

WATER-RESOURCES ASSESSMENT, MONITORING, AND CAPACITY BUILDING IN AFGHANISTAN

An overwhelming majority of the Afghan population lacks an adequate, safe supply of water because of contamination by a wide variety of sources, lack of water-resources management regulation, and lack of basic infrastructure, compounded by the recent 5-year drought and seasonal flooding. Overall objectives of the water-resources part of a U.S. Geological Survey (USGS) program in collaboration with Afghan officials and scientists are to assess the basic hydrology of Afghanistan, install a network of streamflow gages, create a water-quality monitoring program, assess water use in specific population centers, and build capacity of Afghan officials, scientists, and technicians.

Primary objectives of the water-resources part of the program are to:

- Work with Afghan officials to assess and understand the basic hydrology of Afghanistan on issues related to the relation between ground and surface water, ground-water sustainability, contamination of drinking water supplies, flood prediction and prevention, etc.;
- Help Afghan officials re-install a critical network of streamflow gages needed to provide early flood warning and to manage and effectively distribute the country's surface waters;

- Help Afghan officials to immediately begin a water-quality monitoring program to identify and protect safe sources of drinking water;
- Help Afghan officials to estimate the amount of safe water available for use in key population centers of Kabul, Mazar-e-Sharif, Herat, and Kandahar and to identify and document new and sustainable sources of clean water.

Activities have been carried out in close cooperation with Afghan water officials and international agencies in an effort to address immediate needs by starting to create a well-trained, self-sufficient, and sustainable water-resources sector in Afghanistan. The general approach includes:

- Building the capacity of local Afghan officials, scientists, and technicians to monitor, assess, and manage the water resources of Afghanistan;
- Providing training, equipment, and supplies;
- Strengthening existing institutions;
- Establishing a national water-quality laboratory;
- Developing a national water-resources database.

To meet the objectives of the water-resources program, a USGS multidisciplinary water team began several subtasks that include:

- Evaluation of ground water in Afghanistan;
- Characterization of the 1991 flood in the Helmand River Basin;
- A recovery of historic surface-water quantity data for the Helmand River;
- A hydrologic time-series analysis for the Helmand River;
- Installation and demonstration of a streamflow-gaging station;
- A Helmand River Basin ground-water assessment;
- Potential effects of changing glaciers on resources and hazards.



Evaluation of Ground Water in Afghanistan

The USGS is assessing ground-water resources in Afghanistan. A preliminary evaluation of the hydrogeologic and water-quality characteristics of the Kabul area ground-water system has been initiated. Training of Afghani's has occurred, and collection of ground-water well information, including measurements of water levels and water temperature, has begun. Also, water samples were collected and analyzed for bacteria, nitrate, and arsenic concentrations. USGS hydrologists have developed a series of maps showing well locations and properties, and hydrologists are preparing a water-table map for the Kabul area ground-water system.

Characterization of the 1991 Flood in the Helmand River Basin

The U.S. Army Corps of Engineers (USACE) has a need for design flood information on the Helmand River and its tributaries in the Helmand province of Afghanistan for reservoir spillway and head-gate projects they are helping to design. Refurbishment of Kajakai Dam on the Helmand River is one of the principle project works for which hydrologic information is needed. The USACE is interested in characteristics of the available hydrologic data, especially the 1991 flood information. Therefore, the USACE has requested the USGS to compute indirect determinations of discharge at five locations and to characterize the hydrology of the 1991 flood.

For the purposes of this project, the February 1991 flood, which occurred approximately from February 6-17, will be used

as the design flood at the five designated locations. The design flood at each location will be defined in terms of both its instantaneous peak discharge and flood hydrograph. Multiple lines of evidence will be used to best define the peak discharges and flood hydrographs. For example, total flood volumes determined from the flood hydrographs will be compared with known or estimated volumes of inundation resulting from the 1991 flood as a reasonable check of the flood hydrographs.

Indirect determinations of peak discharges will be compared with peak discharges determined using the remote sensing data to provide a convergence of evidence that strengthens conclusions about the size of the 1991 flood. Flood volume has been estimated by documenting changes in storage in the Sistan wetlands, located at the terminus of the river on the border with Iran. The flood volume will be used to develop 1991 flood hydrographs for selected gaging stations on the Helmand River.

