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Sandra Adounvo Date

Developing a Geographic Information Systems (GIS) Training Curriculum for Emergency Management

By

SANDRA A. ADOUNVO
MPH

Hubert Department of Global Health

____
Scott JN McNabb, PhD, MS
Committee Chair
Department of Global Health
Rollins School of Public Health
Emory University

____
Johnathan Edwards, Executive MPH
Committee Member
Biostatistics and Bioinformatics Department
Rollins School of Public Health
Emory University

Developing a Geographic Information Systems (GIS) Training Curriculum for Emergency Management

By

SANDRA A. ADOUNVO
Bachelor of Art in Foreign Affairs & French
University of Virginia
2017

Thesis Committee Chair: Scott JN McNabb, PhD, MS

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Abstract

Developing a Geographic Information Systems (GIS) Training Curriculum for Emergency Management

By: Sandra Adounvo

Background: Emergencies are projected to increase in frequency and complexity in the coming decades, posing significant challenges for LMICs, including risks to public health, safety, and recovery costs. As a result, effective emergency management is crucial to mitigate the impact of these emergencies. Geographic Information Systems (GIS) plays a critical role in supporting emergency personnel by providing accurate and timely information for decision-making. However, there is a notable lack of specialized GIS training programs for LMIC emergency personnel, which poses a risk to vulnerable groups and the effectiveness of emergency management efforts.

Purpose: This project aimed to develop an open-access GIS Training Curriculum for Emergency Management, specifically designed for current and future emergency relief workers in Low- and Middle-Income Countries (LMICs). The curriculum focuses on mapping and analytic analysis skills, aiming to address the GIS skills gap and contribute to the professional development of emergency relief workers and GIS officers worldwide.

Methods: The need for an open-access GIS training curriculum for emergency management was identified through a systematic review of trends and gaps in applications of GIS during emergencies. The curriculum was developed using the ADDIE model of Instructional Design and Knowles' Adult Learning Theory, with input from two public health professors with expertise in GIS and curriculum development.

Results: A total of 36 articles were reviewed, with 24 specifically addressing current applications of GIS during emergencies. Out of these 24 articles, 11 discussed the use of GIS for cartographic and humanitarian logistics, while the remaining articles explored more complex analyses utilizing GIS. The identified gaps in GIS applications during emergencies include limited use of GIS in low- and middle-income countries (LMICs), the need for multivariate spatial analyses, and the need for further validation and comparison of GIS methods. The developed curriculum consists of four modules, pre/posttests, labs, and external resources.

Discussion: Efforts should be made to implement and evaluate this curriculum in LMICs. The curriculum should be adapted for advanced professionals in LMICs. Further research is needed to validate and compare GIS methods and models currently used in emergencies to support increased GIS utilization.

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I am also thankful to all the professors who have guided me during my academic journey, contributing to my growth and learning.

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Table of Contents

Preface

List of Acronyms

ADDIE	Analyze, Design, Develop, Implement, and Evaluate
COD	Common Operational Datasets
DOI	United States Department of the Interior
EOC	Emergency Operation Centre
FEMA	Federal Emergency Management Agency
FIS	Field Information Service
GEMA/HS	Georgia Emergency Management Agency and Homeland Security
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HeRAMS	The Health Resources and Services Availability Monitoring System
HCT	Humanitarian Country Team
HDX	Humanitarian Data Exchange
HHS	United States Department of Health and Human Services
ICT	Information Communication Technology
IDP	Internally Displaced Person
IMO	Information Management Officer
IMWG	Information Management Working Group
ISAC	Inter-Agency Standing Committee
LMIC	Low- and Middle-Income Country
NARAS	Need and Response Analysis Section
NASA	National Aeronautics and Space Administration
OCHA	The United Nations Office for the Coordination of Humanitarian Affairs
PODS	Points of Dispensing
RS	Remote Sensing
SARA	Service Availability and Readiness Assessment
UN	United Nations
UNITAR	United Nations Institute for Training and Research
UNOSAT	United Nations Satellite Centre
USACE	United Nations Army Corps of Engineers
VIU	Visual Information Unit

Chapter 1: Introduction

Introduction and Significance

An emergency is an event posing an immediate threat to human life, health, property, or the environment.[1] Emergencies take various forms such as natural disasters (e.g., hurricanes, floods, earthquakes, cyclones) and man-made disasters (e.g.. droughts, terrorist attacks, war, fires, industrial accidents). Emergencies can happen anywhere and anytime; they have adverse effect on individuals, communities, and countries, particularly those in low- and middle-income countries (LMICs).[2]

The impact of natural and man-made disasters on public health is devastating, causing loss of life, injuries, displacement, and spread of communicable diseases.[2] Different disasters result in various patterns of injuries and mortality.[3] Earthquakes and flooding can lead to blunt trauma and other severe injuries, while population displacement caused by certain disasters (i.e., earthquakes, landslides, tsunamis) can lead to the spread of communicable diseases such as malaria, diarrhea, and acute respiratory infections.[3,4] In LMICs, the impact of disasters on the public's health is more severe due to poor infrastructure, inadequate emergency response systems, and limited access to healthcare services.[5]

According to the United Nations Children's Fund (UNICEF), emergencies have become more frequent and complex in recent years.[6] In 2022, the Emergency Event Database (EM-DAT) recorded 387 natural disasters worldwide, resulting in the loss of approximately 30,000 lives, affecting 185 million people, and causing over USD 223 billion in economic damages.[7] Multiple studies predict that natural and man-made disasters are likely to increase over the next few decades.[8] Therefore, effective emergency management is crucial to mitigate the impact of emergencies on the public's health and safety.

Geographic Information Systems (GIS) play a crucial role in achieving this goal by providing accurate and timely information to emergency responders, enabling effective resource allocation, risk assessment, and damage assessment.[1] It is essential to all phases of emergency management including mitigation, preparedness, response, recovery. Its integration into emergency management allows for more informed planning, analysis, situational awareness, and recovery strategies and results in economic savings, increased collaboration between stakeholders, and a safer population.[9]

There are currently few trainings that provide practical GIS skills to emergency relief workers in LMICs. The lack of specialized training in GIS poses a threat to the effectiveness of emergency management and to the health of populations at risk.[10] Plans for this project includes a review of the trends and gaps in applications of GIS during emergencies, as well as the design of an adaptable introductory GIS training curriculum for emergency management.

Problem Statement

As emergencies and disasters continue to threaten communities worldwide, effective emergency management is crucial. GIS is essential for emergency relief workers in planning, responding to, and monitoring emergencies. However, there is a significant knowledge and skills gap in the workforce regarding the practical applications of GIS during emergencies. This knowledge and skills gap has vast implications that affect the effectiveness of emergency operations and the health and safety of populations at risk. Providing a specialized GIS training course for emergency management to relief workers, especially those in LMICs, will build capacity and contribute to the development of a global emergency response workforce.

Purpose Statement

This Special Studies Project (SSP) will develop a *GIS Training Curriculum for Emergency Management* which could be utilized by current and future emergency relief workers in Low- and Middle-Income Countries (LMICs). By offering emergency relief workers an open access introductory training on GIS mapping and analytic applications during emergencies, this SSP will reduce the skills gap between this population and those of their peers and positively contribute to the workforce development of emergency relief workers and GIS officers globally.

Objectives

In developing this training curriculum several key objectives will be met to…

1. identify trends and gaps in applications of GIS during emergencies and constraining factors.
2. use these findings to inform the design of an adaptable introductory *GIS Training Curriculum for Emergency Management.*
3. provide critical GIS knowledge and skills to current and future emergency relief workers.

Chapter 2: Literature Review

Introduction

Peer and gray literature were reviewed to examine trends and gaps in applications of Geographic Information Systems (GIS) during emergencies to identify competencies, learning objectives, and content for an introductory GIS Training Curriculum for Emergency Management.

Methods

The review was conducted between December 2022 and January 2023 using two electronic databases: PubMed™ and Google Scholar™. A list of search terms was developed to aid in the identification of relevant articles (i.e., "Geographic Information Systems" OR "GIS", "use" OR "application"; and context-based terms "humanitarian emergencies"; "emergency response"; OR "disaster and emergency response"). *A priori* search terms included natural disaster, man-made disaster, decision-making, resource allocation, and needs and risk assessment. Official humanitarian agencies websites and manuals from the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), MapAction, ReliefWeb, and Humanitarian Response were reviewed to provide additional details about current applications of GIS in this context. All articles were published in the past 20 years with full text available. In total, 66 articles were screened in Covidence™; 36 were included (Figure 1).

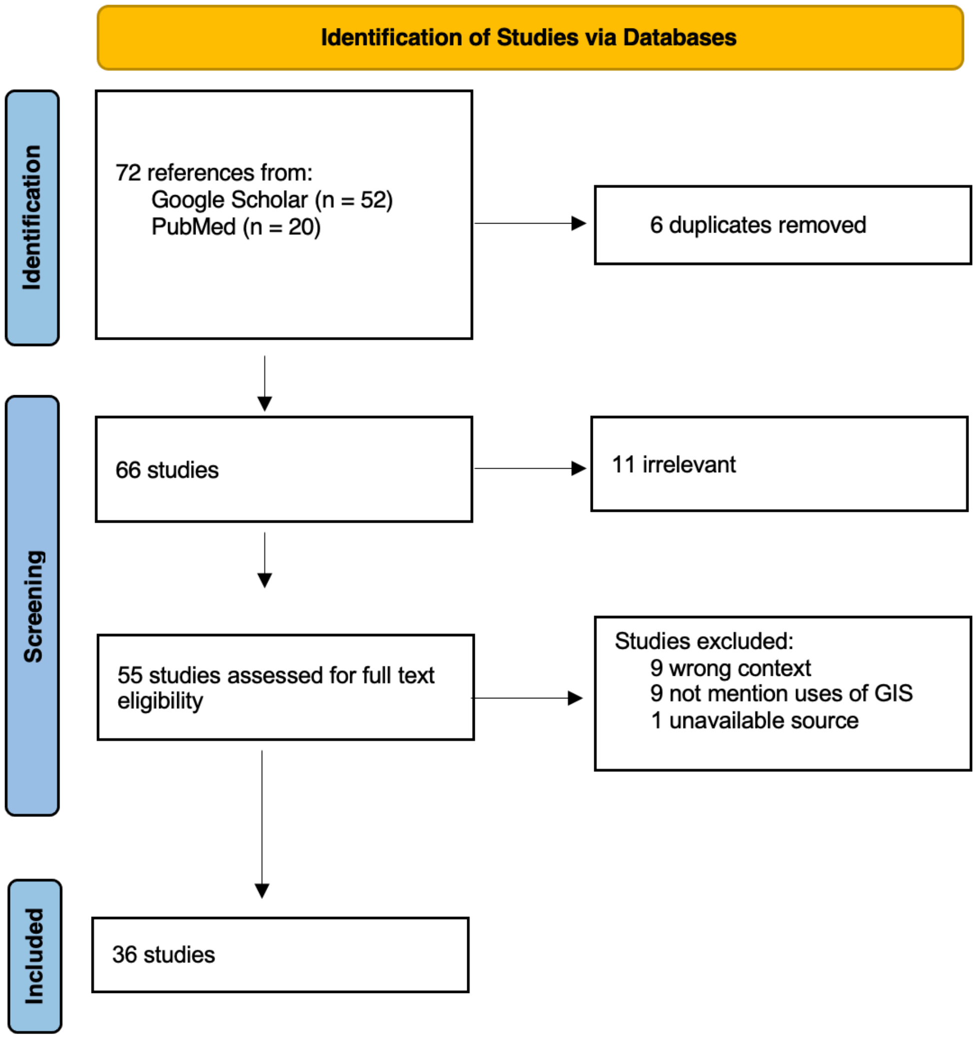


Figure 1: PRISMA Flow Diagram Obtained from Covidence™, 2023

The review yielded the following topics …

1. **Defining Applications of GIS during Emergencies**
2. **Coordination of Geospatial Technologies During Emergencies**
3. **Requirements and Preconditions for Applications of GIS During Emergencies**
4. **Current Applications of GIS During Emergencies**
5. **Gaps in Applications of GIS During Emergencies**

Defining GIS Applications During Emergencies

GIS is most commonly defined as a system (or a computer-based tool) designed to capture, store, manipulate, analyze, and present spatial or geographic data.[11] Since its uptake in the 1990s, GIS has been used in a variety of professions ranging from urban planning to emergency and disaster response. In public health, GIS plays an important role in public health surveillance (PHS), management, and analysis of diseases.[12] GIS helps public health professionals visualize epidemiologic data enabling more informed decisions.

Applications of GIS during emergencies differ significantly from non-emergency contexts. While the main premise of GIS remains the same, its application and operationality differs due to the dynamic and urgent nature of emergencies. Emergencies – whether man-made (e.g., war, terrorism, or biological threat) or natural (e.g., floods, tsunamis, or earthquakes) – require rapid response. GIS provides a starting point for this response. It allows emergency responders and managers to spatially understand emergencies – whether using GIS to map the distribution of vulnerable populations, manage camp resource allocation, or model diseases.

GIS' primary purpose during emergencies is to support decision-making, which is crucial in all four phases of emergency management (mitigation, preparedness, response, and recovery).[13] During mitigation, GIS helps identify risks in advance and reduces their probability.[13] In preparedness, GIS supports the development of emergency response plans.[13] In response, GIS supports rescue operations and damage assessments, and during recovery or reconstruction, GIS optimizes restoration efforts and enables the creation of more sustainable solutions to future disasters.[13] In all, GIS provides emergency professionals with real-time data assess the scope, magnitude, and scale of a disaster; coordinate resources; and map essential infrastructure.

Coordination of Geospatial Technologies During Emergencies

Humanitarian Emergencies

Though GIS plays a crucial role in emergency interventions, it is not currently integrated within the Inter-Agency Standing Committee's (ISAC) Cluster Approach (Figure 2).

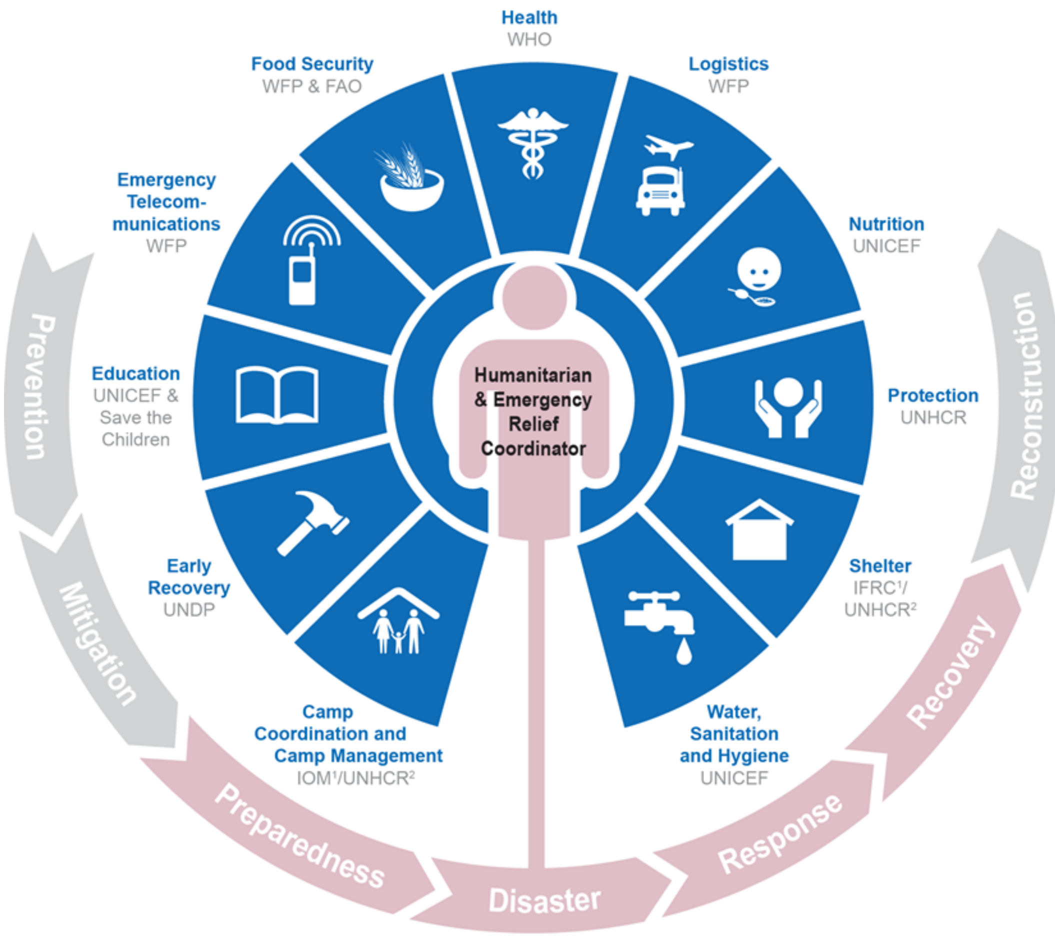


Figure 2: ISAC Cluster Approach

Instead, geospatial data is collected and analyzed by various United Nations (UN) institutions and partnering organizations. The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) "contributes to principled and effective humanitarian responses through coordination, advocacy, policy, information management, and humanitarian financing tools and services".[14] OCHA's offices leverage expertise throughout their organization in response to emergencies. OCHA works closely with Cluster Lead Agencies and NGOs to "ensure that information management activities support national information systems, standards, build local capacities and maintain appropriate links" with relevant governmental authorities.[15]

Within OCHA's headquarters, four sections handle geospatial data:

1. Field Information Service Section (FIS) assists all field officers with information management issues and oversees interagency collaboration on Common Operational Datasets (COD) including administrative boundaries and population statistics. CODs are reference datasets needed to support the operations and decision making of all actors in a humanitarian response.
2. Visual Information Unit (VIU) uses stored data to support global and situational awareness.
3. Need and Response Analysis Section (NARAS) builds OCHAs and its partners' capacity to coordinate multisectoral humanitarian need assessments and analysis.
4. Humanitarian Data Centre provides humanitarian actors access to necessary humanitarian data through platforms such as the Humanitarian Data Exchange (HDX).[16]

OCHA's main GIS activities are carried out in field offices by a multidisciplinary team of Information Management Officers (IMOs).[16] OCHA has approximately 160 IMOs working worldwide on a variety of information activities though few are full-time GIS officers.[16] IMOs in field offices maintain the CODs and other geospatial data in countries with ongoing operations or at high risk of becoming future emergencies.[16] The IMOs analyze the data as part of preparedness, need assessment, and strategic planning, implementation, and monitoring efforts.[16] They produce information materials (e.g., infographics, situation reports, reference and operational maps, and program documents) and make them available on platforms (e.g., HDX, Relief Web, and Humanitarian Response).[16]

Additionally, OCHA convenes several inter-agency working groups on information management for humanitarian organizations at both the global and national level. These groups are commonly referred to as the Information Management Working Group (IMWG). The IMWG supports the work of the Humanitarian or Resident Coordination and the Humanitarian Country Team (HCT) to deliver humanitarian assistance.[17] They usually focus on the following themes: data standards, CODs, indicators, maps, web platforms, information sharing protocols, and assessment-related information coordination. IMWG can create and share the following information products with clusters and sectors IMOs:

1. Who does What Where (3W) databases and products (i.e., maps)
2. Relevant documents on the humanitarian situation (e.g., mission reports, assessments, and evaluations)
3. Geospatial datasets relevant to cluster and inter-cluster decision making (e.g., population data disaggregated by age and sex)
4. Directories of humanitarian partners and IM focal points
5. Country specific disaster-related humanitarian web portals
6. Technical advice on needs assessments survey design[15]

The United Nations Satellite Centre (UNOSAT) – part of the United Nations Institute for Training and Research (UNITAR) – provides satellite imagery analysis and GIS solutions to senior decision makers and field workers and outside partners.[16] It is the focal point of geospatial and satellite mapping activities during humanitarian disasters. UNOSAT currently employs 32 IMOs.[16]

Public Health Emergencies

For decades, GIS has helped public health authorities respond to natural disasters and disease outbreaks. Following the events of 9/11, the anthrax attacks, and hurricane Katrina, public health emergency preparedness and response has become even more dependent on location-based information (e.g., location of incidents, responders, and resources).[18] GIS contributes to emergency preparedness and response through …[18]

- needs assessments and planning.
- evacuation route planning.
- modeling chemical spills.

- targeting emergency notifications.
- determining sites for points of dispensing (PODS).
- enhancing the utility of emergency operations center (EOC) software.

In the United States, emergency preparedness and response are managed at the federal, state, and local government levels. The federal agency tasked with emergency management and response is the Federal Emergency Management Agency (FEMA). "When a disaster is declared, the Federal government, led by the FEMA, responds at the request of, and in support of, States, Tribes, Territories, and Insular Areas and local jurisdictions impacted by a disaster".[19] FEMA then appoints response and recovery personnel (i.e., Field Coordinating Officer and Federal Disaster Recovery Coordinator) to coordinate disaster operations.[19] As the lead emergency management agency, FEMA also manages interagency coordination. FEMA can request support from select agencies including the U.S. Army Corps of Engineers (USACE), U.S. Department of Health & Human Services (HHS), and the U.S. Department of the Interior (DOI).

FEMAs GIS activities are carried out by the Mapping and Analysis Center. They use GIS to share geographic information to Emergency Support Functions - grouping of governmental and private sector entities that provide support, facilities, supplies, and equipment.[20] FEMA recently created the Geospatial Resource Center - an open-source website where governmental, private sector, and volunteer partnering agencies (i.e., HHS, Census, NASA) can access and share disaster response data, maps, and other applications.[21] Upon request, the USACEs Mobile District's Spatial Branch can provide a range of "GIS services, including, but not limited to, mapping and surveying, data conversion, Internet Mapping [WebGIS], database maintenance, software customization and integration, training, implementation, and other services" to disaster operations.[22]

State and local level health departments have also begun leveraging GIS capabilities in their Emergency Operation Center (EOC). An EOC is a physical or virtual site where leaders from state or local level agencies or organizations coordinate incident management information and resources. According to Davenhall and Kinabrew[18], GIS coordinators with EOCs provide the following functions:

- Situational awareness to leadership and partners
- Real-time maps of incidence or clusters
- Map stockpile locations
- Map the location of vulnerable populations
- Real-time maps and analysis of vaccine inventory
- Monitor hospital bed/ surge capacity
- Help infected people locate treatment
- Facilitate mobile response and routing, especially in rural areas
- Call up volunteer and staff by location
- Map distribution of care providers

An example of a state level EOC is the Georgia Emergency Management and Homeland Security Agency (GEMA/HS). The agency's GIS section manages the agency's WebGIS platform and uses geospatial information to support emergency related decision-making and improve risk communication throughout the state.[23]

GIS supports outbreak investigation, PHS, and syndromic PHS efforts. When an outbreak occurs, GIS strengthens field staff data collection, management, and analysis.[18] GIS facilitates the surveillance of case locations by more effectively monitoring the geographic progression of disease. GIS products (i.e., maps and imagery) have been used to identify high transmission areas and areas more conducive to disease vectors.[18] GIS also supports syndromic surveillance by providing visual aids and "detecting abnormalities based on spatial queries".[18]

Requirements and Preconditions for Applications of GIS During Emergencies

For emergency workers to implement GIS during emergencies, certain requirements and preconditions must be met. This section examines the type of hardware, software, data, and funding needed in place to effectively utilize GIS during disasters.

Hardware

The type of hardware used in disaster relief is predetermined by the relief organization's resources and workers personal devices. Laptops, printers, and tablets are the most common types of hardware, while Global Navigation Satellite System (GNSS) receivers (e.g., GPS receivers) and artificial satellites are less common. GPS receivers are becoming more common as their market price has dropped.[24] Given the multitude of organizations utilizing GIS, differences in hardware standards can and should be expected. Differences in hardware impede collaboration among emergency workers and cause interoperability issues. Mitigating these issues is an essential component of emergency preparedness. Hence, emergency workers must be provided with compatible hardware and software to streamline their response efforts.

In *Geographic Information Systems in Disasters*, Polanski's[25] identified certain criteria's that must be met when selecting hardware for emergency operations, including …

- robustness in outdoor use and varying climate conditions.
- reliability and long battery life.
- widespread use and worldwide availability.
- active online communities for support and troubleshooting.
- featuring standard, nonproprietary connections/interfaces (e.g., for transferring data between a GNSS receiver and a computer, (i.e., Universal Serial Bus [USB] cable with Type A and Mini-B-plug).
- GNSS receivers with color display and storage for maps.

