Health GIS Tools and Applications
Informing Decisions in Yemen

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Abstract:

The USAID-funded Partners for Health Reform*plus* Project (PHR*plus*) is assisting five underserved and remote governorates in Yemen to improve their health care systems using evidence-based GIS decision tools based on accurate health and spatial information. Several health GIS applications have been developed to optimize the best available demographics, cleaned and enhanced GIS base map data layers, health facility survey results, and accurate health statistics and household health survey information. These customized GIS tools are improving the capacity of Ministry of Public Health and Population and governorate health office officials to visualize, understand, and make decisions more easily. Integration of these data into a relational database with a GIS interface facilitates efficient use of limited resources for improving health care in the predominately rural areas of Yemen. Four state-of-the-art health GIS applications will be described and demonstrated, namely: (1) health facility viewer: combining a map and health statistics for a health facility with digital images of exterior and interior conditions; (2) health facility targeting: using GIS to screen and/or target health care program interventions based on selection criteria; (3) health care accessibility: determining appropriate access to health facilities based on mode of transportation, road and trail conditions, terrain, and distance; and (4) health risk index: locating populations at risk to waterborne and communicable diseases associated with poor access to clean water and inadequate sanitation systems. These GIS applications demonstrate sophisticated use of health information to enhance facility utilization, improve distribution of preventive and curative care, and provide evidence-based rationale for targeted assistance and service delivery. Additionally, the health GIS may advance decentralization of selected aspects of decision-making and health reform authority.

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Introduction

The USAID-funded Partners for Health Reform*plus* Project (PHR*plus*) is working in five underserved governorates in Yemen (Al Jawf, Amran, Marib, Saada, and Shabwa) to improve health care systems and the quality of health data for planning and management at the district, governorate, and national levels. As part of this strategy, extensive efforts have been undertaken to collect, improve, and integrate the growing amount of spatial data and health statistics currently available in Yemen from government agencies and donor organizations. The PHR*plus* Project has also been involved in new data collection efforts, including working with the Ministry of Public Health and Population (MoPHP) to implement a detailed health facility survey in the five USAID-targeted governorates, as well as piloting facility-based health information systems (HIS) to collect and utilize patient encounter data and accurate registry statistics at the point of service.

A key goal of this effort is to ensure that the growing collection of high quality health data can be easily integrated into a central health GIS, allowing government agencies and donor organizations to derive added value from the synthesis of their own health data with the spatial and health data developed by others. To this end, the PHR*plus* Project is promoting the development and adoption of a geographic coding system that will permit rapid linkage of spatially-enabled health data at any geography (health facility, village, district, governorate) to the base GIS files. By incorporating these standard geographic codes into their files, different agencies and organizations will be able to "plug in" their current and future data sets, and play a role in the on-going development and expansion of health-sector GIS capabilities in Yemen.

Health GIS Applications

As health data from surveys, government statistics, and donor projects are linked into the system, an expanding set of customized health GIS applications are being developed that utilize the best available demographics and the cleaned, georeferenced, and enhanced GIS base map data layers[1]. These GIS tools are improving the capacity of MoPHP and governorate health office officials to visualize, understand, and make decisions more easily. Integration of these data into a relational database with a GIS interface facilitates efficient use of limited health care resources through encouraging data sharing and reducing duplication of effort among different Yemen health-focused agencies and organizations.

GIS-driven applications are being developed for a variety of end users, including those with no specific GIS training. The aim is to bring the benefits of GIS to as wide an audience as possible.

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[1] Original base map data sets used by the PHR*plus* Project were taken from the Yemen Central Statistical Organization (CSO), the Social Fund for Development, and the Yemen Survey Authority.

On the basic level, the GIS can provide map-based ("point and click") access to view information about a particular feature, such as a district or facility, while more advanced users can employ spatial analysis techniques to answer questions related to their health-sector concerns.

Some initial applications are described below. The first three applications demonstrate how the results from the GPS-enabled MoPHP Health Facility Survey are being used as both a basic information tool, as well as an analytical tool that can inform decision-making. The final application shows how health sector-relevant information provided by an organization (in this case, the Yemen Ministry of Planning) is incorporated into the GIS to yield added-value information about targeting resources to reach populations subject to potential environmental health risks.

