GIS for Monitoring Scale-up

Appendix D to Guide for Monitoring Scale-up of Health Practices and Interventions

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APPENDIX D: GIS FOR MONITORING SCALE-UP

Geographic information systems (GIS) are used in various types of research as one type of many tools for managing and analyzing data. GIS provides a set of spatial tools used by researchers to map populations and characteristics of populations, as well as manage and analyze data associated with the population of interest. In a GIS, the data can be uploaded in a series of layers that can include information such as location of health facilities, catchment areas of health interventions, locations of resources, administrative boundaries, roads, rivers, and population-based data. Detailed analysis on the interactions and relationships among those layers can improve understanding of our data. Additionally, a GIS tool and its ability to manage, analyze, and visualize data can help to support evidence-based decision making.

Increasingly, the public health and development community has begun to realize the value of mapping and the need for more sophisticated spatial analysis to improve decision making, policy making, advocacy, and resource allocation. Due to the complexity of family planning (FP) and reproductive health needs and programs, there is a great need for using multi-sectoral data to have a complete understanding of the environment in which these programs are operating.

The complexity of FP programs also arises because such programs have many and diverse stakeholders and include several types of providers (public and private, facility-based, and community-based) working together and separately to address different segments of FP supply and demand in overlapping service areas.[35] Using a GIS tool helps to break down the complexity of the data while adding an additional component — space. By understanding how all of these variables interact and relate to one another in space, we are better able to understand and make sense of our data.

Generally, GIS and mapping have been used for program planning, resource allocation, and monitoring and evaluation (M&E) focusing on mapping unmet need for FP, and calculating and measuring program or facility reach and coverage. This section will explore additional uses for GIS in FP and reproductive health, such as understanding accessibility and utilization of services, stock outs of commodities, and supply and demand for services and commodities.

Value of Mapping and GIS for Monitoring of Scale-up Efforts

There are different aspects of scale-up that can utilize GIS and mapping. Horizontal scale-up, or expansion or replication of a practice or intervention, is inherently geographic in scope, and therefore most any data that contains a geographic component can be imported into a GIS and mapped for use in program planning, evidence-based decision making, learning, program improvement, and advocacy. In addition to mapping, which is essentially a visualization of the data, a GIS tool plays a strong role in linking different data sources together to be able to understand how variables relate to one another in space.

***Space Influences the Diffusion Process* —** One of the most basic laws of geography is Tobler's law which states that everything is related to everything else, but near things are more related than distant things.[36] Understanding a region or health facility and the space with which it operates, or the distance between the health facility and its clients, is important. Since nearer things, in this case populations, tend to be more similar than those populations farther away, space and distance can influence the diffusion process of an intervention or resource.

Cook and Fujisaka, in their discussion of what influences the diffusion or scaling up of interventions, state that "distance will decrease the strength of interactions among individuals. As distance increases, the chances that an intervening process will occur that influences individuals in a different way also increase."[38] Based upon the theories of Tobler, Cook, and Fujisaka, diffusion of an intervention or program is influenced by what is around it; if there is uptake of an intervention in one area, or population, similar areas or population will be more likely to accept the intervention as well due to their commonalities. Similarly, if there is slow or stagnant uptake of an intervention in an area or population, areas that are nearer may be less likely to adopt the intervention as well.

Access or Barriers to Health Services May be Geographic in Nature — Access to health care is a multi-faceted issue that includes availability of appropriate services, availability of quality services, lack of social barriers, and financial and physical accessibility. This is specifically about physical access to a health care service or health resources. Physical access to a health facility or health resources (such as contraceptives) is commonly discussed in terms of the proximity of the user to the facility, which is generally measured in distance. In particular, we often measure Euclidean distance which is a straight line. We also often talk about a catchment area or facility 'reach,' which is quickly and easily created using a buffer function (as seen in figure D1); that the standard for an average catchment area or 'reach' of a health facility is 5 km. However, in most of the developing world, we know that many users' travel time can be one hour or more, particularly in rural areas.

