from open defecation and achieving 100% scientific management of municipal solid waste while also generating awareness about sanitation and its linkage with citizen's health.

India and 2030 agenda

At the Sustainable Development Summit on 25 September 2015, UN Member States adopted the 2030 Agenda for Sustainable Development, which includes a set of 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030. These SDGs will guide policy and funding for the next 15 years and address the root causes of poverty and the universal need for development that works for all people. Having an integrated approach to supporting progress across the multiple goals is crucial to achieving the SDGs.

Emergence of geographic thinking in health

The use of location intelligence for health is neither new, nor unheard of. The relationship between geography and health can be traced back to the time of Hippocrates (400 BC) where physicians observed that certain diseases tend to occur in some places and not others.

By the mid-19th century, with large-scale industrialisation, this relationship became increasingly apparent; also, the need for a public health system was made obvious. Maps based on environmental conditions began to be used by practitioners and clinicians alike – Charles Piquet made colour-coded maps of cholera distribution in Paris; Robert Cowan linked yellow fever to over-crowding in London's Glasgow; and, perhaps most famously, John Snow used maps to trace the source of London's cholera epidemic. In fact, by identifying that cholera was being spread through certain public taps, Dr. Snow's dot-map became the evidence that compelled officials to remove pump handles off of these taps. This one action was the game-changer that slowed down the Broad Street Cholera Outbreak.

Since then, use of location intelligence in healthcare has seen enumerable applications. We have seen the examples of Polio eradication and controlling the spread of Ebola as live examples of the role that GIS has played in the Health sector. Use of GIS based analytics over a period can help in controlling out-break of recurring epidemics like Dengue. Bill Gates-funded Malaria Atlas Project (MAP) helps predict global malaria burdens, while ensuring that countries receive early-warnings for targeted interventions. Using the Landsat Program; the Global Urban Footprint initiative; and GIS, the project crunches data on environmental conditions that influence malarial transmission.

GIS applications in public health

Today, thousands of health organizations use GIS every day. GIS is being used to prevent the spread of infectious disease (disease surveillance); tracking child immunization; promoting and encouraging healthy behaviors (to prevent chronic and infectious diseases); protecting communities against environmental hazards; conducting health policy research; preventing injuries; responding to disasters and assisting communities in recovery; and assuring the quality and accessibility of health services as well as many other programs and services.

GIS is the core foundation of all the key public health functions - assessment, policy development, assurance and operational awareness.

Assessment

To devise effective health care strategies for communities, agencies need to be able to respond to questions such as:

• What are the key health challenges our communities are facing?

• Which are the immediate interventions needed?

• Where these interventions are needed?

The use of GIS technology can enable leaders / public heath agencies to take larger steps in addressing national healthcare needs. GIS helps agencies get these answers from the variety of invaluable data residing in their existing

Data generated through key public health functions - assessment, policy development, assurance and operational awareness - must undergo a systems thinking approach for insightful research.

system such as health MIS and CRM systems. Taking the data that has a geographic component and putting it in the GIS equips them with new perspectives and provides them with the ability to enrich it to make more effective decisions for e.g. which districts / wards are in greater need of specific health services such as senior care facilities. By connecting their own data and adding layers of data that are available through variety of other sources e.g. demographic data, weather data, point of interest data, spatial analysis can be performed to visualize hot spots that can inform and even change a decision to be more effective. This help health agencies to plan targeted interventions in the pockets where health needs are critical by allocating resources where they make a greater impact. For e.g. where to open a new hospital or the specialization to built in a specific service area / district for chronic diseases such as cancer, diabetes or cardiovascular disease.

GIS for health assessment

- Monitor health status to identify community health problems
- Diagnose and investigate health problems and health hazards in the community

GIS for vector-borne disease surveillance and control

When vector-borne disease outbreaks occur, fast, effective response protects people from infection and its consequences. Integrated pest management programs respond through the vital functions of prevention, surveillance, and control activities. Temporal and spatial information are critical to those efforts to curb the spread of disease. GIS can help organizations achieve faster, more efficient response by providing a platform that can capture multiple, complementary areas of expertise among epidemiologists, entomologists, health officials and staff, geographers, and others.
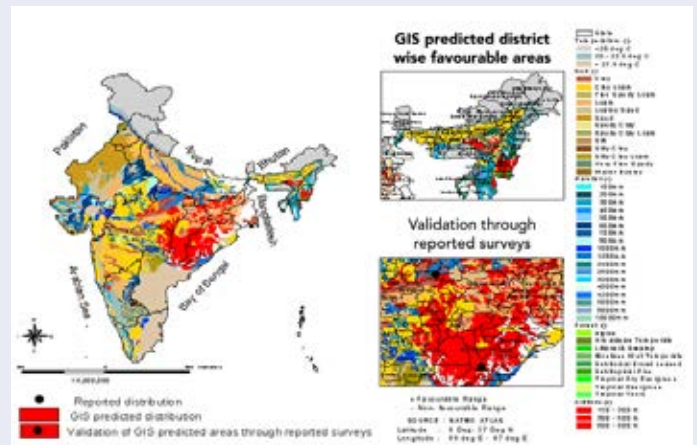
This map shows the GIS-based distribution of An. sergentii in India. (Source: National Institute of Malaria Research)

