US Army Corps of Engineers®
Wilmington District

Southeast Afghanistan Water Resources Assessment – Summary Only

Contour Irrigation, Ster Kalay, Paktya Province

Prepared For:

U.S. Army - Task Force Yukon
4th Brigade Combat Team (Airborne)
25th Infantry Division

October 2009

Authors:

John Hazelton, Spencer Roylance, Wes Brown, Trevor Lancaster: USACE – Wilmington District
Henry Shovic, PhD: Montana State U. (USDA Contract)
Tom Mack, Kevin Vining, Aldo Vecchia: USGS

This summary was compiled from the official USACE document by Henry Shovic, PhD for purposes of information. It is not an official USACE document. The official document is: SE-AFG Water Resources Assessment Final 31Oct09.pdf available from the authors.

Contents of This Document

Summary

Southeast Afghanistan is a region of water resource challenges. Annual potential evaporation from vegetation and land surface greatly exceeds precipitation. Farmers generally rely on irrigation for their crops and groundwater for safe household water supplies. The region has an agrarian-based economy with the majority of settlements located along narrow strips of cultivated land in the river valleys and broad depositional valleys. Most of the land is irrigated by small-scale, traditional methods controlled by small communities. The principal livestock is sheep, a high value component of the region's agriculture. Erosion and sedimentation are on-going and severe problems as are security and remoteness. Poor grazing practices exacerbated many of the water resource problems in the region. The region has some of the largest forested areas in Afghanistan, an important economic resource. Deforestation has also contributed to watershed erosion problems.

The purpose of the Southeast Afghanistan Water Resources Assessment was to evaluate potential water resource improvement projects that the U.S. Army's Task Force Yukon can practically and effectively implement in cooperation with the Islamic Republic of Afghanistan. The study was primarily based on analysis of high-resolution satellite images, digital elevation models, available spatial data, assistance of regional experts, the authors' in-country experience, on-site observations and publications. Though these methods cannot substitute for on-site analyses, remote sensing does allow for the evaluation of hundreds of project sites relatively quickly. The subsequent analysis determined which sites are likely to have the highest potential for success. Time on the ground in this remote, unsecure area can then be focused only on the best project sites, saving both time and funds as well as reducing risk to personnel.

Two hundred and ninety-five potential water resource project locations were evaluated in this study, along with their associated watersheds. Soil, slope, elevation and geological characteristics were evaluated for all project areas. Digital spatial data were used to estimate reservoir and dam engineering characteristics. Of the 295 sites, 159 possible irrigation storage dam sites were identified. Evaluation of these sites was based on storage potential, constructability, irrigation benefits (including potential capacity as well as benefiting existing agriculture), inundation impacts and watershed stability. Components of watershed stability and potential sedimentation included recent deforestation, stream system stability and upland erosion.

Because of the large number of sites and complexity of evaluation factors, a structured decision support model was implemented for both irrigation storage dams and watershed management. The approach both clarified the criteria used in evaluation, and allowed the modification of criteria by Task Force Yukon for changing conditions.

The remaining 136 sites were potential micro-hydropower and irrigation diversion dams. These were subjectively and graphically reviewed because enough detailed data were not available for implementation of a decision support model.

Additional products from this study include groundwater summaries, streamflow and climate datasets, GIS shapefiles, analysis of sedimentation data, a decision support model to guide watershed restoration and project-level planning support provided to field personnel. To address small-scale projects, a workshop was given in June 2009 at FOB Salerno, Afghanistan.

This report emphasizes projects that can be relatively quickly constructed and implemented, but is more importantly intended to be a planning document and the first stage of

implementing a sustainable water management strategy in southeast Afghanistan, including both short-term structural improvements and longer-term watershed restoration.
Afghanistan is indeed a land of challenges. Anecdotal information abounds on its poor watershed conditions and irrigation water supply problems. In addition, recommendations for past improvement projects are often based on poorly defined parameters, or are too generally defined to implement. This study was based on remote sensing data, with limited direct ground-truth. As in the previous Paktika Water Resource Assessment, it provides a consistent and systematic evaluation of "where, when, who, how much, and why". Both studies emphasizes specifically locating projects using well defined criteria, with its accuracy based on *what is known,* both directly and indirectly. The studies give some specific recommendations on irrigation supply structures as well as for longer-term watershed management improvement. Both together should help continue to focus future efforts on cost-efficient solutions in developing safe and productive water supplies for the people of Afghanistan.