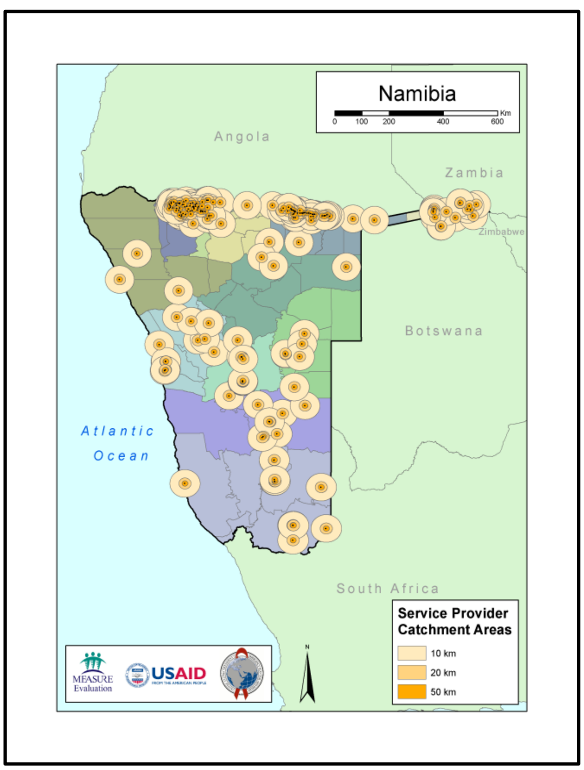

Figure D1. Catchment areas of 10, 20 and 50 km for service providers in Namibia.
Source: MEASURE Evaluation

Figure D1 is a map of Namibia showing the location of one type of service provider. The concentric circles surrounding the central points indicate Euclidean (straight line) radius distances of 10 km, 20 km, and 50 km from each health facility. While this can be a sufficient method for understanding the reach of a health facility for some types of health systems, such as in urban areas, it is not sufficient in areas that are predominantly rural or where terrain is difficult and transportation networks are poor or non-existent.

Figure D2 is another type of map illustrating health facility access in Ethiopia. The red plus signs indicate the location of a tier A health facility, and the dark black boundary lines indicate the 'referral network' or reach of that facility. The yellow and pink polygons illustrate the 'adjusted travel time' to the tier A health facilities based upon terrain and transportation networks. This map shows where some of the pink polygons (that represent an excess of two hours travel time) are very close to a health facility (see black arrows), likely indicating that either there are no roads, roads in poor condition, or some geographical barrier to direct access to the facility such as mountains or rivers. Creating catchment areas using a transportation network analysis can be useful in understanding access, utilization, and diffusion of scale-up interventions for health services.

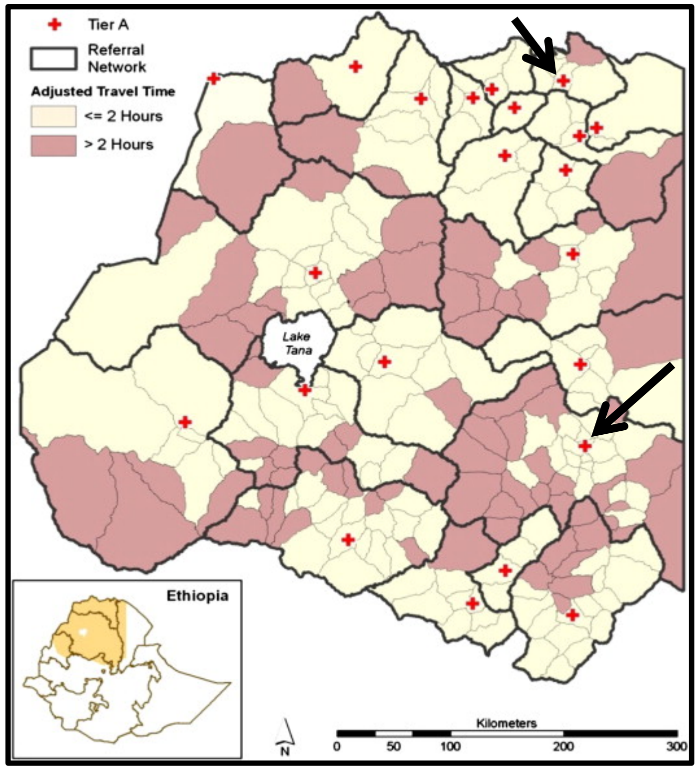

Figure D2. Catchment area in Ethiopia taking into account transportation networks and terrain.

Source: Bailev at al.[37]

Understand Which Locations Are Increasing Uptakes Relative to Others — One of the greatest values of using a GIS to monitor scale-up of an intervention is to understand how and why scale-up is happening in certain locations or areas in relation to others. This can be done quite simply in a GIS by linking various data sources through the use of geographic identifiers and layering contextual data along with programmatic data, such as number of sites implementing the practice, number of health workers trained in a practice, etc. Examples of the contextual data that can add value to the understanding of uptake or diffusion of a practice are: literacy or educational attainment, religion or ethnicity, gender, TV or radio ownership, poverty levels, and population density, among other demographic data. Additionally, as mentioned previously, geographic features can also play a role in how or if a practice or intervention is adopted.

Identify Favorable Areas for Expanding the Scale-up — When we apply contextual data to the service provision or utilization data that we use to monitor geographic expansion of scale-up, we start to understand trends in areas that are increasing uptake of the practice either more quickly than others or more often than others. This context can help us to understand the populations that might be more likely than others to adopt the intervention. By linking demographic and contextual data, not only can we understand the characteristics of an area or population that is benefiting from a scaled-up practice, but we can then apply spatial analysis to find areas or populations with similar characteristics where we would assume would be favorable climates for adopting the intervention.