Policy development

Almost all policy decisions involve location, and frequently that same location component has an impact on finding the solution to community problems. Governments at all scales use GIS to plan, measure and improve operations, and guide policy be it for issues related to demography, strata, or larger issues related to climate change, cleanliness or healthcare accessibility. GIS help to better assess the needs of our communities and the impacts of policy options and decisions. GIS not only helps identify the communities who would be beneficiaries of these policies but also helps analyze, create maps and reports showing the future your policy hopes to deliver. GIS-based maps form the key foundation for communication as agencies such as state departments and NGOs use various thematic maps to communicate, engage and take feedback from the communities about policy matters that affect them most.

Vision Zero is a global initiative whose goal is to reduce severe injuries and deaths in roadway collisions. Through the LA GeoHub you can explore, visualize, and download Vision Zero's location-based Open Data, as well as use and develop web and mobile applications that support this initiative. http://visionzero.geohub.lacity.org/

GIS for policy development

- Inform, educate, and empower people about health issues
- Mobilize community partnerships to identify and solve health problems
- Develop policies and plans that support individual and community health efforts

Assurance

GIS enables health agencies to increase efficiency. GIS facilitates targeting vector control efforts. GIS tools and methodologies can be used to measure compliance with specific legislation (e.g., specific types of industry/ businesses being prohibited from operating within certain distances of rivers or other environmentally sensitive areas or restrictions regarding advertising tobacco within certain distances of schools). GIS helps determine the prudent use of staff in implementing health inspections (calculating location-based workload assessment, finding efficient routes, and determining which vehicle should serve each location in the best stop sequence). Some of other programmatic areas include Improving the accuracy of air pollution health impact assessments with GIS; Assessing the size and dimensions of green spaces and their respective distances from the population of potential users or Detecting regions of higher incidence of say water-borne diseases.

GIS for service assurance

- Enforce laws and regulations that protect health and ensure safety
- Link people to needed personal health services and assure the provision of health care when otherwise unavailable
- Assure a competent public health and personal health care workforce
- Evaluate effectiveness, accessibility, and quality of personal and population-based health services
- Research for new insights and innovative solutions to health problems
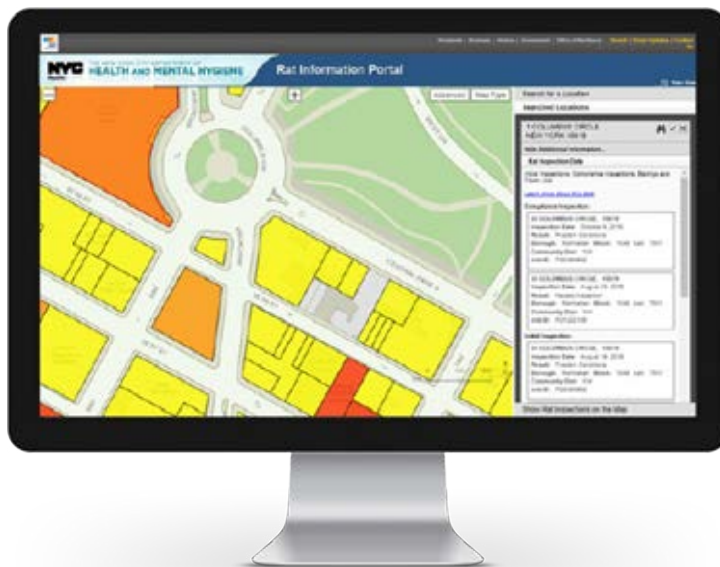
New York City's Rat Information Portal displays map-based details about inspection results across all five boroughs.

Situational awareness

Safeguarding public health and providing protection against health-related threats are responsibilities that fall directly in the purview of public health preparedness professionals. These individuals, the agencies they work for, and their partners generate volumes of data in a variety of systems. Integrating these disparate data types into one comprehensive view so that it is accessible to all stakeholders is a challenge. Location is often the only data feature that's common among these different systems. Public health staff use GIS toolsets to visualise all types of information. Some tools connect different data types. Other tools expose data relationships and patterns that are impossible or difficult to see by using traditional tabular data methods. GIS produces intelligent maps that show where a disease outbreak is occurring and predict where it might occur next. By turning data into intelligence, GIS gives preparedness professionals the situational awareness they need to respond to an emergency efficiently and effectively.

GIS for situational awareness

- Emergency preparedness
- Response monitoring and management

GIS supporting battle against COVID-19

Today, various agencies in India involved in COVID-19 response, at national, state and even at district level, have turned to GIS to develop coherent, synergistic response strategies and surveillance measures. GIS is being used to map existing cases at individual level, identifying hotpots and combining these with local demographic data to identify vulnerable populations. The spatial context of hotspots is enabling informed decision making for health capacities - existing and to develop, quarantine centre capacities and identify new sites to ensure disease containment. Artificial intelligence (AI) and spatial predication models are being used to model various scenarios - pessimistic, optimistic or as-is of disease spread to evaluate preparedness and stay ahead of the curve. GIS based maps and analysis are driving the coordinated and rapid response across multiple agencies - such as health, public safety, NGOs, field staff and policy makers by providing a common operating picture.


