Afghanistan

A Countrywide Overview of Groundwater Resources and Challenges

By: Vincent W. Uhl

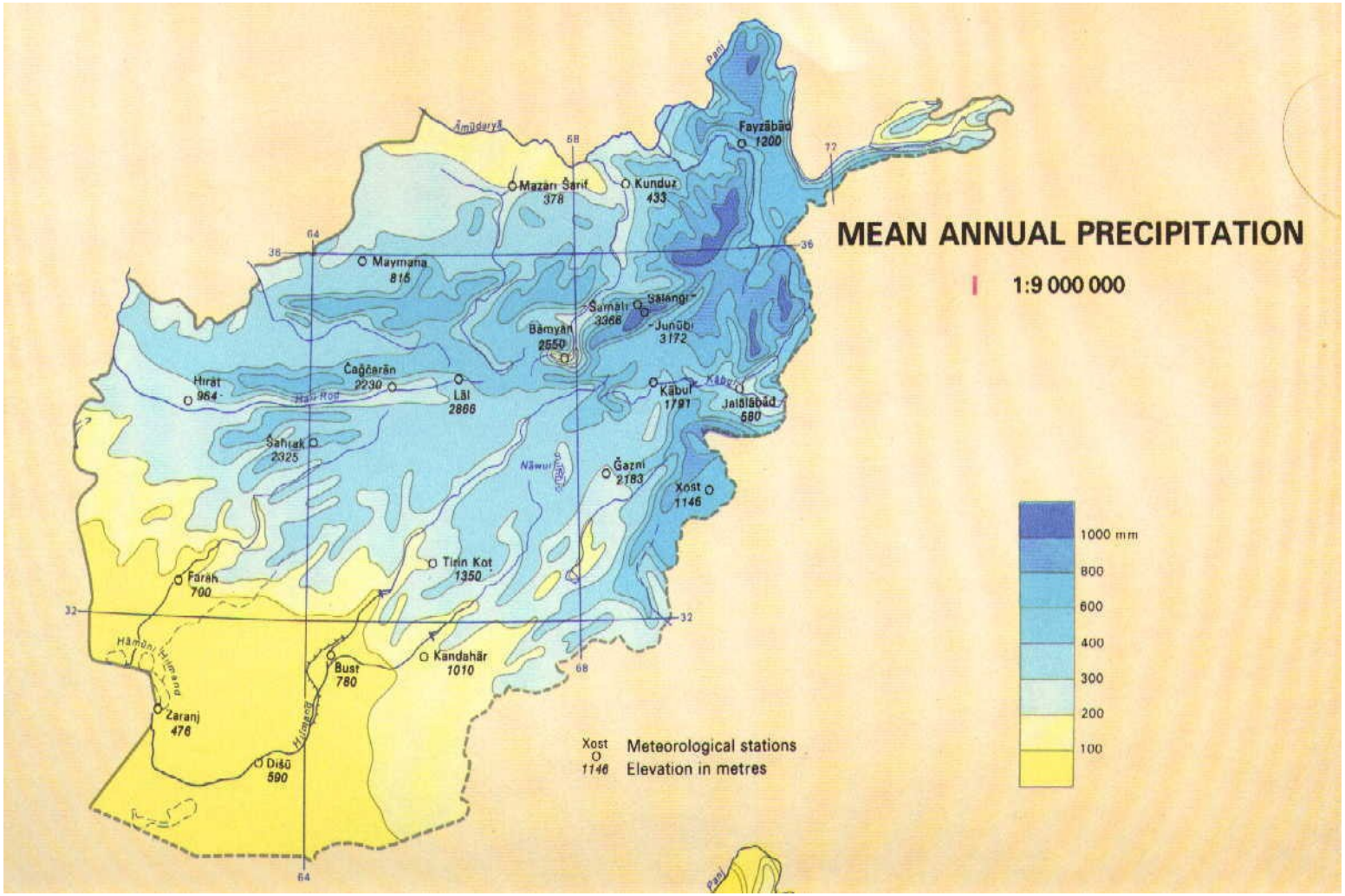
Country Overview

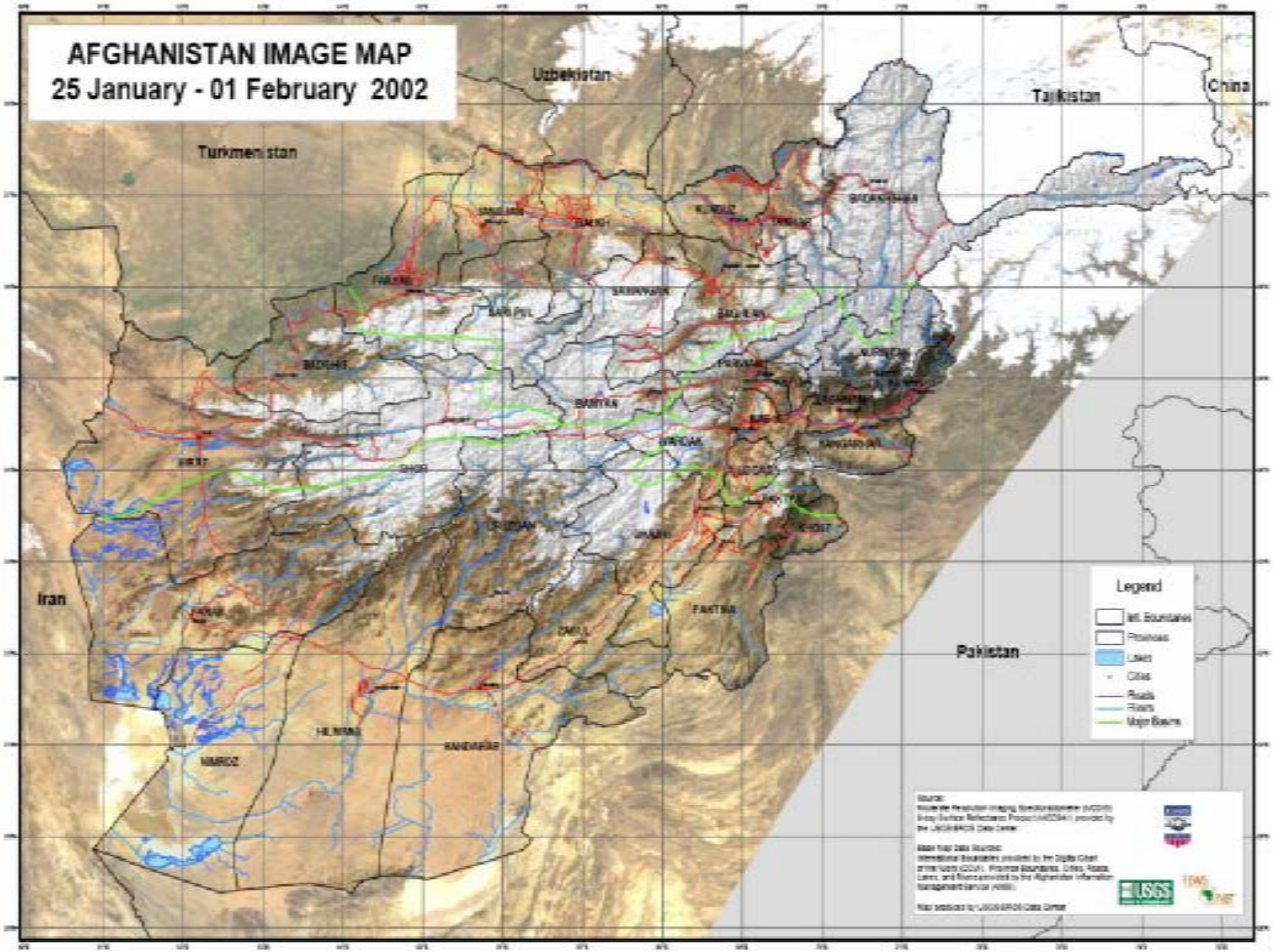
- Area: 647,500 km^2
- Population: +/- 30 Million
- Economy: Principally Agriculture
- ¾ of the country is uplands.
- Lowlands include river valleys and deserts
- Hindu Kush is the main mountain range and extends about 1,000 km from the Pamir ranges in the northwest to the Iranian border in the west.
- Average altitude of the Hindu Kush is 4,000 m