A site that has a suitable condition increases the likelihood of adoption during scaling up or out.[38]

Focus on the Supply and Demand Side of Scale-up **—** When monitoring the expansion of a practice or intervention, the focus is often on the supply side (e.g., number of service providers trained, number of clinics implementing the practice, number of clients receiving the intervention during a specific period of time) while the demand side is overlooked. By linking contextual data in a GIS, we can analyze data and select out areas of demand for the type of intervention. For instance, rather than monitoring only the supply side, we might be interested in monitoring our interventions focusing on areas where unmet need is highest and tracking those numbers to see if they decrease over time. Monitoring both the supply and demand side is essential for monitoring the successful horizontal scale-up of an intervention. A GIS, through data linking and data analysis, can help us to look at both the supply and demand side of the equation.

> *… when the supply side is weak, uneven or erratic, this may further reduce demand for the innovation.[39]*

Patterns, Trends or Associations May Be Evident Only after Viewing Spatially **—** Mapping geographic trends of scale-up may also help to better understand the factors that are involved when an intervention or practice is scaled up. Additionally, most GIS applications have advanced spatial analysis functions that can measure the directional trends of a variable of interest. One way to do this in a GIS is directional distribution. Another common way is through the use of a center mean. While some patterns may be apparent by creating a simple chloropleth* map, spatial analysis, through the use of analysis tools in a GIS, can help to prove these trends or patterns.

Figure D3 illustrates one way of viewing patterns for the purpose of monitoring the trends and movements of a scale-up. In this map the colors represent the values of the total fertility rate (TFR) by district in Bangladesh, with the darker colors representing a higher TFR rate. The blue dot in the center indicates the weighted geographic center of the TFR values. Using the mean center tool is particularly useful for understanding changes in the distribution of values across a country or region. Viewing the center mean of a variable over time allows us to see the movement of values such as number of patients utilizing a service.

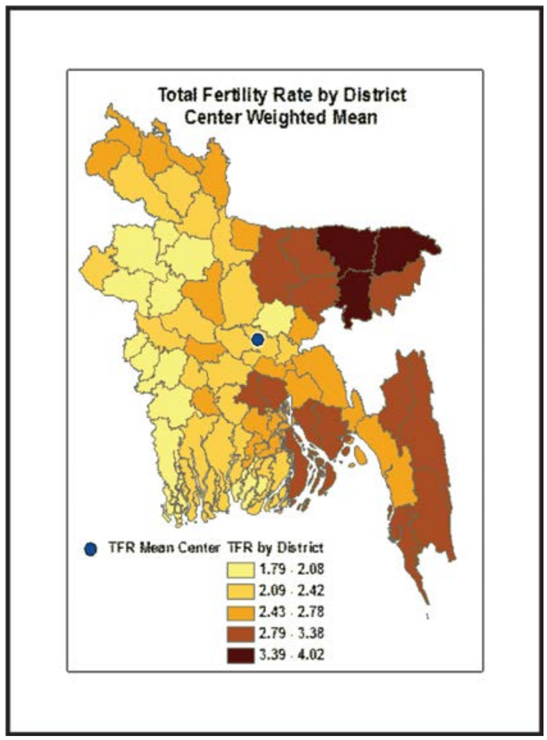

Figure D3. TFR by district showing center weighted mean.
Source: MEASURE Evaluation

Figure D4 shows another example of using patterns and trends to view and illustrate scale-up using the weighted standard deviational ellipse. The ellipse is weighted based upon the values of the variable of

* A chloropleth map is a basic map that shows values of a variable by geographic boundary allocated to a specific color. Frequently, these values and colors are in a descending or ascending color scheme such as seen in figure D3. In general, a chloropleth map uses different colors to denote different values.

interest, in this case the TFR by district. The directional distribution ellipse takes into account and summarizes the spatial characteristics of central tendency, dispersion of the values and trends of the values. As we can see in figure D4, the width of the ellipse shows that there is a wide variety of values that are spread out, but that the trend is showing lower to higher rates moving west to east and north to south. Plotting these weighted directional ellipses can help model the scale-up trends of the intervention or activity over time.

