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Developing Sustainable Geographic Information System (GIS) Services for Parliamentary Clients

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Abstract:

Parliamentary libraries and research centres work primarily with text-based documents and reports. A common challenge faced by Members of Parliaments and their staff is finding time to read all of the information surrounding a complex issue. Visualization of this information can lead to a faster and improved understanding of multidimensional policy issues. Geographical Information System (GIS) services can provide such visual presentation and analysis. This paper describes what is involved in setting up a reputable GIS service as well as some of the challenges encountered in making it sustainable in times of budget constraints.

Keywords: Geographic Information Systems, GIS, data, analysis, visualization, parliamentary libraries

1 INTRODUCTION

1.1 What is GIS?

The acronym GIS stands for "geographic information systems." Dr. Robert Tomlinson, a Canadian geographer, was the first to suggest that computers could be used to automate map analysis. He coined the term "GIS" in the early 1960s to refer to "any computer application that performed functions with geospatial data" (Bishop and Mandel 2010, 537). In everyday language, the term "GIS" is most often associated with map-making, or cartography. GIS is much broader than maps, however; GIS can be used to visualize, analyse, and interpret data with a geographic element.

1.2 Data Analysis through GIS

Data analysis using GIS can range from simply looking at locations on a map to a sophisticated analysis of statistical significance in any given geographically-related data set. To analyse or create data in GIS, one starts by layering different data sets on top of each other and then combining or comparing the data to discover relationships often not observable otherwise.

To give an example: you may have a table containing the addresses of all of the libraries in your country. Your Member of Parliament may be interested in what areas, and which populations, have access to libraries and which do not.

You can import the table of addresses into GIS software by putting the addresses through a process called “geocoding.” Geocoding will place the addresses on the appropriate location on the map. You have now created a “layer” of data.

On top of your library layer, you may place other data, often retrieved through government, not-for-profit, or educational sources. (Several international data sources are listed in Appendix A of this paper.) You or your requester may have data on, for instance, population density, age of population, or education levels of the population for your country. As long as the data have a geographical component (e.g., the province name or the latitude and longitude), they can be brought into the map. Alternately, a number of sources, like many of those listed in the appendix, provide data in GIS-ready files, called shapefiles and geodatabases, which make the data particularly easy to import into a GIS program.

Once you have multiple layers of data in your map, you can begin to compare them. You may, for instance, want to overlay areas of high library density with areas of high population density. Are these the same areas, or are they different? You can also use tools within GIS to look for statistical significance in your data. For instance, if the areas of high library density are different than the areas of high population density, what is the statistical significance of that difference? Knowing the statistical significance of the difference will help you to understand the import of your discoveries.

Data creation is part of the process of analysis in GIS. To continue in the example above, you may have created a new layer of data that shows areas of high population density that do not have a library within a 3-km radius. A typical product resulting from GIS analysis is data or information that was not previously available, as a result of combining different sets of data.

1.3 Why is GIS attractive in a research setting?

A visual explanation is often stronger than a verbal one. Libraries and information centres often work primarily with text based documents and reports. However, in an environment of information overload, a common challenge faced by decision makers is finding the time to read all of the information surrounding a complex issue.