Conclusions

This assessment includes the provinces of Khost, Paktya, Logar, Wardak and Ghazni in southeast Afghanistan. See location map below. This semi-arid region has an agrarian-based economy and most farmers rely on irrigation for their crops. The people of this region face serious water resource problems, including lack of safe household water supplies, an existing irrigation system in disrepair and lack of dependable water for agriculture. Some of the problems with flash flood damage, sedimentation and loss of productive rangeland can be directly related to poor land management in the deteriorating watersheds, while others are related to the extreme climatic and geologic situation.

The purpose of this assessment was to identify and evaluate potential water resource projects that Task Force (TF) Yukon can implement to benefit the people of this region in cooperation with local governing bodies and Ministries within the Islamic Republic of Afghanistan. This assessment also discusses the nature of landscape and hydrologic patterns in the study area and the fundamental causes of the water resource challenges, including the constraints put on any proposed project by the natural environment of Afghanistan.

A large component of this assessment was the data collection effort. During the past years of turmoil, streamflow and precipitation records, soils and geological maps, engineering reports and even general knowledge of the region's hydrology have been lost. As part of this effort, the USGS was tasked with collecting and organizing available historic streamflow records into a publically accessible database. Analysis of the stream gage records revealed large influences of irrigation withdrawals.

Only monthly historic precipitation data was located that matched the 1960 to 1980 period of the streamflow records. There was insufficient streamflow and precipitation data to calibrate hydrologic or hydraulic computer models of the watersheds and rivers. A simple correlation was used to establish a relationship between precipitation over a watershed and the resulting runoff recorded at the stream gage. This relationship was used to estimate flows at water resource

project sites with similar watershed characteristics. This method does have limitations and it is recommended that streamflow characteristics at a project be confirmed with local inhabitants.

The study was primarily based on analysis of high-resolution satellite images, digital elevation models, available land-cover and soils spatial data, assistance of experts familiar with the region, the authors' in-country experience, observations by on-site personnel and publications. Remote sensing methods have the advantage of being able to investigate the hydrologic, social, land use and geologic patterns of southeast Afghanistan without the expense and effort of actually being on the ground in an un-secured environment. Disadvantages of remote sensing include the unwieldy size of the dataset, large effort required to process the data and the limitation of analysis scale, e. g. not being able to accurately evaluate small-scale features such as irrigation canals, check dams, rill and sheet erosion.

To address small-scale village improvement projects in this assessment, a hands-on workshop for military and civilian personnel was delivered by the USDA Foreign Agricultural Service. The four-day workshop at FOB Salerno, Khost reviewed soil assessments, water supply, watershed restoration, irrigation methods and erosion control. The participants recommended that a similar, expanded workshop be provided to those working on water related projects before deployment to Afghanistan.

Groundwater is the primary and safest source for household water supply in southeast Afghanistan. The lack of available hydrogeologic data and knowledge of aquifers can make utilizing groundwater resources a risky endeavor. Installing a high capacity well can negatively affect surrounding wells and karezes, ultimately being counter-productive in efforts to help the community. The best technique in evaluating an aquifer is dependent on the available hydrogeologic data. As part of this assessment, the USGS conducted an extensive data gathering effort and appraisal to determine the best technique in evaluating groundwater resources. It is recommended that TF Yukon utilize the dataset collected by the USGS and proceed with their strategy for evaluating and utilizing groundwater resources.