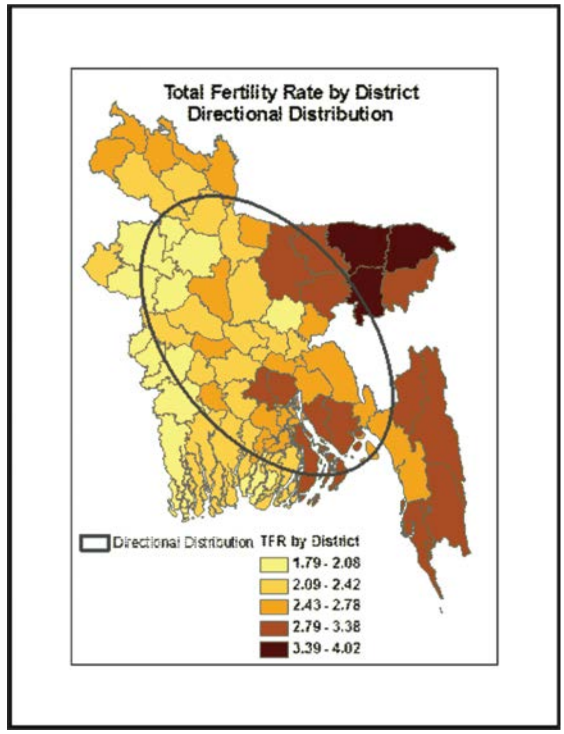

Figure D4. TFR by district showing directional distribution.
Source: MEASURE Evaluation

Mapping for Scale-up

There are many ways to display and visualize specific indicators for monitoring the scale-up of an intervention. When monitoring data, we are interested in looking at changes over time; time series maps or maps that can be viewed side-by-side allow the individual doing the monitoring to visually understand changes in indicators. The best way to display these is by using chloropleth maps.

Additionally, when tracking indicators to monitor the process of scaling up, we might be interested in looking only at the 'delta' or change in value in a given geographic area over time. In many GIS, a variable can easily be created to calculate the difference in values. The new variable (e.g., change in value X from 2005 to 2010) can then be displayed via a chloropleth map to understand areas of greater and lesser change in the value of interest.

Other ways to use GIS to analyze and visualize the monitoring of scale-up of an intervention is by using multiple indicators. When we visualize a map with different indicators represented on it, we can see associations or patterns that may not have been apparent in a tabular format. Additionally, in a GIS we are able to link data sources from disparate places based upon a common geographic identifier.* By linking data from different sources, such as health management information system (HMIS) data and stock-out data, we may see associations that help us to better understand the situation and our data overall.

In the following mapping examples, the indicators referenced in this guide will be used to show how these maps can be created to manage, analyze, and visualize data to help monitor the expansion/replication aspect of scale-up. We will utilize multiple indicator maps and other maps that show time-series and change in values.

* A geographic identifier is an identifier that is unique to the geographic area of interest; such as a street intersection, a GPS location, a region name, a country name, etc.

Domain: Access to physical resources

Indicator: Percent of facilities with adequate physical infrastructure to implement the practice

The map in figure D5 shows multiple indicators key to the scale-up of a particular intervention or practice. Two indicators referenced in this guide are represented: the number of sites in a geographic region currently implementing the practice, and the percent of facilities with adequate physical infrastructure to implement the practice. This map is specifically showing the percent of facilities having an adequate water and electricity supply by district in Bangladesh. (Note, this is dummy data used just for illustrative purposes, thus, an actual practice has not been defined. For this example, the assumption is that an adequate water and electrical supply at the health facilities is essential to implementing and scaling up the practice of interest.)