Standard emergency relief hardware must meet the needs of emergency workers, while being compatible with local software and adaptable to different environments.

Software

There is an ever-growing amount of software being developed for GIS during emergencies.[26] They are referred to as GIS software and used by emergency workers to create, manage, analyze, and visualize geospatial data.[26] Though beneficial to emergency management, the prevalence makes it hard for emergency workers to choose which is most suitable for an emergency operation. This process can be challenging with limited control over the type of hardware their organization uses and the data available on-site. Ultimately, emergency workers must decide how they want to use GIS and select appropriate software.

According to MapAction[26], there are three categories of GIS software tools.

- GIS viewers are software packages that allow you to view spatial data and assemble it into relevant layers (e.g., ArcGIS Pro, CadCorp Map Express, QGIS). Some packages allow you to view data in various ways but do little else.
- GIS editor tools help manipulate and change spatial data (e.g., create features, align existing features, and reshape existing features). For example, editor tools can add new locations to a dataset of clinics.
- GIS analysis tools help answer questions about data and create new outputs (e.g., buffer, merge, and dissolve tools). For example, analysis tools can create a new map layer showing travel times based on different modes of transport.

Additionally, data management tools are considered the fourth category of GIS software tools. Data management tools are a collection of tools that can be used to create, manage, maintain feature classes, datasets, layers, and raster data structures (e.g., feature class, 3D objects, and attachments).[27] These diverse tools and packages are often referred to as desktop GIS.

Additional GIS software include WebGIS and MobileGIS. WebGIS is a type of information system that has at least a server (i.e., GIS server) and a client (i.e., web browser, desktop application, or mobile application).[28] WebGIS is defined as any GIS that uses web technology to communicate between a server and a client (e.g., Esri).[28] WebGIS has several distinct advantages over a traditional desktop GIS. First, it can be accessed on multiple devices (i.e., computer or mobile) anywhere in the world. Second, multiple users can use the system simultaneously. Third, most WebGIS software is free. Forth, the software is usually very user-friendly. And finally, there is minimum maintenance that must be done to update the system for all clients.[28]

MobileGIS is a type of GIS used in the field. It uses the capabilities of a mobile device, GIS, and GPS to capture, store, manipulate, and analyze geospatial data in the field.[29]

MobileGIS often functions as an extension of desktop GIS. This software is advantageous because of its portability and convenience. MobileGIS allows users to make edits on the go, increasing data accuracy and saving time.[29]

Though GIS software provides a variety of functions, it often requires significant investment in training and money. Particularly, professional desktop GIS software require intensive training in advance of deployment and usually ranges from $700 to $4000, excluding hardware.[30] To reduce costs and increase access, some humanitarian and public health organizations have resorted to using open-source GIS software because it is generally free (i.e., QGIS). Open-source GIS software is advantageous because it allows users to view, overlay, and analyze data on multiple databases. Contrastingly, it is not beginner friendly nor ideal for map-making. Open-source GIS software tends to be outdated and unreliable. These reasons prevent it from becoming the predominant type used in disaster relief.

In his thesis, Polanski[25] identified several criteria's that must be met when selecting GIS software for disaster relief:

- Tried and tested for its appropriateness and usability
- Compatibility with older hardware
- Compatibility of different operating systems (OS)
- Supporting common data formats
- Available for download free of charge
- Easy to share and install
- Working with bandwidth or without internet access

Data

To properly respond to an emergency, a variety of credible, reliable, and updated spatial data must be available. Without this, GIS technology is rendered useless. MapAction defines spatial data as any data that answers the question 'Where' and can be recorded and mapped.[26] There are two standard types of spatial data formats: vector and raster data. Vector data represents geographic information as points, lines, or polygons. These data have specific coordinates and attributes that can be shown in a table. Esri's proprietary file format, shapefiles, is a common way to share this data. Raster data represents geographic data as a grid of cells that each contain an attribute value. "The coordinates of certain points such as corners are specified, but 'features' (such as a road) cannot be described or attributed specifically in the database".[26] Raster data is often represented as a snapshot of the earth's surface or a scan of a two-dimensional map. The process of combining spatial data layers into new data combinations is how maps are created in GIS software.[26]

The most common types of spatial data layers used in relief work are …

- terrain data is a series or collection of points that represent the high and low extremes of a terrain that define topographic features such as levees, ridges, and streams.[31] For example, Google Earth has a terrain model built in. A digital elevation model (DEM) is a type of terrain model which can create a contour map layer and represent features such as hills and valleys.[26]
- remote sensed (RS) images also known as satellite imagery refers to data obtained from sensors on satellites.[24] Remote sensing images integrated into a GIS can be used to track population movement, land usage, and surface of areas with water.
- base maps are reference maps on which data can be overlaid from layers and visualized geographic information.[32] Base maps can be made of multiple features, raster, or web layers. They provide context to maps and other dataset layers.
- administrative boundaries are vector files that show levels of a country's administrative geography (e.g., provinces, districts, villages).[26] This data is essential to emergency relief because it is the normal administrative data collected by the host country (e.g., health outcomes, hospital records). To map for example, disease incidence by county it is necessary to have county boundary data.[26] For geospatial preparedness, Pre-crisis data should also be linked to administrative boundaries.[33]

- situational and operational data is also essential to emergency relief. These data most often includes locations of the beneficiary population, aid sources, relief staff, and more.[26] Situational data can be collected by relief workers with the use of hand-held GPS receivers or obtained from partnering organizations. These data should be linked to other datasets such as assessment data and program plans.

These data layers form the basis of two common types of maps used in disaster relief: reference and thematic maps. Reference maps focus on location, they display natural and man-made structures. Reference maps are also known as base maps because they provide background context. Examples include streets, roads, subways, and buildings. An example of a reference map is the United States Geological Survey's topographic map of the US and NASA World Wind – satellite imagery.[34]

Over the past decade, the use of reference maps in disaster settings has increased due to the advent of free mapping tools that have instant reference mapping capabilities.[34] Two examples of this are Google Earth™ and OpenStreetMap. Though the advent of instant reference maps is important to emergency preparedness, it is also detrimental because these maps cannot be modified. Thus, instant reference maps may not be appropriate for more advanced disaster mapping.

Contrastingly, thematic maps represent spatial relationships. They convey specific messages or themes such as population trends, disease rates, or weather patterns. There are several types of thematic maps but the most common are: choropleth maps, proportional symbol maps, isarithmic maps, and dot density maps.[34] Thematic maps are beneficial to disaster relief because they can easily be created with GIS tools. However, they can be disadvantageous when not properly designed because they can misrepresent data.

Additional maps are produced during humanitarian emergencies. The first designed depicts the magnitude of the emergency. They help responders "understand the impact, most affected areas, and critical needs".[33] They are followed by the 3W maps, which provide context on the current operational picture. The 3W maps illustrate the situation and the location of responders. Maps created in the first 24-72 hours are provided to field and remote responders and maps created later are given to donors.[33]

However, before these maps can be created, baseline data are needed. These data come in the form of terrain, administrative boundaries, and situational data layers (i.e., COD and FOD). Finding these data proves challenging for responders. One responder reported, “Sometimes basic questions like determining the boundaries of the disaster may take a lot of time and effort. But there is nothing that can be done before those questions are answered. Before trying to figure out how many people are in need, I should know how many people there are”.[33] This shows how important it is to have accurate and reliable data on hand during the humanitarian response process.

Over the past four years, significant improvements have been made in the availability of core geo-data in the humanitarian sector. This is due to humanitarian organization and partner commitment to sharing and maintaining publicly available data on the HDX platform. Since the introduction of Data Grids on HDX in 2019, there have been a 19% increase in data completeness in locations with humanitarian response plans.[35] Categories with no available data have dropped by 18%.[35] This increase in data completeness amounts to approximately 73% of complete crisis data being available across 25 locations with humanitarian operations. The most complete categories of data are administrative divisions, baseline data, funding, food prices, Internal displaced persons (IDP), and refugees and persons of concern.[35] Gaps in categories of data still remain in certain topic areas (e.g., climate impact, access constraints, acute malnutrition) and need to be addressed.[35]

Funding

For GIS to be applied to emergency operations, funding must be available for equipment, personnel, and capacity-building expenses. On average, relief agencies and partners can spend over $100,000 to hire one IMO, build their capacity, and outfit them with the necessary GIS hardware and software.[24] At the low end of the spectrum, an organization can hire an IMO with the necessary skills, hardware, and software for less than $2,000.[24] Costs vary depending on the agency’s operational and data standards.

Additional costs include time investment and financial resources for acquiring, preparing, and maintaining spatial data.[34] Kemp, *et* al. found that, "virtually every agency, in every sector, finds it expensive to acquire the GIS/RS data it needs to have a baseline or current overview of the situation on the ground".[36] Thus, cost can be a major barrier to applications of GIS in emergency relief. Relief organizations with limited funding and low resource host countries may also find it challenging to utilize this technology.

Current Applications of GIS During Emergencies

In *Geographic Information Systems in Humanitarian Assistance: A Meta-Analysis,* David Ortiz developed a typology summarizing the different geospatial tasks that can be performed in humanitarian settings.[8] For the purpose of this literature review, this typology has been adapted to describe current applications of GIS in public health and humanitarian emergencies. The adapted typology includes:

- **Cartography and Humanitarian Logistics:** Using maps, remote sensing imagery, visual aids, and rapid assessment for infrastructure, population, disease, or resource monitoring and evaluation.
- **Crisis Simulation and Risk Assessment:** Conducting hazard and vulnerability assessments to identify at risk populations and analyzing what if scenarios, consequences of disasters, and forecasting.
- **Vulnerability Risk Assessment:** Integrating socio-economic and environmental data in vulnerability assessments to serve as an early warning alert.
- **Decision-making Support:** Conducting network and locations analysis to support resource allocation and optimization.
- **Surveying and Population Enumeration:** Using public participatory surveying and crowdsourced data to identify vulnerable populations and assess related associations.

The following articles (a total of 24) were found to pertain to these criteria. *Table 1* is structured by geospatial task category, study's purpose, disaster phase, cause of emergency (i.e., man-made or natural disaster and type of disaster) and region or country of study.

Table 1. Applications of GIS for Emergencies, by Geospatial Task

Authors	Purpose	Disaster Phase	Cause	Region
Abdalla, R. (2016).[37]	Evaluate how GIS has been used in urban (natural hazards and man-made) emergencies in the United States and abroad	Preparedness Response	Natural Floods, Wildfire, Dust and Storms Technological Manmade	India
Bull, M. et al (2012).[38]	Literature review of recent applications and benefit of using GIS during legionnaires disease outbreak investigations.	Response	Natural Disease Outbreak	Hereford, UK
Kemp, R. B., & Khagram, S. (2006).[36]	Describes novel use of GIS, GPS, and RS in disaster response and humanitarian relief and compares that to landscape monitoring that occurred in the Pingree Forest using data from the Indian Ocean Tsunami and flood in the island of Hawaii.	Response	Natural Tsunami Flood	Hawaii, US Indonesia
Fuad, A. et al (2006).[39]	Aims to describe the process of health facilities rapid assessment post disaster (2004 Tsunami in Aceh) and analyze the use of free GIS software during this process.	Response	Natural Tsunami	Aceh Province, Indonesia
Giardino, M. et al.[40] (2012).	Describes uses of GIS and geomatics in all phases of emergencies for field applications and inventory purposes.	All	Natural Hurricane Earthquake	Guatemala Mozambique
Hodgson, M. E., Davis, B. A., & Kotelenska, J. (2010).[41]	Provides data on the use of GIS and remote sensing information by state level emergency management offices during the response and	Response Recovery	Natural Hurricane	Louisiana, Mississippi, Florida, and

Authors	Purpose	Disaster Phase	Cause	Region
	recovery phases using data from Hurricane Katrina, Andrew, and Floyd.			North Carolina, US
Masuya, A., Dewan, A., & Corner, R. J. (2015).[42]	Evaluates the spatial distribution of flood shelters and vulnerable residents units in Dhaka, Bangladesh in relation to flood hazards.	Preparedness	Natural Flood	Dhaka, Bangladesh
Puttinaovarat, S., & Horkaew, P. (2020).[43]	Developed a prototype interworking system on a mobile device for flooding disaster mitigation, by using real time remote sensed data and geographical data.	Mitigation	Natural Flood	Surat Thani, Chumphon and Nakhon Si Thammarat, Thailand
Waring, S. et al (2005).[44]	Describes how GIS methodology was integrated in the planning, implementation, and reporting of the rapids needs assessment conducted after the disastrous flooding associated with tropical storm Allison.	Response	Natural Flood	Texas, US
Young, S., Sanchez, C., & Malilay, J. (2005).[45]	Provides an overview of the main uses of GIS for rapid needs assessment in emergency contexts.	Response	Natural Hurricane Earthquake	United States
Zambrano, L. I. et al (2017).[46]	Retrospective cross-sectional study of how GIS was used in the epidemiological mapping of dengue fever and chikungunya incidence in Central America.	Preparedness	Natural Disease Outbreak	Central America

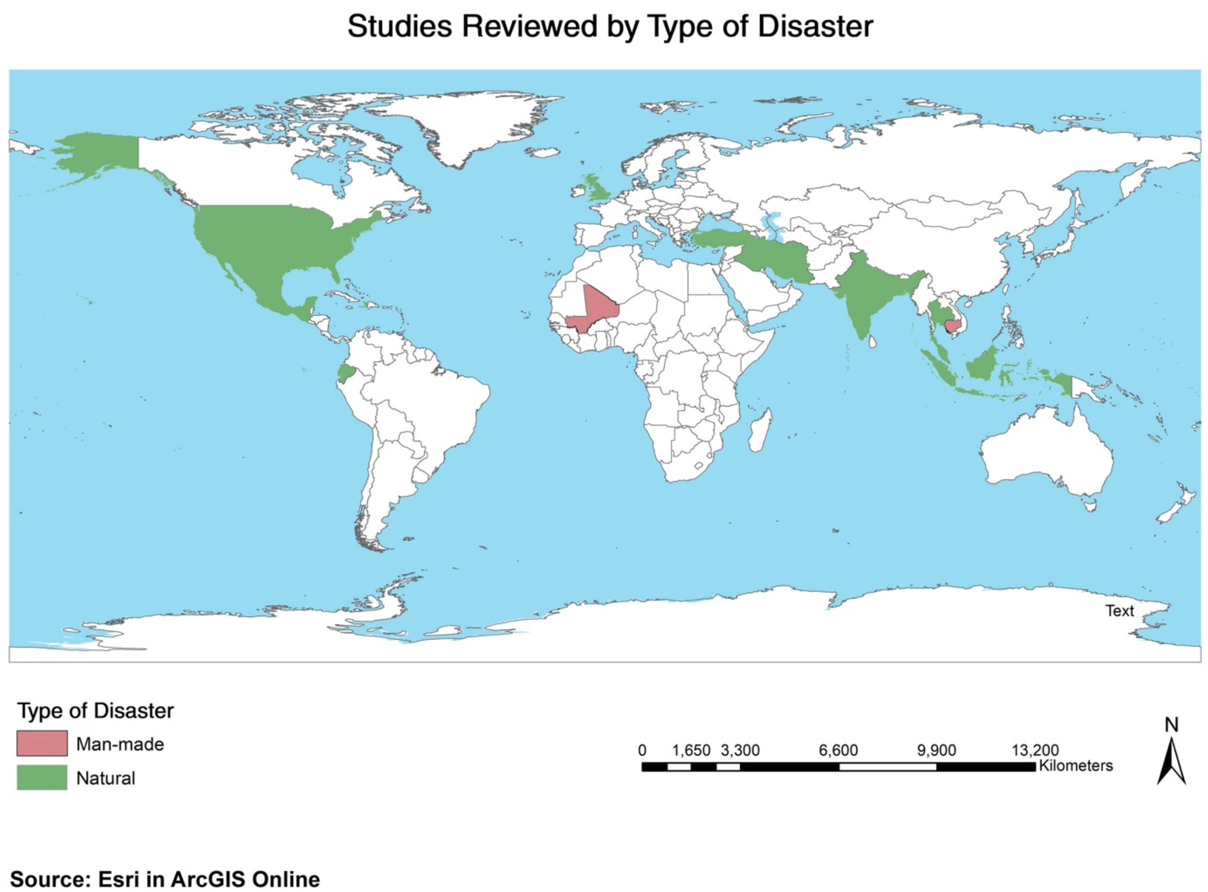
Authors	Purpose	Disaster Phase	Cause	Region
Belal, A.A. et al (2014).[47]	This review examines existing literature on drought risk assessments, summarizes the primary GIS/RS methods used in these assessments, and investigates challenges and limitations.	All	Natural Drought	N/A
Bono, F., & Gutierrez, E. (2011).[48]	Evaluates the reduced accessibility of the urban space in post-earthquake Port-au-Prince through a network analysis. This analysis aims to capture disruptions to the urban road networks and the isolation of dwelling space to emergency services.	Recovery	Natural Earthquake	Port-Au-Prince, Haiti
Crooks, A.T., & Wise, S. (2013).[49]	Highlights how web 2.0 technologies and their data products can be used in addition to traditional data sources can be used for simulation efforts such as agent-based-modeling (ABM) to aid humanitarian response efforts.	Recovery	Natural Earthquake	Haiti
Safaripour, M. et al (2012).[50]	Developed a new flood risk assessment model composed of five factors (i.e. number of flood occurrences, life lost, financial loss, populations vulnerable to floods, and density of residential centers) to map areas affected by the flood in Golestan.	Recovery	Natural Flood	Golestan Province, Iran
Biass, S., Frischknecht, C., & Bonadonna, C. (2012).[51]	Evaluates the risk associated with tephra fallout at Cotopaxi volcano based on vulnerability and risk levels factors (i.e. social, economic, environmental, physical, and territorial) and creates thematic vulnerability and risk maps.	All phases	Natural Volcano	Ecuador

Authors	Purpose	Disaster Phase	Cause	Region
Sahoo, B., & Bhaskaran, P.K. (2018).[52]	An in-depth evaluation on the coastal vulnerability of the Odisha coast of India associated with landfalling cyclones. Uses physical, social, and environmental factor to assess the risk and vulnerability of this region.	Preparedness	Natural Cyclones	Odisha coast, India
Tufekci-Enginar, D., Suzen, M. L., & Yalciner, A. C. (2021).[53]	Examines the content of the tsunami awareness and preparedness parameter (the n value) introduced in the MeTHuVA method.	Preparedness	Natural Tsunami	Istanbul, Turkey
Esmaelian, M. et al (2015).[54]	Proposes a conceptual and methodological framework for combining GIS and Multi-Criteria Decision Support Systems into a single system that can identify shelters and emergency services locations in urban evacuation planning.	Preparedness	Natural Earthquake	Tehran, Iran
Rodríguez-Espíndola, O., Albores, P., & Brewster, C. (2018).[55]	Aims to show the importance of incorporating GIS and optimization in the decision-making of flooding zones locations and distribution using data from two major floods in Mexico.	Preparedness	Natural Flood	Veracruz and Villahermosa, Mexico
Rodriguez, H. et al (2007).[56]	Examines the need for spatial decision-making support systems, identifies examples of GIS current application in disaster settings, and presents some direction for future research.	All	Natural Hurricane	N/A
Greenough, P. G., & Nelson, E. L. (2019).[11]	Explores the contemporary uses of GIS in public health and the humanitarian field and argues for the integration of new geospatial methods (population enumeration, sample size estimating, programmatic management) in humanitarian health.	All	Natural Flood Earthquake Drought Disease outbreak	Haiti Iraq Thailand Malaysia Nepal

Authors	Purpose	Disaster Phase	Cause	Region
Jitt-Aer, K., Wall, G., Jones, D., & Teeuw, R. (2022).[57]	Developed an application to identify the number of disasters impacted people in a given district of Thailand following the 2004 Indian Ocean Tsunami, by integrating GIS and population estimation algorithms, to facilitate humanitarian relief logistics.	Preparedness Response	Natural Tsunami	Phuket, Thailand
Tunçalp, Ö. et al (2015).[58]	Analyses the association between conflict and displaced populations access to sexual health care service in post conflict Mali by surveying healthcare facilities data	All	Man-made Conflict	Mali
Williams, C., & Dunn, C.E. (2003).[59]	Evaluates the role of participatory surveying in assessing the risk to local populations from landmines in post conflict settings.	Recovery	Man-made Conflict	Cambodia

Gaps in Applications of GIS During Emergencies

Eleven of the 24 studies identified pertain to applications of GIS for cartographic and humanitarian logistic purposes. The rest show applications of GIS for more complex analyses. Though few articles pertain specifically to applications of GIS for crisis simulation[48,49] and population enumeration.[57] Twenty-two of the 24 studies refer to natural hazards, showing the need for more research in man-made and technological disasters (Map 1).



Map 1: Studies Reviewed Symbolized by Type of Disaster

The current gaps in applications of GIS in emergencies are limited application of GIS in emergencies in low- and middle-income countries (LMIC); the need for multivariate spatial analyses; the need for further validation and comparison of GIS methods.

Limited Applications of GIS During Emergencies in LMICs

Three authors reported a lack of studies on applications of GIS in low resource settings. Fuad et al suggested that GIS has been underutilized in Indonesia due to the limited availability of trained personnel, affordable GIS software, and intersectoral coordination and information sharing.[39] This is in line with the evidence mentioned in the Funding section about the financial barriers of implementing GIS in these settings. Similarly, Sahoo and Bhaskaran reported no prior GIS studies conducted in the Indian coast on the combined effect due to storm surge and inundation during tropical cyclones[52] and Zambrano reported a lack of studies in Central America utilizing maps for infectious disease investigation.[46] These examples show that GIS has been underutilized in LMICs, particularly, in public health emergency contexts. Addressing these gaps through an open access training curriculum is imperative to strengthening low resource countries' public health emergency operations.

Need for Multivariate Spatial Analyses

Several authors noted the need for multivariate spatial analyses – an "array of statistical methods for quantifying the relations among variables in a set of observations".[60] Safaripour requested that future studies consider "other flood related factors 'such as environmental ones' into account in order to achieve a more comprehensive [flood] risk system".[50] Sahoo and Bhaskaran called for more research on the combined effect of inundation volume during the landfall of a tropical cyclone[52] and Williams, *et* al. identified the need for more socio-political economic factors in post conflict examinations of landmine clearance.[59]

Four studies also identified the need for less static analyses using GIS; they called for more spatial research in co-localities, dense populations, and continuous problems.[37,53,54,55] Abdalla argued that "the co-locality of an impact as a result of a series of events may require more progressed spatial analysis answers for giving details about the extent of damage, cost of harm, distribution of vulnerable populations, [and] the indicators of vulnerability and the mean for a response".[37] Esmaelian, *et* al. stated that future Multi-Criteria Decision Support Systems "must not be only spatial but spatiotemporal".[54] To address the unique challenges of modern emergencies, future spatial research must incorporate multivariate and spatiotemporal analyses.

Need for Further Validation and Comparison of GIS Methods

Jitt, *et* al., Safaripour, *et* al., and Tunçalp, *et* al. identified the need for further validation and comparison of GIS-based methods. Jitt, *et* al. welcomed "further validations and comparisons against future methodologies across a range of geographic case studies from different Tsunami affected countries".[57] Safaripour, *et* al. called for further validation of flood risk assessment models. Suggesting a pressing need for more evaluation of existing GIS-based methods, especially for natural hazards. Tunçalp, *et* al. also found it "essential to keep improving to keep improving the HeRAMS survey by examining and aligning the questions, indicators and their definitions, where possible, with other relevant and/or applicable tools such as Service availability and Readiness Assessment (SARA) and Balance Scorecard to facilitate the continuity and comparability of monitoring outside of emergencies"[58]; while, Greenough and Nelson identified the need for more "evidence based and standardized geospatial methods in humanitarian health".[11] To streamline future emergency operations, existing GIS methods must be validated and standardized to ensure their effectiveness and efficacy.

Additional considerations in current applications of GIS in emergencies include …

- high data demand and cost.
- accuracy of available data.
- data and information frameworks and interoperability.
- data sharing cooperative agreements.
- effectiveness of application of GIS during emergencies.

