Chapter 4.8
Geographic Information Systems

Qian Ye
Shihui Guo

Learning objectives

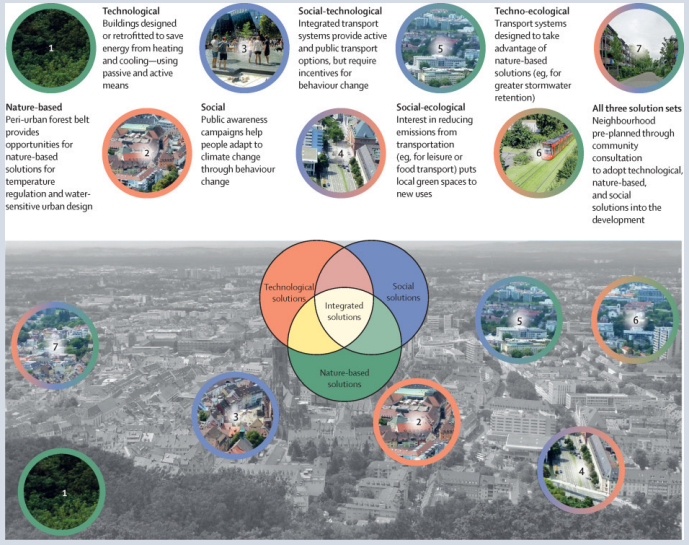
To understand the following about geographic information systems (GIS):

- The basics of GIS.
- The role of geospatial analysis in disaster health.
- The use and challenges of GIS in health emergency and disaster risk management (Health EDRM).

Introduction

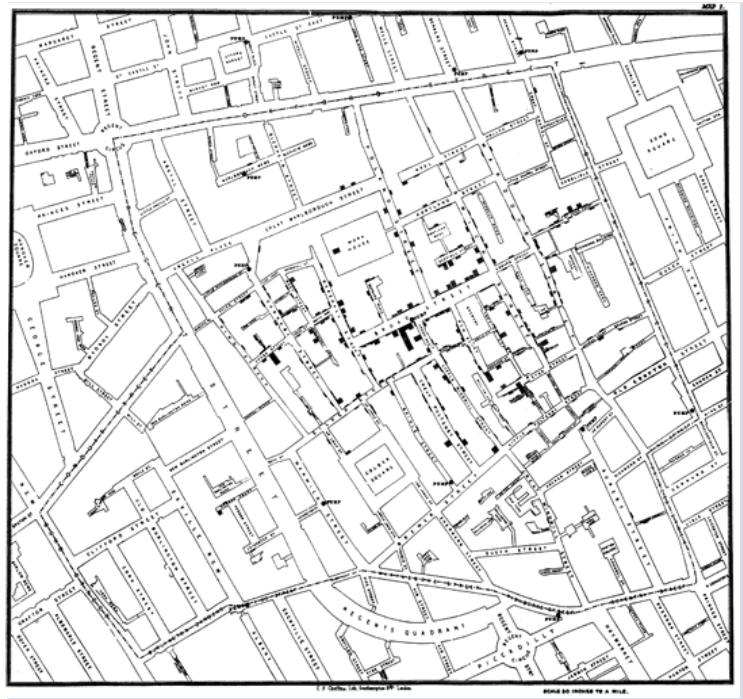
- Health and safety are highly influenced by place and location