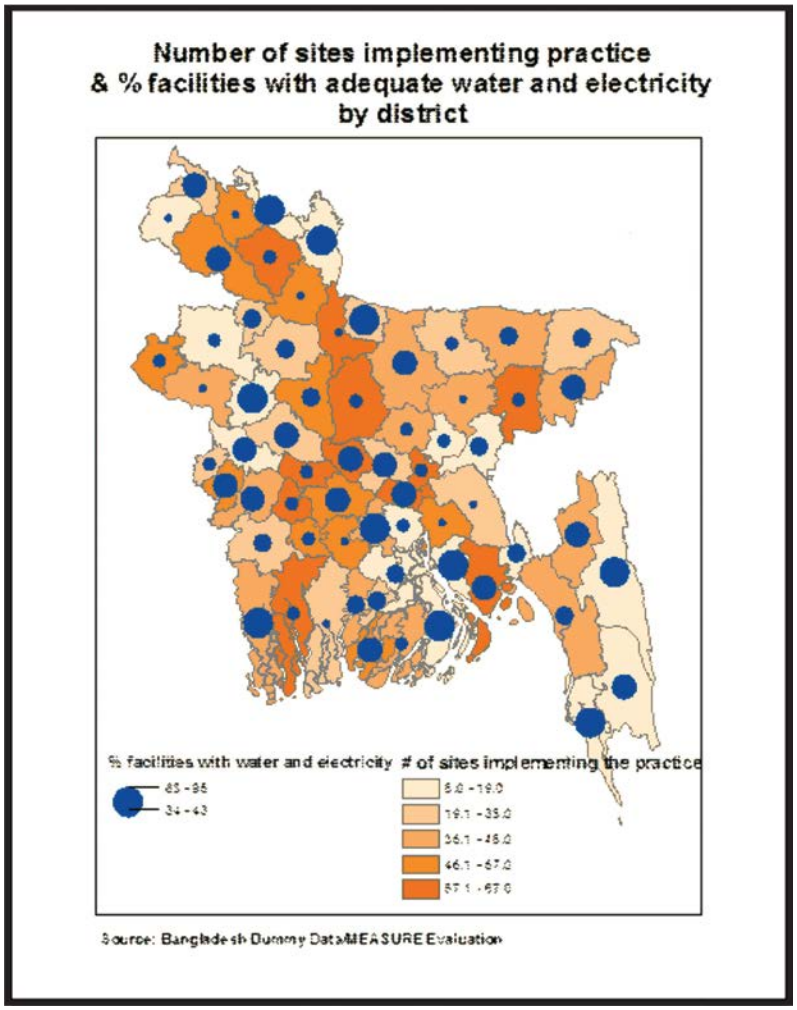

Figure D5: Multiple indicator map.

A few different things can be visualized in this map. First, we notice the difference in colors among the districts across the country. The darker colors represent more sites implementing the practice in a district, while lighter colors represent fewer sites implementing the practice in a district. The different sized blue dots are called graduated symbols and are representative of the values of the indicator. The larger the blue dot, the higher the percent of facilities in the district that have adequate supplies of electricity and water. By layering these two indicators, it is apparent that while some of the districts have a high percentage of facilities with adequate water and electricity, a low number of sites are actually implementing the practice. While this can lead us to question why the practice has not been scaled up, or scaled up well, in the districts with adequate health facility infrastructure, what we cannot deduce from this map is the total number of facilities in each district (i.e., the denominator) to understand what percentage of sites are implementing the practice and what percentage of sites still need to implement the practice.

Domain: Access to physical resources

Indicator: Percent of facilities or community-based providers that experienced a stock out of commodity at any point during a specified time period

Figure D6 looks at stock outs by district. Values are indicated by shades of purple for each district with the darker colors representing a higher percent of facilities experiencing a stock out of condoms within the last three months. The larger orange circles indicate a larger percent of community health workers (CHWs) experiencing a stock out of condoms within the last three months. As in the previous figure, we are able to see associations, patterns, and anomalies in our data by viewing it visually. We can also take this map and create a time series map, which looks at percent of facilities and CHWs experiencing a stock out within the last three months a year or two years ago in order to understand and visualize the difference in values.