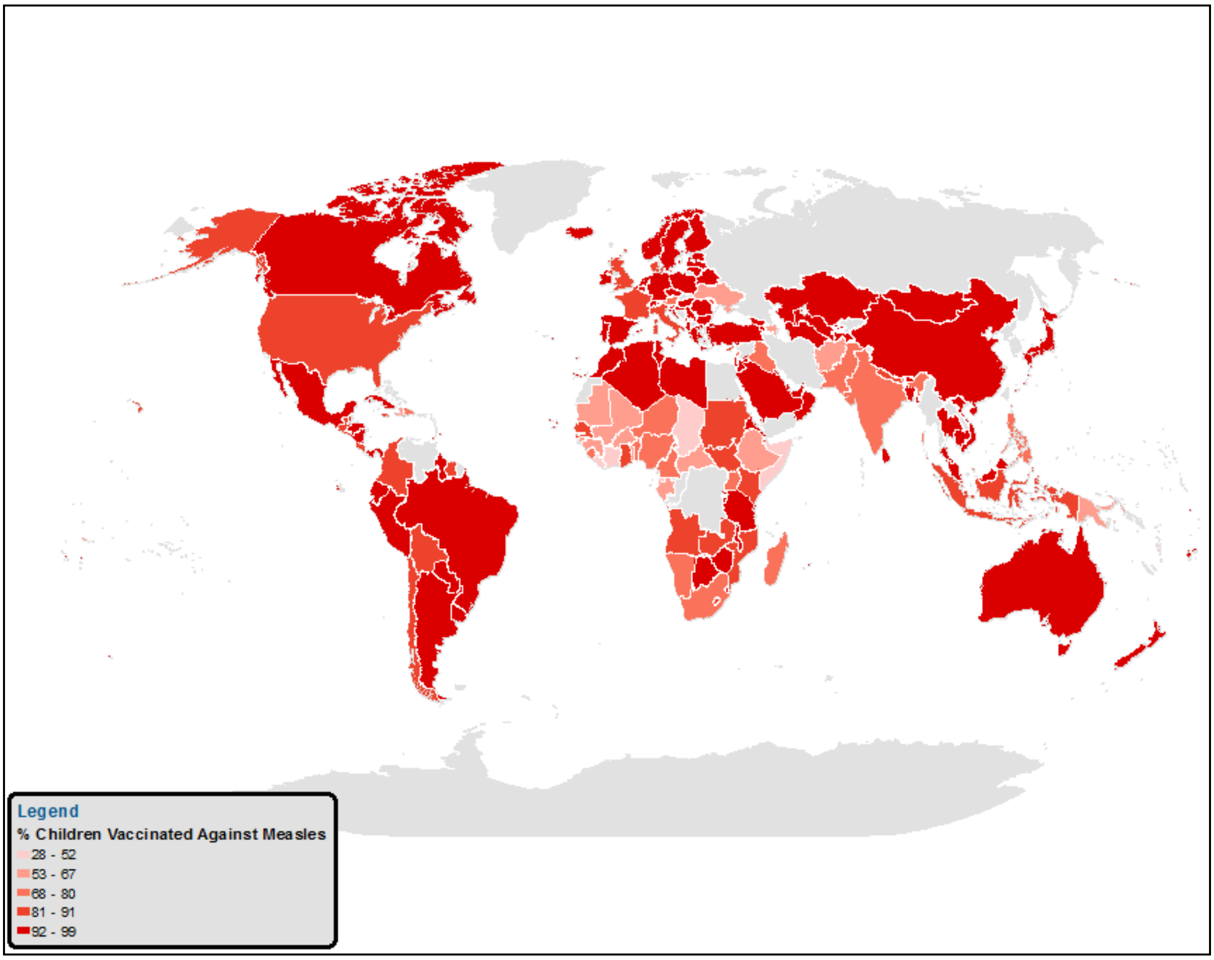
Visualization of information tends to lead to a faster and improved understanding of multidimensional issues. In the words of Dr. Don Norman, “Aesthetics matter: attractive things work better.” In one of his studies, Norman found that “Positive affect makes people more tolerant of minor difficulties and more flexible and creative in finding solutions." (Norman 2003). More specifically, a study of GIS used in marketing found that even persons with moderate spatial ability and hardly any map experience found that maps were helpful as decision support tools (Ozimec, Natter, and Reutterer 2010, 6).

As a result of their ease of use, maps and other graphics are becoming more common conveyers of information. World newspapers often use interactive maps on their websites to illustrate complex, international stories. With the introduction of sites such as Google Maps and Bing Maps, mapping has also become more prevalent in everyday life, as people use the sites for everything from directions to looking at neighbourhoods through the "street view." As interactive maps become more commonplace, clients expect to see such products offered by their parliamentary libraries and research centres.

Parliamentary research questions often concern national policy, or "macro level" policy. A sample question might be, "How many children worldwide have been immunized against measles?" A traditional answer to this question might include a table listing the world's countries and the percentage of children who have been immunized in each country.