Hydropower potential in southeast Afghanistan is limited more by the lack of available streamflow than from suitable terrain. The steep stream slopes in the study area offer large elevation changes over short distances, providing excellent driving head for hydropower turbines. The issue was that many streams are dry for months each year. This assessment team evaluated hydropower at 120 locations. Of these, 61 sites had generating potential over 100 kW and two sites over 1.5 MW. Many locations were in remote areas with low population density requiring long transmission lines. The most promising project was at Sinak on the upper Helmand River. Because of the high streamflows at Sinak, the headrace channel may be able supply enough flow to support both hydropower and irrigation demands in the open valley. Installing hydropower capabilities at the irrigation storage dams in southeast Afghanistan is not recommended. Irrigation has the higher priority for limited water and relying on the head produced by the dam would be sufficient only a few months of the year. All hydropower in this assessment utilized the more reliable head produced by the steep stream slopes for run-of-river type projects.

Irrigation Diversion Structures: This assessment utilized the remote sensing dataset to identify locations for potential irrigation diversion structures. However, limitations in the remote sensing dataset resolution hindered the analysis. The diversions rely on centimeters of elevation differences to drive water out of the streams and into the canals and irrigated crops. The elevation dataset did not have the resolution to appropriately evaluate potential sites and estimate benefits. It is recommended that TF Yukon focus efforts on existing diversion structures along stable river channels that do not show severe sedimentation issues. Many of the existing structures need replacement of sluice gates or complete replacement of the structure. TF Yukon should avoid building new permanent structures on the unstable streams with high sediment loads. The traditional, temporary structures that are re-built each spring may be more appropriate on sediment-laden streams. One result of the diversion analysis was the development of individual map books of irrigated river valleys. With an organized and portable collection of high resolution images in *.pdf format, TF Yukon or PRT personnel can use the maps in the field to zoom-in on diversion structures that may be hidden from the roadway by vegetation.

Irrigation Storage Dams: In terms of irrigation storage dams, the terrain and condition of the watersheds in southeast Afghanistan are generally unfavorable. However, through an intensive canvassing process 159 potentially successful locations were identified and described. These project sites and associated watersheds were intensively analyzed to discover their true potential for further investigation.

Decision Support Models: To make sense of the complex criteria and large number of potential projects, structured decision support models were developed to help prioritize the 159 irrigation storage dams for further investigation and all 295 project watersheds for restoration potential. The criteria and factor weightings were developed in consultation with TF Yukon, and they can be easily modified as situations change. The list of ranked projects included in this report (Table 6-16) is only a tool. Final recommendations were not only based on these rankings, but also on additional information and professional interpretation. Some factors were consciously excluded, e.g. local security or cultural relationships.

Results showed the majority of the sites had little reservoir storage potential or the dam's watershed condition presented serious sedimentation issues. The mountainous terrain in Afghanistan results in streams with very steep gradients. Therefore, the reservoirs have little storage per height of dam. Many sites had a dam construction volume over 20% of the reservoir storage volume and were judged infeasible. Many watersheds had large areas of relatively-high active gully erosion and deforestation with unstable stream systems. Some sites, though favorable from an engineering standpoint, were located on wide-unstable streams that present significant challenges in design, implementation, and maintenance.

Sediment accumulation in reservoirs will be a continuous, long-term maintenance issue for dams in southeast Afghanistan. The high sediment load of Afghanistan's streams should not prevent the construction of all storage dams. Sites have to be carefully selected to avoid steep stream slopes and watersheds in poor condition. It is recommended that TF Yukon consult with international experts on appropriate outlet designs to encourage sediment passage through dams.

Watershed Restoration: However, these negative factors also present opportunities in watershed restoration. Areas having relatively high erosion and deforestation also present potential for gully control and reforestation. In areas having relatively stable streams, bank stabilization may be effective in reducing sediment and improving water quality. This potential was spatially reviewed using a decision support model similar to the irrigation storage model, to identify the best candidates for restoration efforts. These watersheds must be further investigated, as not all potentially important factors were considered, e.g. vegetation condition.