TURKMENISTAN
TAJIKISTAN
Dushanbe
Murgab
Kerki
Mary
Kulyab
Kurgan-Tyube
Nizhniy Pyandzh
Termez
Keleft
Jeyretān
Khorog
Feyzābād
Eshkāshem
Lasht
JOWZJĀN
BALKH
Mazār-e Sharīf
Kholm
KONDOZ
Kondūz
Tāloqān
TAKHĀR
BADAKHSHAN
Sheberghān
Sar-e Pol
SAR-E POL
Samangān
SAMANGĀN
Baghlān
Pol-e Khomrī
BAGHLĀN
Meymaneh
FĀRYĀB
Chitrāl
Gilgit
Kushka
BADGHIS
Towraghondī
Tūnel-e Sālang (Salang Tunnel)
Mahmūd-e Rāqī
KONAR
LAGHMĀN
Asadābād
Qal'eh-ye Now
BĀMĪĀN
Bāmīān
Chārikār
PARVĀN
KĀPISA
Mehtarlām
KĀBOL
Herāt
Chaghcharān
Kowt-e Ashrow
Kabul
Jalālābād
HERĀT
Harīrūd
GHOWR
VARDAK
LOWGAR
NANGARHĀR
Khyber Pass
Landi Kotal
Baraki
Peshāwar
Islāmābād
Pārachinār
Kohāt
Rāwalpindi
Farāh Rūd
Gardeyz
PAKTIA
Khowst
Shīndand
ORUZGĀN
Ghaznī
GHAZNI
Thal
Zareh Sharan
Bannu
Tarīn Kowt
Khāsh Rūd
Darya-ye Helmand
Darya-ye Arghandāb
PAKTĪKĀ
FARĀH
Farāh
Delārām
Qalāt
ZĀBOL
Tānk
Jhelum
Chenāb
Indus
Sargodha
Lahore
Lashkar Gāh
Qandahār
Zhob
Zaranj
Zābol
HELMAND
KANDAHĀR
NĪMRŪZ
Chaman
Darya-ye Helmand
PAKISTAN
Quetta
Khost
Gowd-e Zereh (intermittent lake)
Afghanistan
International boundary
Province boundary
National capital

Physical Setting

- Hindu Kush Mountain Range cuts country in half from northeast to southwest.
- Precipitation is mainly in the form of snow and decreases from northeast to southwest.
- Total precipitation in the range of 180,000 million m3/year


MEAN ANNUAL PRECIPITATION
1:9 000 000
Amüderyā
Panj
Fayzābād 1200
Mazār Šarīf 378
Kunduz 433
Maymana 816
Šamālī 3366
Šalangī
Junūbī 3172
Bāmyān 2550
Hirat 964
Čağčarān 2230
Hari Rūd
Lāl 2866
Kābul 1791
Kābul
Jalālābād 580
Šahrak 2325
Nāwur
Ğazni 2183
Xost 1146
Tirin Kot 1350
Farāh 700
Hāmūn-i Hilmand
Bust 780
Kandahār 1010
Hilmand
Zaranj 476
Dišū 590
1000 mm
800
600
400
300
200
100
Xost Meteorological stations
1146 Elevation in metres


AFGHANISTAN IMAGE MAP
25 January - 01 February 2002
Uzbekistan
Tajikistan
China
Turkmenistan
Iran
Pakistan
Legend
Int. Boundaries
Provinces
Lakes
Cities
Roads
Rivers
Major Basins
USGS
FAWS NET