Conclusion

This review defined how applications of GIS during emergencies differ from non-emergency contexts. It explained how public health and humanitarian agencies utilize GIS and identified four requirements and preconditions to its application during emergencies. Lastly, this review identified current applications of GIS during emergencies and discerned gaps in its application for which a training curriculum could be developed.

Chapter 3: Methods

Justification for Curriculum

The need for an open-access, GIS Training Curriculum for Emergency Management targeted to emergency responders in LMICs was identified through a systematic review of the trends and gaps in applications of GIS during emergencies. Although no formal need assessment was conducted with this population, the need for this type of training was identified by several researchers and humanitarian and public health agencies.

Additionally, a search for emergency related GIS training was conducted (Table 2). Ten current and past training were identified; only one was free and two charged an enrollment fee. Two out of the three current training were virtual and only one was in person in Massachusetts, United States. Six out of seven past training were held in person in various places (e.g., Thailand, Kenya, Hungary, United Kingdom) and only one was virtual. The cost for these training sessions ranged from $159 to $2,375. All training sessions and e-learning modules were implemented by universities, governmental agencies, and non-governmental organizations.

Table 2. Current and Past GIS Trainings for Emergency Operations

Name	Implementer	Type of Training	Current/ Past	Location	Cost
GIS Open Tools For Humanitarian Mapping[61]	Ong 2.0	Online	Current	Online	$159
Humanitarian Geospatial Technologies Workshop[62]	Harvard Humanitarian Initiative	In-person	Current	USA	$2,150
Applications of GIS for Emergency Management[63]	FEMA	Online	Current	Online	Free
Humanitarian Mapping Course (2017)[64]	MapAction	In-person	Past	UK	$437 - $1154*
Geographic Information Systems (GIS) for the Humanitarian Community (2020)[65]	ISEPEI Project	In-person	Past	Hungary	1084*
GeoCRIS Training (2022)[66]	Caribbean Risk Information System	Online	Past	Online	Free
Training Course on GIS And Remote Sensing In Disaster Risk Management Course (2018)[67]	Active Learning Network for Accountability and Performance	In-person	Past	Kenya	$800
Emergency Preparedness for GIS (2022)[68]	URISA workshop	In-person	Past	USA	200
GIS Online Training & Onsite Training in Disaster Risk Assessment Modeling (2011)[69]	Florida International University & USAID/OFDA	Online & In-person	Past	USA	Free
14th Training Course On GIS For Disaster Risk Management (2019)[70]	Asian Disaster Preparedness Center	In-person	Past	Thailand	$2,375

**Foreign currency conversion based on 03/17/23 rate.*

Training Curriculum Development

This training was developed with the help of two public health professors who have strong backgrounds in GIS and curriculum development. The ADDIE Model of Instructional Design and Knowles' Adult Learning Theory informed the development of this training. The format is modeled on existing asynchronous training curricula and the Rollins School of Public Health Introduction to GIS asynchronous course (INFO 530).

The target audience are current and future emergency relief workers in LMICs > 18 years of age. Emergency relief workers may include, but are not limited to people working the humanitarian, disaster, and public health fields. The content included was deemed most appropriate for an asynchronous course structure. The training consisted of four modules ranging from 1 to 1.5 hours in length. Each module also included an assessment in the form of either a post-test or lab.

Training modules content was obtained from various sources including GIS textbooks, reliable online sources such as the Centre for Humdata and FEMA, and MapAction Field Guide to Humanitarian Mapping. Labs developed with publicly available data. All datasets were obtained from the Humanitarian Data Exchange and GitHub. Training modules and labs were developed in approximately five to ten hours each and were reviewed by a GIS professor and a public health professor – both with curriculum development experience.

IRB Approval

This Special Studies Project did not require IRB approval because it is not designed to contribute to generalizable scientific knowledge, nor does it involve human subjects or any experiments. This project will not need any special data considerations. It will only include open-source GIS data in the design of the training.

Chapter 4: Results

Overview

The GIS training curriculum included four modules ranging from 60 to 90 minutes. Each module is designed to be completed asynchronously by the participant and includes an assessment either in the form of lab or a pre- and post- test. The following is an overview of the curriculum's modules:

- **Module 1**: Introduction to GIS for Emergency Operations
  - This 60-minute module focuses on the use of Geographic Information Systems (GIS) in emergency management. Emergencies are spatial problems that occur in specific geographic locations, and GIS can be a valuable tool for guiding decision-making. The module provides an overview of GIS, its current utilization in the four phases of emergency management, and its coordination in public health and humanitarian emergencies. It also highlights the tools needed for GIS to be effectively utilized in emergency contexts.
- **Module 2**: Fundamentals of Spatial Data and Software Tools
  - This 60-minute module builds on the previous one by introducing the concept of spatial data and its importance in emergency management. It discusses the types of spatial data layers that are necessary for effective emergency management. The module also provides an overview of GIS software tools, including their general costs.
- **Module 3**: Cartography Basics using QGIS
  - This 90-minute module expands on the previous two modules by introducing participants to the fundamental elements of cartography using QGIS, a free GIS software. It covers essential GIS skills, including system navigation, data layer loading, mapping variable relationships, map symbolization, layout creation, and map exportation. The module also includes a practical lab for hands-on practice of these concepts.
- **Module 4**: Spatial Data Collection and Analysis

- This 90-minute module expands on the topic of spatial data, covering the collection of both primary and secondary data sources. It includes a demonstration of how to use secondary sources and introduces the concept of spatial analysis, including common types of analyses. Essential GIS skills, such as performing a near function analysis and buffer analysis, are also covered.

Chapter 5: Discussion

Effective emergency management is a critical priority in countries worldwide, and even more so in LMICs where access to disaster management resources is often limited.[39] This curriculum serves as a starting guide for emergency relief workers on how to utilize GIS technology during emergencies. My aim for creating this curriculum was to address the fundamental lack of knowledge in this area in LMICs. By increasing access to appropriate GIS training for emergency relief workers in LMICs, we hope to empower them to actively learn GIS skills, utilize spatial thinking in decision-making, and effectively manage future emergencies.

Strengths

This project had several strengths. Firstly, the curriculum was developed using open-access spatial data, making it accessible and reusable for all participants. Additionally, the curriculum has been tailored to accommodate the busy schedules of emergency relief workers, providing them with an introductory course on GIS for emergency management that can be completed at their own pace and prior to being deployed to a disaster. Another strength is that the curriculum design was informed by Knowles' Adult Learning Theory and includes 4 hands-on labs for participants to learn basic GIS mapping and spatial analysis skills.

Limitations

This training curriculum had several limitations. One limitation of this project was that no primary data was collected during the development of the curriculum. The labs created using secondary data were limited in their application and analysis functions due to the type and quality of spatial data provided in the datasets. For example, some of the shapefile data in the London Cholera Outbreak dataset did not include geographic coordinates, which restricted the use of spatial join analyses. Additionally, some datasets were missing base data layers. For instance, if the London Cholera Outbreak dataset had separate layers for cholera death points and the Soho streets base map, participants could have completed an additional spatial join analysis map showing the cumulative death rates during the outbreak. Therefore, the quality of accessible secondary data severely restricted the types of maps that could be created.

Another limitation of the curriculum is its lack of generalizability. As the curriculum is specifically tailored to current and future emergency responders in LMICs, it may be too elementary for implementation with advanced GIS users and current relief workers in high-resource countries. Additionally, the curriculum is solely designed in English, which may pose accessibility challenges for some participants in LMICs and other regions. However, while the curriculum may not be directly applicable to all audiences, its structure and key components can serve as a starting point for designing additional curricula in the emergency management field.

Additionally, the curriculum has not yet been fully implemented nor evaluated. It is important to consider whether the curriculum effectively meets its objectives and provides the intended skills to participants. Further evaluation is needed to assess the curriculum's effectiveness in its entirety.

Recommendations

The following recommendations aim to address the limitations of this project and expand the scope of evidence-based GIS research and practice:

1. Develop an advanced open-access GIS training curriculum for emergency relief workers in LMICs that includes instruction on primary spatial data collection, mapping product creation, and spatial and multivariate analyses. This training would be beneficial in addressing sudden or complex emergencies where access to spatial datasets may be limited and would expedite response efforts by equipping emergency managers with necessary GIS skills.

2. Conduct further research to validate and compare GIS methods and models currently used during emergencies, as highlighted in the literature review.[57] Ensuring that these methods are evidence-based not only protects vulnerable populations, but also justifies their use in emergency situations.

3. Conduct more evidence-based research on multivariate and spatiotemporal analysis to address the increasing complexity of emergencies. Such research would provide a deeper understanding of complex geographic problems and contribute to more effective emergency management strategies.[37]

Overall, these recommendations highlight the need for advanced GIS training, evidence-based GIS methods, research, and practice in emergency management, particularly in LMICs.

Conclusion

The process of developing a GIS training curriculum for emergency management, targeting current and future emergency personnel in LMICs, was at times lengthy and challenging. However, in the end, the developed curriculum achieves its intended purpose of providing critical GIS knowledge and skills to this specific audience. This curriculum holds promise in reducing the knowledge gap between emergency relief workers in low and high-income countries and contributes positively to the workforce development of emergency personnel on a global scale. My hope is that this curriculum empowers emergency personnel to utilize spatial thinking in decision-making during emergencies.

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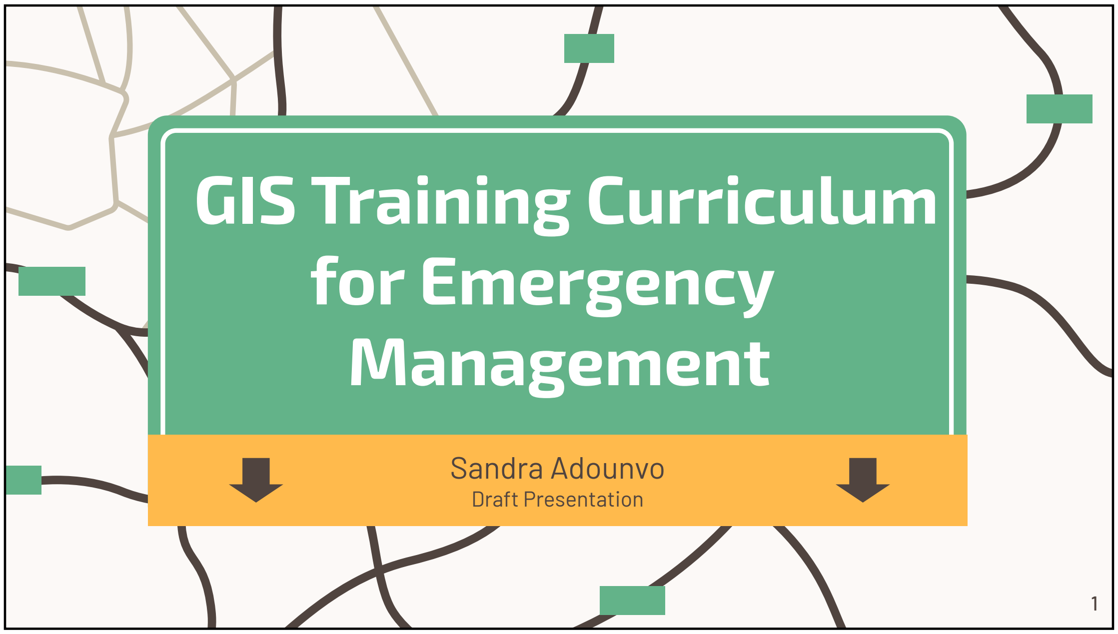
Appendix:

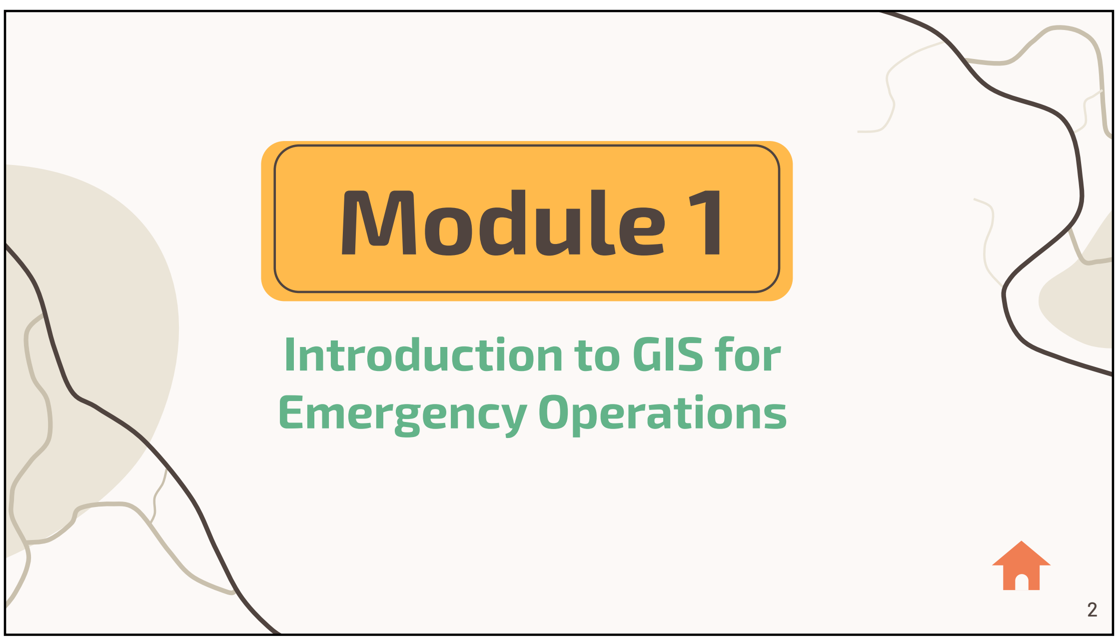
GIS Training Curriculum for Emergency Management

An Introductory GIS Curriculum for Current and Future Emergency Relief Workers in LMICs Created by Sandra Adounvo

GIS Training Curriculum for Emergency Management A GIS training created by: Sandra Adounvo	
Introduction	This GIS training curriculum is designed to introduce current and future emergency relief workers in LMICs to applications of GIS during emergencies. The curriculum incorporates several teaching methods such as lectures, video-based instruction, podcasts, and hands-on labs to facilitate different styles of learning.
Aim	This training curriculum aims to provide current and future emergency relief workers in LMICs with the skills necessary to execute common GIS tasks related to emergency management.
Modules	The training curriculum consists of the following five modules: 1. Introduction to GIS for Emergency Operations 2. Fundamentals of Spatial Data and Software Tools 3. Cartography Basics using QGIS 4. Spatial Data Collection and Analysis
Target Audience	The intended audience for this training is current and future emergency relief workers in LMICs aged 18 and older. Emergency relief workers may include but are not limited to people working the humanitarian, disaster, and public health fields.
Setting	This training is designed for an asynchronous learning environment but could be adapted to an in-person setting.
Technology	Participants need access to a computer with internet access and the free QGIS software.
Timeframe	Modules range in length from 60 to 90 minutes. Novice GIS users should complete the training sequentially. More experienced GIS users may opt to select modules of interest. This asynchronous learning format allows training participants to complete the training on their own schedule.

GIS Training Curriculum for Emergency Management ***Module 1***: Introduction to GIS for Emergency Operations	
Time	60 min
Summary	This module focuses on the use of Geographic Information Systems (GIS) in emergency management. Emergencies are spatial problems that occur in specific geographic locations, and GIS can be a valuable tool for guiding decision-making. The module provides an overview of GIS, its current utilization in the four phases of emergency management, and its coordination in public health and humanitarian emergencies. It also highlights the tools needed for GIS to be effectively utilized in emergency contexts.
Goal/Objectives	The goal of this module is to educate participants on the utilization and coordination of GIS during emergencies. By the end of this module, participants will be able to: 1. Explain what GIS is and how it commonly utilized during emergencies 2. Identify key institutions that support the coordination of GIS during public health and humanitarian emergencies 3. Identify the four preconditions necessary for GIS application during emergencies
Materials	Computer and internet access
Assessments	Pre/Post test


GIS Training Curriculum for Emergency Management
Sandra Adounvo
Draft Presentation
1


Module 1
Introduction to GIS for Emergency Operations
2

Module 1: Learning Objectives

01

Explain

What GIS is and how it is commonly utilized during emergencies

02

Identify

Key institutions that support the coordination of GIS technologies during humanitarian emergencies

03

Identify

The 4 preconditions needed for GIS application during emergencies

3

Pre Test

1. GIS is a system designed to capture, store, manipulate, analyze, and visualize data. True or False?
   a. True
   b. False
2. Which organization is responsible for GIS-based coordination of humanitarian assistance?
   a. OCHA
   b. UNHCR
   c. UNICEF
3. The common operational and fundamental operational dataset are maintained by IMOs. True or False?
   a. True
   b. False
4. The 4 preconditions to GIS applications during emergencies are __________, ____________, ______________, and _____________.
   a. Hardware, software, data, funding
   b. Cash, people, technology, maps
   c. Hardware, funding, software, information

4

Geographic Information Systems

- Geographic Information Systems (GIS) is commonly defined as a system or technology designed to capture, store, manipulate, analyze, and present spatial or geographical data.
- Spatial data includes digital maps, GIS software with unique location functions, and other mapping applications.
- Since its uptake in the 1990s, GIS has been used in various professions ranging from urban planning, engineering, and emergency response.

5

GIS for Emergency Operations

A

Information Sharing

While maps are used for navigation in everyday life, during emergencies, maps generated through GIS are a means of communicating and sharing complex information that is crucial to emergency response.

B

Spatial Thinking

GIS allows emergency relief workers and managers to think spatially about disasters.

C

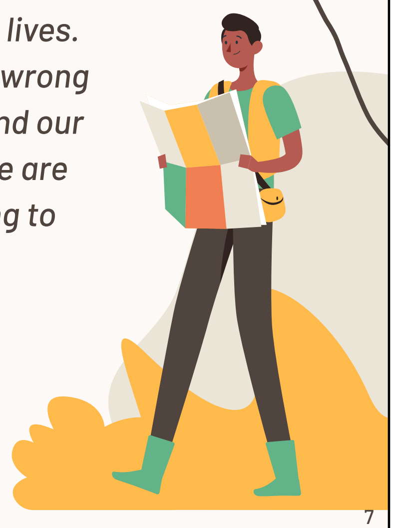
Decision-Making

GIS primary purpose in emergencies is to support decision-making in all **4 phases of emergency management.**

6

"Information is very directly about saving lives. If we take the wrong decisions, make the wrong choices about where we put our money and our effort because our knowledge is poor, we are condemning some of the most deserving to death or destitution."

—JOHN HOLMES
UN Emergency Relief Coordinator
2007-2010



Applying GIS to Emergency Management Phases

MITIGATION
GIS helps identify risk before they occur and reduce their probability

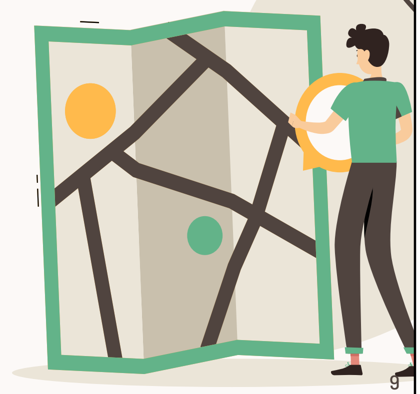
RECOVERY
GIS optimizes restoration efforts and facilitates more sustainable solutions

PREPAREDNESS
GIS supports the development of emergency response plans

RESPONSE
GIS supports search and rescue (SAR) efforts and damage assessments

"In an emergency we want maps of the affected population and displacements, major routes, other actors, clinics, water points and so on. All the things you need if you are sitting hundreds of miles away, to plan and coordinate the response."

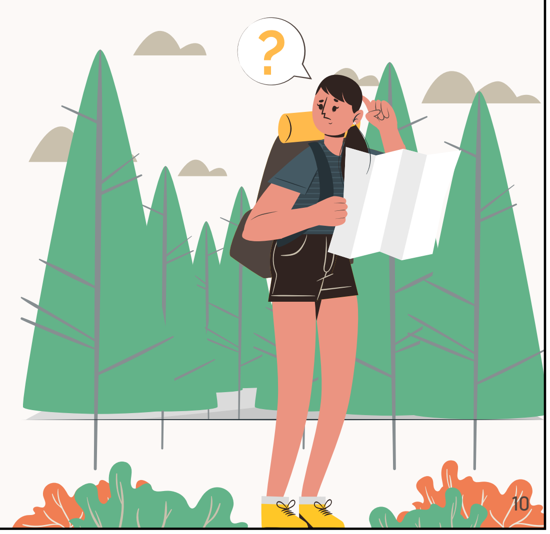
—CHARLIE MASON
Logistician, Save the Children UK



9

Recap

GIS provides real time data to emergency professionals which enables them to assess the scope, magnitude, scale of disaster, coordinate resources, and map essential infrastructures.



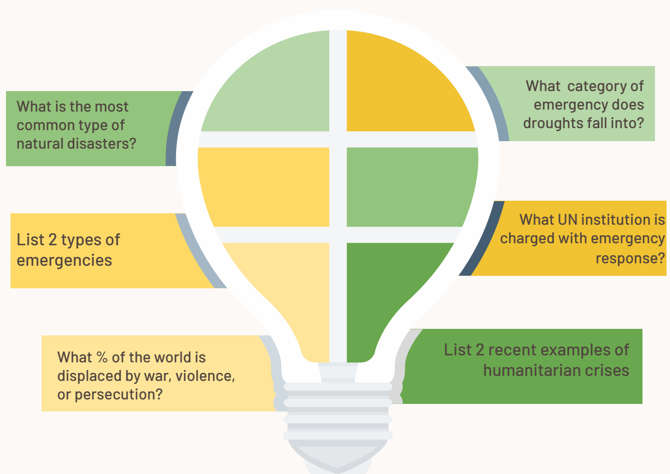
10

How is GIS Coordinated During Emergencies?

The answer depends on the type of emergency. Generally, humanitarian emergencies are coordinated much differently from public health emergencies.

11

Brainstorm



12

Types of Emergencies

Natural disasters
Occur as result of natural processes such as earthquakes, tornadoes, tsunamis, etc..

Man-made disasters
Unplanned events or accidents resulting from human activity such as epidemics, chemical spills, drought, etc..

Internal Conflicts
Planned activities by a group or individual to cause a disruption. Example include riots, strikes, etc..

Energy and Material Shortage
Shortages such as price wars, resource scarcity, etc..

Attack
Includes acts of terrorism, war, bioterrorism, etc..

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GIS Tasks Coordination During Humanitarian Emergencies

- → Most humanitarian emergencies (HE) fall under three categories: natural disasters, man-made disasters, and complex emergencies (a combination of man-made, natural disasters, and attacks). Examples include Haiti's 2010 Earthquake, Northern Ethiopia's Severe Drought, and the Russo-Ukrainian War.
- → GIS data is collected and analyzed by various United Nations (UN) institutions and partnering organizations
- → The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) is responsible for GIS-based coordination of humanitarian assistance.
- → OCHA "contributes to principled and effective humanitarian response through coordination, advocacy, policy, information management and humanitarian financing tools and services" (UNOCHA)

14

Why is this important?

IMO should have a solid understanding of emergency management coordination, as it is crucial to avoid the duplication of response efforts and GIS products.

15

GIS Tasks Coordination During Humanitarian Emergencies

→ OCHA's main GIS activities are carried out in field offices by multidisciplinary teams of Information Management Officers (IMOs).

→ IMOs in field offices maintain the following datasets:
- Common Operational Data (administrative data and population statistics)
- Fundamental Operational Data (dataset that are specific to particular sector)
- Other geospatial data in countries with ongoing crises

→ IMOs analyze the collected data as part of preparedness, need assessment, and strategic planning, implementation, and monitoring efforts then produce information materials such as infographics, situation reports, reference and operational maps, and program documents.

16

GIS Tasks Coordination During Humanitarian Emergencies

→ OCHA also convenes several Inter-Agency Working Groups (IMWG) on information management for humanitarian organizations at both the global and national level. These groups support the work of the Humanitarian or Resident Coordinator and the Humanitarian Country Team to deliver humanitarian assistance.