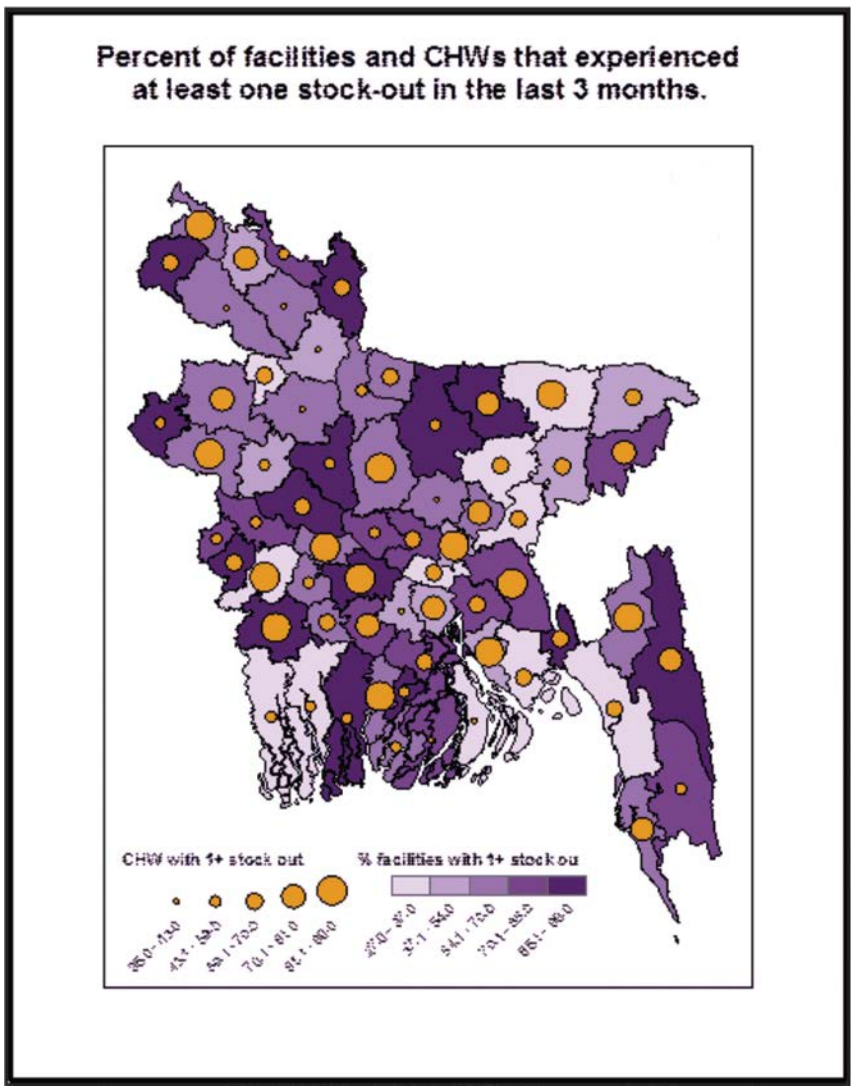

Figure D6: Map showing stock outs by district.

Figure D7 illustrates a time series map of facilities with at least one stock out of condoms within the previous three months. On the left map we see the values by district in January 2010 and on the right map we see the values by district in January 2011. By visualizing the change in colors from one map to the next we will be able to locate districts in which positive and negative change has occurred.

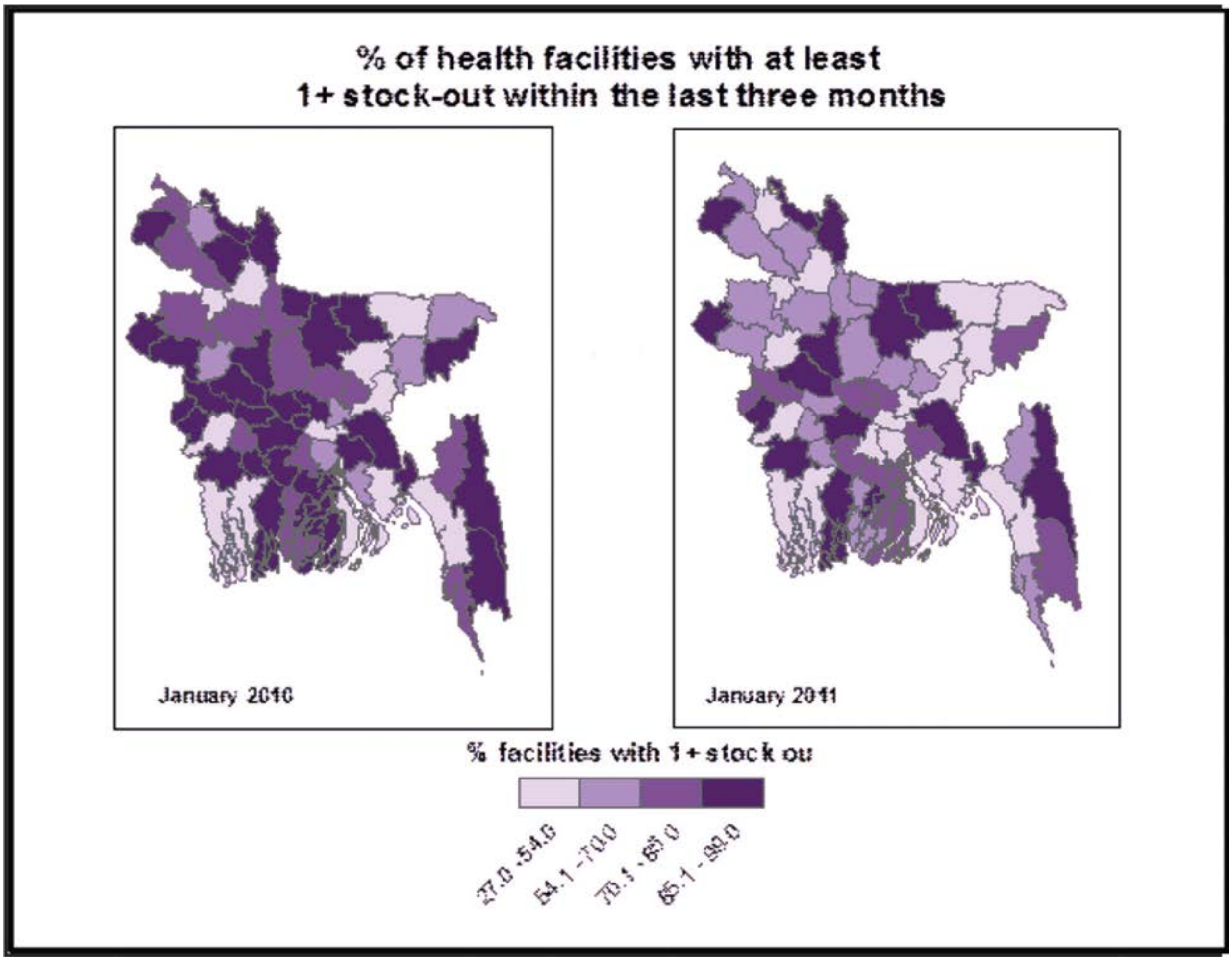

Figure D7: Map showing a time series.

Domain: Service deliver

Indicator: Number of sites implementing the practice

There are several ways to visualize the number of sites that are implementing a practice. A simple chloropleth map as can be seen in figure D8 shows the number of sites implementing a practice by district. We can also display this chloropleth map by taking the number of sites implementing the practice (the numerator) and dividing by the total number of sites by district (the denominator) to display the percent of sites per district that are implementing a practice. The implementation or scale-up of a practice can be monitored over time by viewing the percent of facilities implementing the practice in a district or region.

Additionally, with access to actual global positioning system (GPS) points of the facility, the precise location of the facility that is implementing a practice can be mapped. An example of this is in figure D9. With the GPS locations of the facilities, data sets associated with these facilities can be linked, such as an HMIS, in order to display and analyze more information about the facility or site. Also, in the interest of monitoring the expansion or replication of the practice or intervention, catchment areas of these facilities can be created to take into account the location of the facility as well as the number of clients served, services utilized, or commodities dispensed.

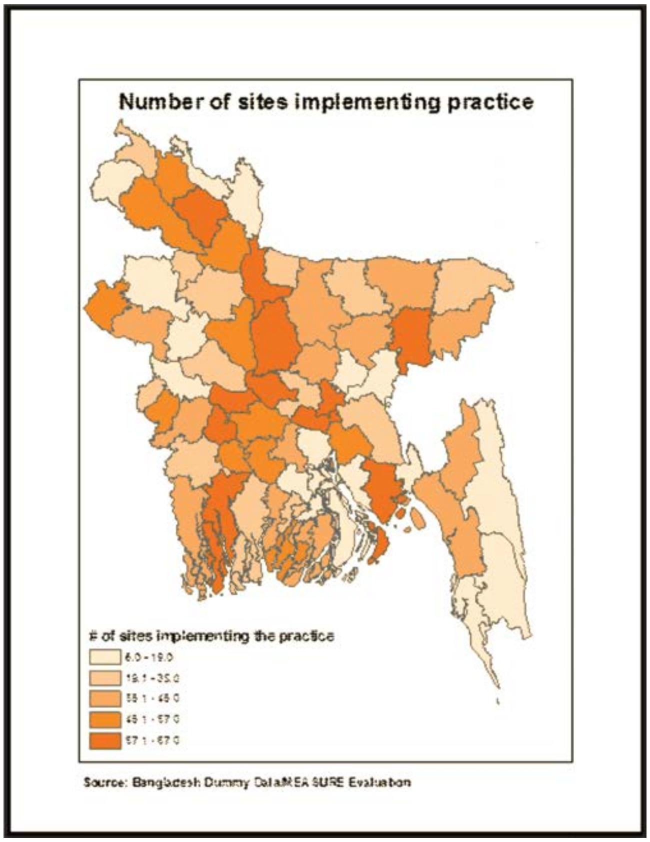

Figure D8: Chloropleth map of number of sites per district.

Figure D9: GPS location of sites implementing practice in District X.

Domain: Service deliver

Indicator: Number of clients receiving the practice of interest in a given timeframe

Similarly, there are a variety of ways to display on a map the number of clients receiving a practice of interest over a given time period. If we are interested in seeing if there has been an increase in the overall number of clients served by an intervention, comparing simple chloropleth maps like in figure D10 from various points in time can be a good visual representation of the data. Regional maps can be made if we are interested only in a certain region of a country which shows locations of facilities or service provider with graduated symbols indicating number of people served in a specified timeframe. We could also create a rate map showing the number clients receiving the intervention over a time period such as a week, a day, or a month.

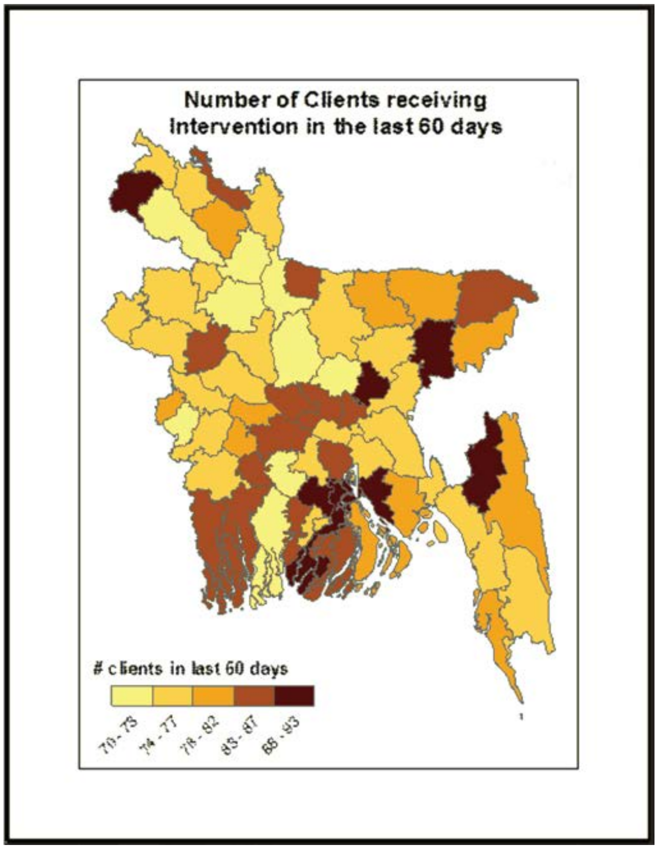

Figure D10: Number of clients receiving an intervention within last 60 days.

Conclusion — GIS and its functionality in mapping, managing, and analyzing data is important to monitoring the horizontal scale-up of interventions because of the inherently geographic features of scale-up or replication. When we look at the replication and uptake of programs, projects, interventions, or health practices we are interested in the size as well as the extent of uptake. The scale-up of interventions can be visualized in multiple ways and via multiple types of maps. Looking at maps across time provides a better understanding of the spread of the intervention. Layering on multiple variables provides a snapshot of how indicators relate to one another in space and in relation to the intervention. In a GIS, we also have the robust ability to link disparate and multi-sectoral data sets into one table of attributes. Displaying these layers on top of one another is helpful for analyzing and understanding barriers as well as accelerators to scale-up.

Technical Information and Resources

This section provides technical and reference information on the requirements needed for mapping data in a GIS, how to format data for use in a GIS, where to find data for use in a GIS, and how to link data together in a GIS.

Requirements for Mapping Data — In order to import data into a GIS and map it, the data need to be formatted in a way that the GIS can properly display the data.

Formatting data:

1. Importing Data from Excel Spreadsheets: Dos, don'ts, and updated procedures for ArcGIS 10 http://www.esri.com/news/arcuser/0312/files/excelmagic.pdf

2. How to Create a GIS Ready Excel Spreadsheet @ImcGIS, 2011 http://lmcgis.blogspot.com/2011/06/how-to-create-gis-ready-excel.html

Finding shapefiles and data:

1. Global Administrative Areas http://www.gadm.org/country
2. HIV Spatial Data Repository http://www.hivspatialdata.net/
3. DIVA-GIS http://www.diva-gis.org/
4. UN Second Administrative Level Boundaries http://www.unsalb.org
5. MEASURE DHS: Demographic and Health Surveys http://www.measuredhs.com/Data/
6. Multiple Indicator Cluster Survey (MICS) http://www.unicef.org/statistics/index_24302.html

Data linking:

1. GIS Data Linking to Enhance Multi-Sectoral Decision Making for Family Planning and Reproductive Health: A Case Study in Rwanda, MEASURE Evaluation Working Paper 2012 http://www.cpc.unc.edu/measure/publications/WP-11-129
2. ArcGIS 10.0 Desktop: About Joining and Relating Tables http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//005s0000002n000000
3. Using ArcMap 10 to join Excel data with a shapefile: Journalism GIS http://www.youtube.com/watch?v=mfyEXkkeLAg

***GIS Software* —** Available GIS software can be proprietary or open-source. Often considered the 'gold standard' of GIS software, ArcGIS is proprietary software with highly advanced data management and analysis capabilities. http://www.esri.com/

Quantum GIS (QGIS) is free and open-source GIS software that is increasingly being used around the globe. Because it is open-source it is constantly being upgraded by volunteers who can make edits to the software and create additional plug-ins to enhance the capabilities of the software. http://www.qgis.org/

Excel to Google Earth (E2G) 2.0 is a free mapping tool from MEASURE Evaluation. E2G allows users to create chloropleth maps in Google Earth using simple Excel spreadsheets for administrative divisions (provinces and districts). Data is available for 40 countries around the globe. http://www.cpc.unc.edu/measure/tools/monitoring-evaluation-systems/e2g

Open GeoDa is free and open source spatial data analysis software that includes mapping functionality along with robust geospatial analysis. https://geodacenter.asu.edu/

District Health Information Software 2 (DHIS-2) is widely-used free and open-source GIS software. In addition to its capacity to manage, analyze and map data, it has the additional capacity as a data collection tool. http://dhis2.org/

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Acronyms

CHW	Community Health Worker
FP	Family Planning
GIS	Geographic Information Systems
GPS	Global Positioning System
M&E	Monitoring and Evaluation
TFR	Total Fertility Rate