Analysis of the Sistan wetlands began by comparing the surface areas (2,834 km²) for the two westernmost lakes (Hamoun-i Saberi and Hamoun-i Helmand). The surface areas were determined from a 10-m resolution SPOT image acquired on August 12, 1991, and a 1-km resolution AVHRR image acquired on August 13, 1991. Because the surface areas compared favorably, this technique was used to estimate surface areas for all 37 AVHRR scenes (fig. 1).

A Recovery of Historic Surface-Water Quantity Data for the Helmand River

In 1952, the USGS, in cooperation with the predecessor of USAID, established a streamflow-gaging program in the Hel-

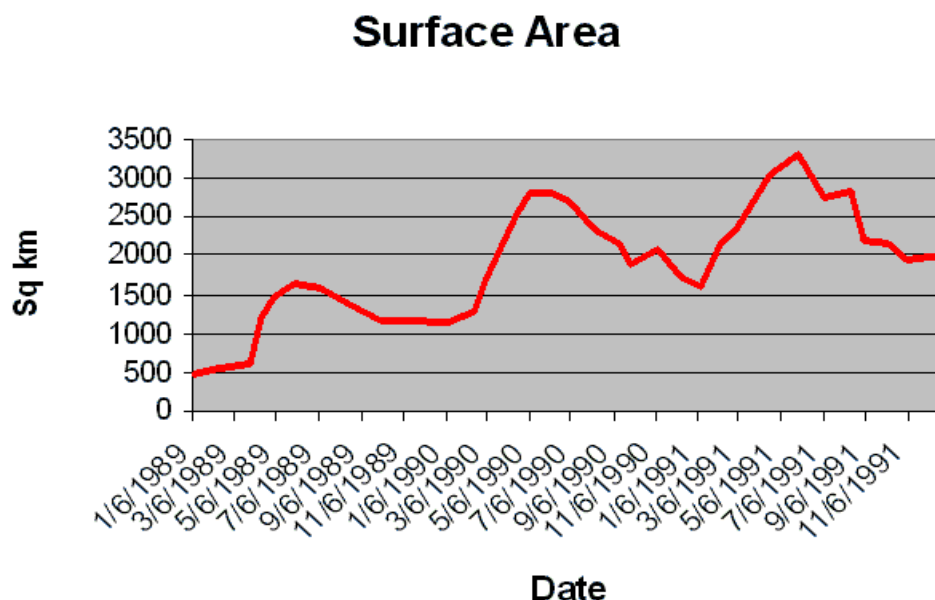


Figure 1. Total surface area for Sistan wetlands from AVHRR, January 1989-December 1991.

mand River Basin. The program expanded in 1963 to include all streamflow-gaging stations in Afghanistan. As a direct result of the USGS cooperative program with USAID, Afghanistan had a modern streamflow-gage network of about 150 gages by the late 1960's, but, after 25 years of neglect, the network has been completely destroyed. However, much of the streamflow data for about 35 streamflow gages in the Helmand River Basin will be recovered, converted to digital data, and loaded into National Water Information System Web (NWISWeb) delivery. All of the hydrologic data for Afghanistan can be retrieved from NWISWeb in tabular format or as a graphic. As an example, an NWISWeb plot of daily streamflow for the Helmand River above Kajakai Reservoir near Dehraut is shown in figure 2. Historic streamflow data will be used by water managers to complete water-resource assessments, conduct project planning, make operational water-management decisions, conduct hydrologic modeling, estimate water availability, and issue flood forecasts.

A Hydrologic Time-Series Analysis for the Helmand River

Historic streamflow data for all streamflow-gaging stations ends in about 1978, but water managers need continuous long-term streamflow records to complete water-resource assessments, conduct project planning, conduct hydrologic modeling, and estimate future water availability. USGS hydrologists will use historic hydroclimatic data to extend the stream-

flow record for the last 25 years (1979-2004) and to fill in the data gaps prior to 1979. The objectives are to:

- Develop a time-series model to explain monthly streamflow variability, given historical monthly streamflows, precipitation, and snow-water equivalent data;
- Use the time-series model to reconstruct a complete set of monthly streamflow for the study area for 1950 to the present (2005);
- Generate potential future monthly climatic inputs and streamflows and estimate the probabilities of future droughts or floods for a 50-year planning period.

The model will be calibrated and verified using rainfall and temperature data from existing Afghanistan rainfall stations (fig. 3) and estimates of snow-water equivalent in the Helmand River Basin headwaters, which lie in the Hindu Kush mountain range. Snow-water equivalent for 1970-2004 will be estimated from monthly remote-sensing data using relations between reflectivity, temperature, snow depth, and snow density.