- Emergency preparedness and health risk reduction are spatial problems



Lin, et al., 2021

Example: 1854 Cholera outbreak in London, UK

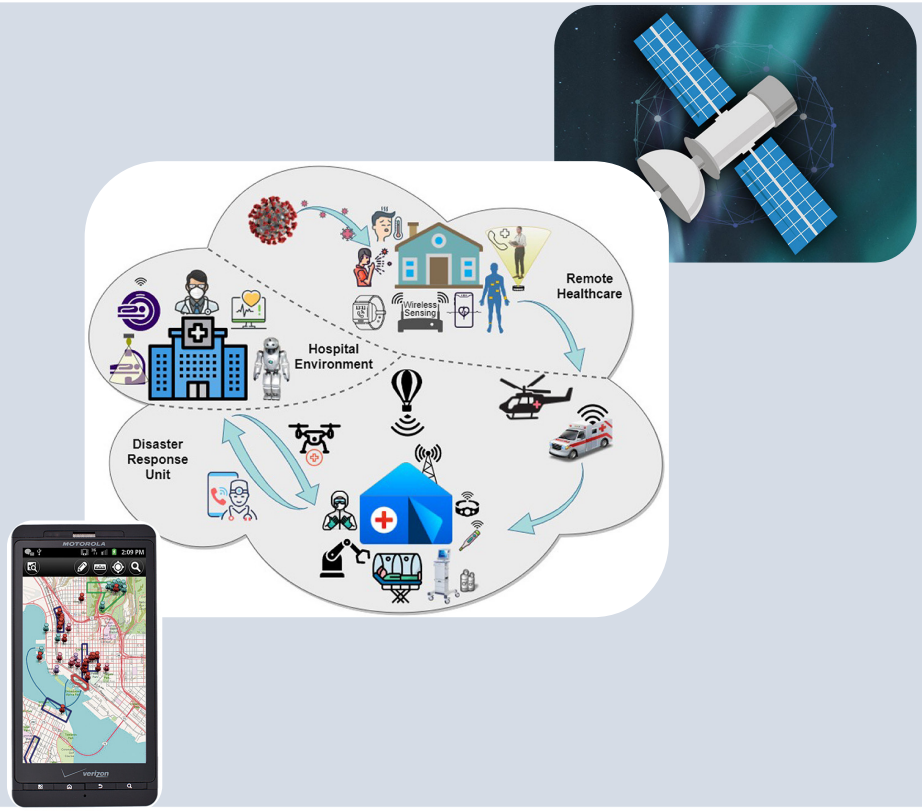


John Snow's cholera map in London UK, 1854

- By mapping the locations of water pumps and the homes of the people who died, **John Snow**, a physician was able to identify a contaminated water pump.
- After the removal of the handle of the pump, there was a decrease in the number of new cholera cases.

Advances in information technology

- Supported by satellites, computers, the internet and smart phones, all location-based information can be now visualized.
- Relationships, patterns and trends of various components of the social-ecological system are better understood.



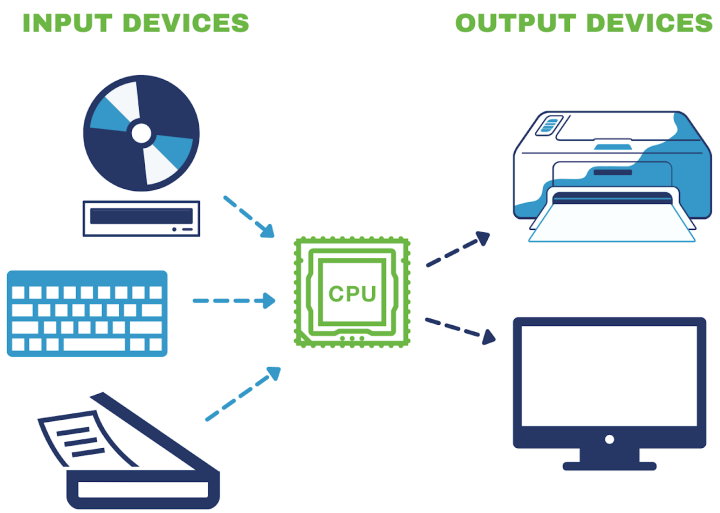
What is GIS?

Visualizing and Understanding *what is where*.