→ IMWG create and share the following information products with clusters and sectors IMOs:

- **Who does What Where (3W)** databases and products (maps)
- Relevant documents on the humanitarian situation (eg, mission reports, assessments, and evaluations)
- Geospatial datasets relevant to cluster and inter-cluster decision making (population data listed by age and sex)
- Directories of humanitarian partners and information management focal points
- Country specific disaster-related humanitarian web portals
- Technical advice on needs assessment and survey design

Explore OCHA's Map Portals

Who What Where Portal

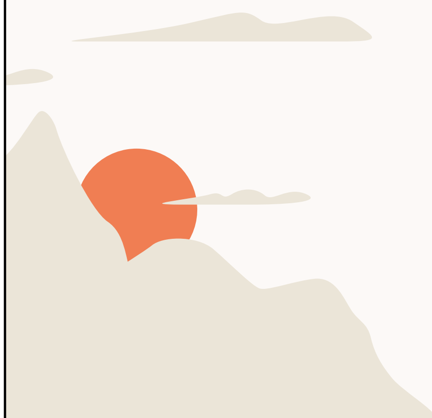
Humanitarian Response Maps

GIS Tasks Coordination During Public Health Emergencies

- GIS helps public health authorities respond to natural and man-made disasters, attacks, and internal conflicts (i.e. COVID-19 pandemic, Ebola Outbreak in Uganda, California urban fires, 2022 European Heatwaves, and etc..).
- One of the earliest applications of GIS in public health occurred during the 1846 Cholera outbreak in London. Dr. John Snow used hand drawn maps to show the locations of cholera deaths and trace them to a single street pump responsible for the outbreak.

GIS Tasks Coordination During Public Health Emergencies

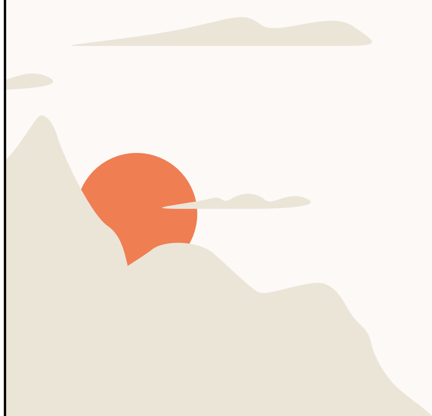
- GIS contributions to emergency preparedness and response through:
  - Needs assessments and planning
  - Evacuation route planning
  - Modeling chemical spills
  - Targeting emergency notifications
  - Determining sites for points of dispensing (PODS)
  - Enhancing the utility of emergency operations center (EOC) software



GIS Tasks Coordination During Public Health Emergencies

- In the US, emergency preparedness and response is managed at the federal, state, and local government levels. The federal agency tasked with emergency management and response is the Federal Emergency Management Agency (FEMA).
- FEMA then appoints response and recovery personnel. As the lead emergency management agency, FEMA also manages interagency coordination and can request support from select agencies (i.e. US Army Corps of Engineers, the US Department of Health and Services, and etc..).

21



GIS Tasks Coordination During Public Health Emergencies

- FEMAs GIS activities are carried out by the Mapping and Analysis Center. They use GIS to share geographic information to governmental and private sector entities that provide materials, supplies, and support to response efforts.
- US state health department also use GIS to support disease outbreak investigation, disease surveillance, and syndromic surveillance efforts.

However, it is important to note that every country coordinates their emergency GIS activities differently.

22

What Preconditions Must be Met Before GIS Can be Utilized During Emergencies?

Emergency relief workers must have access to appropriate, updated, and reliable:

- → Hardware
- → Software
- → Data
- → Funding

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Preconditions to GIS Application During Emergencies

01

Hardware

Including laptops, printers, tablets, and GPS

02

Software

Including ArcGIS, ArcMap, QGIS, etc..

03

Data

Including terrain data, base maps, administrative boundaries, etc..

04

Funding

For IMO personnel salaries, IMO trainings, hardware, software, and data

24

Post Test

1. GIS is a system designed to capture, store, manipulate, analyze, and visualize data. **True or False?**
   a. True
   b. False
2. Which organization is responsible for GIS-based coordination of humanitarian assistance?
   a. OCHA
   b. UNHCR
   c. UNICEF
3. The common operational and fundamental operational dataset are maintained by IMOs. **True or False?**
   a. True
   b. False
4. The 4 preconditions to GIS applications during emergencies are ___________, _____________, _______________, and ______________.
   a. Hardware, software, data, funding
   b. Cash, people, technology, maps
   c. Hardware, funding, software, information

25

The Next Module

Will examine what types of spatial data are needed for emergency operations.

26

Thank you!

27

Pre/Post Test Answer Key

1. GIS is a system designed to capture, store, manipulate, analyze, and visualize data. **True or False?**
   a. True
   b. False
2. Which organization is responsible for GIS-based coordination of humanitarian assistance?
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   a. **Hardware, software, data, funding**
   b. Cash, people, technology, maps
   c. Hardware, funding, software, information

28

Module 1: Introduction to GIS for Emergency Operations Pre/Post Test

1. GIS is a system designed to capture, store, manipulate, analyze, and visualize data. **True or False?**
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    b. False

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    c. UNICEF

3. The common operational and fundamental operational dataset are maintained by IMOs. **True or False?**
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4. The 4 preconditions to GIS applications during emergencies are ___________, _____________, _______________, and ______________.

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Module 1: Introduction to GIS for Emergency Operations Pre/Post Test

Answer Key

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    a. **True**
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    a. **OCHA**
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3. The common operational and fundamental operational dataset are maintained by IMOs. **True or False?**
    a. **True**
    b. False

4. The 4 preconditions to GIS applications during emergencies are __________, ____________, ______________, and _____________.

    a. **Hardware, software, data, funding**
    b. Cash, people, technology, maps
    c. Hardware, funding, software, information

PowerPoint Slides References

Slide 1 -4

Slide 5

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Slide 9

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Slide 10-12

Slide 13

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Slide 16

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Slide 18

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Slide 23-24

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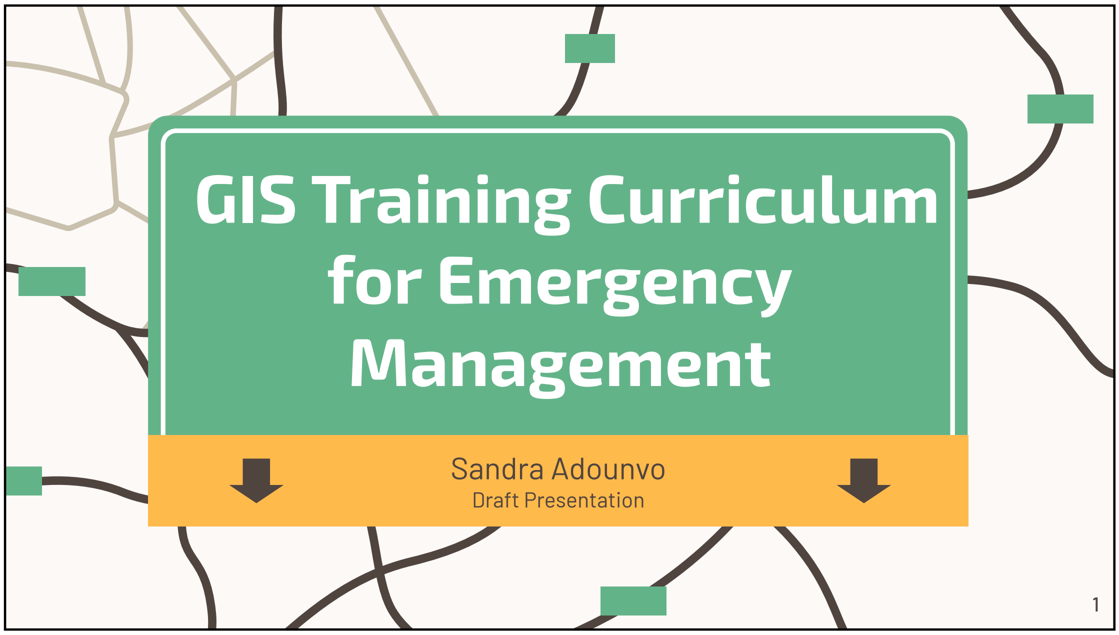
Slide 25-30

GIS Training Curriculum for Emergency Management ***Module 2***: Fundamentals of Spatial Data and Software Tools	
Time	60 min
Summary	This module builds on the previous one by introducing the concept of spatial data and its importance in emergency management. It discusses the types of spatial data layers that are necessary for effective emergency management. The module also provides an overview of GIS software tools, including their general costs.
Goal/Objectives	The goal of this module is to educate participants about types of spatial data, data layers, and GIS software tools commonly used in the coordination of GIS during emergencies. By the end of the module participants will be able to: 1. Define spatial data, data types, and data layers categories 2. Identify the types of data layers needed during emergencies 3. Explain what GIS software tools are and how they differ
Materials	Computer and internet access
Assessment	Pre/Post test


GIS Training Curriculum for Emergency Management
Sandra Adounvo
Draft Presentation
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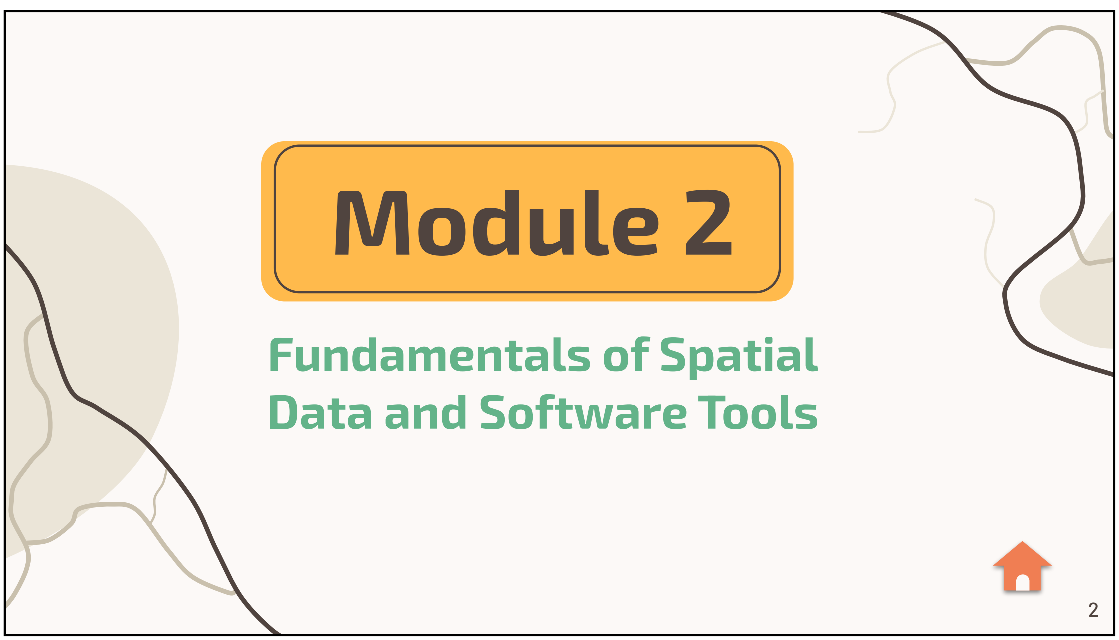

Module 2
Fundamentals of Spatial Data and Software Tools
2

Module 2: Learning Objectives

01

Define
Spatial data, data types, and data layer categories

02

Identity
The types of data layers needed during emergencies

03

Explain
What GIS software tools are and how they differ

3

Pre Test

1. Spatial data describes where objects, people, events, or other features are in proximity to their location on the earth's crust. **True or False?**
   a. True
   b. False
2. What are the 5 common types of spatial data layers utilized during emergencies?
   a. Terrain, remote sensed, base maps, administrative boundaries, and topographic
   b. Terrain, base maps, remote sensed, administrative boundaries, and operational data
   c. Terrain, base maps, remote sensed, administrative boundaries, and satellite data
3. Terrain, administrative boundaries, and situational data layers make up UNOCHAs Common Operational Datasets. **True or False?**
   a. True
   b. False
4. GIS software tools are help relief workers __________, ____________, ______________, and _____________ spatial data.
   a. Analyze, trace, visualize, manage
   b. Create, manage, analyze, visualize
   c. Create, manage, analyze, transform

4

What is Spatial Data?

- Spatial data (also known as geospatial data) is the answer to the question ***Where.*** Spatial data is any information that can be mapped or referenced.
- Examples
  - A village where you are delivering supplies
  - A district health office where you're collect health statistics
- Spatial data describes where objects, people, events, or other features are in proximity to their location on the earth's surface.

5

Photo by Robert Penaloza on Unsplash

Spatial Data

- All spatial data have **coordinates** (*where*) and **attributes** (*what*)
  - Coordinates include latitude and longitude
  - Attributes describe the specific place
- Emergency relief workers need access to credible, reliable, and updated spatial data to effectively respond to emergencies.
- Good spatial data is crucial to any GIS task.
- There are two types of spatial data: vector and raster

6

Types of Data

Vector data

Represents geographic information as points, lines, or polygons. This data has coordinates and attributes that can be shown in a table. A vector is the space between two lines connected at one end to create an angle. These angles stay the same no matter how you manipulate them.

Ex: Esri proprietary file type - Shapefiles

Raster data

Represents geographic data as a grid of cells that each contain an attribute value. Raster data consists of pixels, with low dots per inch (DPI). These images cannot be be well manipulated either. Raster maps are usually aerial photographs or satellite images.

Each data type has its use!

7

Photo by Andrey Metelev on Unsplash

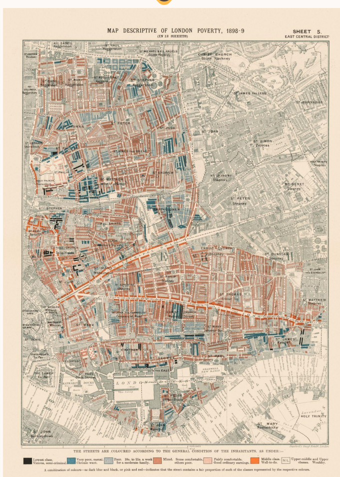
Vector or Raster? Game Rules

➔ In the next 3 slides decide which image is an example of a vector or raster map.

➔ Answers are on slide 12..

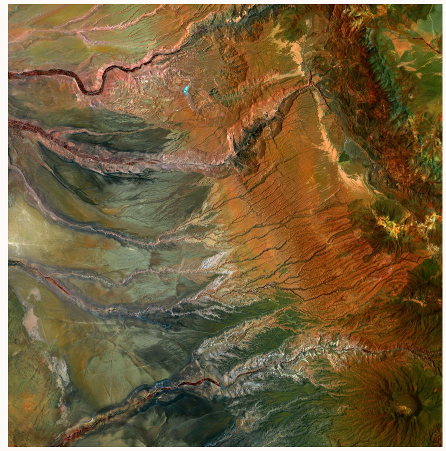
8

A



Map Descriptive of London Property, 1898-9
Photo by LSE Library on Unsplash

B



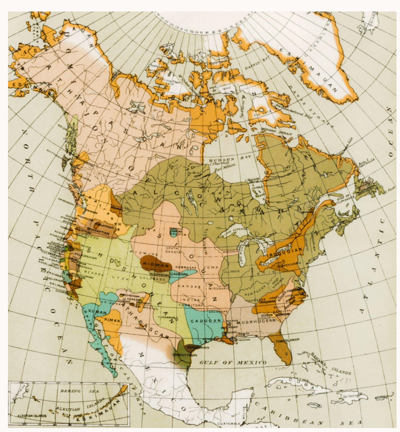
View of Cerro Guachiscota, Camarones, Chile
Photo by USGS on Unsplash

9

C

Australia View
Photo by Mohit Kumar on Unsplash

D



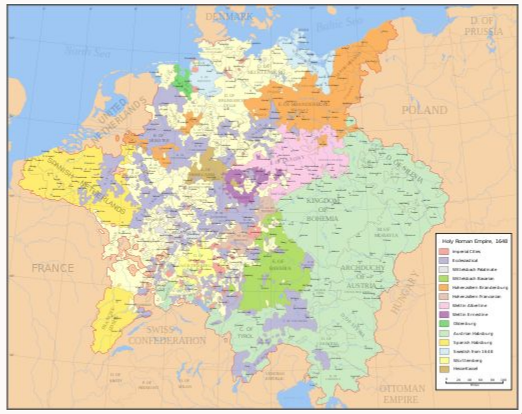
US States by Native American Tribes
Photo by British Library on Unsplash

10

E

Norway View
Photo by USGS on Unsplash

F



Holy Roman Empire, 1648
From Wikimedia Commons
Image was created with Inkscape

11

Game Answers

- A Vector
- B Raster
- C Raster
- D Vector
- E Raster
- F Vector

12

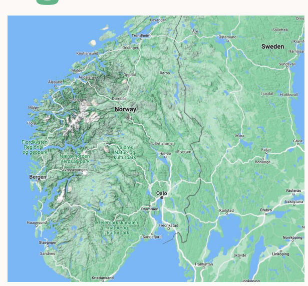
What are spatial data layers?

They are a collection of objects of the same kind (layers) that give you access to geographic data that is displayed in a map or scene. Their data source mostly consists of vector or raster data.

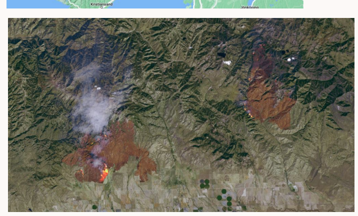
Common Types of Spatial Data Layers used in Emergencies

Terrain data
Collection of points that represent the high and low of a topographic features such a ridges or streams. Google Earth has a terrain feature built in.

Remote sensed Imagery
Also known as satellite imagery refer to data obtained from sensors or satellites. RS images integrated into a GIS can be used to track population movement, land usage, and areas with water.



Norway Terrain View
From Google Maps



Detailed Satellite Imagery of the Idaho Wildfires
By: NOAA
From Flickr

Common Types of Spatial Data Layers used in Emergencies

Base map of Uganda
Credit: EC-JRC (ECHO)
From Wikimedia Commons

Base maps
Are reference maps made of multiple features, raster, or web layers. They provide context to other maps and datasets.

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Common Types of Spatial Data Layers used in Emergencies

Administrative boundaries
Are vector files that show levels of a country's administrative geography such as villages and provinces.

This data is essential to emergency management because they show a place's the authority structure.

Administrative boundary data are usually collected by the host country.

Situational and operational data
Provide the location of populations at risk, aid sources, relief staff, camp logistics, and more.

Relief workers usually collect situational data using handheld GPS.

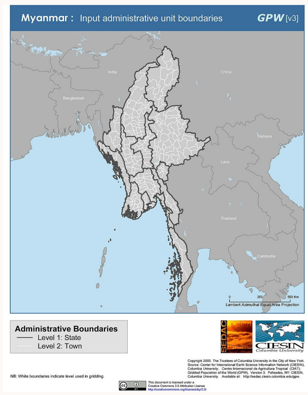
These datasets should be linked to other datasets such assessment data and program plans.

Terrain, administrative boundaries, and situational data layers make up UNOCHAs Common Operational Datasets

16

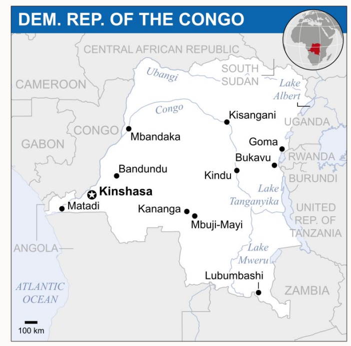
Common Types of Spatial Data Layers used in Emergencies

Administrative boundaries



Administratives boundaries of Myanmar
Author: SEDAC-Maps
From Flickr

Situational and operational data



DRC COD
Credit: OCHA
From Wikimedia Commons

17

The process of combining spatial data layers into new data combinations is how maps are created in GIS software

—MapAction
Field Guide to Humanitarian Mapping, 2011

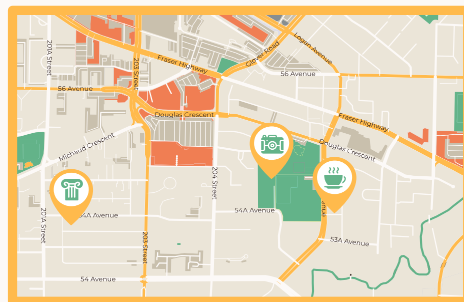
18

From Data Layers to Maps

The data layers previously mentioned serve as the foundation for two main types of maps commonly used in emergency management:

Reference Maps

Display natural and man-made structures such as roads, water, and building structures.



Thematic Maps

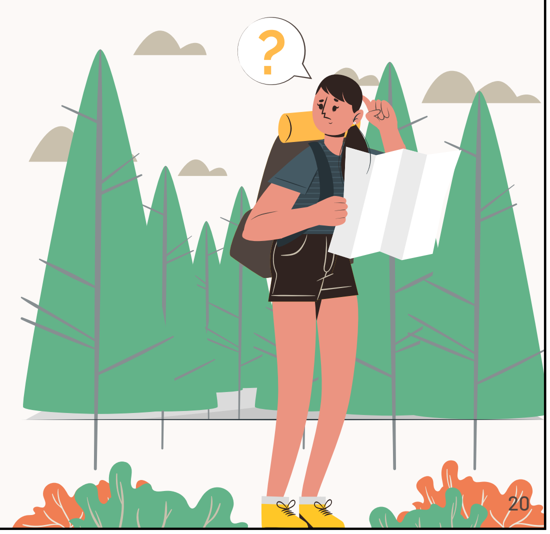
Help convey specific relationships or themes such as population trends, disease rates, and weather patterns.

Caution!

Map production and or possession can be viewed suspiciously by some governments during complex emergencies, so it is important for relief workers to exercise caution.

Be aware of local data privacy and security protections. No data collected should ever cause harm to anyone.

For instance, producing maps of displaced persons could lead them to be targeted.



20

GIS Software Tools

Are used by relief workers to create, manage, analyze, and visualize spatial data.

Given the multitude of softwares being developed for GIS, it is no surprise that one of the hardest tasks for relief workers is choosing which software is more suitable for their work.

The 3 main types of GIS software tools are GIS viewer, editor, and analysis tools.

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Types of GIS Software Tools

GIS Viewers: Allow you to view spatial data and assemble it into relevant layers. **Examples include QGIS and ArcGIS.**

GIS Editor: Help manipulate spatial data. **For example, editor tools can add new locations to a dataset.**

GIS Analysis: Help answer questions about data and create new output. **Examples includes buffer, merge, and dissolve tools.**

Data Management: A collection of tools that are used to create, manage, and maintain features, classes, and datasets.

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Other GIS Softwares

- **MobileGIS**
  - A type of GIS that is used in the field to capture, store, and manipulate data.
  - It is convenient due its portability and convenience
- **WebGIS**
  - Defined as any GIS that uses web technology to communicate between a server and a client.
  - It is advantageous because it can be assessed on multiple devices by multiple users.

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GIS Softwares Cost

- Most GIS softwares usually cost upward of 700 to 4000 USD, excluding hardware cost.
- To make this training accessible to all, a free GIS software (QGIS) will be used for demonstration and lab purposes.

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Post Test

1. Spatial data describes where objects, people, events, or other features are in proximity to their location on the earth's crust. **True or False?**
   a. True
   b. False
2. What are the 5 common types of spatial data layers utilized during emergencies?
   a. Terrain, remote sensed, base maps, administrative boundaries, and topographic
   b. Terrain, base maps, remote sensed, administrative boundaries, and operational data
   c. Terrain, base maps, remote sensed, administrative boundaries, and satellite data
3. Terrain, administrative boundaries, and situational data layers make up UNOCHAs Common Operational Datasets. **True or False?**
   a. True
   b. False
4. GIS software tools are help relief workers ___________, _____________, _______________, and _____________ spatial data.
   a. Analyze, trace, visualize, manage
   b. Create, manage, analyze, visualize
   c. Create, manage, analyze, transform

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The Next Module

Will introduce the basic elements of cartography using QGIS.

26

Thank you!

Pre/Post Test Answer Key

1. Spatial data describes where objects, people, events, or other features are in proximity to their location on the earth's crust. **True or False?**
   a. **True**
   b. False
2. What are the 5 common types of spatial data layers utilized during emergencies?
   a. Terrain, remote sensed, base maps, administrative boundaries, and topographic
   b. **Terrain, base maps, remote sensed, administrative boundaries, and operational data**
   c. Terrain, base maps, remote sensed, administrative boundaries, and satellite data
3. Terrain, administrative boundaries, and situational data layers make up UNOCHAs Common Operational Datasets. **True or False?**
   a. **True**
   b. False
4. GIS software tools are help relief workers ___________, _____________, _______________, and ______________ spatial data.
   a. Analyze, trace, visualize, manage
   b. **Create, manage, analyze, visualize**
   c. Create, manage, analyze, transform

Module 2: Fundamentals of Spatial and Software Tools Pre/Post Test

1. Spatial data describes where objects, people, events, or other features are in proximity to their location on the earth's crust. **True or False?**
    a. True
    b. False

2. What are the 5 common types of spatial data layers utilized during emergencies?
    a. Terrain, remote sensed, base maps, administrative boundaries, and topographic
    b. Terrain, base maps, remote sensed, administrative boundaries, and operational data
    c. Terrain, base maps, remote sensed, administrative boundaries, and satellite data

3. Terrain, administrative boundaries, and situational data layers make up UNOCHAs Common Operational Datasets. **True or False?**
    a. True
    b. False

4. GIS software tools are help relief workers __________, ____________, ______________, and _____________ spatial data.

    a. Analyze, trace, visualize, manage
    b. Create, manage, analyze, visualize
    c. Create, manage, analyze, transform

Module 2: Fundamentals of Spatial and Software Tools Pre/Post Test

Answer Key

2. Spatial data describes where objects, people, events, or other features are in proximity to their location on the earth's crust. **True or False?**
   - **a. <u>True</u>**
   - b. False

5. What are the 5 common types of spatial data layers utilized during emergencies?
   - d. Terrain, remote sensed, base maps, administrative boundaries, and topographic
   - **e. <u>Terrain, base maps, remote sensed, administrative boundaries, and operational data</u>**
   - f. Terrain, base maps, remote sensed, administrative boundaries, and satellite data

6. Terrain, administrative boundaries, and situational data layers make up UNOCHAs Common Operational Datasets. **True or False?**
   - **c. <u>True</u>**
   - d. False

7. GIS software tools are help relief workers __________, ____________, ______________, and _____________ spatial data.
   - d. Analyze, trace, visualize, manage
   - **e. <u>Create, manage, analyze, visualize</u>**
   - f. Create, manage, analyze, transform

PowerPoint Slides References

Slide 1 -4
Slide 5-6

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Slide 8

- Image:https://unsplash.com/photos/DEuansgqjns?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText

Slide 9

- Left image: https://unsplash.com/photos/_mn9oGqeWRA
- Right image: https://unsplash.com/photos/Fm95IBf5buw

Slide 10

- Left photo: https://unsplash.com/photos/6M9xiVgkoN0?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText
- Right photo: https://unsplash.com/photos/Gw_UOoFk4Wk?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText

Slide 11

- Left image: https://unsplash.com/photos/IHdQVLwEIdk?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText
- Right image: https://commons.wikimedia.org/wiki/File:Holy_Roman_Empire_1648.svg

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- Administrative boundaries of Myanmar. Author: SEDAC-Maps. From: https://flickr.com/photos/54545503@N04/5457153275
- DRC COD. Credit: OCHA. From https://commons.wikimedia.org/wiki/File:Democratic_Republic_of_the_Congo_-_Location_Map_(2013)_-_COD_-_UNOCHA.svg

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- MapAction. Field Guide to Humanitarian Mapping 2011. https://maps.mapaction.org/dataset/3febc5f4-cf9f-40d5-9f47-82bb2ebef18b/resource/069394dc-464a-40a

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Slide 21-22

- Source: MapAction. Field Guide to Humanitarian Mapping 2011. https://maps.mapaction.org/dataset/3febc5f4-cf9f-40d5-9f47-82bb2ebef18b/resource/069394dc-464a-40aEsri. Data layers.

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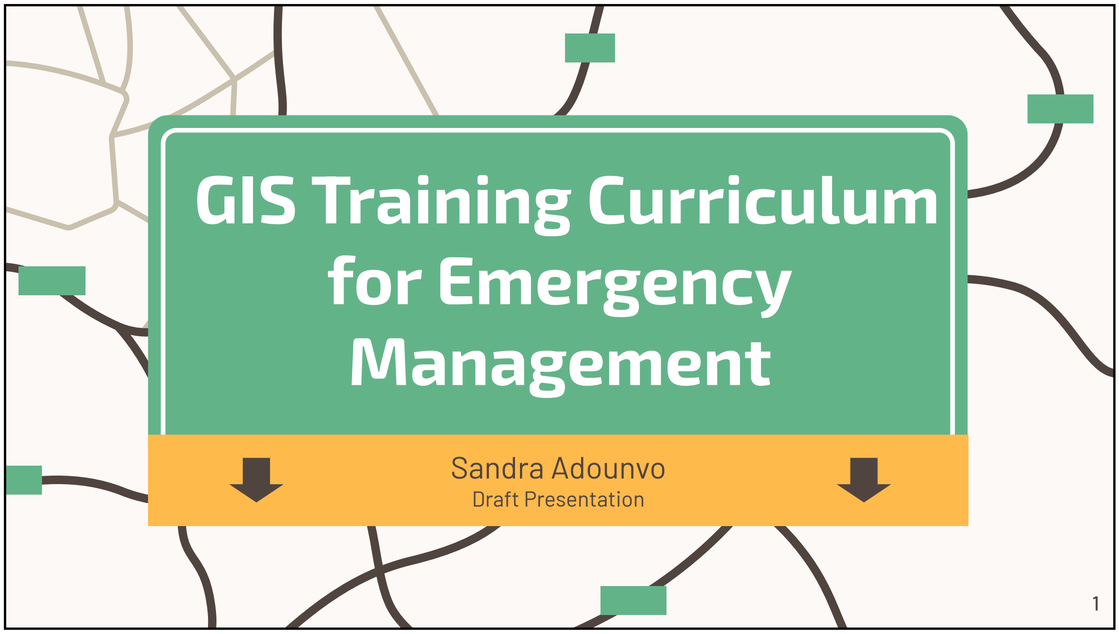
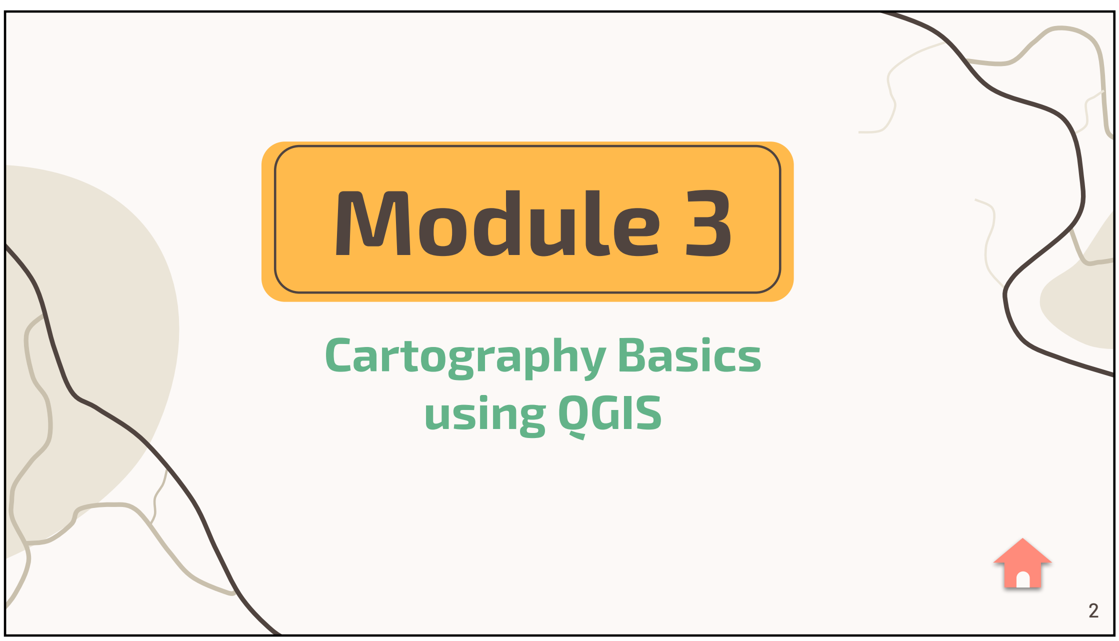
Slide 25-28

GIS Training Curriculum for Emergency Management ***Module 3***: Cartography Basics using QGIS	
Time	90 min
Summary	This module expands on the previous two modules by introducing participants to the fundamental elements of cartography using QGIS, a free GIS software. It covers essential GIS skills, including system navigation, data layer loading, mapping variable relationships, map symbolization, layout creation, and map exportation. The module also includes a practical lab for hands-on practice of these concepts.
Goal/Objectives	The goal of this module is to introduce participants to QGIS and the four basic elements of a map. By the end of this module, participants will be able to: 1. Identify the seven elements of map and the most common types of map projections 2. Navigate through QGIS and load data layers 3. Map the relationship between two variables, symbolize a map, create a layout, and export a map as a picture
Materials	Computer and internet access QGIS Software Humanitarian Data Exchange datasets
Assessments	Pre/Post Test Lab 1: Maps 1-2


GIS Training Curriculum for Emergency Management
Sandra Adounvo
Draft Presentation
1


Module 3
Cartography Basics using QGIS
2

Module 3: Learning Objectives

01

Identify

The 6 elements of a map and the common types of map projections

02

Navigate

Through QGIS and load data layers

03

Map

The relationship between 2 variable, symbolize a map, create a layout, and export a map as a picture

3

Pre Test

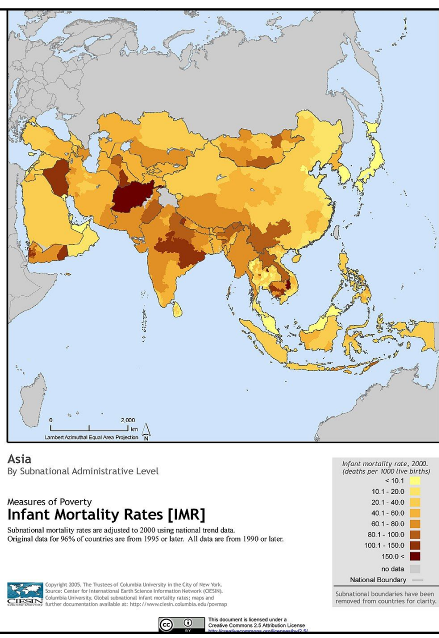
1. All map projections have similar distortion characteristics. **True or False?**
   a. True
   b. False
2. What are the 5 elements of a map?
   a. Map title, scale, projection, legend, data/time, and data sources
   b. Map title, scale, north arrow, legend, data/time, and data sources
   c. Map title, scale, projection, legend, data/time, and features
3. A map should be easily understood. **True or False?**
   a. True
   b. False
4. The 6 most common map projections are __________, ____________, ____________, __________, __________, and _____________.
   a. Mercator, Molly, Miller, Robinson, Lambert Conic Conformal, Winkel-Tripel
   b. Mercator, Miller, Robinson, Mollweide, Winkel-Tripel, Lambert Conic Conformal
   c. Mollweide, Winkel-Tripel, Lambert Conic Conformal, Porter, Miller

4

What to consider when designing a map?

- ➔ What is the purpose of your map?
- ➔ Who is your target audience?
- ➔ What area should your map cover?
- ➔ What data do you need?
- ➔ Where can you get this data?
- ➔ What features of your maps should be prominent?
- ➔ Can your map be easily understood?

5



Consider this Map

What is its purpose?

- ➔ It shows infant mortality rates (IMR) by Asian country. IMR is considered to be a measure of poverty in public health.

Who is the target audience?

- ➔ Public health officials, governments, organizations working on poverty alleviation, researchers, etc...

What areas and features does the map cover?

- ➔ Mortality rates by Asian countries (i.e. national trends of IMR).

What data does it include?

- ➔ Asian countries national and subnational boundary data, global subnational IMR, ocean (i.e. no data).

Where can you find this data?

- ➔ UNOCHA COD, United Nations Child' Fund under 5 mortality data.

Can this map be easily understood?

- ➔ Yes!

Infant Mortality Rates by Asian Country
Source: SEDAC
From: Flickr , License: CC BY 2.0

6

The Elements of a Map

Map title
Describes the main idea/theme of the map.

Legend
List what symbols and or dataset were used .

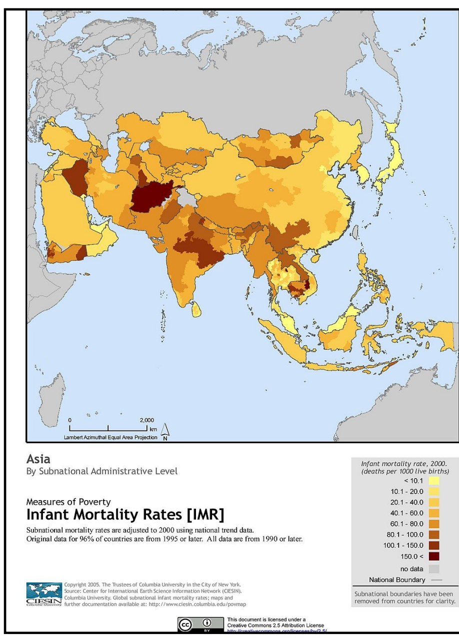
North Arrow
Helps the viewer orient themselves.

Date/Time
Helps the viewer know when the map was made and or when the data sources were collected.

Scale
Provides a visual representation of distance and features size.

Sources of data
Lists where the data originated and often provides contact information for that party.

7



What are the elements of this map?

Map title
Infant Mortality Rates: Asia

Legend
Shows IMR by graduated colors, national boundary, and areas with no data

North Arrow
Next to the scale

Date/Time
Subnational and national boundary data is from 1995; Subnational IMR adjusted data is from 2000

Scale
In kilometers
Lambert Azimuthal
Equal Area Projection

Sources of data
Columbia University Center for International Earth Science Information Network (CIESIN).

Infant Mortality Rate: Asia
Source: SEDAC
From: Flickr , License: CC BY 2.0

8

What are map projections?

Map projections render the Earth's spherical shape to a two dimensional shape (2D). They give us a distorted representation of the Earth's surface. Different map projections have different distortion characteristics.

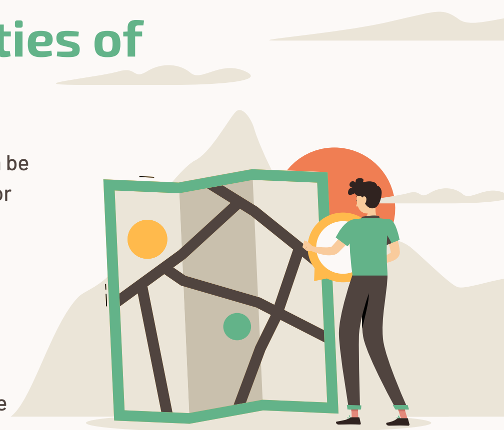
9

What are the properties of map projections?

Map projections are classified by the properties (can be multiple) they preserve (i.e. angles, areas, distance) or don't.

Here are the 4 most common properties:

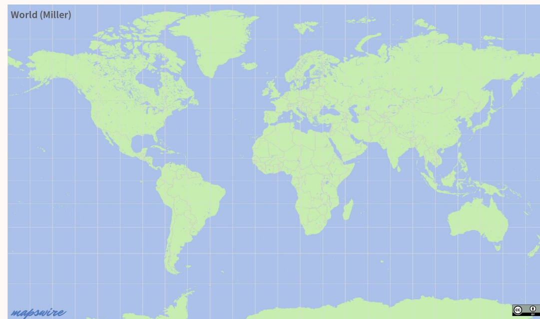
- Conformal: projections that preserve angles locally.
- Equal-area: projections that preserve area measure; they distort the edge of a map.
- Equidistant: projections that preserve distance from a standard point or line.
- Compromise: projections that preserve metric properties (they seek a balance).



10

Examples of Map Projections

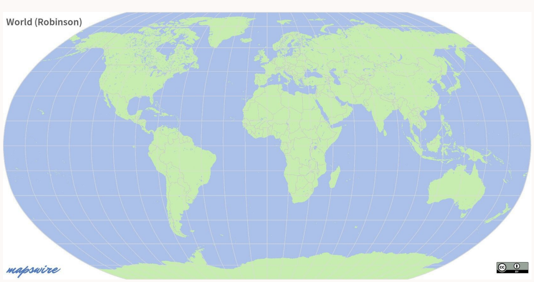
World (Mercator) – License: CC BY 4.0, Mapwire
Most common projection used. It preserves angles.



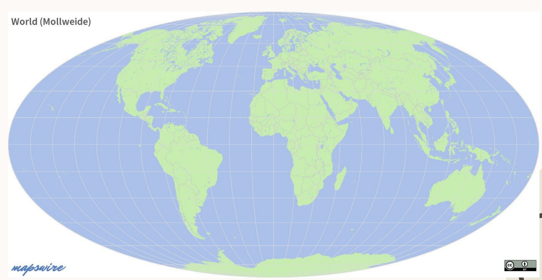
World (Miller) – License: CC BY 4.0, Mapswire
Is a compromise projection. It isn't equal in area, equidistant, or conformal, and doesn't sacrifice either one.

11

Examples of Map Projections



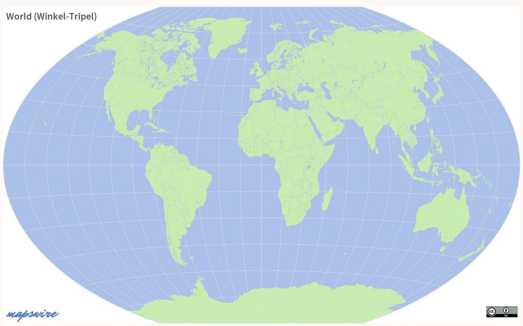
World (Robinson) – License: CC BY 4.0, Mapwire
Is another compromise distortion between size and shape. It preserves neither scale or area.



World (Mollweide) – License: CC BY 4.0, Mapswire
Is an equal-area projection. It preserve size of figures but distorts the shapes near the edge of the map.

12

Examples of Map Projections



World (Winkel Tripel) – License: CC BY 4.0, Mapwire
Is similar to the Robinson and Mollweide projections. It preserves neither shapes, areas, distances, directions, and angles.

Europe (Lambert Conic Conformal) – License: CC BY 4.0, Mapswire
Often used in medium scale map of countries. It preserves angles and shapes at the smallest scale.

Post Test

1. All map projections have similar distortion characteristics. **True or False?**
   a. True
   b. False
2. What are the 5 elements of a map?
   a. Map title, scale, projection, legend, data/time, and data sources
   b. Map title, scale, north arrow, legend, data/time, and data sources
   c. Map title, scale, projection, legend, data/time, and features
3. A map should be easily understood. **True or False?**
   a. True
   b. False
4. The 6 most common map projections are __________, ____________, ____________, __________, __________, and _____________.
   a. Mercator, Molly, Miller, Robinson, Lambert Conic Conformal, Winkel-Tripel
   b. Mercator, Miller, Robinson, Mollweide, Winkel-Tripel, Lambert Conic Conformal
   c. Mollweide, Winkel-Tripel, Lambert Conic Conformal, Porter, Miller

Intro to QGIS

Now that you're more familiar with map elements and design concepts, you're going to try some hands-on mapping.

The next section of this module is an instructional video on QGIS interface.

Before you need to download QGIS and the necessary datasets for the demo.

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QGIS Software

Download QGIS here:

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Demo datasets

This demo uses Columbia's subnational administrative boundaries data and 2022 subnational population statistics.

These datasets are publicly available on the Humanitarian Data Exchange website:

Columbia Subnational Administrative Boundaries

- ➔ Download
  - COL Administrative Divisions Shapefiles.zip
    - Layers needed
      - col_admbnda_adm0_mgn_itos_20200416.shp
      - col_admbndl_admALL_mgn_itos_20200416.shp

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Demo skills

This demo will teach you the follow skills:

1. Load multiple layers
2. Rename layers
3. Change a layer's symbology
4. Find joins
5. Create a print layout
6. Find map elements in print layout
7. Export a map as a JPEG

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GIS Tools Definition

Symbology
Way to represent the features and attributes of a layer

Attribute table
Table that stores the information inside a layer

Graduated symbols
Used to show quantitative differences between mapped features using a color scale

Join (Table)
Pairs up rows of a table based on a select field

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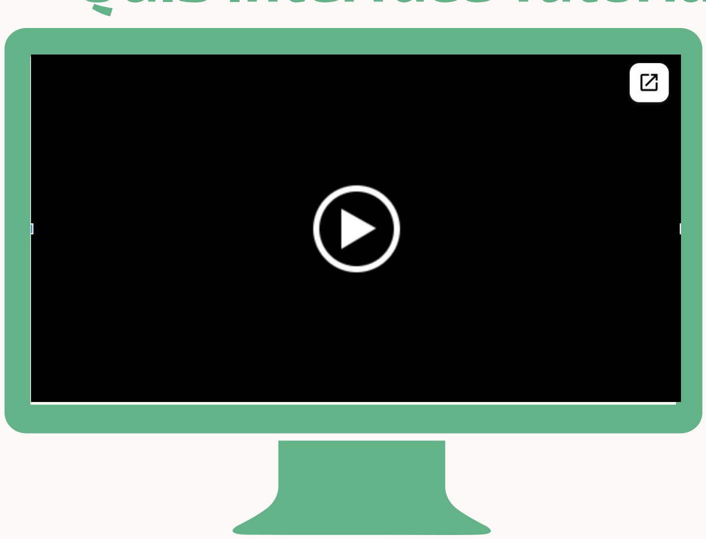
QGIS Interface Tutorial



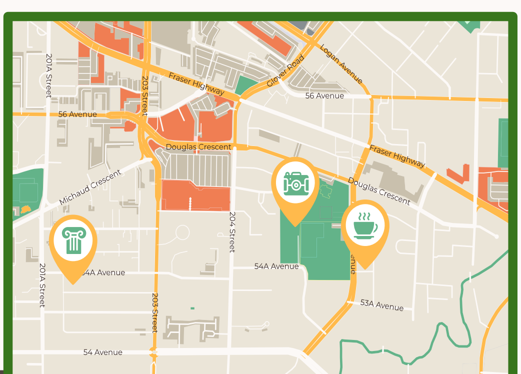
20

LAB 1

Hands-on practice

Maps 1-2

Lab 1 - Map 1



Goal

Learn how to use QGIS, load data, make a country map with the department boundaries.

Skills

1. Open QGIS
2. Load layers
3. Joins
4. Change symbology
5. Add an alias
6. Create a layout
7. Add map elements
8. Export a map as a JPEG

L1- Map 1 dataset

These datasets are publicly available on the Humanitarian Data Exchange website:

Columbia Subnational Administrative Boundaries

- ➔ **Download (same as the demo)**
  - ◆ **COL Administrative Divisions Shapefiles.zip**
- ➔ **Layer needed**
  - ◆ **Col_admbnda_adm1_mgn_20200416.shp**

Columbia Subnational Population Statistics

- ➔ **Download**
  - ◆ **Col_admpop_2022.xlsx**
- ➔ **Layer needed**
  - ◆ **col_admnpop_adm1_2022**

23

Instructions

1. Open QGIS -> click on **New Project**
2. **Click on Project -> Save as -> "Lab 1 -Map 1"** Save this project in your files
3. Click the **Open Source Manager (OSM) button** on the toolbar
   a. In the **OSM** box **click on Vector** ->**click the browse button** on the right of **Vector Dataset**
      i. Add the following data from your downloaded files: **Col_admbnda_adm1_mgn_20200416.shp**
         - The **Data Source Manager** box should open - **Click add**
      ii. Next add the data: **col_admnpop_adm1_2022**
         - **The Data Source Manager** box should open - **Click add**
4. In your layer panel, make sure that **col_admbnda** layer is above the **admpop** layer
5. Open the attribute table of both layers and look at the columns they contain
6. Next, you're going to join the population layer to the administrative layer.
   a. To do this, **right click** on the **col_admbnda** layer
      i. **Click on properties**
      ii. In the dialogue box, **click on Joins** Joins
      iii. **In Joins, click the add new join data** button (**+**)
         - In the **Add Vector Join box, click the down arrow** next to **Join layer** - **select the admpop layer**
         - **Click the down arrow** next to **Join field & Target field - select ADM1_PCODE** (the department code) for both
         - **Click OK**

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Instructions

7. Open the **col_admbnda** layer attribute table to make sure the **admpop layer** was properly joined - close the table.
8. **Right click** on the **col_admbnda** layer - **Click on properties**
    a. **Click on Attributes Form** we're going to give the field that we're going to symbolize an alias
    b. Click on the **col_adminpop_2022 - col_admnpop_adm1_2022_T_TL**
        i. Under **General** (box on the right) write **"Total Pop"** in box next to **Alias - Click Apply**
    c. **Then, click on symbology -** At the top of the dialogue box you should see **Single Symbol** - **Click the down arrow** on its right
        i. Select **Graduated** - Use the down arrow next to the **Value** field to select **Total Pop**
        ii. Use the down arrow next to the **Color ramp** field and select **The Blues**
        iii. **Click Classify** at the bottom of the box to show the population values (*you should have 5 classes of values*) - **Click Apply**
    d. Next **Click on Source**, rename the layer to **Departments by Population - Click OK**
9. **Your Turn**: Using **Source** rename the **admnpop layer** **" 2022 Population Statistics"**
10. Your map should now be in a blue color gradient .
11. Next you're going add the names of the department to the map.
12. To do this, you **right click on Properties**
    a. **Click on Show Labels**

25

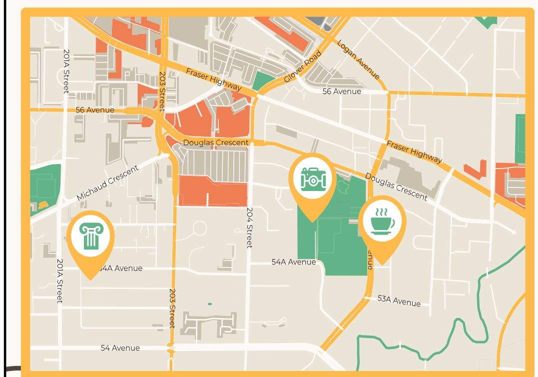
Instructions

13. Now you're going to **create a new layout**
14. **Click on Project -> New Print Layout -> Title the layout " Columbia Population by Departments"** -> **Click OK**
15. The new layout will open.
16. To add your map **click on Add Map** **-> Click OK->** Using your mouse to drag the corners of the map to the edge of the print layout sheet.
17. Next **Click on Add Label** to add your title
    a. **Under Main Properties write "Columbia Population by Departments, 2022"**
    b. Scroll down **click on Font** -> **Bold the font and change it to size 24**
18. **Your Turn:** add another **Label** -> **"Source: Departamento Administrativo Nacional de Estadística (DANE)"** -> Bold the font
19. **Add the Legend** - using your mouse create a box shape - the legend will generate inside it.
20. **Add the Scale** - use your mouse to resize the scale.
21. **Add the North Arrow** - use your mouse to resize it.
22. To save your map **click on Layout -> Export as Image**
23. **Export Resolution 500 dpi -> Click Save.**
24. Save the completed project

The maps key is at the end of the module

26

Lab 1 - Map 2



Goal

Learn how to make a two map layout comparing population by gender.

Skills

1. Load multiple layers
2. Change symbology
3. Create a 2 map layout
4. Add map elements
5. Export a map as a JPEG

27

L1- Map 2 dataset

These datasets are publicly available on the Humanitarian Data Exchange website:

Columbia Subnational Administrative Boundaries

- ➔ **Download (same as the demo)**
  - ◆ **COL Administrative Divisions Shapefiles.zip**
- ➔ **Layer needed**
  - ◆ **Col_admbnda_adm1_mgn_20200416.shp**

Columbia Subnational Population Statistics

- ➔ **Download**
  - ◆ **Col_admpop_2022.xlsx**
- ➔ **Layer needed**
  - ◆ **col_admnpop_adm1_2022**

28

Instructions

1. Open **Lab 1- Map 1** project - **Click on Project** -> **Save as** -> **Lab 1- Map 2** - this will duplicate your project
2. Open **Lab 1- Map 2**
   a. In the **Layers box** -> **Right Click** on **Departments by Population** -> **Click Properties -> Create an alias** for the following fields:
      i. **col_adminpop_2022 - col_admnpop_adm1_2022_F_TL -> "Departments by Female Population"**
      ii. **col_adminpop_2022 - col_admnpop_adm1_2022_M_TL -> "Departments by Male Population"**
      iii. **Click Ok**
   b. In the **Layers box** -> **Right Click on Departments by Population** -> **Click Copy Layer**
   c. In the **Layer box** (white space) -> **Right click** -> **Paste Layer/Group**
3. Now you should have two layers with the same name
4. You're going to change the symbology of each layer to show total population by gender.
5. **Your Turn:**
   a. Change the top layers **Symbology** from **Departments by Population layer to-> "Departments by Female Population" (Remember to click Classify and OK).**
   b. Change the bottom layers **Symbology** from **Departments by Population layer to -> "Departments by Male Population"**
   c. Rename the top layer to **"Female Population" (Hint: You can Rename the layer by right clicking)**
   d. Rename the top layer to **"Male Population"**

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Instructions

6. In your layers, **Uncheck the Male Population Layer**
7. Open a **New Print Layout** -> **Name** the layout
8. In the layout, **Add Map** (*this will add the Female Population Layer*)
   a. In **Item Properties** (on the right) under **Layers** -> **Check Lock Layers & Lock Styles for Layers**
9. Go back to QGIS main interface, **Uncheck the Female Population Layers** -> **Check the Male Population Layer**
   a. Open the Print Layout you just created -> Click **Add Map** (*this will add the Male Pop layer)*
   b. In **Item Properties** (on the right) under **Layers** -> **Check Lock Layers & Lock Styles for Layers**
10. Now you want the Maps you added to be the same size (make their box the same size too)
    a. In **Items** -> **Click on Map 1**
    b. In **Item Properties** under **Main Properties-> Scale -> Type "12990000"**
    c. **Follow the same step for Map 2**
11. Once that's done you want to make your add a frame color to both Maps
    a. In **Item Properties** under **Main Properties-> Scroll down to Frame -> Color "Black" -> Thickness "0.30"**
12. **Your Turn**: Add Map Elements
    a. **Main title: Map of Colombia Population by Gender**
    b. **Map 1: Female Population**; **Map 2: Male Population**
    c. **Source**: **Departamento Administrativo Nacional de Estadística (DANE)**
    d. **Scale - Arrow - Legend**
13. **Export Map as Image -> Save as -> Map of Colombia Population by Gender**

The maps key is at the end of the module

30

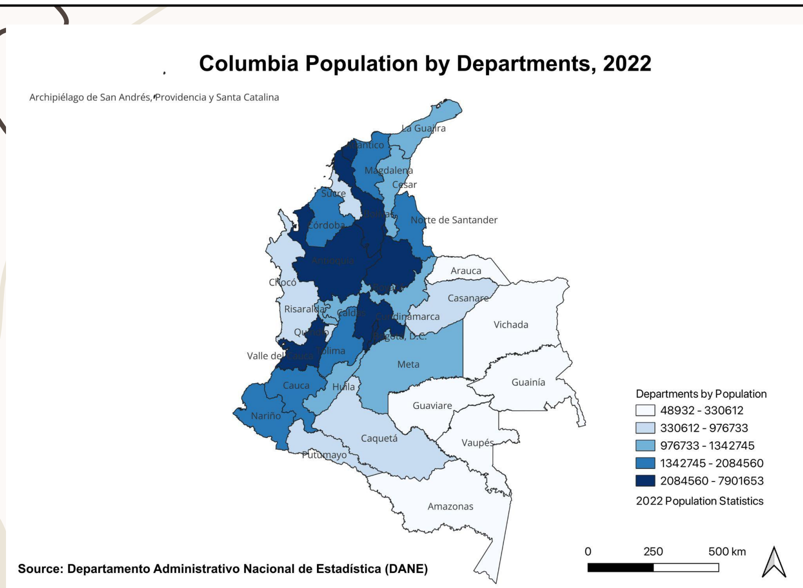
The Next Module

Will introduce the concept of spatial data collection and analysis.

31

Thank you!

32



Lab 1 Map 1 Key

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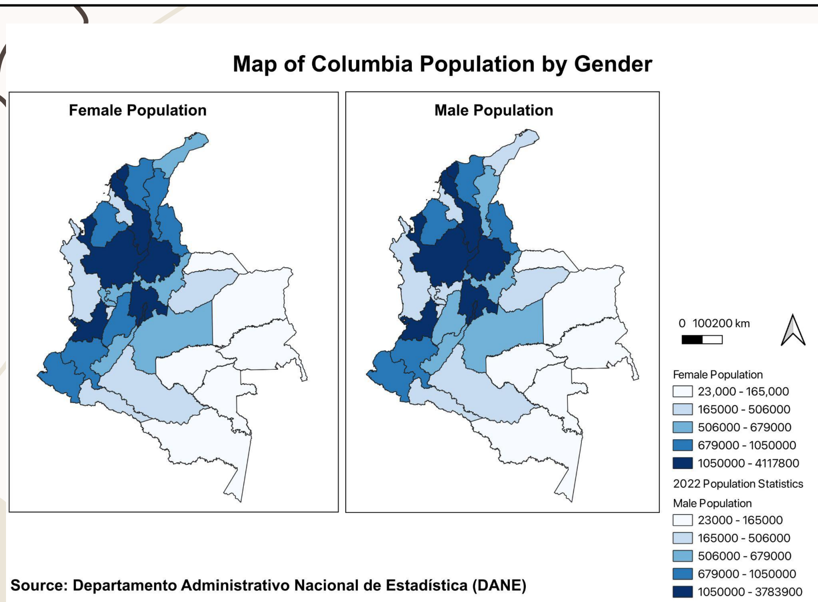


Lab 1 Map 2 Key

36

Module 3: Cartography Basics Using QGIS Pre/Post Test

1. All map projections have similar distortion characteristics**. True or False?**
    a. True
    b. False

2. What are the 5 elements of a map?
    a. Map title, scale, projection, legend, data/time, and data sources
    b. Map title, scale, north arrow, legend, data/time, and data sources
    c. Map title, scale, projection, legend, data/time, and features

3. A map should be easily understood. **True or False?**
    a. True
    b. False

4. The 6 most common map projections are __________, ____________, ____________, __________, __________, and _____________.

    a. Mercator, Molly, Miller, Robinson, Lambert Conic Conformal, Winkel-Tripel
    b. Mercator, Miller, Robinson, Mollweide, Winkel-Tripel, Lambert Conic Conformal
    c. Mollweide, Winkel-Tripel, Lambert Conic Conformal, Porter, Miller

Module 3: Cartography Basics Using QGIS Pre/Post Test

Answer Key

1. All map projections have similar distortion characteristics**. True or False?**
   a. True
   b. False

2. What are the 5 elements of a map?
   a. Map title, scale, projection, legend, data/time, and data sources
   b. Map title, scale, north arrow, legend, data/time, and data sources
   c. Map title, scale, projection, legend, data/time, and features

3. A map should be easily understood. **True or False?**
   a. True
   b. False

4. The 6 most common map projections are __________, ____________, ____________, __________, __________, and _____________.
   a. Mercator, Molly, Miller, Robinson, Lambert Conic Conformal, Winkel-Tripel
   b. Mercator, Miller, Robinson, Mollweide, Winkel-Tripel, Lambert Conic Conformal
   c. Mollweide, Winkel-Tripel, Lambert Conic Conformal, Porter, Miller

PowerPoint Slides References

Slide 1-4
Slide 5

- MapAction. Field Guide to Humanitarian Mapping 2011. https://maps.mapaction.org/dataset/3febc5f4-cf9f-40d5-9f47-82bb2ebef18b/resource/069394dc-464a-40a6-b2b7-56c3fd32ae4b/download/mapaction-field-guide-to-humanitarian-mapping.pdf

Slide 6

- Infant Mortality Rate: Asia. Source: SEDAC, License: CC BY 2.0. https://flickr.com/photos/54545503@N04/5457445203

Slide 7

- MapAction. Field Guide to Humanitarian Mapping 2011. https://maps.mapaction.org/dataset/3febc5f4-cf9f-40d5-9f47-82bb2ebef18b/resource/069394dc-464a-40a6-b2b7-56c3fd32ae4b/download/mapaction-field-guide-to-humanitarian-mapping.pdf

Slide 8

- Infant Mortality Rate: Asia. Source: SEDAC, License: CC BY 2.0. https://flickr.com/photos/54545503@N04/5457445203

Slide 9-13

- Mapswire. Map Projections. Mapswire.com. Published June 24, 2022. Accessed April 13, 2023. https://mapswire.com/map-projections/
- World (Mercator); World (Miller); World (Robinson); World (Mollweide); World (Winkel Tripel); Europe (Lambert Conic Conformal) - License: CC BY 4.0, https://mapswire.com/map-projections/

Slide 14
Slide 15

- QGIS 3.28download link: https://qgis.org/en/site/forusers/download.html

Slide 16

- Demo dataset. Humanitarian Data Exchange: https://data.humdata.org/dataset/cod-ab-col

Slide 17-19
Slide 20

- Demo tutorial link: https://rsph.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=f7951d40-893f-4dc7-97f9-afe5002e982d&start=0

Slide 21-22
Slide 23

- Subnational Boundary Dataset: https://data.humdata.org/dataset/cod-ab-col
- Subnational Population Dataset: https://data.humdata.org/dataset/cod-ps-col

Slide 24-27
Slide 28

- Subnational Boundary Dataset: https://data.humdata.org/dataset/cod-ab-col
- Subnational Population Dataset: https://data.humdata.org/dataset/cod-ps-col

Slide 29-32

Slide 33

- QGIS Development Team, 2023. QGIS 3.28 Geographic Information System User Guide. Open-Source Geospatial Foundation Project. Electronic document: https://docs.qgis.org/3.28/en/docs/training_manual/index.html
- 47.OCHA. Iconography as part of the UN's humanitarian efforts. OCHA. Published March 1, 2020. Accessed April 17, 2023. https://www.unocha.org/story/iconography-part-un%E2%80%99s-humanitarian-efforts-ocha-releases-new-humanitarian-icons

Slide 34-38

- Maps 1 & 2 created by author using QGIS 3.28

Module 3 Lab: Map 1

Goal: Learn how to use QGIS, load data, make a country map with the department boundaries.

Skills:

1. Open QGIS
2. Load layers
3. Change symbology
4. Add an alias
5. Create a layout
6. Add map elements
7. Export a map as a JPEG

Datasets:

1. Columbia Subnational Administrative Boundaries
   a. Download
      i. COL Administrative Divisions Shapefiles.zip
   b. Layer needed
      i. Col_admbnda_adm1_mgn_20200416.shp
2. Columbia Subnational Population Statistics
   a. Download
      i. Col_admpop_2022.xlsx
   b. Layer needed
      i. col_admnpop_adm1_2022

Instructions:

1) Open QGIS -> click on **New Project**
2) **Click on Project -> Save as -> "Lab 1 -Map 1"** Save this project in your files
3) Click the **Open-Source Manager (OSM) button** on the toolbar
   a) In the **OSM** box **click on Vector** ->**click the browse button** on the right of **Vector Dataset**
      i) Add the following data from your downloaded files: **Col_admbnda_adm1_mgn_20200416.shp**
         (1) The **Data Source Manager** box should open - **Click add**
      ii) Next add the data: **col_admnpop_adm1_2022**
         (1) **The Data Source Manager** box should open **- Click add**
4) In your layer panel, make sure that **col_admbnda** layer is above the **admpop** layer
5) Open the attribute table of both layers and look at the columns they contain

6) Next, you're going to join the population layer to the administrative layer
   a) To do this, **right click** on the **col_admbnda** layer
   b) **Click on properties**
      i) In the dialogue box, **click on Joins**
      ii) **In Joins, click the add new join data** button **(+)**
         (1) In the **Add Vector Join box, click the down arrow** next to **Join layer** - **select the admpop layer**
         (2) **Click the down arrow** next to **Join field & Target field - select ADM1_PCODE** (the department code) for both
         (3) **Click OK**
7) Open the **col_admbnda** layer attribute table to make sure the **admpop layer** was properly joined - close the table.
8) **Right click** on the **col_admbnda** layer - **Click on properties**
   a) Click on Attributes Form we're going to give the field that we're going to symbolize an alias
   b) Click on the **col_adminpop_2022 - col_admnpop_adm1_2022_T_TL**
      i) Under **General** (box on the right) write **"Total Pop"** in box next to **Alias - Click Apply**
   c) Then, click on symbology - At the top of the dialogue box you should see **Single Symbol** - **Click the down arrow** on its right
      i) Select **Graduated** - Use the down arrow next to the **Value** field to select **Total Pop**
      ii) Use the down arrow next to the **Color ramp** field and select **The Blues**
      iii) **Click Classify** at the bottom of the box to show the population values (*you should have 5 classes of values*) - **Click Apply**
   d) Next **Click on Source**, rename the layer to **Departments by Population - Click OK**
9) **Your Turn**: Using **Source** rename the **admnpop layer "2022 Population Statistics"**
10) Your map should now be in a blue color gradient

11) Next, you’re going add the names of the department to the map.

12) To do this, you **right click on Properties**

   a) **Click on Show Labels**

13) Now you’re going to **create a new layout**

14) **Click on Project -> New Print Layout -> Title the layout “Columbia Population by Departments”** -> **Click OK**

15) The new layout will open.

16) To add your map **click on Add Map -> Click OK->** Using your mouse to drag the corners of the map to the edge of the print layout sheet.

17) Next **Click on Add Label** to add your title

   a) **Under Main Properties write “Columbia Population by Departments, 2022”**

   b) Scroll down **click on Font** -> **Bold the font and change it to size 24**

18) **Your Turn:** add another **Label** -> **“Source: Departamento Administrativo Nacional de Estadística (DANE)”** -> Bold the font

19) **Add the Legend** - using your mouse create a box shape - the legend will generate inside it.

20) **Add the Scale** - use your mouse to resize the scale.

21) **Add the North Arrow**- use your mouse to resize it.

22) To save your map **click on Layout -> Export as Image**

23) **Export Resolution 500 dpi -> Click Save.**

24) Save the completed project

Module 3 Lab: Map 2

Goal: Learn how to make a two-map layout comparing population by gender.

Skills:

1. Load multiple layers
2. Change symbology
3. Create a 2-map layout
4. Add map elements
5. Export a map as a JPEG

Datasets:

1. Columbia Subnational Administrative Boundaries
   a. Download
      i. COL Administrative Divisions Shapefiles.zip
   b. Layer needed
      i. Col_admbnda_adm1_mgn_20200416.shp
2. Columbia Subnational Population Statistics
   a. Download
      i. Col_admpop_2022.xlsx
   b. Layer needed
      i. col_admnpop_adm1_2022

Instructions:

1) Open **Lab 1- Map 1** project - **Click on Project** -> **Save as** -> **Lab 1- Map 2** - this will duplicate your project
2) Open **Lab 1- Map 2**
   a) In the **Layers box** -> R**ight Click** on **Departments by Population** -> **Click Properties -> Create an alias** for the following fields:
      i) **col_adminpop_2022 - col_admnpop_adm1_2022_F_TL -> "Departments by Female Population"**
      ii) **col_adminpop_2022 - col_admnpop_adm1_2022_M_TL -> "Departments by Male Population"**
      iii) **Click Ok**
   b) In the **Layers box** -> R**ight Click on Departments by Population** -> **Click Copy Layer**
   c) In the **Layer box** (white space) -> **Right click** -> **Paste Layer/Group**

3) Now you should have two layers with the same name
4) You're going to change the symbology of each layer to show total population by gender.
5) **Your Turn:**
    a) Change the top layers **Symbology** from **Departments by Population layer to-> "Departments by Female Population"** (Remember to click Classify and OK).
    b) Change the bottom layers **Symbology** from **Departments by Population layer to -> "Departments by Male Population"**
    c) Rename the top layer to **"Female Population" (Hint: You can Rename the layer by right clicking)**
    d) Rename the top layer to **"Male Population"**
6) In your layers, **Uncheck the Male Population Layer**
7) Open a **New Print Layout** -> **Name** the layout
8) In the layout, **Add Map** (*this will add the Female Population Layer*)
    a) In **Item Properties** (on the right) under **Layers** -> **Check Lock Layers & Lock Styles for Layers**
9) Go back to QGIS main interface, **Uncheck the Female Population Layers** -> **Check the Male Population Layer**
    a) Open the Print Layout you just created -> Click **Add Map** (*this will add the Male Pop layer)*
    b) In **Item Properties** (on the right) under **Layers** -> **Check Lock Layers & Lock Styles for Layers**
10) Now you want the Maps you added to be the same size (make their box the same size too)
    a) In **Items** -> **Click on Map 1**
    b) In **Item Properties** under **Main Properties-> Scale -> Type "12990000"**
    c) **Follow the same step for Map 2**
11) Once that's done you want to make your add a frame color to both Maps
    a) In **Item Properties** under **Main Properties-> Scroll down to Frame -> Color "Black" -> Thickness "0.30"**