While helpful, data in the form of a table can be difficult to understand at a glance, and comparisons are particularly difficult. In Afghanistan, 62% of children have received immunization against measles. Albania, Algeria, and Andorra, the next three countries in the table, all have immunized percentages at or above 95%. Someone scanning the table might conclude that Afghanistan's immunization rate is very low. However, it is also possible that Albania, Algeria, and Andorra are all unusual. Further, once a reader's eye tracks down to Zimbabwe, it can be difficult to remember what Afghanistan's immunization record was. A map, however, is relatively easy to understand quickly, and comparisons are particularly quick.

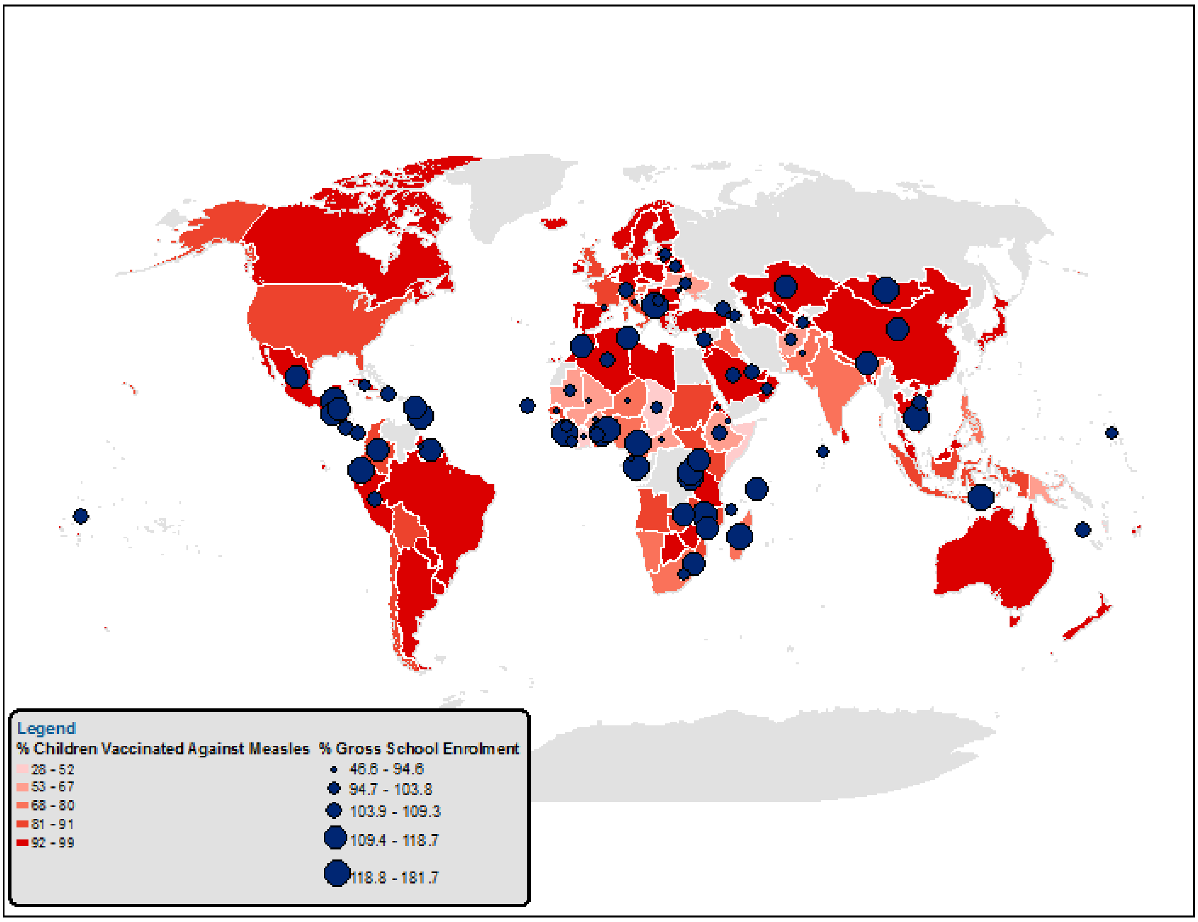
Percent of Children Vaccinated Against Measles, 2011[1]



Mapping a data set also prepares a librarian for on-going research interests. For instance, a researcher looking at the data on measles immunizations may next wonder if measles immunization rates affect school enrolment. You could add the school enrolment data to your table, but doing so could make comparisons between countries even more difficult. If you are using GIS, however, you can add the new data onto your existing map as a separate layer and overlay it on the original data layer.

[1] World Bank. "Immunization, Measles (Percent of Children Ages 12-23 Months)." 2011. At: http://data.worldbank.org/indicator/SH.IMM.MEAS.

Percent of Children Vaccinated Against Measles and Percent of Gross School Enrolment, 2011[2]



From looking at the map, the researcher may be able to see whether there seems to be any correlation between school enrolment and measles immunization and, therefore, whether to pursue this line of questioning. If the questioner were a Member of Parliament, she might consider whether to introduce a measure aimed towards increasing school enrolment by strengthening a measles immunization program.

Policy decisions can also be made on what might be called a "micro level." Examples of "micro level" policy questions a librarian might get that could best be answered through GIS include: "Does this neighbourhood in which I am thinking about purchasing a house have frequent floods?" or "Where do I go to vote?"

Many libraries and information centres also use GIS to evaluate their local systems of information outreach and coverage. In one case study, a GIS-based model used in south Wales in the UK was used to investigate spatial variations in digital services provision and eventually could be used to reallocate resources (Higgs, Langford, and Fry 2013). In their various papers, Bishop Bradley and Laura Mandel have also discussed how to use GIS to

[2] World Bank. "Immunization, Measles (Percent of Children Ages 12-23 Months)." 2011. At: http://data.worldbank.org/indicator/SH.IMM.MEAS. "School enrollment, Primary (Percent Gross)." 2011. This statistic can exceed 100% due to the inclusion of over-aged and under-aged students because of early or late school entrance and grade repetition. At: http://data.worldbank.org/indicator/SE.PRM.ENRR/countries.

analyse library use and better distribute library resources (Bradley and Mandel 2010 and Mandel 2010).

2 REQUIREMENTS FOR A GIS PROGRAM

A successful GIS program requires appropriate staffing, information technology and data. To ensure continual success, especially for smaller parliamentary libraries and research centres, it helps if researchers and/or clients are "GIS-literate."

2.1 Staffing

At a minimum, a GIS program requires a GIS analyst with technical knowledge in geography/cartography, database and data management, and the ability to use one or more GIS software applications. An ideal program would have two GIS analysts so that one can review the work of the other to ensure that a specific GIS product is accurate. The idea of turning librarians or other staff into GIS analysts (along the line of turning librarians into webmasters) may appear attractive to some organizations that wish to offer GIS services but are unable to hire new staff. However, one cannot pick up GIS skills by reading a book or attending a few short courses – skills are acquired through specialized training and honed through experience. There is a potential for non-qualified GIS analysts to produce incorrect results, risking the reputation of the parliamentary library or research centre as a whole. However, librarians can play important roles in a GIS program, depending on their level of skills and experience. At CRS, two librarians attended training and performed GIS work under the tutelage of a GIS analyst. After a year, the training and experience enabled them to take some of the workload off the GIS analyst by identifying and managing data sources, and responding to relatively straight-forward requests. This enabled CRS to slowly expand GIS services while diversifying librarian skills

2.2 Technology

GIS analysis requires information technology (IT) tools and support. Special software is needed to take appropriate data from different sources, and display the results visually on a map, or to extract resulting datasets. In the past, GIS analysis required costly software and hardware. In recent years, technological advancements have lowered hardware costs, increased processing power, and allowed GIS software to run on most standard desktop computers. At the same time, the open source movement and emerging cloud services are providing low-cost software options for those engaged in GIS work. In general, desktop tools are sufficient if one wishes to perform GIS analysis on a small scale. However, there is increasing demand from clients who wish to interact with mapping services: clients want to be able to zoom in/out of a map, to add additional data layers on their own, and to develop what-if scenarios within geographical boundaries. Providing interactive GIS services will require more complex technology, such as GIS and data servers, and user security, which in turn requires that the parliamentary library work closely with the Information and Communication Technology (ICT) group to create a GIS network infrastructure. Appendix B lists some of the more popular software used by GIS analysts.