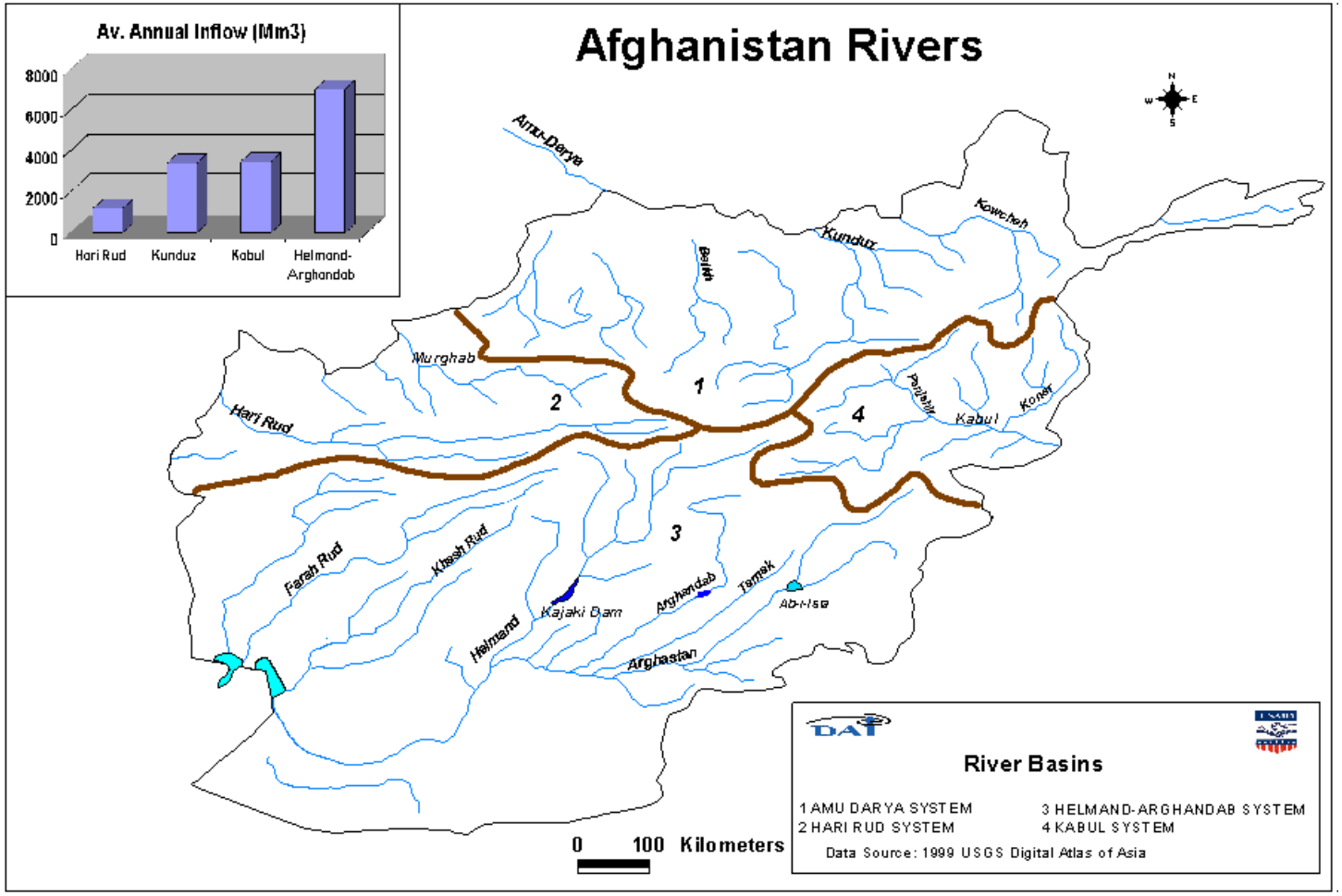
Groundwater Use

- Irrigation – Major Use
- - Drinking Water Supply
  - Urban areas
  - Towns/villages
- Industrial
- Future - