Mapping Community-Based Global Health Programs

A REFERENCE GUIDE FOR COMMUNITY-BASED PRACTITIONERS

MEASURE Evaluation
MANUAL

Mapping Community-Based Global Health Programs

A REFERENCE GUIDE FOR COMMUNITY-BASED PRACTITIONERS

This research has been supported by the President's Emergency Plan for AIDS Relief (PEPFAR) through the United States Agency for International Development (USAID) under the terms of MEASURE Evaluation cooperative agreement GHA-A-00-08-00003-00 which is implemented by the Carolina Population Center, University of North Carolina at Chapel Hill with Futures Group, ICF International, John Snow, Inc., Management Sciences for Health, and Tulane University. Views expressed are not necessarily those of PEPFAR, USAID, or the United States government. MS-13-76 (June 2014).
Cover photo: http://www.flickr.com/photos/mapkibera/8638772284/in/photostream/

Table of Contents

Introduction

Community-based activities can leverage local situational awareness to target interventions to underserved or most-at-risk populations—those who may be stigmatized or disenfranchised, or who may not receive care in the established health care system(Lux & Greenaway, 2006; Clarke 2007; Emmanuel et al., 2010; Muhe, 2002). Monitoring and evaluating such activities requires appropriate information available to key stakeholders in accessible formats("Community Systems Strengthening Framework" 2010; Joint United Nations Programme on HIV/AIDs, 2010; MEASURE Evaluation, 2010). One such format, maps, can support community-based monitoring and evaluation (M&E) by helping define the geographic coverage area of community-based activities and by building and maintaining linkages between community-based programmatic data and other relevant data from the coverage area.

Maps of community-based activities can also support advocacy efforts, improve data quality, and spark discussions regarding existing services and success and future resource allocation. Maps generated by a geographic information system (GIS) allow users to overlay activity data with other contexts, such as population distribution, land use and infrastructure (Tanser & Le Sueur, 2002; Ricketts, 2003).

Despite its potential, the use of GIS and maps for M&E of community-based programs has been limited. Lack of technical expertise and the need for guidance have been regularly identified (World Health Organization, 2010) by community program implementers as challenges to mapping their health programs. In a snowball survey of global health practitioners, 79% of respondents indicated they are collecting geographic information about a community-based project in some form; however, 53% stated that a lack of technical expertise was the major barrier to mapping it.

This document serves as a guidance framework for program managers aiming to use maps to support community-based programs. Following a brief background, the guide discusses how mapping can support a project cycle. The guide identifies key questions to ask when planning a mapping effort—all of which inform the mapping process. Needed resources are reviewed, and the guide outlines four main stages in the mapping process:

1. Community engagement
2. Data collection
3. Visualization
4. Analysis/information use

While the methods and outcomes of mapping community-based activities are context-specific, the guidance framework documents current practices and tools to facilitate the readers' own mapping efforts. The aim is to facilitate mapping of community-based programs where the data infrastructure can support it, and describe the data infrastructure for those instances where it does not. Primary audiences for this guide are those working with community-based organizations (CBOs) and faith-based organizations (FBOs), including implementing partners, U.S. government staff, and staff of national or public advocacy groups.

The topic of mapping for community-based global health programs is expansive and includes significant variety in data collection techniques and visualization tools. The topic includes global maps linking brief description of pinpointed activities—globally or in specific countries (Broenner & Morris, 2013; USAID, 2013; Todd et al., 2009; Kenya AIDS NGOs Consortium, 2009), catchment and coverage estimates based on key informant interviews (Mapala, 2012; Ansumana et al., 2010), and community-based mapping—itself a varied discipline including the closely related fields of participatory GIS (PGIS) and public participation GIS (PPGIS) (Sieber, 2006), as well as interactive community information projects (as illustrated by the Map Kibera Web page, available at http://www.mapkibera.org). At the core of each technique, is a focus on providing accessible information to necessary stakeholders.

Who are the Stakeholders?

In general, maps of community-based programs are targeted at existing or potential donors, decision makers, program managers, or the community itself. In reference to the World Health Organization's relationship with CBOs and FBOs, one source says: "If you are not on the map…you don't exist" (Dickerson et al., 2012). In other words, unless people know who you are, where you are and what you are doing then you are unlikely to be at the table when decisions are being made that your affect program, and will have more difficulty demonstrating the value of your program. As decision makers review programs and allocate resources, maps can be effective tools to stimulate discussion of current efforts and evaluate progress against goals. Furthermore, maps of community-based activities can be shared with the community being served for advocacy or behavior change communication.

Who Leads the Mapping Efforts?

Efforts to map communities' health related information and community-based health activities can be driven by the community seeking further understanding of ongoing challenges and health efforts in their neighborhoods, or by the implementer seeking to better understand the community the community they are working in. While these efforts are not mutually exclusive, the distinction is helpful in defining the process of mapping.

Community-Led Mapping

In community-based mapping, members of the community select the information they feel important, create or gather and map geographic and attribute data. This "ground-truth" information is typically shared openly, contributing to the larger commons of knowledge. These mapping efforts may be part of a larger participatory development, local planning, or advocacy process, and may serve as a base for citizen reporting (Sieber, 2006). Community-based mapping efforts are often facilitated by outside experts who engage the community and build capacity for geographic data collection and mapping efforts. These external stakeholders often link the community to external funding and existing data, allowing the community to incorporate their local knowledge into a broader context. Examples of techniques for engaging a community to support such mapping efforts can be found in Annex 1.

Program-Led Mapping

In program-led mapping—where mapping efforts are driven by a program implementer—managers of community-based programs often need information about their community to better guide implementation—information which might not be collected by community driven mapping efforts in the necessary project-oriented time frame. These mapping efforts include identifying key areas or locations important to disease transmission and thus outreach and prevention efforts (Dongus et al., 2007; Edwards et al., 2012; Mapala, 2012; Welle & Wicken, 2008). Such efforts allow the program manager to contextualize their program, detailing local context and program coverage, yet maintain control over data collection and data dissemination protocols. They also include efforts to identify, from community members, the extent of current program reach. So while these are maps of the community, or of the community-based activities, they are not community driven.

At the heart of both of these methods is a process of community engagement for capturing and organizing local knowledge into a geospatial display to identify resources, visualize challenges, and plan/manage interventions to improve health outcomes. The community engagement process fosters trust between the community and implementing organization, and provides forums for information exchange and communication within the community being served, between the community and those serving it, and between the both of these and funders. Such communication provides implementers with better understanding of the relationship between a community's priorities, existing services, and current disease distribution.

This document primarily focuses on program-led mapping.

Example: Mapping Led by Communities

Map Kiberia is an example of community-led mapping. Supported by GroundTruth, Map Kibera uses citizen mapping in Nairobi to empower the members of one of the world's largest slums. While local communities are the most important stakeholders for identifying their own priorities for projects improving health, education, safety, and water and sanitation. Yet they rarely have access to information on services or infrastructure. Erica Hagen, one of the founders of Map Kibera, explained , "It's more about supplementing what's happening at the community level (than building something completely new)" (Hagen, 2012).

What Does It Mean to Map Community-Based Health Programs?

Mapping community-based activities captures, organizes and communicates knowledge about the community program or the community within its geographic context. In the health sector, such maps can identify and communicate service availability in relation to the community's health needs. Through the community engagement process, programs can promote awareness of local health issues and build community ownership of health resources. Maps of existing reach can empower health workers and program planners to effectively deliver health services to those who need them most. They also allow managers to review gaps in coverage or areas with duplication of efforts, and to link community-based health activities with formalized health infrastructures.

Such maps can be used at every segment of the project cycle to (Figure 1). By detailing program coverage and available resources, and integrating multiple streams of information, such maps can serve as tools for planning, monitoring, managing, and evaluating programs.

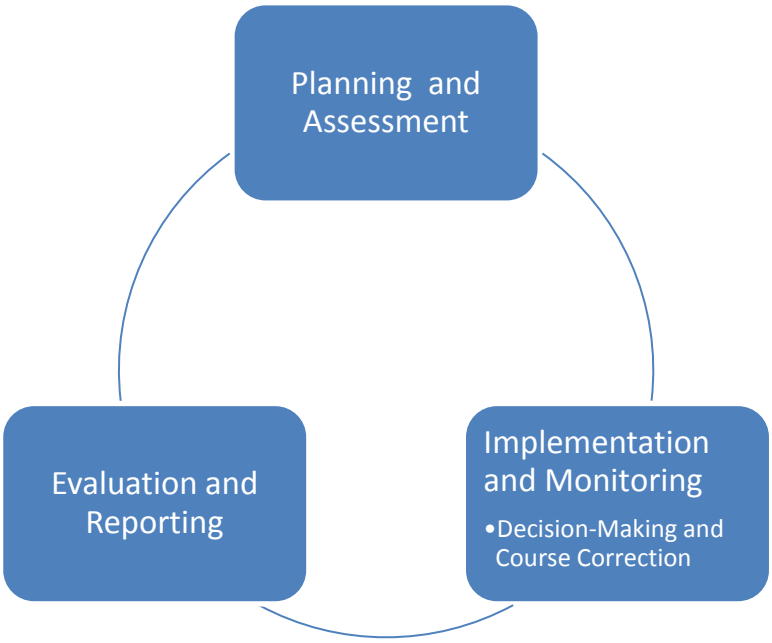

Figure 1: The project cycle.

Stage 1: Planning and Assessment

Mapping community-based activities helps to document ongoing activities to identify gaps and avoid duplication of resources. Further, community-centered maps can gather local knowledge of health that is unavailable through standard government statistics and surveillance. Mapping can collect vital data and engage with the community to build a solid foundation for the intervention. Through this process, it is possible to establish community boundaries, identify community resources, and designate partners for the intervention. Using mapping at the planning stage will help identify the location of a program's target group. As community-based activities are tailored to the communities specific needs, the maps help visual the needs spatially to communicate plans and opportunities better to the formal health system. National or regional maps identifying program coverage can support resource allocation and identify gaps or duplicate efforts.

The following are examples of areas where maps of the community support program planning:

- defining and visualizing the current community needs and community level data (Shkabatur, ND 2012; Dulin et al., 2010; Merkel et al., 2008);
- establishing perceived community boundaries (Ansumana et al., 2010);
- identifying locations in which to target interventions (Emmanuel et al., 2010; Mapala, 2012; Dongus et al., 2007);
- identifying community resources (Shkabatur, 2012; Merkel et al., 2008);

- engaging the community and building relationships in the community through the mapping exercise(Shkabatur, 2012);
- linking community and program information with additional context or formal health infrastructure (Beyer, Comstock & Seagren, 2010; Dulin et al., 2010; Baum et al., 2010); and
- identifying partners and coverage for resource distribution (Mapala, 2012; Todd et al., 2009; Kenya AIDS NGOs Consortium, 2009).

Stage 2: Implementation and Monitoring

Data are continuously collected throughout a project but not always analyzed and consistently used for decision making. Connecting these data with a map provides an immediate way to visualize project data that will expose patterns and gaps within a project. Maps can support data use efforts by making information more accessible to decision makers. Further, maps can be easily shared with the community in multiple settings, increasing their ownership of the activity and keep them appraised of progress and goals.

The following list provides examples of areas where maps of the community support implementation and monitoring by:

- visualizing program operational activities (Mapala, 2012);
- identifying gaps or duplicates in programming(MEASURE Evaluation 2012; Chaulagain, 2012);
- linking community based activities with more formal health structure (Mapala, 2012; Merkel et al., 2008; Shkabatur, 2012);
- supporting and advocating for additional resources; and
- identifying spatial or temporal trends in service coverage (The Global Polio Eradication Initiative, 2010; Gates, 2012).

Stage 3: Evaluation and Reporting

Sets of maps can be used to examine the locations of activities together with changes in disease patterns over time. Maps, due to their ability to communicate large amounts of information effectively and the increasing availability of geo-coded health data, are becoming a standard tool for visualizing health efforts. Placing activities on a map promotes transparency (everyone knows where to go to see if the activities are being done as reported), and allows donors to examine the relative distribution of activities compared with outcomes at an aggregate level. While basic, local area maps might initially be used for monitoring and implementing, a series over time can later be used to communicate project growth and evolution. Geo-tagged information from a variety of local partners or various project sites can be integrated in a GIS to provide a broader picture of overall regional efforts.

The following list provides examples of areas where maps of the community support evaluation and reporting by:

- visualizing project indicators(Chaulagain, 2012; Todd et al., 2009); and
- communicating program impact or reach (Mapala, 2012; USAID, 2013).

In an evaluation context, maps can show pre- and post-values, and can be used to assess geographic patterns for gains and results.

Example: Using Mapping Community-Based Activities throughout the Project Cycle

The USAID-funded Saath Saath project in Nepal provides outreach and facility-based health services in partnership with the government of Nepal and other international nongovernmental organizations (NGOs) to vulnerable populations such as female sex workers, migrants, and persons living with HIV. To best reach their community, managers of the Saath Saath project have been engaged in mapping service coverage achieved by community health workers (CHW) and the distribution of most-at-risk populations; these maps were used for periodic program reviews and program decision making. To produce up-to-date and relevant maps, mapping was incorporated in the monitoring and evaluation plan and work plans, to institutionalize the practice within the workflow of the project. Guidelines and trainings were developed to support CHW. A variety of both basic and high-tech approaches to mapping were shown to be useful for planning and decision making by community volunteers, field-level staff, and program managers. According to one study, USAID's support through the Saath-Saath project has been crucial in providing special training to the Nepal Ministry of Health and NGOs in using GIS to prioritize HIV prevention efforts (Chaulagain, 2012).

Several key questions are important to consider before and during the mapping process. Figure 2 outlines several key questions that should be considered as planning mapping efforts begin. The details of the mapping process, including decisions that influence the choice of tools and for each stage from community engagement to data use, are then discussed below. Many of these decisions will be influenced by resource availability. The over-arching role of ethics and confidentiality in data acquisition and use is also discussed.

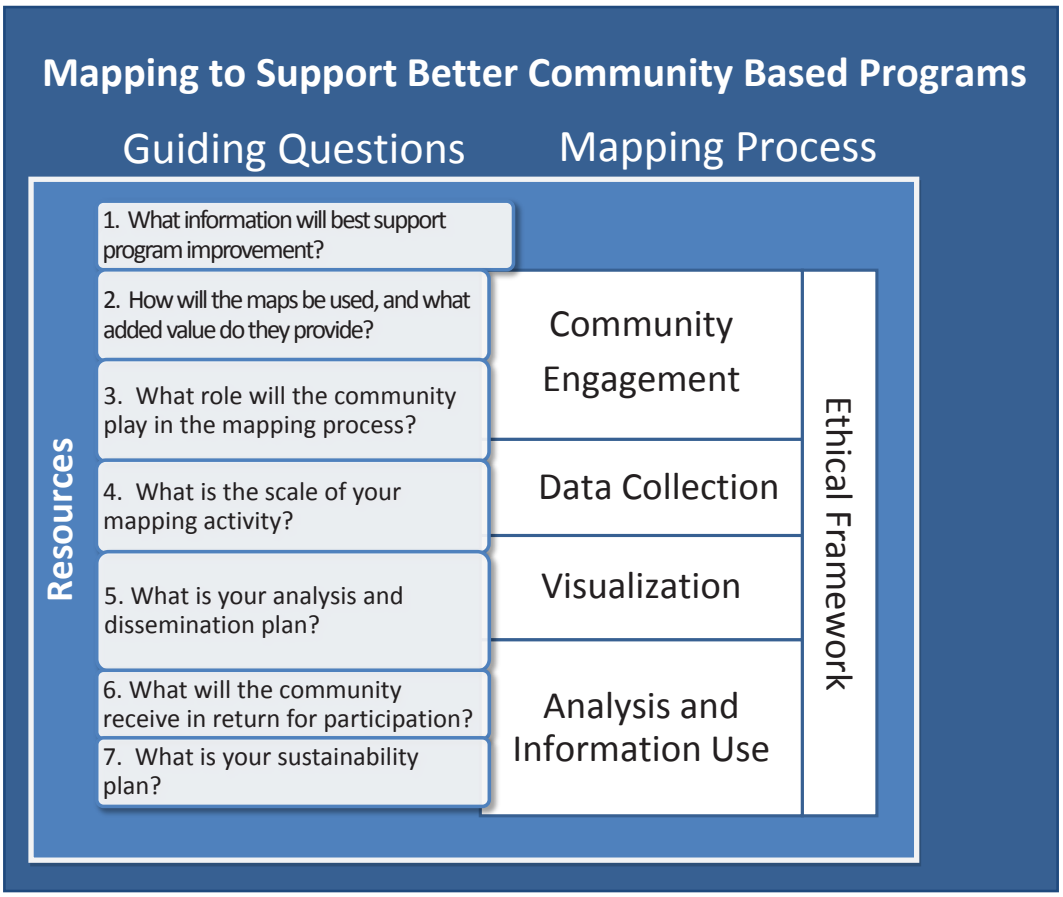

Figure 2: Guiding questions and the mapping process.

Guiding Questions

There are several key questions which should be thought through during a planning phase prior to integrating maps with community based programs. Responses to these questions will influence the entire mapping process, including methods of engaging the community, collecting data, visualizing and analyzing the data geographically, and finally using the data and maps for program improvement (Figure 2). Available resources (human resources, hardware, software, existing data, time, and budget) will often play a dominant role throughout the mapping process. They will influence decisions on community engagement, data collection, visualization, and analysis and information

1. What Information Will Best Support Program Improvement?

As mentioned previously, different information is necessary at different stages in the program cycle. Identifying what information is necessary now, and what information will be helpful later, is a prerequisite for all steps in the mapping process. Such information typically falls into two categories: programmatic data and contextual data.

Programmatic data include information about location and extent of activities—often measured by key indicators. To identify which indicators will be most useful, ask the following:

- How will the mapped indicators be used?
- Which indicators are already being collected?
- Which indicators would be easy to collect geographic information on?
- How are existing indicators being analyzed?
- Is collection and analysis of the indicators feasible?
- Are the indicators fully defined?
- Are they harmonized with indicators you will be aggregating and reporting?

In asking what context needs to be mapped to best understand the program context, you might consider:

- key roads,
- neighborhoods or towns,
- population density,
- health facilities and services,
- administrative boundaries,
- disease patterns and distribution of risk factors,
- schools,
- places of worship,
- markets, and
- water sources.

Focus on your questions rather than the map and technology itself.

Different audiences will require different indicators at different levels of aggregation. Both data users and data producers should be involved in discussions regarding the selection of indicators to be collected. If indicators are already being collected, priority indicators should be selected and mapped based on current analysis and expert knowledge.

2. How Will the Maps Be Used, and What Added Value Do They Provide?

Given the existing barriers to geo-locating and mapping program indicators, it is important to identify the added value they will provide. In general, maps of community based programs can best support efforts to:

- visualize large amounts of data
- mobilize additional support through a powerful "story-telling" tool
- link and overlay multiple data sets based on geography
- assess patterns while considering geographic context
- communicate and spark conversations with decision makers
- demonstrate time trends in disaggregated data

Consider how else the data should be analyzed and presented. Different audiences need the data presented in different ways. Will the maps be used independently or in conjunction with:

- tables and graphs,
- dashboards, and
- community score cards (Singh & Shah, 2004).

3. What Role Will the Community Play in the Mapping Process?

As discussed earlier, though there is overlap, there is a difference between mapping community-based programs and community-based mapping. The former involves mapping the locations and effects of community-based activities in their context to better understand, assess and improve them. In the latter, community members themselves provide much of the information, contextualize it, and typically use it for their own efforts. Identify the following:

- What level of community involvement are you seeking for collecting your data?
- Is the community at least equally involved in the analysis of the data and decisions being made based on the data?

Failing to continue to engage the community limits understanding of local context in interpretations, and may lead to future barriers to mapping efforts with the community. A sustainable mapping effort must be community oriented. It must empower them by involving them in the mapping process and address issues they are concerned with.

In preparing to engage the community, a program must identify:

- the appropriate engagement method (see Appendix 2),
- the appropriate information sources in the community, and
- what roles community members should play in analyzing and disseminating the maps.

4. What Is the Scale of Your Mapping Activity?

Scale can be thought of in terms of the breadth of areas mapped and detail of information being mapped. Breadth deals with the size of the total geographic area being mapped, with larger areas typically being more expensive to map. Detail relates to the smallest geographic level for analysis, with finer detail typically costing more to map and requiring greater community participation. The breadth and detail necessary is dependent upon the users of the data and scope of the program being mapped. Data gathered from additional sources should be at the same scale as your programmatic data.

- How extensive is the programmatic reach being mapped?
- What level of detail is necessary to make decisions on resource allocation or to evaluate the program?
- What is the level of detail for other data being linked into your program?

5. What Is the Analysis and Dissemination Plan?

Addressing the dissemination plan prior to mapping will help in selecting the best data collection tool and visualization program. Consider who will demand these maps and how to share these maps. In addition to the primary users of maps, it is also critical to think through additional audiences that would benefit from using the maps, and what training or support for map literacy may be needed to make the maps more accessible to that audience. This could involve holding a community meeting to share overview of maps identifying the location of community services. Or, with more complex data sources, it could include an in-depth review of the data collection and limitations for decision makers.

Potential audiences include:

- community members
- members of at-risk populations
- community health workers
- district and regional health and planning bureaus
- policy makers

6. What Will the Community Receive in Return for Participation?

Define what immediate compensation (monetary or otherwise) the community will receive for participation. When data are gathered directly from community members, managing expectations will be important throughout the mapping process.

Regardless of the immediate compensation offered, effort should be taken to educate the community to the end goal (better planned health programs, increased access to services, etc.).

7. What Is the Sustainability Plan?

If the mapping exercise is intended to be routine and sustainable, resources will need to be set aside or leveraged to continue the mapping process once the initial mapping effort is completed. This might be done by building routine mapping processes during the exercise, or by training, empowering and funding citizens to continue mapping as a form of citizen engagement. The collection and visualization of community data may provide a strong link to integrate the community-level activity with the formal health system. This integration may provide the community with routine support to keep the maps and data up-to-date. Program managers must ask:

- Should the program be sustainable?
- What resources are being sought or procured that will allow the program to continue independently?

Necessary and Available Resources

The scope of your data collection and mapping efforts may be limited by the resources you have available. Resources can include time, human resources, existing data, GIS software and computer hardware. Not all maps need to be built in a GIS. If basic geospatial infrastructure—such as shapefiles for roads or administrative boundaries—are unavailable and not easily created, paper maps may be preferable to a GIS.

Low cost sketch-maps can provide the necessary current context for planning and monitoring activities in a single, discrete area or set of areas (Dongus et al., 2007). If done using walking papers or another geo-referenced map, such low-tech maps could later be integrated into a GIS as funding becomes available or analysis needs change.

Prior to beginning data collection, it is worth evaluating how long it will take to map the project and what it will cost. Key factors to assess include time and cost of:

1. **Human resource development**
   - Staff able to collect, map and analyze geospatial data

2. **Community engagement**
   - Time spent identifying and engaging key community leaders
   - Potential cost for a community 'champion' who liaises with other community members to promote the activity

3. **Data collection and entry**
   - Existing data compared with data needs
   - Data collection tools (mobile verses paper based)

4. Visualization and analysis

- Hardware
- Software
- Technical expertise

5. Dissemination strategy

- Cost of publishing materials to be disseminated
- Feedback to and from the community

This information will also help define what tools and methods (outlined in the Annexes 1–4) will best suit the needs.

Example: Disaster Preparedness Mapping Using Open Source Tools

The Humanitarian OpenStreetMap Team partnered with regional and federal organizations in Indonesia to create comprehensive maps for disaster planning. The Humanitarian OpenStreatMap Team (HOT) used OpenStreetMap (OSM) , community engagement, paper based maps, walking papers, satellite imagery, and Quantum GIS software (QGIS) for work in Haiti and Indonesia. Open source platforms for mapping, like OSM allow community members with limited computer literacy and basic mapping abilities to generate simple, elegant maps of their own communities. About 41,000 buildings were mapped within one year. The open data storage created increase access to data that was integrated into official disaster plans.

The Mapping Process

Having discussed the mapping planning questions and the important role available resources plays, each stage necessary to create the maps and main ethical considerations are now examined. These four stages are often iterative—as data are analyzed, the need for additional data will arise, and other community members who should have been included during the earlier engagement methods will be identified. In general, community engagement feeds into data collection, which allows data visualization. Accessible data are a prerequisite for data analysis and information use.

In addition to considering what resources are needed for mapping (covered previously), it is also important to understand the mapping process—four components situated within an ethical framework (Figure 3). Community engagement, data collection, visualization, and analysis and information use fall firmly into the world of M&E for community projects. Each component's role during the community mapping process is examined next.

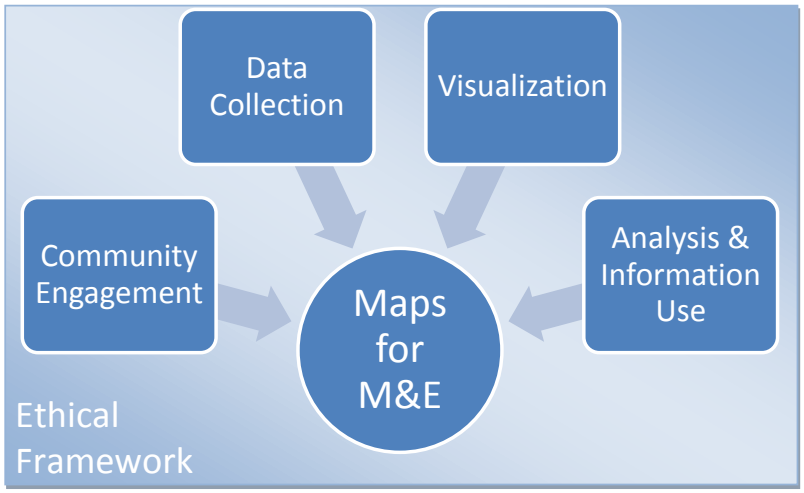

Figure 3: Mapping process.

1. Community Engagement

Understanding and accurately representing local knowledge requires engaging the community throughout the mapping process. There are a variety of community engagement techniques for mapping (Annex 1). Some, such as key information interviews (using a map as context), focus on the views of specific individuals seen as knowledgeable within the community. This may include community leaders, local health care workers, or member of vulnerable populations. Free mapping focuses on community members' understanding of the location and their access to resources. Participatory GIS (PGIS) and Public Participation GIS arose out of different contexts and in response to different needs, but have similar goals. They aim to lower barriers preventing community members from mapping themselves and local resources. They require long-term capacity building partnerships to ensure transfer of GIS technical skill to the community.

Trust and Relationship Building

Trusting relationships with the community can provide stronger and more accurate maps. Transparency within the mapping exercise can support community engagement. Clearly outlining the objectives of the mapping exercise and managing expectations by stating the intended outcomes and outputs early in the process will help to demystify the mapping process. Understanding what the community will (or will not) receive in return for their support of this activity can change their incentive to participate. By limiting the scope of the exercise, the practitioner will be in the position to defer the community's needs not addressed within the scope of the community mapping, but may provide the community with a tool (the map produced) to better discuss those needs in another forum.

2. Data Collection

Most community health activities already collect a wide range of indicators. Often these data are aggregated for reporting purposes. When used for monitoring and evaluation, data are often presented in tables and graphs. The collection of additional geographic information can allow users to link key indicators to their locations to examine patterns or gaps in coverage. This geographic context can be collected and displayed through a variety of methods depending on end-user needs (Appendix 4). Prior to your own data collection, it is important to connect with community organizations or government agencies to see what mapping efforts have already been undertaken. These groups will often have a wealth of geographic data and collaborating with them with benefit both parties. Compare the available geographic data with your needs. Unless you are performing distance calculations or advanced geographic modeling, proxies for exact geographic coordinates of locations can be used to facilitate the visualization of com-

munity level data on a map. It is important to build in data verification procedures to ensure good quality maps. The burden of the collection of additional data needs to be considered and compared with the anticipated added value the maps will provide. A detailed list of tools for collection geographically referenced information can be found in Appendix 3.

It is essential to have a firm outline on how data will be analyzed and used, as the data collection process will determine the scale, quality, and usability of the data set. As in any data collection process, validating and test-piloting your data collection protocol prior to extensive data collection is important.

Data Format

Some programs may need something as simple as a paper map identifying community zones for planning local responses and efforts. In other cases, the data collected will need to be stored digitally. Which data need to be:

- directly linked to other health information systems?
- aggregated?
- harmonized with current data collection/monitoring efforts?

As many health mapping projects will capture sensitive information, it is important that data are stored securely to protect individuals' privacy. What security systems are in place?

Time and Training for Data Collectors

Capturing GPS coordinates will require training and a significant time commitment for those collecting geographic data. Community-based services frequently lack the fixed location that characterize facility services. Collecting data on the location or locations the activities cover will require increased training and time, as data collectors will often need to gather data identifying an area rather than a single location.

- How accurate do locations services are offered need to be?
- Have you planned a data verification process during and after data collection?

Data Management

Effective data management allows data to be used more readily, shared with other partners, or archived for future use. When integrating community-based mapping into a project, factors influencing data management that should be considered include the following:

- How often do the data need to be updated—and what is the corresponding burden on those updating data?
- How are data currently collected, and can data be directly linked to the GIS?
- Have unique, meaningful IDs for programmatic reach or program location been established?

Example: Mapping Households for a Community-Based Information System

In the HMIS Scale-up Project in Ethiopia, community health workers know exactly who needs treatment and where they are located. The community health workers make hand drawn maps to identify households by household number or head of household name and include a basic health profile based on their knowledge of the community. The community health worker then cross reference information from their community visits with clinic data to determine who needs follow ups and where. Every two months they check up on each family through home-visits. When patients fail to show up for scheduled appointments, the family folder system helps community health workers to follow-up with service defaulters (Azim, 2012).

3. Visualization

There are a range of options to create maps that can used, depending on human resources and level of analysis necessary. In general, a GIS requires strong technical ability and established geographic infrastructure allowing users to link data from varied sources. Paper maps bypass the required geospatial infrastructure, but are also more difficult to maintain and update—especially across broad areas. Often data visualization and information use (described below) happen simultaneously, and may be iterative. The initial maps raise additional questions which require further analysis and new maps.

Paper Maps

The most basic maps can be created with paper. Paper maps can be a hand drawn conceptual representation of the community or currently available political or satellite maps. Hand-drawn maps use symbols to represent households and key landmarks in the community. The hand-drawn maps can be drawn from memory by or by walking through the community with key informants. These maps can provide a low barrier to entry method that can engage staff and/or community members in mapping the community and can be especially useful in communities that do not have official maps. Hand-drawn maps typically do not rely geolocation, which make it difficult to connect these maps with more formal maps. To geolocate conceptual maps, political or satellite paper maps can be usedto situate the program in a larger geographic context. These should not be undervalued, as they can provide a cost-effective way to show geographic relationships between local health facilities, schools religious sites, clean water, and other community resources.

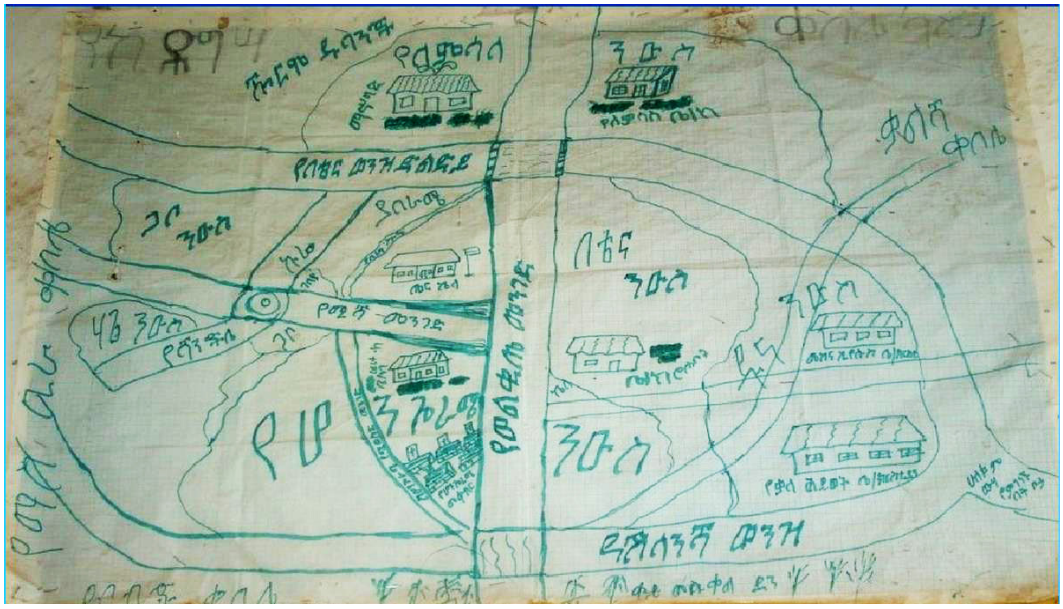

Figure 4: Example of a hand drawn map.

GIS

GIS allows for interactive data visualization and straight forward addition of new data. At the most basic level, Google Maps can be used. ArcGIS is the most commonly used and sophisticated GIS software. QGIS is an open source strong alternative.

A GIS system creates the opportunity to integrate of program data with data from other sources including administrative boundaries, health facility information, roads and hydrology, census data on population and poverty additional health information from surveillance or survey efforts. When operating at small scale in high detail, much of the additional value a GIS provides is lost if this information such information is unavailable and cannot be easily created from

existing paper maps. At the very least, administrative boundaries and key roads are necessary to contextualize the programmatic or community data.

While open source GIS software has developed to the point where software cost should not be a limiting factor, a GIS requires funds set aside for training and payment of a GIS user with access to a computer with consistent electricity. Further, if indicator information is not already being converted to an electronic format, a data entry staff member might be needed. During the initial set-up, the GIS user will likely dedicate 100% of their time to managing data collection and integration of the electronic data with the GIS. Once the project is running, depending on its scope, the GIS user might expect to spend between 50% and 100% of his/her time managing new data, updating old maps, creating new maps, and conducting basic data analysis efforts.

Hybrid Maps

Community maps can be produced in an iterative process moving between paper maps and a geographic information system. Investing in developing a GIS map can be a longer process in which paper maps are used to pilot the feasibility and usability of maps. Many community mapping exercises utilize a variety of methods to produce the final maps. While the community may feel most comfortable with paper maps, the research may be able to verify their input using a GPS device or by digitizing the paper maps produced by the community. There are innumerable ways to combine mapping technologies to incorporate users of different skills and knowledge in creating one map.

4. Analysis and Information Use

In combination with other analysis techniques, maps can be used for advocacy, planning, monitoring and evaluation, as mentioned earlier. From the perspective of the community, the maps can often serve as advocacy tools identifying gaps in services and inequitable distribution of resources. From the perspective of an M&E officer working with community based programs, the maps can provide an instant over-view of current progress of all programs at a highly disaggregated level. Maps may be preferable to tables and charts when geography is important or the number of services being offered is too large to include in a graph. Mapping allows us to visualize, better understand, and communicate indicators representing local data to a variety of stakeholders.

Resource Allocation

Mapping communities and community based programs allow program managers to leverage local knowledge and better understand the context their programs are operating in. Maps may show gaps in coverage, or areas with duplicate efforts, allowing better resources allocation.

Create a Local Advocacy Tool

Mapping of community health activities allows those working at the community level to visualize their activities or assess potential health needs in the community. By visualizing community activities and health data, those working in the community are equipped with a strong tool to make program decisions and advocate for specific health needs within the larger health system. This visualization helps to inform key audiences and stakeholders. Increasing communication and data flow equips policy makers with accurate information to effectively respond to community health needs; it also empowers communities to advocate for their needs.

Advocate More Globally: Putting Your Program on the Map

The advent of internet base based mapping, such as ArcGIS Online, has driven both the demand and value of being able to put information in a map. Unless people know who you are, where

you are, and what you are doing, then you are unlikely to be at the table when decisions are being made that your affect program and also been able demonstrate the value of your program.

Connect Community Programs with facility health services

Mapping both community programs and health facility services creates the opportunity for more structured synergy between them. Community programs can better identify where to refer patients for additional follow-up, and health facility managers can identify community programs which may be willing to support outreach efforts.

Example: Defining Community Boundaries to Target Services

"Participatory mapping and transect walks were used to inform the research and intervention design and to begin building community relations in preparation for Project Accept, a community-randomized trial sponsored by the National Institute of Mental Health. Project Accept is being conducted at five sites in four countries: Thailand, Zimbabwe, South Africa, and Tanzania. Results from the mapping exercises informed decisions such as defining community boundaries and identifying appropriate criteria for matching community pairs for the trial as well as where to situate the services. The mapping also informed intervention-related decisions such as where to situate the services" (Maman et al., 2009).

Ethics

Other articles and reviews provide detailed discussions of ethics in community mapping efforts (Rambaldi, Chambers, McCall & Jefferson, 2006). Briefly, when mapping community-level data, project managers should consider informed consent, protection of human subject data (confidentiality), sensitivity to vulnerable populations, and how the maps will serve the community. These issues reflect the increased granularity geospatial data at the community level provides, the consequent data burden on the community, the risk of disclosure of sensitive personal information, and how maps may portray the community to outside audiences.

Informed Consent

Who in the community is being mapped?
Are they aware and engaged in the mapping process?
Have they given permission for the project to collect the data?
Do they understand how the data will be used?

Confidentiality

Collecting sensitive health information can help produce maps that can improve the overall health system. Mapping experts and community members are equally concerned with protecting the privacy of health information during the mapping of community-based activities. It is critical to build in protections for sensitive data. In some cases this might mean creating separate maps to be shared with separate audiences.

Vulnerable Populations

Identifying vulnerable populations is a challenge for any health program. Community mapping creates an opportunity for researchers and health practitioners to engage the community to identify community members that are often stigmatized and excluded from formal health structures. Collecting personal data from such groups requires heightened concerned of privacy. Garnering participation can also be challenging. A map typically simplifies a complex

environment to communicate it to others. It is important to ensure the perspectives of vulnerable populations in the community are reflect in the map to provide them with adequate voice in representing themselves—especially when the maps are used to stake claim to resources.

Community Results

While appropriate community engagement can play a mitigating role, collecting GIS information about a community program can be seen as invasive. We encourage continuing to engage the community at all stages in the mapping process—from data collection through analysis and information use.

Example: Using Confidential Health Data Map to reach underserved populations

The Iringa, Tanzania mapping exercise demonstrated the role community informants play in identifying HIV-transmission hotspots and gaps in service coverage in Iringa. "Street leaders and village leaders are knowledgeable about the area," according to Yohana Mapala of MEASURE Evaluation. While these community members listed locations where people meet new sexual partners, health facility supervisors mapped out the reach of ongoing local HIV outreach efforts. Verbal informed consent was sought from each of these key informants. Maps integrating both sets of data are being used by health officers to better position health workers to reach underserved populations, strengthen linkages where needed and minimize duplication of resources.

Key Challenges

In addition to resources, community engagement, building a culture of data use, and other issues discussed in this document, there are several other challenges worth mentioning or re-emphasizing.

Data Ownership

The ownership of the data collected through a community mapping process is complicated both legally and logistically. As the information is captured through community engagement, the community may feel ownership over the resulting maps. This may be beneficial for community buy-in, but may present challenges when collecting sensitive health information. In collaboration with the community and local health officials, clearly define who will have access and maintain ownership of the data during and after the mapping exercise.

In cases where data ownership must remain with an outside entity or when protecting sensitive information of community members is needed, there are mapping techniques to obscure this sensitive information while being able to create an informative map for distribution. The maps produced can limit the level of detail viewed by users. For example, disease diffusion maps can aggregate analysis to small geographic areas rather than to specific households or locations, in order to protect participants. The maps distributed to the community could share community resources and local knowledge without sharing specific health information.

Bias and Data Quality

Any data source may have quality issues. Reported data may be incomplete or may be subject to double counting. Indicators need to be well defined and collectable. Community maps may rely on key informants, which carry their own biases and misrepresentations. Acknowledging for these biases and misrepresentations will help produce an actionable map.

Conclusion

In conclusion, maps can be powerful tools for sharing information and mobilizing support from within a community or from outside stakeholders. Data collection and mapping techniques must be tailored to the data required for the targeted audience. While donors or national level stakeholders may require a general sense of what regions contain what ongoing efforts and are seeing what progress, program managers will need more granular data to guide resource allocation and plan continuing activities. While more time and resource intensive than collecting and reporting aggregate data, community-based mapping techniques carry the added value of incorporating local perspectives on community activities, and may be helpful for further refining project goals to meet needs perceived by the community.

References

Ansumana R, Malanoski AP, Bockarie AS, Sundufu AJ, Jimmy DH, Bangura U, Jacobsen KH, Lin B, Stenger DA. Enabling methods for community health mapping in developing countries. *Int J Health Geographics*. 2010;9(1):56. Doi:10.1186/1476-072X-9-56.

Azim T. Mapping communities for health in SNNPR Ethiopia. An ICT solution &a community-based solution [slide presentation]. Presented July 30, 2012 at Workshop on Mapping Community Based Global Health Programs for M&E. Accessed 22 July 2013 at http://www.slideshare.net/measureevaluation/mapping-communities-for-health-an-ict-solution-and-a-local-communitybased-solution-in-snnpr-ethiopia.

Baum S, Kendall E, Muenchberger H, Gudes O, Yigitcanlar T. Geographical information systems: an effective planning and decision-making platform for community health coalitions in Australia. *HIM J*. 2010;39(3):28–33.

Beyer KMM, Comstock S, Seagren R. 2010. Disease maps as context for community mapping: a methodological approach for linking confidential health information with local geographical knowledge for community health research. *J Comm Health*. 2010;35(6):635–644. Doi:10.1007/s10900-010-9254-5.

Broenner C, Morris L. ICT in conflict & disaster response and peacebuilding [Web page]. Accessed 19 July 2013 at https://ict4peace.crowdmap.com/.

Chaulagain M. Mapping for informed decision making and strengthening project M&E: lessons and challenges from the experience of FHI360 Nepal [slide presentation]. Presented July 30, 2012, Workshop on Mapping Community Based Global Health Programs for M&E. Accessed 22 July 2013 at http://www.slideshare.net/measureevaluation/mapping-for-informed-decision-making-and-strengthening-project-me-lessons-and-challenges-from-the-experience-of-fhi-360-nepal#btnNext.

Chirowodza A, van Rooyen H, Joseph P, Sikotoyi S, Richter L, Coates T. Using participatory methods and geographic information systems (GIS) to prepare for an HIV community-based trial in Vulindlela, South Africa (Project Accept–HPTN 043). *J Comm Psych.* 2009;37(1):41–57. Doi:10.1002/jcop.20294.

Clarke G. Agents of transformation? donors, faith-based organisations and international development. *Third World Quart*. 2007;28(1):77–96. Doi:10.1080/01436590601081880.

Dickerson C, Grills N, Henwood N, Jeffreys S, Lankester T. The World Health Organization engaging with civil society networks to promote primary health care: a case study. *Global Health Gov.* 2012;VI(1). Accessed at http://blogs.shu.edu/ghg/2012/12/31/volume-vi-issue-1-fall-2012/.

Dongus S, Nyika D, Kannady K, Mtasiwa D, Mshinda H, Fillinger U, Drescher AW, Tanner M, Castro MC, Killeen GF. Participatory mapping of target areas to enable operational larval source management to suppress malaria vector mosquitoes in Dar Es Salaam, Tanzania. *Int J Health Geographics*. 2007;6(1): 37. Doi:10.1186/1476-072X-6-37.

Dulin MF, Ludden TM, Tapp H, Blackwell J, de Hernandez BU, Smith HA, Furuseth OJ. Using geographic information systems (GIS) to understand a community's primary care needs. *JABFM*. 2010;23(1):13–21. Doi:10.3122/jabfm.2010.01.090135.

Dunn, C. Participatory GIS—A People's GIS? *Prog Hum Geogr*. 2007; 31(5). Doi: 10.1177/0309132507081493

Edwards J, Weir S, Walker D, Kibao Z, Masako P. PLACE-lite: a method to Identify gaps in HIV prevention coverage in Iringa, Tanzania [poster session]. International AIDS Conference, 2012, July, Washington, DC. Accessed at http://pag.aids2012.org/Abstracts.aspx?AID=19555.

Emmanuel F, Blanchard J, Zaheer HA, Reza T, Holte-McKenzie M. 2010. The HIV/AIDS Surveillance Project mapping approach: an innovative approach for mapping and size estimation for groups at a higher risk of HIV in Pakistan. *AIDS*. 2010;24(Suppl 2):S77–S84. Doi:10.1097/01.aids.0000386737.25296.c4.

Gates B. Digital mapping technology helps polio vaccinators zero in. *The Gates Notes* [Internet blog]. November 5, 2012. Accessed at http://www.thegatesnotes.com/GatesNotesV2/Topics/Health/Digital-Mapping-Technology-Helps-Polio-Vaccinators-Zero-In?WT.mc_id=11_7_2012_DigitalMapping_fb&WT.tsrc=Facebook.

Goodchild MF. Citizens as sensors: the world of volunteered geography. In: *The Map Reader*, (eds.) Dodge M, Kitchin R, Perkins C. Hoboken, NJ: John Wiley & Sons, Ltd.;2011:370–378. Accessed at http://onlinelibrary.wiley.com/doi/10.1002/9780470979587.ch48/summary.

Hagen E. Map Kibera: methods for citizen engagement in mapping and reporting [presentation slides]. Workshop on Mapping Community Based Global Health Programs for M&E, July 2012. Accessed 19 July 2013 at http://www.slideshare.net/measureevaluation/map-kibera-methods-for-citizen-engagement-in-mapping-and-reporting.

Joint United Nations Programme on HIV/AIDS. *Supporting Community Based Responses to AIDS, TB and Malaria: A Guidance Tool for Including Community Systems Strengthening in Global Fund Proposals*. Geneva, Switzlerland: Joint United Nations Programme on HIV/AIDS; 2010. Accessed 22 July 2013 at http://data.unaids.org/pub/BaseDocument/2010/201007_unaidscss_en.pdf.

Kenya AIDS NGOs Consortium. KANCO map of AIDS and TB service organizations [Web page, 2009]. Accessed 22 July 2013 at http://kanco.ushahidi.com/main.

Lux S, Greenaway K. *Scaling up Effective Partnerships: A Guide to Working with Faith-Based Organisations in the Response to HIV and AIDS*. Geneva, Switzerland: Ecumenical Advocacy Alliance; 2006.

Maman S, Lane T, Ntogwisangu J, Modiba P, Vanrooyen H, Timbe A, Visrutaratna S, Fritz K. 2009. Using participatory mapping to inform a community-randomized trial of HIV counseling and testing. *Field Meth*. 2009;21(4):368–387. Doi:10.1177/1525822X09341718.

Mapala Y. Experience with community-based mapping: Iringa, Tanzania [slide presentation]. Presented July 30, 2012, Workshop on Mapping Community Based Global Health Programs for M&E. Accessed 22 July 2013 at http://www.slideshare.net/measureevaluation/experience-with-communitybased-mapping-iringa-tanzania.

MEASURE Evaluation. Community-Level Program Information Reporting for HIV/AIDS programs [Web page]. Chapel Hill, NC: MEASURE Evaluation, 2012. Accessed 23 May 2013 at http://www.cpc.unc.edu/measure/tools/hiv-aids/clpir.

MEASURE Evaluation. Report of a technical consultation on information systems for community-based HIV programs [workshop summary]. Chapel Hill, NC: MEASURE Evaluation; 2010. http://www.cpc.unc.edu/measure/publications/ws-10-15.

Merkel S, Otai J, Archer L, Lynam P. *Making Comprehensive Care for HIV a Reality in African Urban Slums: Linking Health Providers and Community Members to Optimize Health Care for HIV/AIDS: Best Practices and Lessons Learned from a Two-Year Program in the Slums of Nairobi, Kenya*. Baltimore, MD: Jhpiego; 2008.

Muhe L. *Community Involvement in Rolling Back Malaria*. Geneva, Switzerland: Roll Back Malaria, World Health Organization; 2002.

Rambaldi G, Chambers R, McCall M, Fox J. 2006. Practical ethics for PGIS practitioners, facilitators, technology intermediaries and researchers. *Participatory Learn Action*. 2006;54 106–113.

Ricketts TC: Geographic information systems and public health. *Annu Rev Public Health* 2003, 24:1–6.

Shkabatur J. How-to notes, getting on the map: a community's path to better services, draft. [unpublished]. Washington, DC: The World Bank; June 2012. Accessed 22 July 2013 at http://blogs.worldbank.org/ic4d/call-for-feedback-how-to-note-on-community-mapping-for-better-services.

Sieber R. Public participation geographic information systems: a literature review and rramework. *Annals Assoc Amn Geographers*. 2006;96(3):491–507. Doi:10.1111/j.1467-8306.2006.00702.x.

Singh J, Shah P. *Operational Manual for Community Based Performance Monitoring*. Banjul, The Gambia: World Bank [USA], Department of State for Finance and Economic Affairs [The Gambia]; 2004. Accessed 19 July 2013 at http://siteresources.worldbank.org/INTPCENG/1143333-1116505690049/20509292/CSCmanual.pdf.

Tanser FC, Le Sueur D. The application of geographical information systems to important public health problems in Africa. *Int J Health Geographics*. 2002;1(1):4.

The Global Fund To Fight AIDS, Tuberculosis and Malaria. *Community Systems Strengthening Framework.* Geneva, Switzerland: The Global Fund To Fight AIDS, Tuberculosis and Malaria; 2010. Accessed 19 July 2013 at http://www.who.int/tb/dots/comm_hss.pdf.

The Global Polio Eradication Initiative. Nigeria: new technology helps reach more children with life-saving polio vaccine [media release]. Geneva, Switzerland: The Global Polio Eradication Initiative; 20 December 2010. Accessed 22 July 2013 at http://www.polioeradication.org/tabid/167/iid/83/Default.aspx.

Todd S, Brubaker G, Chand S, Franzén C, Hafner C, Kimambo A, Pamba P. Human resources-geographical information systems data development and systems implementation for the Christian Social Services Commission of Tanzania [final report]. Chapel Hill, NC: The Capacity Project, IntraHealth International; 2009.

U.S. Agency for International Development (USAID). Development credit authority loan data [Web page]. Washington, DC: USAID; 2013. Accessed 22 July 2013 at http://www.usaid.gov/results-and-data/progress-data/data/dca.

Welle K, Wicken J. 2008. Mapping as a basis for sanitation implementation in Pakistan: the case of the Orangi Pilot Project. In: *Beyond Construction: Use by All: A Collection of Case Studies from Sanitation and Hygiene Promotion Practitioners in South Asia*. London, United Kingdom: WaterAid and Delft, The Netherlands, IRC International Water and Sanitation Centre; 2008. Available at http://www.irc.nl/page/40450.

World Health Organization. *WHO-CIFA Consultation: NGO Mapping Standards Describing Religious Health Assets. Health Partnership Series*. Bogis-Bossey, Switzerland: WHO Programme on Partnerships and UN Reform; 2009.

Illustrative Community Engagement Techniques for Mapping Community-based Health Activities

This list is an adaptation from the International Institute for Environment and Development's Mapping for Change: Practice, Technologies, and Communication (Rambaldi et al., 2006) with additional contributions from a literature review of community-based mapping. Creating maps of community-based activities requires a technique of engagement to capture local geographic knowledge. The following community engagement techniques are illustrative of methodologies used by mapping practitioners to partner with communities and gather community information for mapping.

Community health assessments are used to identify and address health issues in a given population. Effective CHA requires timely and comprehensive information from a wide variety of sources, such as: socio-economic data, disease surveillance, healthcare utilization, environmental data, and health resource allocation.

Free mapping, where community members draw maps of their community highlighting what they find important. This allows the analyst to 'see' the community from their perspective and gives a sense of components like the difference between the geographic distance to a health center and the perceived or culturally important distance.

Key informant interviews are used in the mapping of community-based activities to gain first-hand knowledge from community members who best understand the community. The purpose of key informant interviews is to capture information from community experts who can provide insight on community problems and potential solutions. In the relationship to mapping, key informants help to define the reach of the community and provide key health information such as locate vectors of disease and community health resources.

Community drive mapping includes **countermapping** and **participatory GIS:** Community drive mapping refers to the wealth of literature of countermapping and participatory GIS. Counter-mapping refers to "how maps could be used by communities to represent themselves and stake claims to resources" (Sieber, 2006; Dunn, 2007). Participatory GIS (PGIS) is "a variety of approaches to make GIS and other spatial decision-making tools available and accessible to all those with a stake in official decisions" (Sieber, 2006). The goal of PGIS and countermapping is to democratize spatial governance.

"Community based organizations use PGIS to capture organizational knowledge and experience, develop networks of collaborative relationships, and investigate organizational priorities, strategies, and status" (Sieber, 2006). PGIS methodologies present various challenges to implementation. The PGIS methodologies are imbued with skill levels and group relationships that may not be relevant in another setting. Context is key. Laws, culture, politics, and history of the community, city, region, or nation all shape the output of PGIS. PGIS often faces poorly defined objectives, which affect the utility of the mapping outcomes.

PPGIS (Public Participation GIS) is an intersection of participatory planning and geographic information technologies and systems (Sieber, 2006). In inner cities and indigenous communities where technical competency and cost have been barriers to GIS implementation, PPGIS applications occur within several organizational arrangements including: community-university partnerships with inner city communities; grassroots social organisations; and Internet-based PPGIS. These organizations combine GIS with a host of modern communication technologies to facilitate dialogue and data usage among local groups.

Illustrative Geospatial Data Collection Tools

There are geospatial data collection tools for every level of budget and skills. Below are a few examples of tools mentioned throughout the guidance document.

GPS Devices: GPS devices use global positioning signals to capture the latitude and longitude location of the device. These tools are useful in remote locations and when GPS accuracy is essential for your data collection (when geospatial analysis like distances will be required).
Smart Phones: Most smart phones contain the ability to capture GPS points. Smart phones are particularly helpful for capture GPS points and conducting surveys electronically when coupled with tools such as Open Data Kit or Episurveyor (tools with electronic survey administration and aggregation capability).

Paper maps: Paper maps can refer to hard copy maps or hand drawn maps. In many locations, paper maps provide an easy, low cost methodology for engaging communities in mapping their health. As technology may be off-putting to some, this low barrier method can engage more people. In particular, the site Walking Papers allows user to enter their location and receive a printable OpenStreetMap.

Hybrid Method: Many community mapping exercises utilize a variety of methods to produce the final maps. While the community may feel most comfortable with paper maps, the research may be able to verify their input using a GPS device or by digitizing the paper maps produced by the community. There are innumerable ways to combine mapping technologies to incorporate users of different skills and knowledge in creating one map.
Geocoding and digitization: Based off printed maps, satellite imagery, lists with administrative boundaries.

Crowd Sourcing and Volunteered Geographic Information: As the technology for geocoding and uploading geographic information becomes more ubiquitous, crowd-sourced or volunteered geographic information has become another source of geographic data. In open crowd-sourced effort, any individuals can upload their own geographic information or 'tag' existing information online. In a closed system, the ability to provide information is limited to a set of authorized users. (Goodchild, 2011)

Visualizing Your Community—Geospatial Data Mapping Methodologies

Mapping methodologies for community-based activities create the visual output from community engagement mapping activities. Each mapping methodology requires different skill levels and cost considerations. Ultimately, the selection of a mapping methodology defines who will have access to and utilize the output of a community-based mapping exercise.

Community Information Systems (CIS) are map-based multimedia information systems in which local knowledge is documented by community members using digital video, digital photos and written text, stored on computers and managed and communicated through the interface of an interactive map.

Ephemeral map: A temporary map such as a ground map. Intended to be kept for a short time only. This most basic mapmaking method consists of drawing maps on the ground. Informants use raw materials like soil, pebbles, sticks and leaves, to reproduce the physical and cultural landscapes in the manner they perceive them to be. Such ephemeral maps disappear in a puff of wind. Acquired knowledge is isualize by participants and mentally recomposed when needed (Rambaldi et al., 2006).

Sketch map: A method for mapping on paper. A drawing of a place or area, not drawn with accurate or measured scale or direction. Features are depicted by the use of natural materials or more frequently by coloured marker pens or chalk. Participants usually have a range of choices regarding what materials to use for the drawing and how to Visualize desired items. Features are exaggerated in size to match the importance participants attach to them. If properly facilitated, the process is documented and records are kept in terms of the keys necessary for interpreting depicted symbols. The lack of a consistent scale and geo-referencing of the data leaves room for subjective interpretation of the final map. A scale sketch map is a sketch given scale by fitting it onto a topographic map without a field survey (Rambaldi et al., 2006; Dongus et al., 2007).

Scale mapping: More sophisticated method of sketch mapping, aimed at generating geo-referenced data to facilitate discussions and allow community members to develop maps that can stand the scrutiny of adversarial parties. The method is based on effective selection of symbols and colours for depicting indigenous spatial knowledge on transparencies superimposed on a geo-coded and scaled map (Rambaldi et al, 2006).

- *Photomaps:* are a subset of scale mapping in which printouts of geometrically corrected and geo-referenced aerial photographs (orthophotographs). Orthophoto-maps are a source of accurate, remotely sensed data that may be used for large-scale community mapping projects. The information may be digitized.
- *Participatory 3D Modelling (P3DM):* This method integrates indigenous spatial knowledge with data on elevation of the land and depth of the sea to produce stand-alone, scaled and geo-referenced relief models. It is typically used for researching agriculture and has been specifically helpful in analyzing watersheds.

Illustrative Geospatial Visualization Programs

There are innumerable GIS software packages that can be used to visualize community health maps. The following is an illustrative list of software packages that have been recommended by public health practitioners, and is not intended to be exhaustive. Many are free, and open source which will allow new mappers to experiment with GIS software.

Program	Description	For More Information
DIVA-GIS **DIVA**	DIVA-GIS is a free computer program for mapping and geographic data analysis (a geographic information system (GIS). With DIVA-GIS you can make maps of the world, or of a very small area, using, for example, state boundaries, rivers, a satellite image, and the locations of sites where an animal species was observed. We also provide free spatial data for the whole world that you can use in DIVA-GIS or other programs.	http://www.diva-gis.org/
 **Q GIS**	Quantum GIS (QGIS) is a powerful and user friendly Open Source Geographic Information System (GIS) that runs on Linux, Unix, Mac OSX, Windows and Android. QGIS supports vector, raster, and database form ats. QGIS is licensed under the GNU Public	http://www.qgis.org/
esri **ArcGIS**	Our technology enables organizations to create responsible and sustainable solutions to problems at local and global scales. At Esri, we believe that geography is at the heart of a more resilient and sustainable future. Governments, industry leaders, academics, and nongovernmental organizations (NGOs) trust us to connect them with the analytic knowledge they need to make these critical decisions that shape the planet.	http://www.esri.com/
MapBox **Mapbox**	MapBox helps you design beautiful maps and publish them across the web and mobile devices at scale. Our open source tools and cloud infrastructure are the base of a new kind of platform, making maps more social.	http://mapbox.com/
 **Google Earth/Google Map**	Google Maps is a Google service offering powerful, user-friendly mapping technology. Google Maps is a map service that you view in your web browser.	https://maps.google.com/
 OpenStreetMap The Free Wiki World Map **OpenStreetMap**	A rights-free map of the world being created by volunteers using copyright free sources and GPS tracks. Includes an interactive map and details of how to get involved. OpenStreetMap is a wiki-style map of the world that anyone can edit. In some places, participants are creating the first freely-available maps by GPS survey.	http://www.openstreetmap.org/

MEASURE Evaluation

Carolina Population Center
University of North Carolina at Chapel Hill
400 Meadowmont Village Circle, 3rd Floor
Chapel Hill, NC 27517

www.measureevaluation.org