2.3 Data

The best GIS skills, hardware and software will not produce superior GIS services without the raw material for GIS analysis: data. Parliamentarians are interested in a wide range of issues; it follows that GIS analysis will require a wide range of data sources. Yet not all data lend themselves to GIS analysis: a dataset must contain a geographical reference (latitude/longitude, country, state, city or address). Joining disparate datasets (e.g. unemployment statistics from one organization and cost-of-living data from another organization) can be complicated and require knowledge of how the data was collected and organized. It also required awareness of how temporal and other relevant characteristics of the data may have a bearing on how the GIS results may be interpreted. This is an area where librarians and researchers (who are the subject matter experts) can contribute to the GIS work and reduce the burden on the GIS analyst. GIS-literate librarians and/or researchers can more effectively identify and evaluate the datasets that are appropriate for analysis. In some cases, the researcher may even take on the role of merging and manipulating datasets prior to analysis and presentation in GIS software. The partnership between researcher and GIS analyst would be more efficient, since the analyst would not have to spend time trying to understand the nuances of a specific dataset. In addition, GIS literacy facilitates communication between the researcher and the GIS analyst, leading to a better understanding of the GIS product by the researcher.

3 ELEMENTS OF A SUCCESSFUL GIS PROGRAM

3.1 Standard Procedures and Risk Mitigation Measures

A sustainable GIS program requires efficient procedures and effective risk mitigation measures. At CRS, we anticipated risks related to (1) authoritativeness of our products arising from non-standard data and mapping issues; (2) client confusion, due to inadequate communication on what the program can and cannot do; and (3) inability to meet overwhelming demand, due to overselling the program.

To address these potential problems, we (1) created standard operating procedures and other documentation which we shared on a common SharePoint site; (2) created groups to train, inform, and ask for input from colleagues; and (3) included GIS products in CRS's extensive review process, and educated reviewers on how to review such products.

3.1.1 Documentation

One key piece of documentation is our "Standard Operating Procedures." This document contains the following sections: GIS Standard Operating Procedure (SOP) (discussed below); GIS Basic Training (tips on GIS basics, plus where to go to receive more training in GIS); GIS Product Review; File Structure, Storage, and Naming Conventions; Data Source and Documentation (metadata); Standard Map Documents (our standard basemaps of the U.S. and the world); and Best Practices (examples).

The SOP section of the document outlines our process for prioritizing requests, a call for input on the GIS program, and a statement on what can be expected from the GIS analyst or librarian and what can be expected from the researcher or client who places a GIS request. We have found that outlining expectations for both parties is a key ingredient in a successful GIS program. A GIS program can easily become overwhelmed by requests if the GIS analysts and/or librarians are required to locate as well as map data. Further, no GIS analyst or librarian can possibly be an expert on each of the topics on which they may be asked to create a map or analyse data. In order to ensure that the data being used are the most authoritative, timely data available, a GIS project demands collaboration between the expert in the field and the GIS analyst or librarian. As an example, here is the language we have included in our SOP concerning expectations: “Links to the authoritative data to be analysed must be provided by policy analysts, who are the subject matter experts ... The GIS analyst will provide the geographic base layer(s).”

Along with the "Standard Operating Procedures," we also created a Microsoft Sharepoint site to share information on the GIS program, called the GIS Portal. (Parliamentary libraries which do not have SharePoint could create a basic website for the same purpose.) On the site, we placed the SOP as well as such information as a glossary of GIS terms, a "top tips" for GIS, and other helpful, basic information about GIS. Perhaps most importantly, we have also created a compilation of GIS data sources, some of which can also be found in Appendix A of this paper. Since the researcher is expected to provide the data that is to be mapped or analysed, this list of data sources provides a helpful starting place for the researcher who wants something mapped but does not know where to find the data.