GIS hardware

A complete GIS includes:

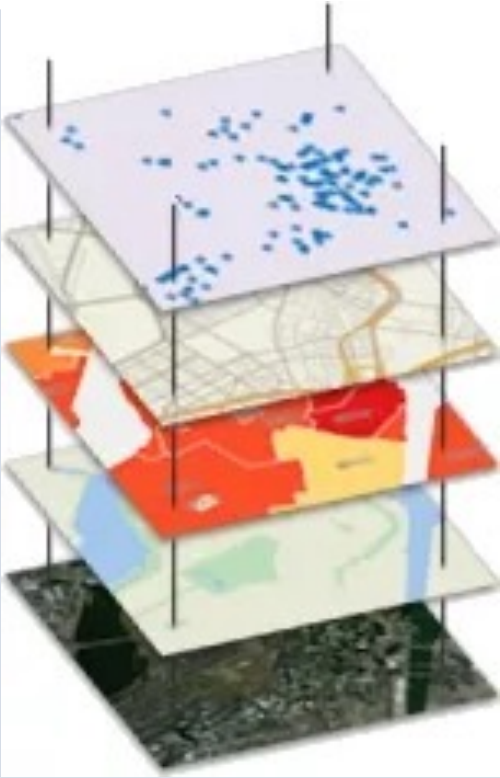
- Individual computers such as mobile phones, personal computers (low-end) or supercomputers and X-Terminals (high-end)
- Networks
- Input devices
- Storage systems
- Output devices (such as 3D printers)
- Virtual reality display systems



GIS software

There are five generations of GIS software:

1. **Desktop GIS**: extends GIS applications to geographic data management, analysis and visualization.
2. **Web GIS**: provides global access to geospatial data, delivers real-time data, allows collaborative data collection and mapping and is widely used by the general public (e.g. Google Maps).
3. **GIService**: combines functions of GIS and Web Service.
4. **Cloud GIS**: provides powerful capability in storage, computation and network through cloud computing.
5. **Smart GIS**: makes GIS available everywhere, all the time and for everything.



Before using GIS

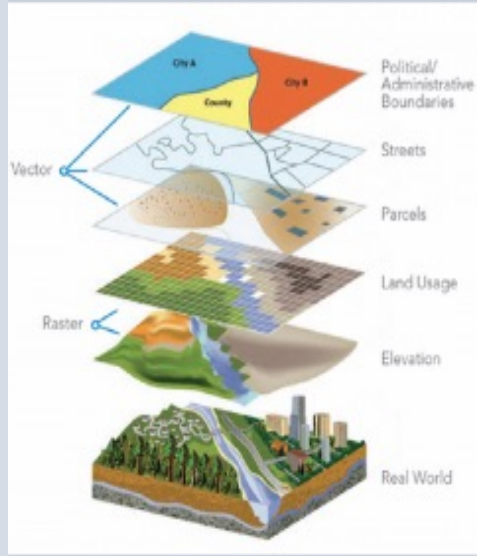
When choosing hardware and software to use for a GIS, it is important to consider:

- Needs of the organization;
- Desired functionality;
- Funding available; and
- Period during which the system is planned.

Foundation of Using GIS

Developing a GIS-based database:

1. **Data acquisition**: acquiring GIS-related information such as data on the ecosystem, climatology, geology, hydrology, landform, soil, social economy, etc. Data are obtained through satellite images, maps and literature.
2. **Data digitization**: transforming data from other formats to a standard data format used by GIS software.
3. **Data modelling**: using available data to derive additional types of data.
4. **Data quality assurance and quality control (QA/QC)**: validating the GIS data transformed from different sources by comparing the geographic coordinates of pre-determined locations to the field survey.
5. **Spatial Analysis**: understand the spatial correlation of various factors in a research region based on visualization.



GIS application in disaster health

GIS can enhance the effectiveness of Health EDRM.

- Disasters increase the demand for emergency services. GIS can help better **coordinate** the health sector with other sectors for more efficient and effective emergency medical response.

GIS application in disaster health - Before a disaster

- Before a disaster strikes, it is important to have accurate data on air, water, sanitation, utilities and community healthcare facilities, and geo-referenced baseline demographic data and healthcare boundaries.

- GIS can be used together to develop **plans for disasters**, including having sufficient personnel, supplies and equipment, and protocols to meet potential threats.