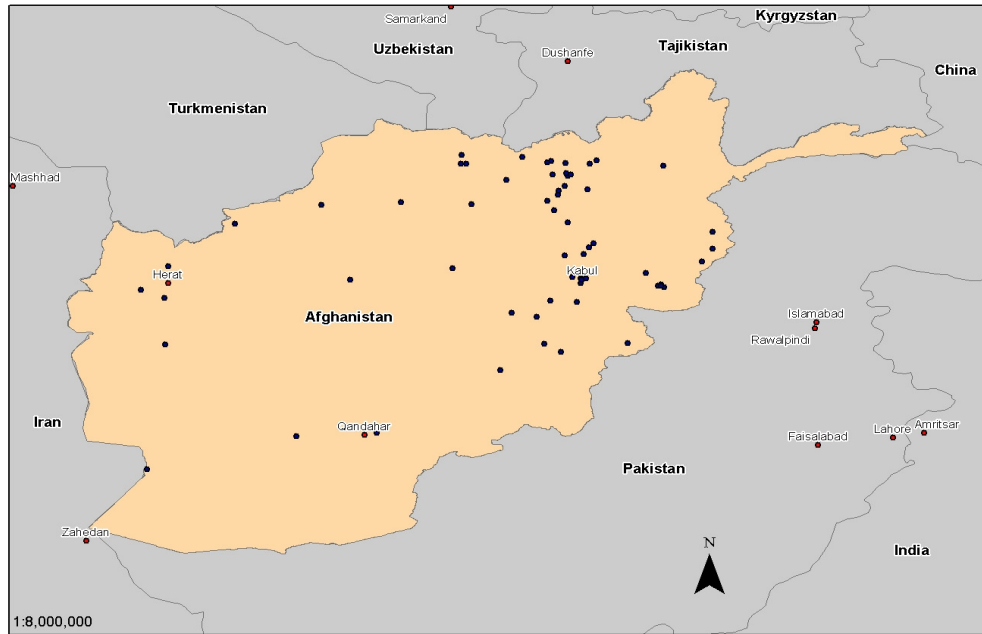
Installation and Demonstration of a Streamflow-Gaging Station

Afghanistan has plans to modernize and rehabilitate the hydrologic and meteorologic networks in Afghanistan and the



Figure 2. Daily streamflow for the Helmand River above Kajakai Reservoir near Dehraut, Afghanistan.

Afghanistan rainfall stations



Data: Chris Funk, Stephen Ervin & ESRI

Figure 3. Distribution of Afghanistan rainfall stations for 2003 and 2004 data.

USGS proposes to take the lead role in capacity building of Afghanistan hydrologists and hydrologic technicians. The USGS also proposes to install a state-of-the-art demonstration gage to be used as a training facility as a beginning to capacity building. Planned environmental monitoring sensors at the gage include water level, specific conductance, water temperature, air temperature, and precipitation. The Panjshir River near Gulbahar has been selected as the site to establish as a demonstration gage.

Potential Effects of Changing Glaciers on Resources and Hazards

This project investigates the current and projected future condition of glaciers in Afghanistan and in areas of Pakistan, Tajikistan, and Kyrgyzstan that drain into or along the border of Afghanistan. Glacier activities primarily involve the use of various temporal/spatial resolution, remotely-sensed data sets to investigate the ability to assess changes in glacial extent and permanent snowpack that may affect Afghan water resources.

Project results thus far include:

- Identification of existing Corona/Keyhole and Landsat images as well as images from other sources;
- Outlining an area where new ASTER data are needed;
- Initiating analysis of ASTER images to assess the current state of exposed snow, ice, and ice-contact lakes;

- Multispectral reflectance analysis to map glaciers and lakes in two Afghanistan test scenes as well as in test scenes in Peru and Alaska;
- Development of a sophisticated digital analytical solution that addresses various issues associated with mapping snow, glacier ice, and water in full scenes of satellite imagery.

Results indicate that topographic and shape information are critical for identifying and differentiating glacier features and glacial-related lakes and for establishing an objective framework for assessing hazard potential. The results represent a positive proof-of-concept, with fine tuning to be accomplished in phase II. Preliminary results indicate successes of this approach in dealing with debris-covered glaciers where reliance purely on multispectral data fails.

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