3.1.2 Communication

To facilitate communication on the GIS program, and to solicit input from analysts and others who may not be immediately affiliated with the program, we have developed the following communication routes.

- A GIS Working Group. This group acts as the steering committee for the GIS program. Members do not have to be users of GIS – indeed, most of them are not – but all of them have an interest in the program, and each acts as a representative from their division within CRS.
- A GIS Users Group. This group consists of the GIS team (the GIS analyst and two GIS librarians) and any researchers who have begun to use, or who are interested in using, GIS in their research. This is a much more hands-on group featuring discussions on the practical use of GIS software.
- Rotating talks on GIS. The GIS team has visited most of the research divisions within CRS to talk about the GIS program and give examples of the work they have done. Examples are tailored to each division, and time is reserved for questions after the talk.
- GIS talks for other audiences. The GIS team has also given presentations on the GIS program to management audiences and to congressional staffers. Again, the presentation is tailored for the audience and time is reserved for questions after the talk.

3.1.3 Review

CRS has an extensive review process in place, and the GIS program has largely used that process, but has added an extra step.

The review process already in place includes: peer review (by a subject expert); section review (by an immediate supervisor); division review (by the office of the Assistant Director); and front office review (by professional editors in the Director’s office). To this process, the GIS program has added review by another person on the GIS team. Reviewers are looking for the same elements as they are in any other product – authoritative, non-partisan, and non-biased information presented clearly – but with an added eye towards making sure the graphic (if there is any) is clear and well represents the underlying data.

4 CONCLUSION

In an environment of budget constraints, it is a challenge to offer new or non-traditional research and information services. On the other hand, technological advances and the expectations of clients for visual analysis and visual presentation of information have made it difficult for many parliamentary libraries and research centres to ignore requests for GIS services. CRS started offering GIS analysis about 4 years ago, and has slowly built the service so that it can be sustained over the long term.

When starting a GIS program, where to place this service within the parliamentary library or research centre may make a difference in the program's continued success. In an ideal world, it would be great if there is one GIS analyst for each subject area, so that the analyst gains background knowledge to enable him/her to provide in-depth support. At CRS, the GIS program is placed with the Knowledge Services Group which provides information research support via librarians to the research divisions organized broadly topical areas. By doing so, GIS was seen as an organization-wide service and the GIS analyst was not expected to focus on any particular research areas, but instead was expected to work closely with subject matter experts. In addition, the GIS analyst is embedded with, and rotates through, research divisions every three months so as to facilitate contact with researchers throughout the organization, and to reinforce the message that the analyst is an organization-wide resource.

An important factor for the success of any program is communication with users and clients. When faced with limited resources to offer GIS services, parliamentary libraries or research centres must carefully manage client expectations and not over-advertise the service. Communication can take a variety of forms. At CRS, the GIS team went to each research division one at a time, detailing the expectations on both sides (GIS team and clients) to ensure a successful project. Documenting procedures, sharing information and best practices on an intranet keeps GIS services visible. Establishing an organization-wide GIS working group or committee can keep researchers engaged while providing a venue to communicate new developments and to seek input and requirements from clients.

Finally, the program should be set up in such a way that one can measure its performance. At CRS, all requests for GIS work are coded so that we can extract statistics on how many GIS requests were completed, as well as the nature of the requests and the clients (whether researchers or congressional staff). Successes were celebrated and communicated, and data sources and GIS products were documented and archived for possible re-use, thereby saving time and effort. One indicator of the program's success is reflected by the way researchers are now fully engaged in the GIS process, and some have taken an in-house GIS course themselves.

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APPPENDIX A: ANNOTATED INTERNATIONAL GIS DATA SOURCES

Harvard Geospatial Data Library
http://calvert.hul.harvard.edu:8080/opengeoportal/
This site houses thousands of layers of digital geospatial data. The Library uses traditional text searching combined with map/coordinate based searches. Data can be viewed on-line, or downloaded for use in a desktop GIS.