The COVID-19 dashboard by MoHFW, Govt of Tamil Nadu shows the update on the COVID-19 response strategies in the State of Tamil Nadu.

Enterprise GIS strategy for public health agencies

Geospatial technology leads the way giving public health agencies / stakeholders / policy makers the location-based intelligence and spatial analysis they need to build and maintain a healthy community. Government agencies realize significant return on investment and fulfill their mission every time they use GIS to solve problems.
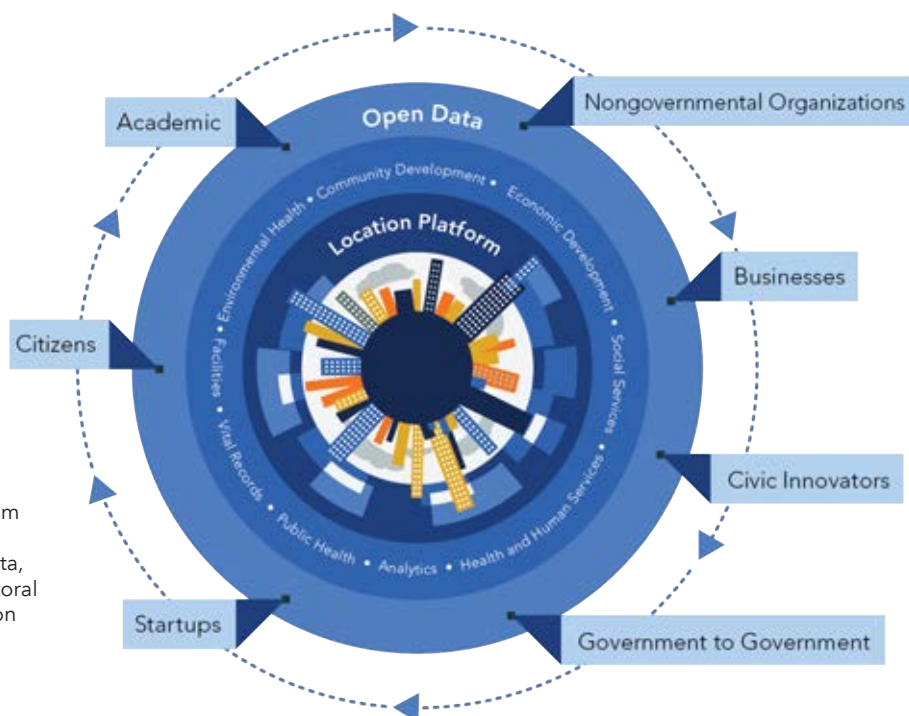
A responsive health ecosystem demands that multiple stakeholders access open data, and can reinterpret it for sectoral improvement upon a common location platform.

4 steps to create a successful strategy that supports a healthy community

1 **Start with a world-class GIS platform**
The ArcGIS platform gives governments the power to approach problems in a way that serves decision makers, residents, fieldworkers, GIS professionals, and non-GIS users. ArcGIS supports major government workflows including data collection, analysis, what if scenarios, operational awareness, field operations, and civic engagement.

2 **Build a location-based strategy**
A location-based strategy enables governments to prioritize the GIS applications they need. An organization can analyze issues department by department or tackle a single concern (such as children and family services) to meet goals within a more limited scope.

3 **Deliver real solutions that serve government priorities**
Governments know their biggest health and human services challenges include eliminating health disparities, improving access to care, maximizing resources, and designing effective interventions to improve community health. Esri's ArcGIS applications are free for users to download and share with their organization and community.

4 **Develop strong relationships with the Esri Partner Network**
The Esri Partner Network is a community of organizations that helps you get the most out of your GIS investment. Esri partners deliver sophisticated solutions that can fulfill your organization's requirements such as licensing and inspection and community health needs assessments. These solutions are built on top of the ArcGIS platform and can extend customized solutions that scale with a state, municipal, or regional government over time.

Evolving technology landscape and the future of healthcare with GIS

Everyday technology ecosystem is evolving rapidly. Health agencies are collecting more and more data for analysis to build further efficiencies and effectiveness into their decision making, operations and processes. In all this data, location continues to play an integral part for strategies, planning and decision making for both population and individual health. Integration of AI, ML, big data analysis and data science methods and tools with spatial analysis will enable more accurate, efficient, and productive insights with potential applications across several disciplines within public health, precision medicine, and Internet of Things-powered smart healthy cities. These can help in predictive modelling to identify populations at high risk for disease, in healthcare delivery of tele-medicine / mobile health to masses or even integrating social media feeds for syndromic surveillance.

GIS will continue to be the core foundation to support the heath tech revolution we are witnessing.