12) **Your Turn**: Add Map Elements

a) **Main title: Map of Colombia Population by Gender**

b) **Map 1: Female Population**; **Map 2: Male Population**

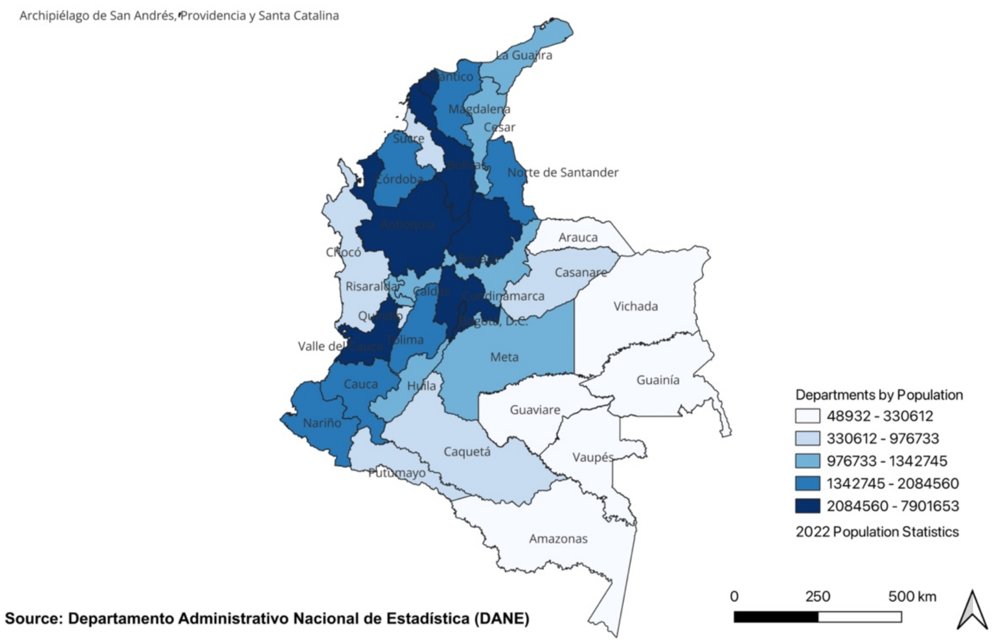
c) **Source**: **Departamento Administrativo Nacional de Estadística (DANE)**

d) **Scale - Arrow- Legend**

13) **Export Map as Image -> Save as -> Map of Colombia Population by Gender**

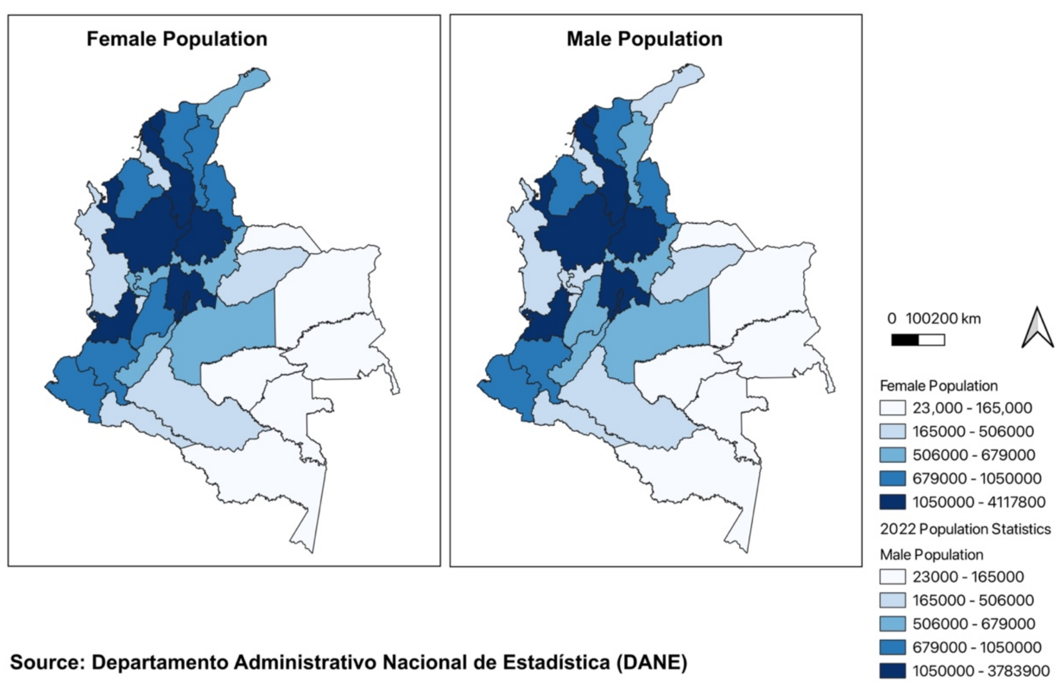
Lab 1 – Map 1 Answer Key

Columbia Population by Departments, 2022

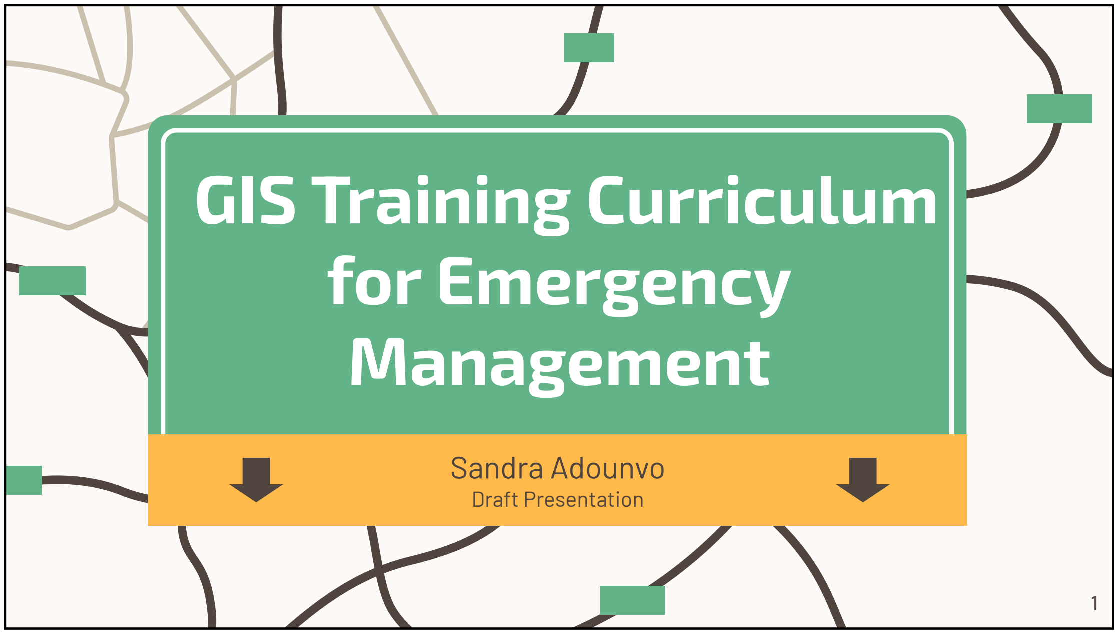


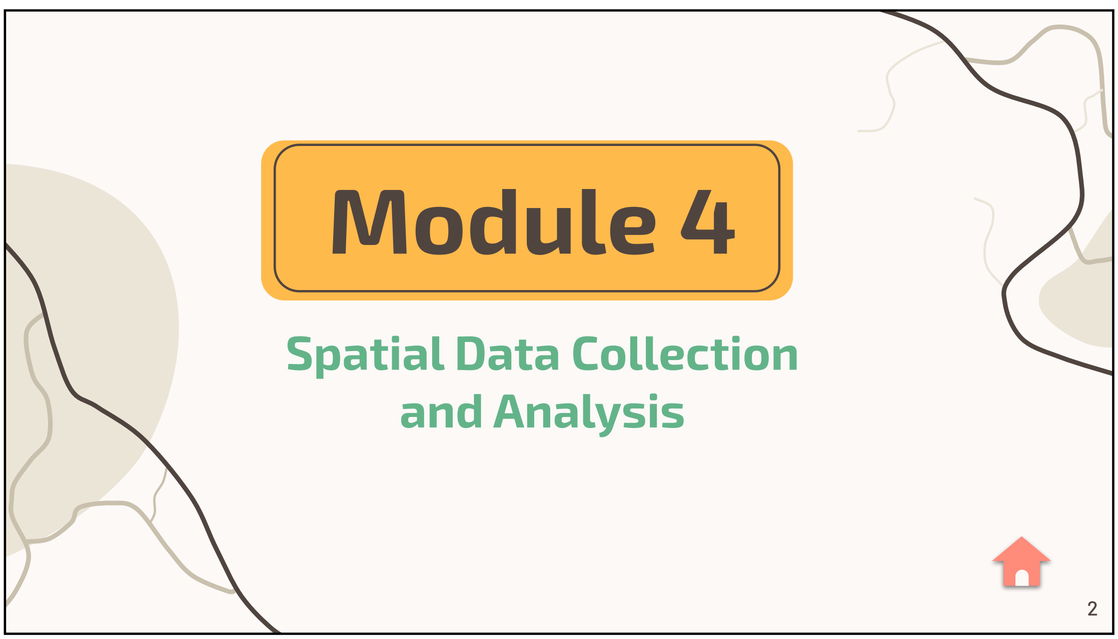
Lab 1 – Map 2 Answer Key

Map of Columbia Population by Gender



GIS Training Curriculum for Emergency Management ***Module 4*:** Spatial Data Collection and Analysis	
Time	90 min
Summary	This module expands on the topic of spatial data, covering the collection of both primary and secondary data sources. It includes a demonstration of how to use secondary sources and introduces the concept of spatial analysis, including common types of analyses. Essential GIS skills, such as performing a near function analysis and buffer analysis, are also covered.
Goal/Objectives	The goal of this module is to familiarize participants with spatial data collection methods and spatial analysis techniques for emergency management. By the end of this module, participants will be able to: 1. Explain the difference between primary and secondary spatial data collection and understand their applications in emergency situations. 2. Identify five common methods for collecting spatial data. 3. Define spatial analysis and identify common types of analyses used in emergency management. 4. Utilize GIS software to perform spatial join, spatial statistics analysis, and near function analysis.
Materials	Computer and internet access QGIS Software GitHub Cholera Outbreak datasets
Assessment	Pre/Post Test Lab 2: Maps 1-2


GIS Training Curriculum for Emergency Management
Sandra Adounvo
Draft Presentation
1


Module 4
Spatial Data Collection and Analysis
2

Module 4: Learning Objectives

01

Explain

The difference between primary and secondary spatial data collection and understand their applications during emergencies

02

Identify

Four common methods for collecting spatial data

03

Define

Spatial analysis and identify common types of analyses used in emergency management

04

Utilize

QGIS to perform a near function and buffer analysis

3

Pre Test

1. Spatial analysis allows you to solve complex location based problems and, explore and understand data from a geographic perspective. **True or False?**
   a. True
   b. False
2. What is the difference between primary and secondary spatial data collection?
   a. Primary spatial data collection is cost efficient while secondary data collection is not
   b. Primary spatial data collection consists of digitized hard copy data while secondary data usually occurs in the field through surveys.
   c. Primary spatial data collection usually occurs in the field through surveys while secondary data consists of digitized hard copy data of maps
3. Finding appropriate spatial data is very easy for responders.**True or False?**
   a. True
   b. False
4. The 5 most common methods of spatial data collection are __________, ____________, ____________, __________, and _____________.
   a. Remote sensing, scanning, surveying, LiDAR, and digitization
   b. Remote photography, photography, surveying, digitization, and LiDAR
   c. Photography, remote sensing, surveying, digitization, and projection

4

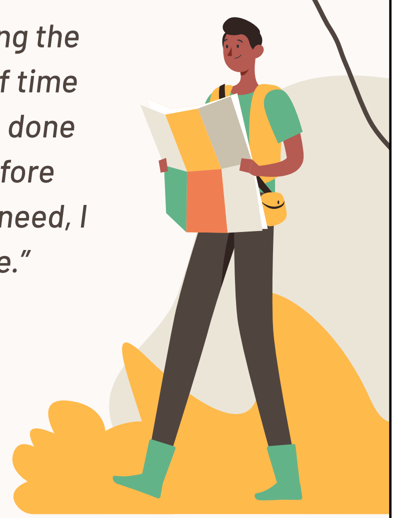
Why is spatial data important to emergency operations?

- ➔ To properly respond to an emergency, a variety of credible, reliable, and updated spatial data must be available. Without this data, GIS technology is rendered useless in this setting.
- ➔ Finding this data often proves challenging for responders.

5

"Sometimes basic questions like determining the boundaries of the disaster may take a lot of time and effort. But there is nothing that can be done before those questions are answered. Before trying to figure out how many people are in need, I should know how many people there are."

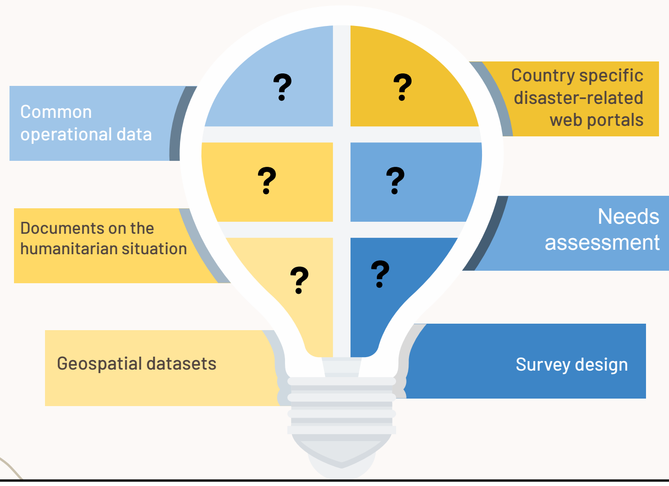
— Interviewed Volunteer & Manager
NGO, Field & Remote Support
2016-2017



Brainstorm

As mentioned in Module 1, IMWG create and share the following information products with clusters and sectors IMOs.

What type of spatial data do you think is needed to make these products?



7

How is spatial data collected?

During emergencies, spatial data is usually collected through primary sources or secondary sources.

- Primary data sources consist of raster and vector data collected in the field.
- Secondary sources consist of digitized hard copy data such as maps, printed images, etc. Digitizations allows different forms of data to interact.

8

Primary Data Collection

Vector data methods

01 **Survey**

Ground surveys are the most accurate and useful form of vector data collection, though they are neither efficient nor cost effective. Their basic principle is that location (of objects) can be determined by assessing the direction and distance from other known locations. This is usually done using a GPS. Surveys tend to be the method of choice for measuring buildings (e.g. site planning and locations surveys), property lines (e.g. boundary surveys), and land (e.g. topographic survey). An example of such surveys is the Emergency Response Rapid Survey by Utz Pape, World Bank.

02 **LSurvey iDAR**

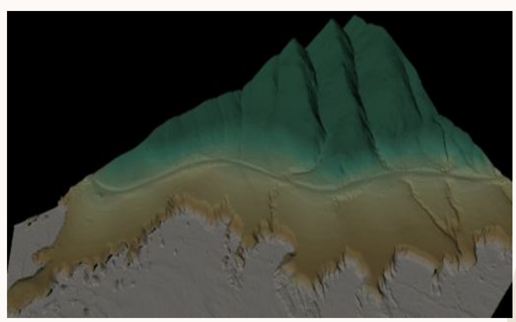
Light Detection and Ranging collect spatial data using lasers. LiDAR is a new complex technology that uses both low-flying aircraft and GPS. It gathers detailed information on the Earth's surface shape by scanning an area with flashing lights, resulting in an instantly accurate topographic survey.

9

Survey of groundwater tapping

USGS, Landsat, Public domain, via Wikimedia Commons

LiDAR Map



View of Cerro Guachiscota, Camarones, Chile
Photo by Rebecca equator, CC BY-SA 4.0, via Wikimedia Commons

10

Primary Data Collection

Raster data methods

01 Remote Sensing

Gathers the chemical, physical, and biological properties of an area without having to make physical contact - making it one of the most preferred methods for data collection in emergencies. RS is carried out by satellite and aircraft sensors. They measure the electromagnetic radiation of objects on the earth's surface.

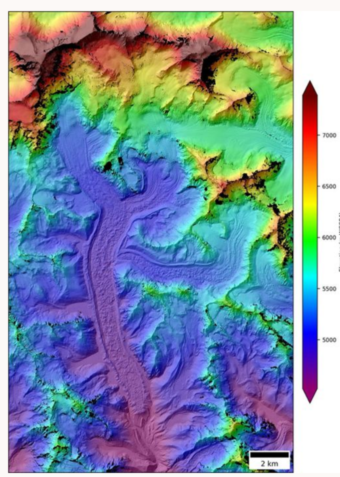
Photography

Is another form of RS that is typically captured using high quality analog optical cameras. The data collected can come in many forms including satellite imagery, aerial photography, thermal imaging, and digital elevation models (DEMs). Aerial photography is one of the earliest and easiest forms of spatial data collection.

RS: Satellite map

Impact craters between the villages Sychivka, Ivanhorod, Chortoryia, Kalnyk on the border of Cherkasy region and Vinnytsia region, Ukraine
By: Латуха Валерій Іванович, CC BY-SA 4.0, via Wikimedia Commons

RS: DEM photo



Digital elevation model (DEM) of the Mt. Everest region
Photo by NSIDC on Flickr, CC by 2.0

Data collection

Is the first step in the emergency response planning process. Though the map designer may not have collected the data themselves, they still need to ensure that data collection is well planned and rigorous. Also, all data collected for emergency purposes should include GPS coordinates.

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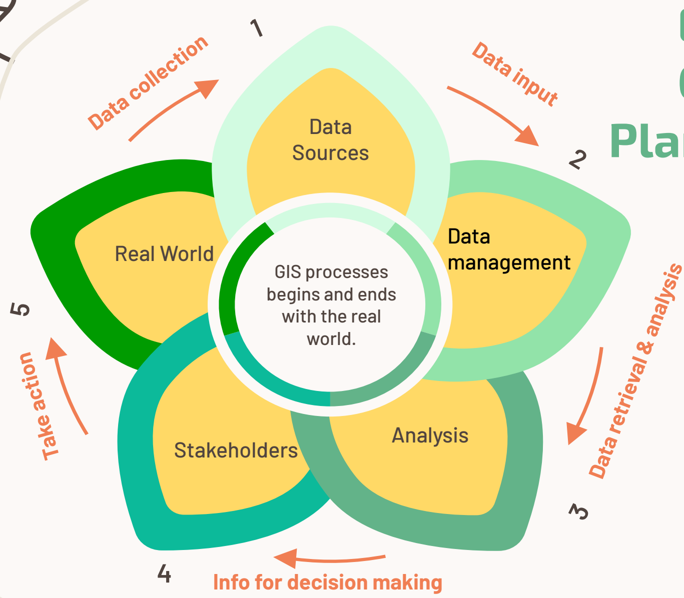
Emergency Operations Planning Process



During emergency operations, data collection is sometimes done on site by field GIS officers who go through the following processes to produce spatial products.

16

Demo datasets

This demo illustrates how to collect spatial data using secondary data sources from OpenStreetMaps.

No external datasets will be used in this demo. A plugin in QGIS will be installed.

Plugin's name

➔ QuickMapServices

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Demo skills

This demo will teach you the follow skills:

1. Install plugins
2. Crop a layer
3. Add data points
4. Create a print layout
5. Add a grid and coordinates to the layout
6. Export a map as a JPEG

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GIS Tools Definition

Plugins
Adds additional functionalities to QGIS

Add Polygon Feature
Lets you capture a set of points around the perimeter of a polygon

OpenStreetMap
Free GIS database maintained by a community of volunteers via open collaboration

Add Point Feature
Lets you capture specific data points in a polygon based on coordinates

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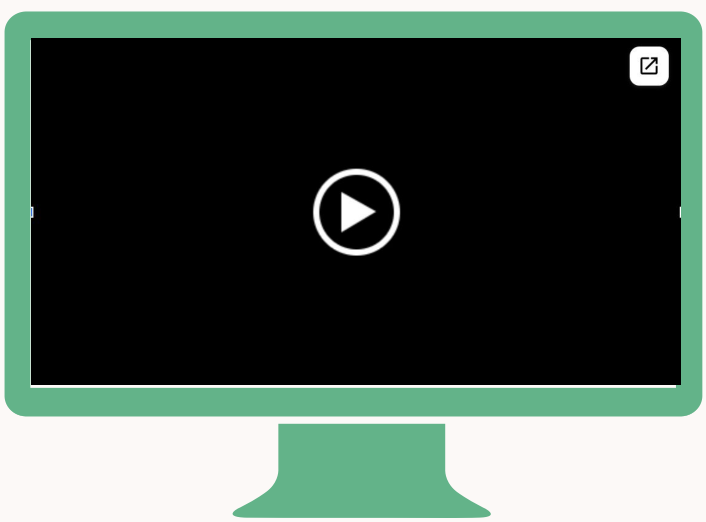
Secondary Sources Tutorial



20

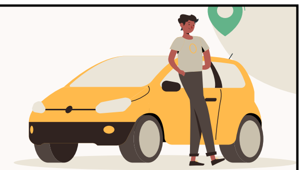
What is spatial analysis?

- Spatial data analyzes data quantitatively, considering geometric, geographic, and topographical properties. It allows you to solve complex location-based problems and explore and understand data from a geographic perspective.
- Spatial analyses generate new data in the form of **new layers, tables, or values**
- The results of an analysis can either represent the same variable as the original data (e.g. computing the average value) or a different variable (e.g. computing a slope layer from an elevation layer).

Spatial Analysis

- **Can answer questions related to:**
  - **Position or extension**: ability to perceive two or more objects positions in space relative to oneself.
  - **Shape or extension**: defines the corners (shape) of raster data within a given coordinate system
  - **Spatial association**: relationship between variables over space
  - **Spatial interaction:** any movements of people, goods, or information over space
  - **Spatial variation**: a difference in terms of population, population density, and life expectancy over an area of the earth's surface.

Spatial Analysis



→ Examples of spatial analyses used emergencies:

- **Spatial queries**: reveal information but do not change or produce new data. It uses tools such as scatter plots, residuals, and query language. **This analysis can be used to determine potential water sources near internally displaced persons (IDP) settlements.**
- **Measurements**: measure spatial properties using tools such as distance, area, length, shape. Used in emergencies to determine the length between food distribution points.
- **Transformations**: creates new data from existing data using tools such as a buffer analysis. Used to comply with Sphere humanitarian standards. **For example, it can be used to ensure that toilets are within 50 meters of shelters.**
- **Spatial interpolation**: intelligently guesses the value of discrete objects using tools such as kriging and inverse distance weighting. **It can be used to predict infection rates within IDP settlements.**

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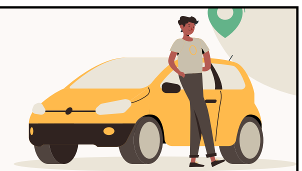
Spatial Analysis



→ Examples of spatial analysis used emergencies:

- **Point optimization:** determines the best location among nodes of a networks (i.e. pieces that make up the network) using tools such as a network analysis. **It is used to select critical locations such as food storage areas.**
- **Route optimization:** determines the best routes among nodes of a network using network analysis. **It is used to assess accessibility of a road networks for potential IDP settlements.**
- **Centroid analysis:** identifies trends over various phenomena (i.e. disease outbreak) using the spatial analyst tool. **It can be used to determine of infectious diseases and household income level within refugee settlements.**
- **Pattern analysis:** identifies distribution points using the spatial analyst tool. **It can be used to find links between water wells and cholera outbreak.**

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Post Test

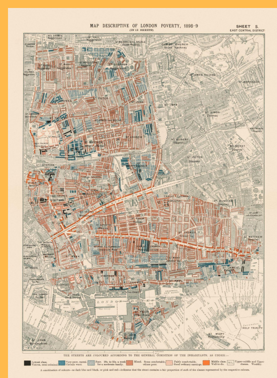
1. Spatial analysis allows you to solve complex location based problems and, explore and understand data from a geographic perspective. **True or False?**
    a. True
    b. False
2. What is the difference between primary and secondary spatial data collection?
    a. Primary spatial data collection is cost efficient while secondary data collection is not
    b. Primary spatial data collection consists of digitized hard copy data while secondary data usually occurs in the field through surveys.
    c. Primary spatial data collection usually occurs in the field through surveys while secondary data consists of digitized hard copy data of maps
3. Finding appropriate spatial data is very easy for responders.**True or False?**
    a. True
    b. False
4. The 5 most common methods of spatial data collection are ___________, _____________, _____________, ___________, and ______________.
    a. Remote sensing, scanning, surveying, LiDAR, and digitization
    b. Remote photography, photography, surveying, digitization, and LiDAR
    c. Photography, remote sensing, surveying, digitization, and projection

LAB 2

Hands-on practice

Maps 1-2

Context

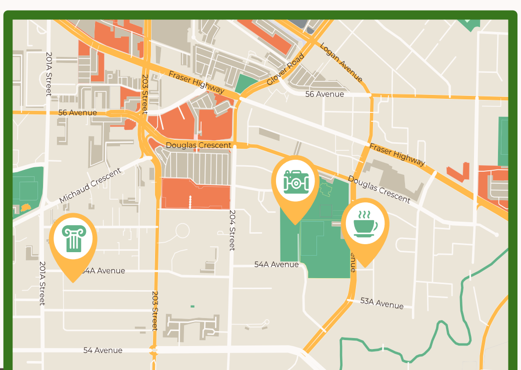


Map Descriptive of London Property, 1898-9
Photo by LSE Library on Unsplash

Imagine that you have been sent back to 1856 to help Victorian physicians like John Snow evaluate the London Cholera Outbreak. Using GIS capabilities, you must create two maps for public health officials to guide their decision-making. The maps should answer these questions:

1. What is the nearest cholera death to each pump?
2. What is the distance between each cholera death and pump? To which pump were cholera cases least likely to go?

Lab 2 - Map 1



Question

What is the nearest cholera death to each pump?

Goal

Learn how to add a new web service map, conduct a distance-to-nearest hub analysis, and arrange layers in order.

Skills

1. Open QGIS
2. Load layers
3. Load a web service map
4. Symbolize
5. Nearest hub analysis
6. Order layers
7. Print layout & export a map

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L1- Map 1 dataset

These datasets are publicly available on GitHub.