There are indeed challenges in water resource development in southeast Afghanistan. However, there are also many opportunities. The terrain, climate and hydrology vary greatly across the five-province assessment area. The appropriate type of water resource improvement project will also vary across the area. Each province has a different potential and different challenge. The type of projects recommended for further investigation depend on those unique characteristics.

Recommendations: Irrigation storage dams are not recommended in the Helmand River watershed in northern Wardak Province. Impounded water is not needed given the high year-round streamflows and small amount of arable land in the valley. Hydropower and irrigation diversions are recommended.

The Shamal, Chamkani and Ghazni Upper (Gardez) River watersheds in the Khost and Paktya Provinces are not favorable for irrigation storage dams. The evaluated sites had little storage and high potential for sedimentation. The watersheds of Shamal and Chamkani do have one unique resource in Afghanistan and that is the forest and orchards. Efforts should concentrate on their conservation and restoration. Gardez has a few recommended dams and had high potential for successful watershed restoration.

The Logar River watershed in Wardak and Logar Province has many recommended irrigation storage dams. It is also recommended that the series of existing irrigation diversions along the Logar and tributaries be high priority projects for rehabilitation. There are also existing dams at Chak Wardak and Khwar that should be prioritized high for repairs.

Western Ghazni Province included the study watersheds of Garmab, Samanka, Arghandab and Tarnak. Only Samanka had recommended irrigation storage dams. All watersheds except Tarnak included recommended locations for hydropower and irrigation diversions.

Southeastern Ghazni Province included the Ghazni Lower (Sardeh) watershed. The watershed does not hold much potential for hydropower, but includes four storage dams recommended for further investigation. There is a series of existing irrigation diversions below the Sultan Dam that should be priority projects for rehabilitation.

The greatest uncertainty in the evaluation of project sites was in the estimation of streamflow water budgets and design flood flows. The uncertainty was a result of the short length of streamflow and precipitation gage records. Another issue was the estimation of flows on streams without gages. Additional streamflow characteristics should be obtained from local Mirabs. Dam structures and spillways should be carefully designed with constant quality control inspection during construction to help compensate for the uncertainties in flood flows. The level of analysis

in this assessment was unable to address geotechnical and seismic conditions at the project sites and require further investigation. There are also uncertainties in quantifying the benefits of watershed restoration programs and reducing soil erosion, especially if improved local grazing practices are not included.

Afghanistan is indeed a land of challenges. Anecdotal information abounds on its poor watershed conditions and irrigation water supply problems. In addition, recommendations for past improvement projects are often based on poorly defined parameters, or are too generally defined to implement. This study was based on remote sensing data, with limited direct ground-truth. As in the previous Paktika Water Resource Assessment, it provides a consistent and systematic evaluation of "where, when, who, how much, and why". Both studies emphasizes specifically locating projects using well defined criteria, with its accuracy based on *what is known*, both directly and indirectly. The studies give some specific recommendations on irrigation supply structures as well as for longer-term watershed management improvement. Both together should help continue to focus future efforts on cost-efficient solutions in developing safe and productive water supplies for the people of Afghanistan.

Location and Scope

TABLE OF CONTENTS for Complete Report

TABLE OF CONTENTS, continued

TABLE OF CONTENTS, continued

LIST OF TABLES

LIST OF TABLES, continued

LIST OF FIGURES

LIST OF FIGURES, continued

LIST OF APPENDICES

APPENDIX	DESCRIPTION
A	Remote Sensing Data Effort
B	Precipitation Data
C	Streamflow Data and Runoff Ratio
D	Literature Search and Supporting Documents
E	Study Watershed & Resource Maps & GIS Shapefiles
F	USGS Groundwater Results
G	Project Location & Supporting Maps
H	Irrigation Storage Dam Results
I	Irrigation Storage Dam Inundation Maps
J	Decision Support Model – Irrigation Dam Results
K	Sedimentation Results
L	Hydropower Maps and Results
M	Irrigation Diversion Structures
N	Decision Support Model – Watershed Results
O	Watershed Tables

Note: Due to the large size of the Appendices, the documents are provided upon request in digital format.