GIS application in disaster health - During a disaster

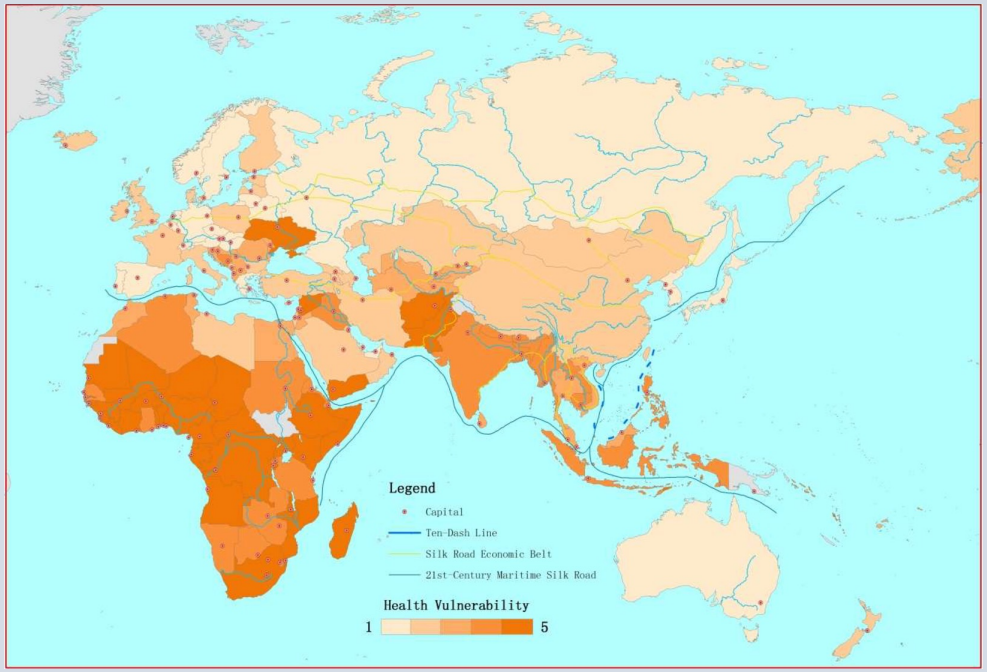
During disasters, healthcare organizations need surge capacity that allows them to accommodate increased demand and expand beyond normal service levels.

GIS can be used to **track** patients and healthcare personnel in real-time.

Case study 1: *Map of health vulnerability and disaster risk*

Health vulnerability of 147 countries from the Belt and Road region (Chan, et al., 2019)

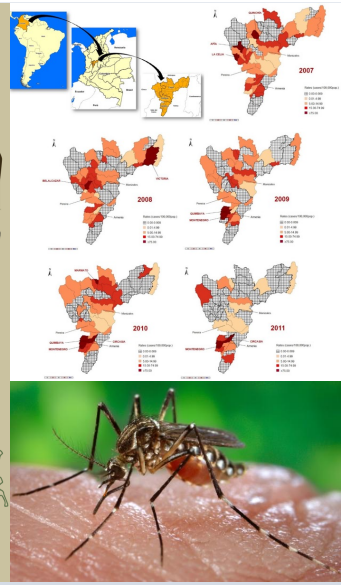
Combining **three factors** from 9 health indicators: **population status, disease prevention**, and **coping capacity** to make a **Health Vulnerability Index**.



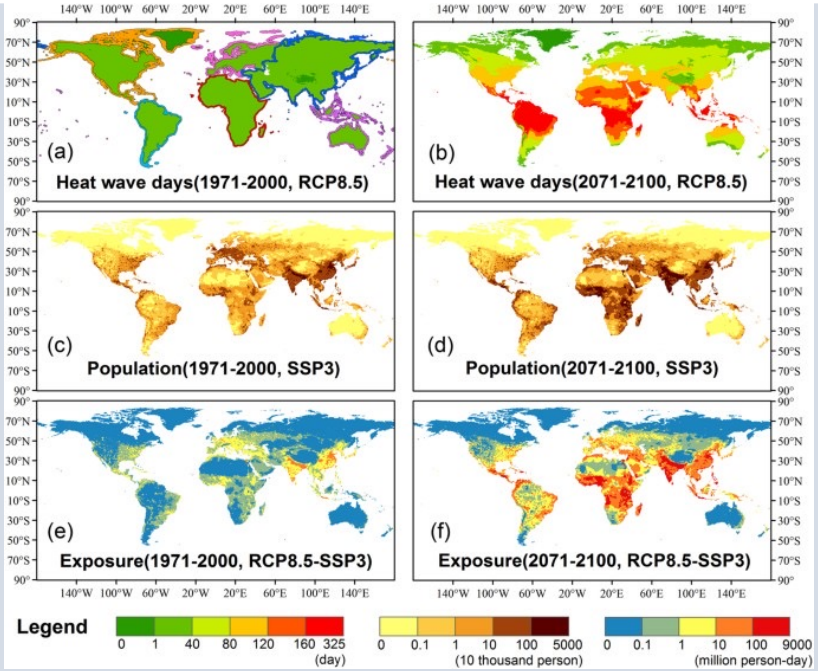
Case study 2: *Chikungunya in Latin America*