John Snow & 19th Century Cholera Epidemic

- **Download**
  - Download Data Link

- **Layers Needed**
  - Deaths_by_bldg
  - Pumps

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Instructions

1. Open QGIS -> click on **New Project**
2. **Click on Project -> Save as -> "Lab 2 -Map 1"** Save this project in your files
3. **Add the dataset to the map**
   a. Change the **Pumps layer-> Symbology** -> to **Green (circle size: 4)**
   b. Change **Death_by_bldg layer** -> **Symbology** -> to **Red (circle size: 2)**
4. Rename the following layers
   a. **Deaths_by_bldg** -> rename **Deaths_by_Buildings**
5. Click on **Web -> QuickMapsServices** -> Click on **Search** -> type **Positron** -> **Add to map**
6. In your toolbar -> Click on **Geoprocessing** -> A dialogue box will open -> **Search for "Distance to Nearest Hub"** -> **Click on the one with (line to hub)**
7. Once the box opens
   a. **Source layer -> Deaths_by_Buildings**
   b. **Destination Hub distance -> Pumps**
   c. **Hub layer name attribute -> ID**
   d. **Measurement units -> Meters**
   e. **Click Run** (a new layer should have been created)

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Instructions

8. **New Layer**
   a. Rename it from **Hub Distance** -> **Pumps_to_nearest_death**
   b. Change the **layer symbology to a color of your choice**
9. Make sure your **layers are in the following order:**
   a. **Deaths_by_Buildings**
   b. **Pumps**
   c. **Pumps_to_nearest_death**
   d. **Positron**
10. **Your Turn**:
    a. **Add the labels for the Pumps names** (Hint: Properties)
11. Open a **new Print Layout**
    a. **Add the Map**
    b. **Map Elements**
    c. **Make sure to site the source**
    d. **Save the layout as an Image**
    e. **Resolution 600 DPI**

The maps key is at the end of the module

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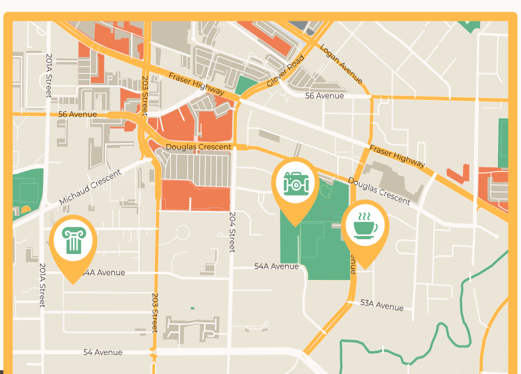
Lab 2 - Map 2



Question

What is the distance between each cholera death and pump? To which pump were cholera cases least likely to go?

Goal

Learn how to perform a multi-ring buffer analysis to assess distance decay.

Skills

1. Open QGIS
2. Load layers
3. Change symbology
4. Perform a buffer analysis
5. Change color ramp
6. Print layout
7. Export a map

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L2- Map 2 dataset

These datasets are publicly available on GitHub.

John Snow & 19th Century Cholera Epidemic

- **Download**
  - **Download Data Link**

- **Layers Needed**
  - **Death_by_bsrings**
  - **Deaths_by_bldg**
  - **Pumps**

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Instructions

1. Open a **New project** **->** **Save as** **->** **Lab 2- Map 2**
2. **Add the listed datasets to the map**
3. **Rename the following layers**
   a. **Death_by_bsrings** -> **Deaths_by_Radius**
   b. **Deaths_by_bldg** -> **Deaths_by_Buildings**
4. **Double click on Deaths_by_Radius** (should open the properties box)
   a. **Go to Symbology** -> **change symbology to Graduated** **->** **set the precision at 4**
   b. **Color ramp** **->** **Select a color**
   c. **Change the Mode to Natural Breaks**
   d. **Classes to 10**
   e. **Click Classify**
   f. **Click Ok**

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Instructions

7. In your layers box **make sure your layers are in the following order**
   a. **Deaths_by_Buildings**
   b. **Pumps_buffer**
   c. **Deaths_by_Radius**
8. Create a **new Print Layout**
   a. **Add the Map**
   b. **Map Elements**
   c. **Make sure to site the source**

The maps key is at the end of the module

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Extra Practice

➔ **Using the Cholera Outbreak dataset, try to complete 2 more spatial analyses using this resource:**
   - **Centers for Spatial Science Analysis of the 19th Century Cholera Epidemic.**

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Instructions

5. To create a buffer around the 8 broad street pump we will need to do a multi-ring buffer analysis. To do this, you:
    a. Click on Processing on your toolbar
    b. A new dialogue box should open
    c. Search for multi-ring buffer
        i. Double click on it once you find it:
            1. Input Layer -> Pumps
            2. Number of Rings -> 6
            3. Distance between rings -> 6 meters
            4. Multi-ring buffer -> Click the down arrow -> Save to file -> Save as -> Pumps_buffer -> Click Save
            5. Then in the multi-ring buffer box -> click Run (***See next slide for picture example of this***)
6. A new layer should have been created
    a. Rename the layer to Pump_buffer
    b. Then double click on the layer (should open the properties box)
    c. Go to Symbology
        i. Stay on Single Symbol
        ii. In the favorites box -> click on outline blue
        iii. Change the color from blue to gray
        iv. Click OK

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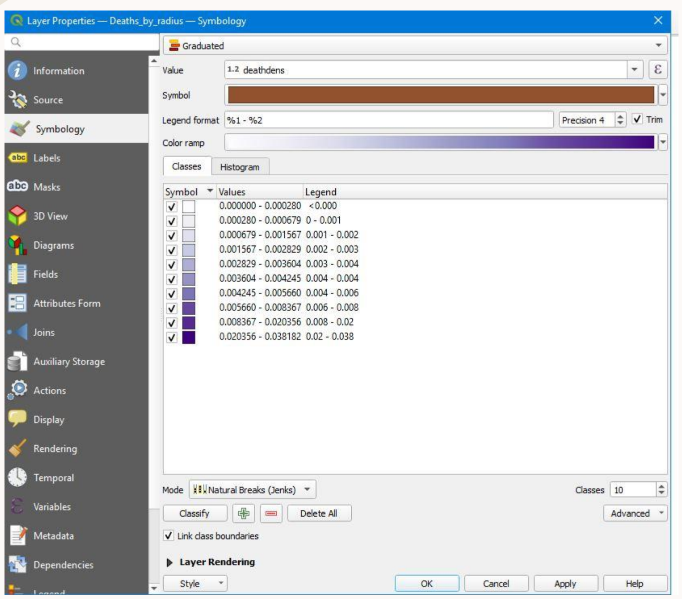

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Extra Sources

- OCHA maintain a complete set of public domain humanitarian icons for mapping projects.
- QGIS Training Manual

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Thank you!

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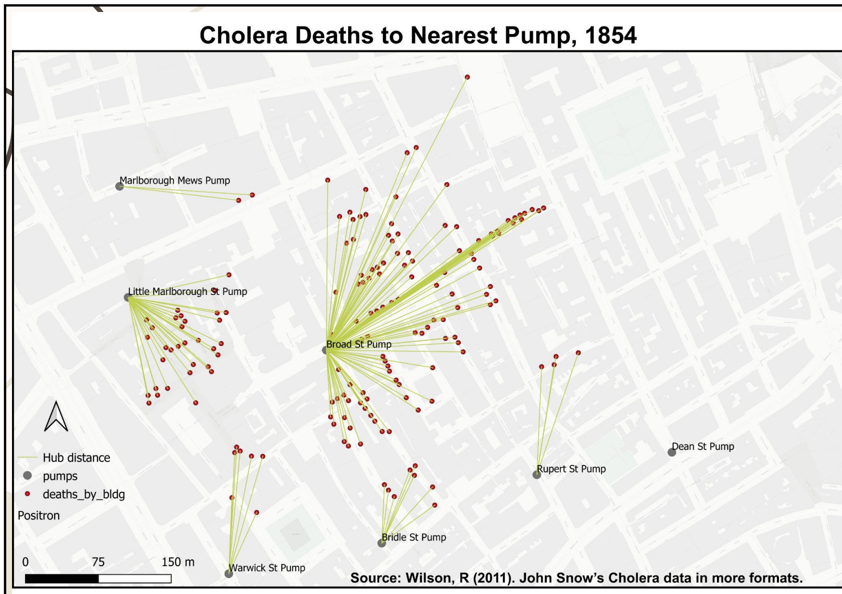
Pre/Post Test Answer Key

1. Spatial analysis allows you to solve complex location based problems and, explore and understand data from a geographic perspective. **True or False?**
   a. **True**
   b. False
2. What is the difference between primary and secondary spatial data collection?
   a. Primary spatial data collection is cost efficient while secondary data collection is not
   b. Primary spatial data collection consists of digitized hard copy data while secondary data usually occurs in the field through surveys.
   c. **Primary spatial data collection usually occurs in the field through surveys while secondary data consists of digitized hard copy data of maps**
3. Finding appropriate spatial data is very easy for responders. **True or False?**
   a. True
   b. **False**
4. The 5 most common methods of spatial data collection are __________, ___________, ___________, __________, and _____________.
   a. **Remote sensing, scanning, surveying, LiDAR, and digitization**
   b. Remote photography, photography, surveying, digitization, and LiDAR
   c. Photography, remote sensing, surveying, digitization, and projection

41



Lab 1 Map 1 Key

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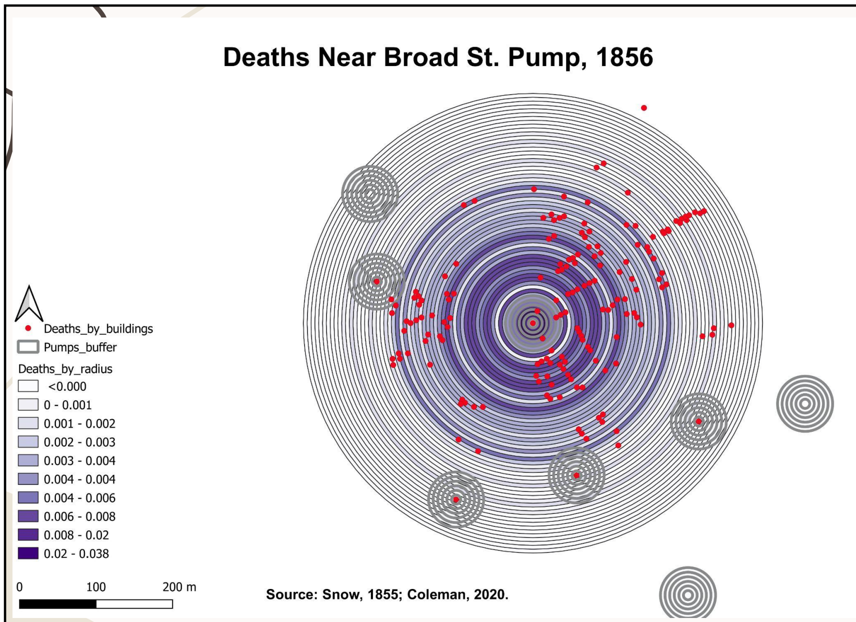

Lab 2 Map 2 Key

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References

Slide 1-5

Slide 6

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Slide 6

- Infant Mortality Rate: Asia. Source: SEDAC, License: CC BY 2.0. https://flickr.com/photos/54545503@N04/5457445203

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- Management ITFoI. Guidance Responsibilities of Cluster/Sector in OCHA in Infromation Management Geneva ISAC Task Force on Information Management;2008.
- Istanbul FIST. Information Management Working Group/Network -. https://humanitarian.atlassian.net/wiki/spaces/imtoolbox/pages/217546783/Information+Management+Working+Group+Network. Published 2022. Accessed February 20, 2023.

Slide 8-9

- Olaya V. Introduction to GIS. Accessed April 16, 2023. https://volaya.github.io/gis-book/en/index.html
- Nash A. GIS Data Collection: Where it Comes From & How it Gets There. MapRight. Published May 20, 2021. https://www.mapright.com/gis-data-collection/

Slide 10

- USGS, Landsat, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Groundwater_tapping_in_Wadi_As-Sirhan_Basin,_Saudi_Arabia.png
- View of Cerro Guachiscota, Camarones, Chile Photo by Rebecca equator, CC BY-SA 4.0, via Wikimedia Commons, https://creativecommons.org/licenses/by-sa/4.0

Slide 11

- Nash A. GIS Data Collection: Where it Comes From & How it Gets There. MapRight. Published May 20, 2021. https://www.mapright.com/gis-data-collection/

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Module 4: Spatial Data Collection and Analysis Pre/Post Test

1. Spatial analysis allows you to solve complex location-based problems, explore and understand data from a geographic perspective. **True or False?**
    a. True
    b. False

2. What is the difference between primary and secondary spatial data collection?
    a. Primary spatial data collection is cost efficient while secondary data collection is not
    b. Primary spatial data collection consists of digitized hard copy data while secondary data usually occurs in the field through surveys
    c. Primary spatial data collection usually occurs in the field through surveys while secondary data consists of digitized hard copy data of maps

3. Finding appropriate spatial data is very easy for responders. **True or False?**
    a. True
    b. False

4. The 5 most common methods of spatial data collection are __________, ____________, ____________, __________, and _____________.
    a. Remote sensing, photography, surveying, LiDAR, and digitization
    b. Remote photography, photography, surveying, digitization, and LiDAR
    c. Photography, remote sensing, surveying, digitization, and projection

Module 4: Spatial Data Collection and Analysis Pre/Post Test

Answer Key

1. Spatial analysis allows you to solve complex location-based problems, explore and understand data from a geographic perspective. **True or False?**
   - **a. <u>True</u>**
   - b. False

2. What is the difference between primary and secondary spatial data collection?
   - a. Primary spatial data collection is cost efficient while secondary data collection is not
   - b. Primary spatial data collection consists of digitized hard copy data while secondary data usually occurs in the field through surveys
   - **c. <u>Primary spatial data collection usually occurs in the field through surveys while secondary data consists of digitized hard copy data of maps</u>**

3. Finding appropriate spatial data is very easy for responders. **True or False?**
   - a. True
   - **b. <u>False</u>**

4. The 5 most common methods of spatial data collection are __________, ____________, ____________, __________, and _____________.
   - **a. <u>Remote sensing, photography, surveying, LiDAR, and digitization</u>**
   - b. Remote photography, photography, surveying, digitization, and LiDAR
   - c. Photography, remote sensing, surveying, digitization, and projection

PowerPoint Slides References

Slide 1 -5

Slide 6

- Abdalla R. Evaluation of spatial analysis application for urban emergency management. SpringerPlus. 2016;5(1):1-10.

Slide 6

- Infant Mortality Rate: Asia. Source: SEDAC, License: CC BY 2.0. https://flickr.com/photos/54545503@N04/5457445203

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- Istanbul FIST. Information Management Working Group/Network -. https://humanitarian.atlassian.net/wiki/spaces/imtoolbox/pages/217546783/Information+Management+Working+Group+Network. Published 2022. Accessed February 20, 2023.

Slide 8-9

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- Nash A. GIS Data Collection: Where it Comes From & How it Gets There. MapRight. Published May 20, 2021. https://www.mapright.com/gis-data-collection/

Slide 10

- USGS, Landsat, Public domain, via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Groundwater_tapping_in_Wadi_As-Sirhan_Basin,_Saudi_Arabia.png
- View of Cerro Guachiscota, Camarones, Chile Photo by Rebecca equator, CC BY-SA 4.0, via Wikimedia Commons, https://creativecommons.org/licenses/by-sa/4.0

Slide 11

- Nash A. GIS Data Collection: Where it Comes From & How it Gets There. MapRight. Published May 20, 2021. https://www.mapright.com/gis-data-collection/

Slide 12

- Impact craters between the villages Sychivka, Ivanhorod, Chortoryia, Kalnyk on the border of Cherkasy region and Vinnytsia region, Ukraine By: Латуха Валерій Іванович, CC BY-SA 4.0, via Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/2/2e/Ukraine_Leukhy_2016-12-07_Sentinel-2A_L1_EO_Browser_Sentinel_hub_Custom_script.jpg
- Digital elevation model (DEM) of the Mt. Everest region. Photo by NSIDC on Flickr, CC by 2.0, https://www.flickr.com/photos/189007038@N05/50090950171/

Slide 13

- Nash A. GIS Data Collection: Where it Comes From & How it Gets There. MapRight. Published May 20, 2021. https://www.mapright.com/gis-data-collection/

Slide 14

- Grant Land, northern Ellesmere Island. Photo by Matti&Keti, CC BY-SA 4.0, via Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/e/ea/Ellesmere_Island_08.jpghttps://unsplash.com/@usgs?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText

Slide 15

Slide 16

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Slide 17-19

Slide 20

- Secondary data collection demo: https://rsph.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=264ac361-4e63-4954-88bd-afe70040548d&start=0

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- Olaya V. Introduction to GIS. Accessed April 16, 2023. https://volaya.github.io/gis-book/en/index.html
- Abdalla R. Evaluation of spatial analysis application for urban emergency management. SpringerPlus. 2016;5(1). doi:https://doi.org/10.1186/s40064-016-3723-y

Slide 25-28

Slide 29

- Cholera outbreak dataset download:https://geodacenter.github.io/data-and-lab/snow/

Slide 30-32

Slide 33

- Cholera outbreak dataset download:https://geodacenter.github.io/data-and-lab/snow/

Slide 34-37

Slide 38

- Centers for Spatial Science Analysis of the 19th Century Cholera Epidemic: https://geodacenter.github.io/data-and-lab/data/geoda_scripts_snow.pdf

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Slide 40-48

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11. Vinten-Johansen, P. (2022). A Pest Field, Plague Pits, New Sewers, and a Cholera Outbreak in St. James, Westminster. Preprint on Researchgate (December).
12. Wilson, R (2011). John Snow's Cholera data in more formats. http://blog.rtwilson.com/john-snows-cholera-data-in-more-formats/. Reprojected data can also be downloaded from Dani Arribas-Bel's 'reproducible john snow' BitBucket repository at https://bitbucket.org/darribas/reproducible_john_snow/src/master/.

Module 4 Lab: Map 1

Question: What is the nearest cholera death to each pump?

Goal: Learn how to add a new web service map, conduct a distance-to-nearest hub analysis, and arrange layers in order.

Skills:

1. Open QGIS
2. Load layers
3. Load a web service map
4. Symbolize
5. Nearest hub analysis
6. Order layers
7. Print layout & export a map

Datasets:

1. Deaths_by_bldg
2. Pumps

Instructions

1) Open QGIS -> click on **New Project**
2) **Click on Project -> Save as -> "Lab 2 -Map 1"** Save this project in your files
3) **Add the dataset to the map**
    a) Change the **Pumps layer**-> **Symbology** -> to **Green (circle size: 4)**
    b) Change **Death_by_bldg laye**r -> **Symbology** -> to **Red (circle size: 2)**
4) Rename the following layers
    a) **Deaths_by_bldg** -> rename **Deaths_by_Buildings**
5) Click on **Web -> QuickMapsServices** -> Click on **Search** -> type **Positron** -> **Add to map**
6) In your toolbar -> Click on **Geoprocessing** -> A dialogue box will open -> S**earch for "Distance to Nearest Hub"**-> **Click on the one with (line to hub)**
7) Once the box opens
    a) **Source layer -> Deaths_by_Buildings**
    b) **Destination Hub distance -> Pumps**
    c) **Hub layer name attribute -> ID**
    d) **Measurement units -> Meters**

e) **Click Run** (a new layer should have been created)

8) **New Layer**

   a) Rename it from **Hub Distance** -> **Pumps_to_nearest_death**

   b) Change the **layer symbology to a color of your choice**

9) Make sure your **layers are in the following order:**

   a) **Deaths_by_Buildings**

   b) **Pumps**

   c) **Pumps_to_nearest_death**

   d) **Positron**

10) **Your Turn**:

   a) **Add the labels for the Pumps names** (Hint: Properties)

11) Open a **new Print Layout**

   a) **Add the Map**

   b) **Map Elements**

   c) **Make sure to site the source**

   d) **Save the layout as an Image**

   e) **Resolution 600 DPI**

Module 4 Lab: Map 2

Question: What is the distance between each cholera death and pump? To which pump were cholera cases least likely to go?

Goal: Learn how to add a new web service map, conduct a distance-to-nearest hub analysis, and arrange layers in order.

Skills:

1. Open QGIS
2. Load layers
3. Change symbology
4. Perform a buffer analysis
5. Change color ramp
6. Print layout
7. Export a map

Datasets:

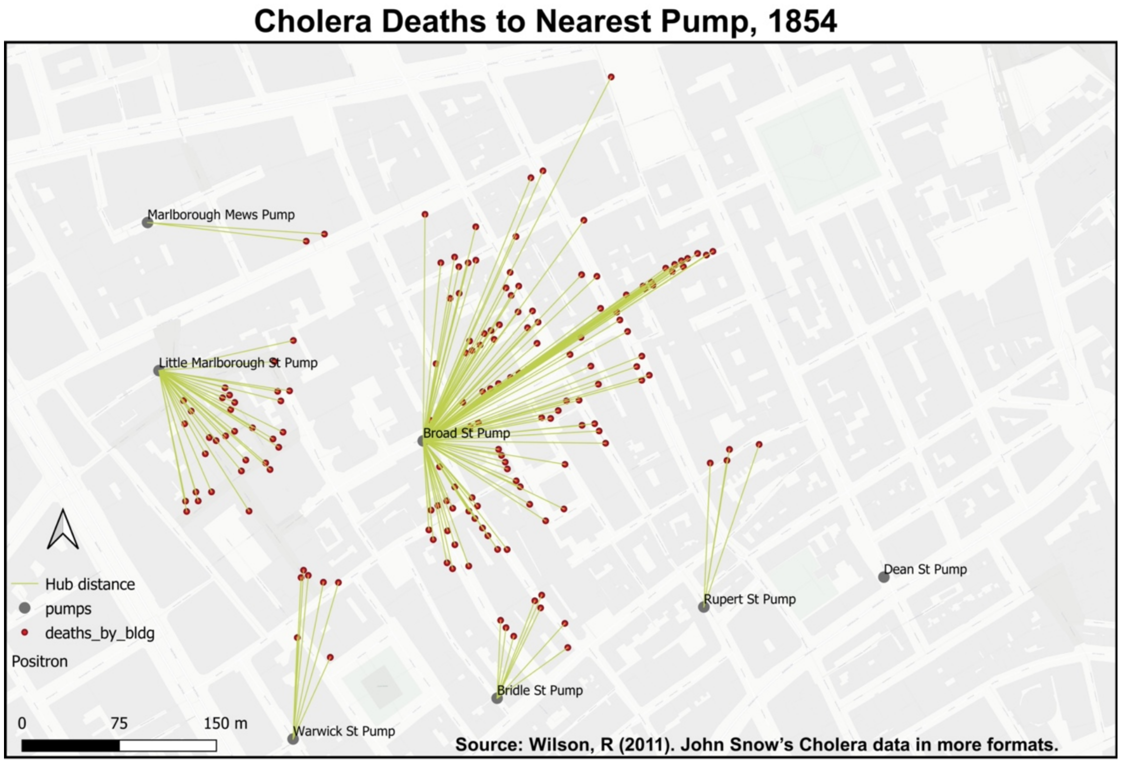
1. Death_by_bsrings
2. Deaths_by_bldg
3. Pumps

Instructions

1) Open a **New project -> Save as -> Lab 2- Map 2**
2) **Add the listed datasets to the map**
3) **Rename the following layers**
    a) **Death_by_bsrings** -> **Deaths_by_Radius**
    b) **Deaths_by_bldg** -> **Deaths_by_Buildings**
4) **Double click on Deaths_by_Radius** (should open the properties box)
    a) **Go to Symbology** -> **change symbology to Graduated -> set the precision at 4**
    b) **Color ramp -> Select a color**
    c) **Change the Mode to Natural Breaks**
    d) **Classes to 10**
    e) **Click Classify**
    f) **Click Ok**

5) To create a buffer around the 8 broad street pump we will need to do a multi-ring buffer analysis. To do this, you:
    a) **Click on Processing on your toolbar**
    b) A new dialogue box should open
    c) Search for **multi-ring buffer**
        i. Double click on it once you find it:
            1. **Input Layer -> Pumps**
            2. **Number of Rings -> 6**
            3. **Distance between rings -> 6 meters**
            4. **Multi-ring buffer -> Click the down arrow -> Save to file -> Save as -> Pumps_buffer -> Click Save**
            5. **Then in the multi-ring buffer box -> click Run (*See next slide for picture example of this*)**
6) A **new layer should have been created**
    a) Rename the layer to **Pump_buffer**
    b) Then **double click on the layer** (should open the properties box)
    c) Go to **Symbology**
        i. Stay on **Single Symbol**
        ii. **In the favorites box -> click on outline blue**
        iii. **Change the color from blue to gray**
        iv. **Click OK**
7) In your layers box **make sure your layers are in the following order**
    a) **Deaths_by_Buildings**
    b) **Pumps_buffer**
    c) **Deaths_by_Radius**
8) Create a **new Print Layout**
    a) **Add the Map**
    b) **Map Elements**
    c) **Make sure to site the source**

Lab 2 – Map 1 Answer Key



Lab 2 – Map 2 Answer Key