Health Facility Viewer

The *health facility viewer* (see Exhibit 1) is an informational tool that is available to users with no specific GIS knowledge. It provides a user-friendly interface for viewing the results of the MoPHP Health Facility Survey through map-based navigation. The survey gathered three types of information: the GPS coordinates of the facility, digital photographs of the building's exterior and interior conditions, and information on the facility's staff, conditions, available services, utilities, and financing.
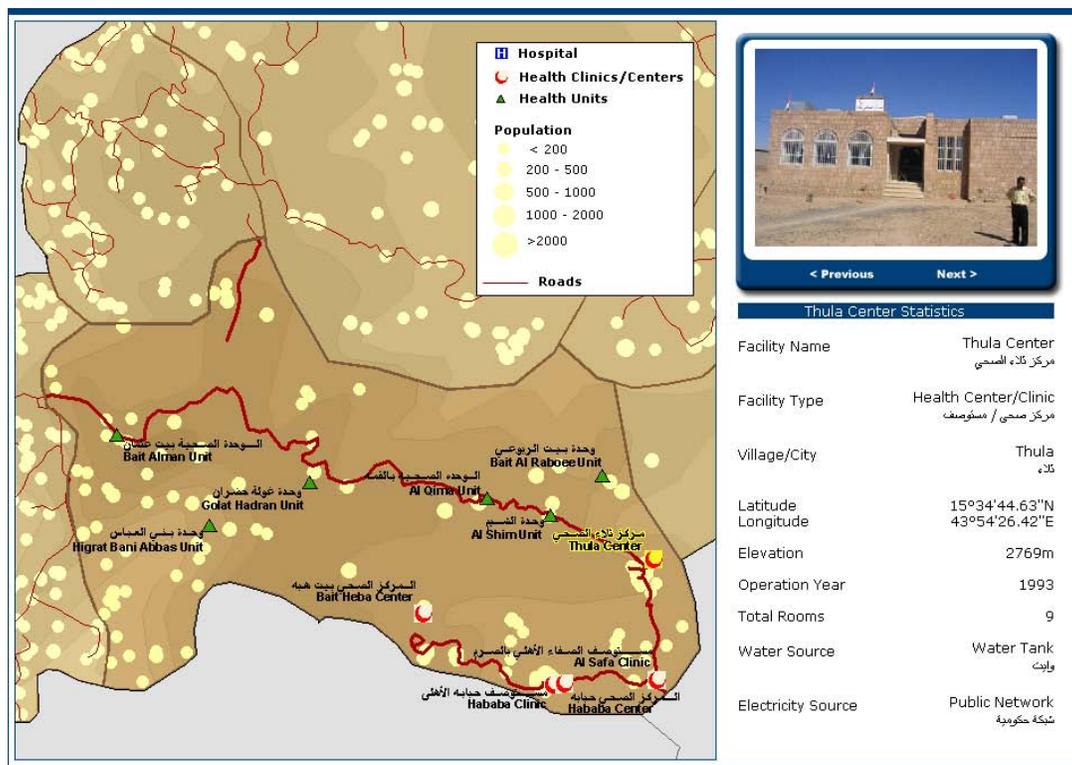

Exhibit 1. Snapshot of the Prototype Health Facility Viewer

The user can zoom into a district of interest, and then use the map to select a facility (hospital, health center, or health unit). This pulls up the survey information for that facility, including a 'photo viewer' that allows the user to flip through the set of facility photos gathered during the survey, as well as tables of information and statistics about the particular facility. At any time, the user can step back to select a different facility within the district, or view a new district.

District and Governorate health office (DHO and GHO) officials are able to query and examine the conditions, status, and needs of all health facilities under their management. In the past, remote access to and inaccurate reports from health facilities has inhibited DHOs and GHOs ability to plan and budget according to the specific needs of each facility. The *health facility viewer* provides a baseline assessment of each facility and provides evidence-based rationale for future facility-based health care service availability, equipment, staffing, and other decisions.

The *health facility viewer* is being developed as a standalone product that does not require users to have expensive GIS software on their own computers. It is being implemented in Flash and HTML, so it is adaptable to the web, but can also be delivered on a CD-ROM and run locally on a desktop PC without internet access.

Facility Targeting

The MoPHP Health Facility Survey has generated up-to-date information on the current conditions and services offered at Yemeni health facilities. By incorporating this information into a GIS, decision makers can not only see where all facilities are located, but also focus in on a subset of facilities that meet a certain criteria (e.g., facilities that offer immunization services, or have an electricity source available to run equipment). This "filtering" approach helps decision makers better understand how localized populations are currently being served.

For example, a map that displays all facilities in a populated region may, on first glance, appear to offer adequate service coverage in the local area. However, the accurate picture may be different, once filters are applied to show only facilities that are fully functioning and staffed with a trained health care provider. For another example, if a donor organization is able to provide new equipment to several health facilities, the GIS can help them quickly identify which facilities are optimal candidates for this support by locating only those facilities that have electricity (see Exhibit 2) and serve the largest population catchments. The filtering approach helps decision makers target specific health centers or populated regions for interventions, improvements, or new programs. Mapping the spatial distribution of particular facilities relative to populated areas provides analysts with an easy way to visualize and target areas of need.
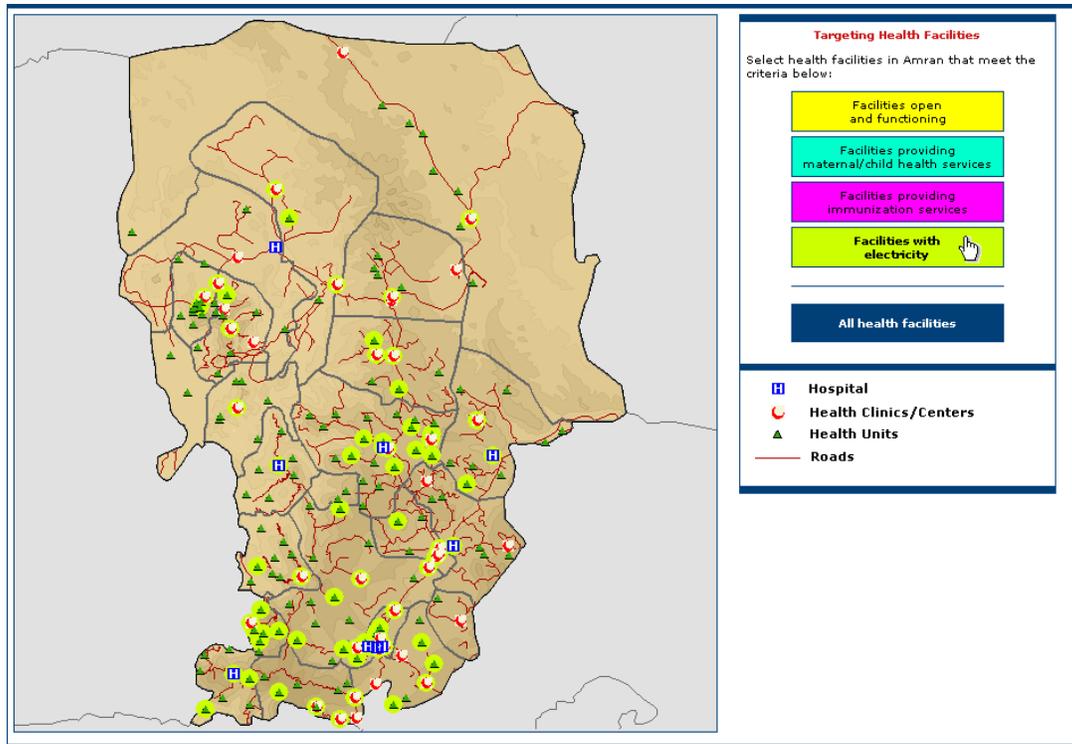
Exhibit 2. Targeting Health Facilities with Electricity

Health Care Accessibility

Ensuring adequate access of rural populations to health care is an important goal of health systems strengthening in Yemen. Integrating the GPS-enabled Health Facility Survey into a GIS gives decision makers instant access to critical information. Facility locations can be displayed along with the existing road network, the complexity of the terrain, and other geographic features that may assist or prohibit access to a particular location. The prototype health care accessibility GIS application developed for Yemen estimates accessibility based on distance alone (see Exhibit 3). The PHRplus Project is currently developing a three-tiered approach to measure accessibility based on time-travel estimates to account for the unique needs of Yemen's rural population, particularly those that live in mountainous terrain or outlying areas with minimal road networks. In Yemen's rural areas, most people travel by foot, thus pedestrian access to health facilities is the first accessibility tier. The second accessibility tier is equal to the spatial extent to which health care workers based at a facility can reach the surrounding population and the third accessibility tier is based on the reasonable travel time to the health facility using motorized transportation.

The travel time/distance measure capabilities of a GIS can assist decision makers in several ways. It can be used as an exploratory data analysis tool, answering questions, such as 'what is the average distance to a facility from a populated area?' Or, if a policy is aiming to ensure that all villages have access to health care within a particular distance, the GIS can be used to select populations that currently fall outside of a pre-determined 'suitable distance.' In this way, health

care planners can quickly determine populated areas that should be targeted for new facility construction or mobile clinic visits.
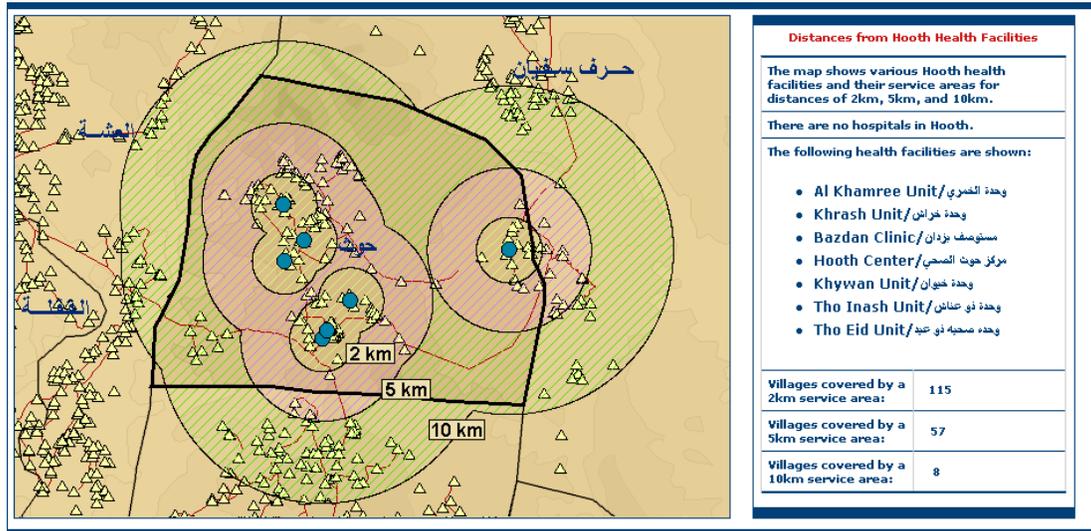

Exhibit 3. Health Care Accessibility Based on Distance Alone

Environmental Health Risk Mapping

The PHR*plus* Project is collecting and integrating data from many government sources, and creating applications that show how the health GIS can make use of these government statistics in new, innovative ways. For example, the Ministry of Planning (MoP) provided PHR*plus* with district-level data for the governorate of Shabwa, detailing the percentage of population with access to safe drinking water, as well as information on the percentage of population using various sanitation types (sewer system, closed pit, open pit, pipe to wadi, dry latrine, or nature). This information, combined with demographic data provided by the Central Statistical Organization (CSO), was used to calculate a water and sanitation health risk index (HRI) for each district in Shabwa (see Exhibit 4). In this manner, the HRI was based equally on two contributing factors, drinking water quality and the sanitation system available weighted according to type (i.e., sewer systems posed the least risk and no sanitation system posed the highest risk).

The HRI analysis results are easily visualized on the GIS's map interface. The HRI alone for each district is informative, however, using the GIS to weight the potential risk by the population distributed throughout each district adds increased value to the analysis. The three districts in Shabwa with the highest HRI (At'talih, Jirdan, and Markhah Al Alya) were not the same three districts with the highest populations at risk (Ataq, Jirdan, and Markhah Assufla). Integrating different sources of data into a population-weighted risk index gives health care professionals vital new information that helps them prioritize their intervention efforts by targeting the largest population area at high risk for waterborne and communicable diseases.
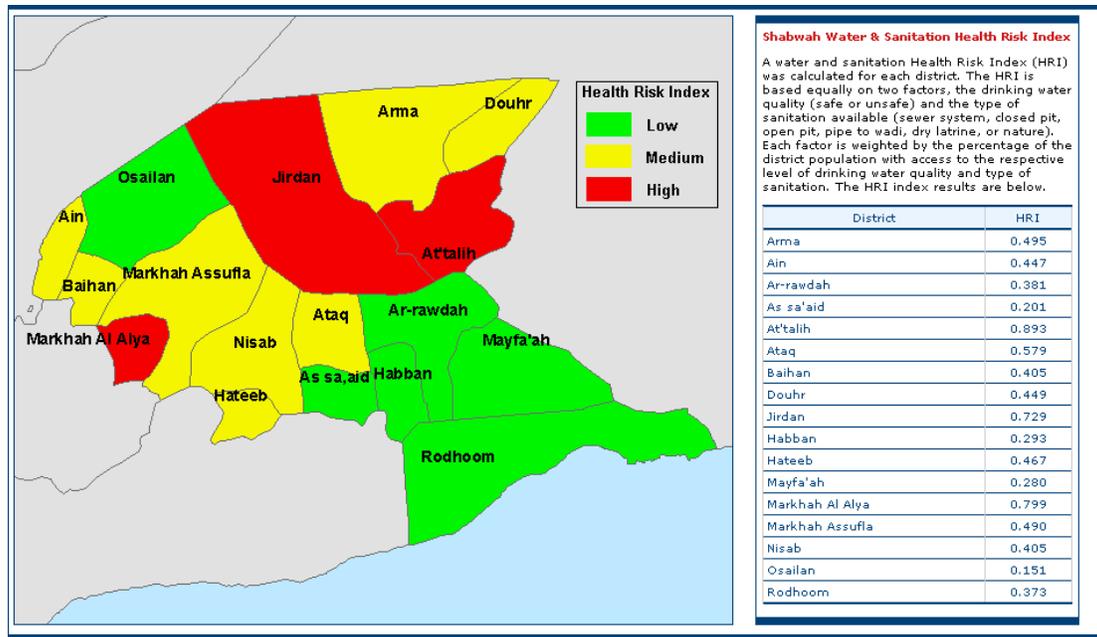
Health Risk Index
- Low
- Medium
- High

District	HRI
Arma	0.495
Ain	0.447
Ar-rawdah	0.381
As sa'aid	0.201
At'talih	0.893
Ataq	0.579
Baihan	0.405
Douhr	0.449
Jirdan	0.729
Habban	0.293
Hateeb	0.467
Mayfa'ah	0.280
Markhah Al Alya	0.799
Markhah Assufla	0.490
Nisab	0.405
Osailan	0.151
Rodhoom	0.373

Exhibit 4. Water and Sanitation Health Risk Index in Shabwa

Conclusion

Use of GIS in Yemen by the MoPHP and other decision-making organizations in the past has involved mostly preparation of maps to show the locations of specific features. However, the underlying data has not been reliable and inconsistent across the Yemen GIS user community. The PHR*plus* Project cleaned and enhanced GIS base map data layers to form the underpinnings for developing health-based decision tools and applications.

The PHR*plus* Project has been maximizing the use of accurate health data and spatial information to improve the health system in Yemen.   The tools and applications described in this paper highlight the important role spatial considerations can play when analyzed in combination with a comprehensive health facility database, demographic and population data, health information systems, and summary statistics. The four tools and applications specifically demonstrate sophisticated use of a health GIS to enhance facility utilization, improve distribution of preventive and curative care, and provide evidence-based rationale for targeted assistance and service delivery. Easy-to-use health GIS tools are being designed to assist governorate- and district-level officials with local health care decisions in support of the Yemen health sector strategy to promote health system decentralization.