In 2014, the Chikungunya virus outbreak spread across Latin America, including the Coffee-Triangle region (a tourist area) in Colombia. GIS was used to develop **epidemiological maps** for the virus in the region and allowed:

- Integration of preventive and control strategies.
- Travelers to be aware of the risk of infective biting exposure.
- Travelers to assess the risk of going to high transmission destinations.
- Prevention advice to be given to government officials and the public.

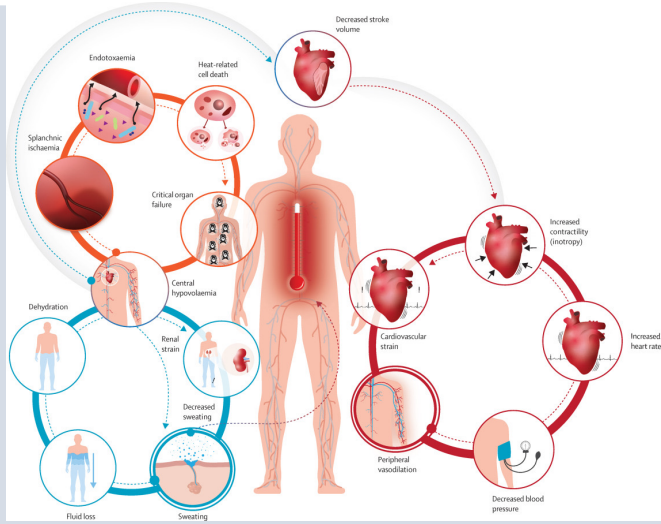


Case study 3: *Mapping Health risk distribution of people with high-temperature disasters*