IPUMS-International
https://international.ipums.org/
The IPUMS project is a collaboration of the Minnesota Population Center, National Statistical Offices, and international data archives. IPUMS-International is an effort to inventory, preserve, harmonize, and disseminate census micro-data from around the world. The census samples are coded and documented consistently across countries and over time to facilitate comparative research. IPUMS-International also provides boundary files (shapefiles) to facilitate national and international data mapping.

Open Geoportal
http://opengeoportal.org/
The Open Geoportal (OGP) is a collaboratively developed, open source, federated web application to rapidly discover, preview, and retrieve geospatial data from multiple organizations. The project is led by Tufts University along with Harvard and MIT. Several other partner organizations are assisting with the development of the program.

The Socioeconomic Data and Applications Center
http://sedac.ciesin.columbia.edu/
This Center is one of the Distributed Active Archive Centers (DAACs) in the Earth Observing System Data and Information System (EOSDIS) of the U.S. National Aeronautics and Space Administration and is hosted by Columbia University. SEDAC focuses on human interactions in the environment. Examples of shapefiles available for download here include the environmental performance index, climate estimates, and global roads. You can also view maps created by them using their data.

Stanford Geospatial Center: Global datasets
http://lib.stanford.edu/GIS/data
This site offers links to free datasets organized by geographical area. Some areas or countries (e.g., Africa) are better covered than others (India has a note "Coming soon"). Data links include boundaries, natural resources, transportation, population, social and some ethnographic data.

U.N. Data
http://data.un.org/Explorer.aspx?d=CLINO
This is a clearinghouse for U.N.-generated data. While none of the data is in GIS format (shapefile or geodatabase), almost all of it is listed by country, making it relatively easy to import into a GIS program.

World Bank Data
http://data.worldbank.org/
This site lists World Bank data by country, indicator, and by topic. Topics range from agriculture and rural development to health to science and technology. The site also allows you to map much of their data using their online mapping program, http://maps.worldbank.org/.

APPENDIX B: GIS SOFTWARE

There is a variety of GIS software, both open source and commercial. Below is a description of a few widely used software tools.

Selected GIS Desktop software

GIS tools integrate different types of geographically referenced data, projecting the results on to a map. These tools are not designed just to produce maps; they are often used to perform analysis by joining different datasets to visually reveal patterns and trends. The more commonly used desktop tools used for GIS are listed below.

GRASS GIS (Geographic Resources Analysis support System) http://grass.ibiblio.org/index.html

Open source. Originally developed by the US Army Corps of Engineers' Construction Engineering Research Laboratory, GRASS GIS became a project under the Open Source Geospatial Foundation in 2006. It is supported by an international community with user groups in Canada, the Czech Republic, India, Italy, Poland and the USA. The software is available on multiple operating systems.

QGIS (Quantum GIS) http://www.qgis.org

Open source. This open source GIS software runs on Linux, Unix, Mac OSX, Windows and Android. QGIS supports vector, raster and database formats, and is licensed under the GNU Public License. It is supported by an active user community, with user guides available in multiple languages (English, French, German, Italian, Japanese, Korean, Portuguese, Russian, Spanish.)

ArcGIS for Desktop http://www.esri.com/software/arcgis

Commercial. Desktop tool for spatial analysis, data management, mapping and visualization and other GIS functions. There are several software levels/options, from basic to advanced, and software extensions available for more specialized analysis.

Selected GIS Server software

One can be engaged in GIS work without a GIS server. However, organizations wishing to provide extensive GIS services will find it more efficient to manage GIS data and services using a GIS server. End-users still need desktop tools such as those described above to analyse and render the datasets offered by GIS servers. The two below are widely used and supported, and have the most developed capabilities.

GeoServer http://geoserver.org/display/GEOS/Welcome

Open source. GeoServer allows users to share, process and edit geospatial data. It is Java-based, widely supported and has extensions that integrate it to other services such as Google Earth, and Yahoo Maps.

ArcGIS for Server http://www.esri.com/software/arcgis/arcgisserver

Commercial. ArcGIS for Server enables centralized management over data and GIS services, and can operate on Microsoft Windows Server or Linux.