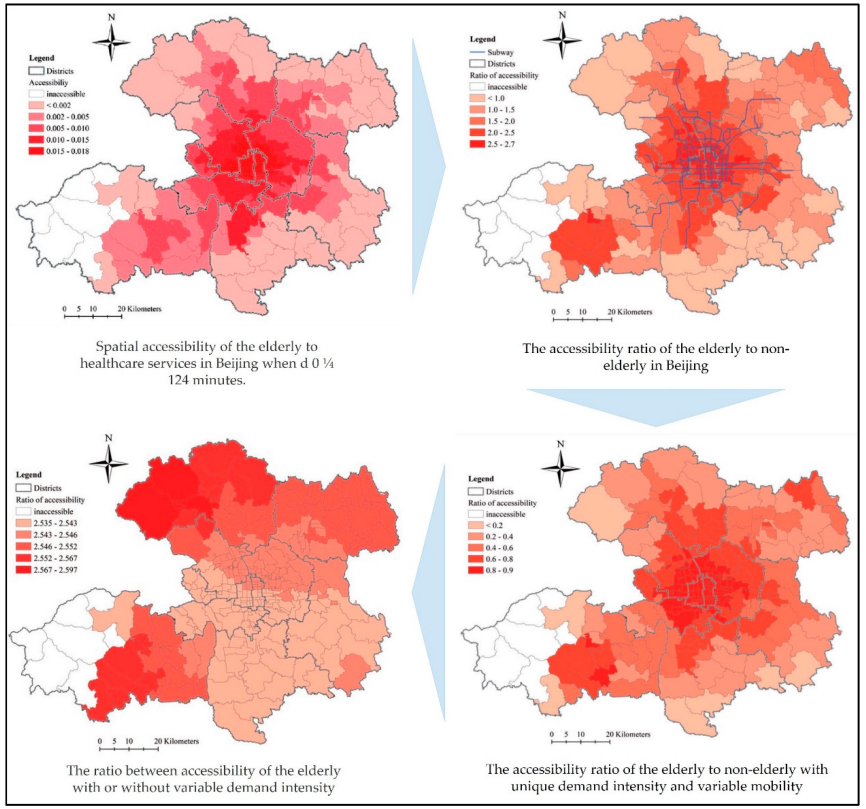


Map of high temperature stress-social vulnerability-population exposure

Examples: the 1995 heatwave in Chicago, USA and the 2003 heatwave in Europe caused a large number of deaths. Heatwaves can lead to cardiovascular, respiratory, and digestive tract disease



Case study 4: *GIS for population-wide health monitoring in Germany*



The Robert Koch Institute (RKI) uses GIS for up-to-date mapping and visualization for national health monitoring in Germany, which:

- Uses physical information (climate, vegetation, land use) and information on the built environment.
- Links socioeconomic and sociodemographic data to healthcare information and environmental stress.
- Presents nationwide, representative and meaningful health-monitoring results.
- Requires data protection regulations to be used during development and use.

Challenges for Using GIS

- **Safety** of data collected, stored, analyzed and displayed by GIS.
- **Cost** of using GIS in disaster response with continuous financial support.
- **Coordination** of multiple data sources, including wireless LANs, GIS, patient-tracking systems and online medical resource databases.

Summary

GIS technology can be used in Health EDRM for:

- **Disaster health risk detection**
- **Modelling**
- **Assessment**
- **Response planning**
- **Public health policy development**

GIS is also dependent on a complex social-ecological system and using GIS in disaster health science requires **multi-** and **trans-disciplinary** trained professionals.

Key messages

- A main strength of GIS lies in its powerful ability to combine, analyze and display spatial and attribute data.
- This will help to satisfy the need for large-scale data analysis and processing in disaster response planning and improved Health EDRM.

Further readings (1)

Mansour S. Spatial analysis of public health facilities in Riyadh Governorate, Saudi Arabia: a GIS-based study to assess geographic variations of service provision and accessibility. Geo-spatial Information Science; 2016: 19(1): 26-38.
This article explores a GIS analysis to assess the availability and accessibility of public health facilities across the Riyadh Governorate in Saudi Arabia.

Yafei Z, Mao L. GIS-based urban fire risk assessment and its application in disaster mitigation planning. Journal of Catastrophology; 2010: 25(S1): 258-63.
This article explores how GIS is used to develop an urban fire risk assessment model.

Further readings (2)

Nagata T, Kimura Y, Ishii M. Use of a Geographic Information System (GIS) in the Medical Response to the Fukushima Nuclear Disaster in Japan. Prehospital and Disaster Medicine; 2012: 27(2): 213-15.

This article describes the use of GIS to visualize the risk of radiation exposure and to help allocate medical teams after the 2011 Fukushima nuclear disaster.

Kawasaki A, Berman M L, Guan W. The growing role of web-based geospatial technology in disaster response and support. Disasters; 2013: 37(2): 201-21.

This article examines changes in disaster response due to the use of web-based geospatial tools.

References

This chapter: Ye Q, Guo S. Chapter 4.8: Geographic Information Systems

Health vulnerability index for disaster risk reduction: application in Belt and Road Initiative (BRI) region: International Journal of Environmental Research and Public Health; 2019: 16(3): e380.

Incorporating social vulnerability to assess population health risk due to heat stress in China: Acta Geographica Sinica; 2015: 70(7): 1041-51.

Information technology and emergency medical care during disasters: Academic Emergency Medicine; 2004: 11(11): 1229-36.

Contact information

Professor YE, Qian
Beijing Normal University
19 Xinjiekouwai Street, Beijing
100875, China
Email: qianye@bnu.edu.cn

Health EDRM Research Network Secretariat
WHO Centre for Health Development (WHO Kobe Centre)
Email: wkc_tprn@who.int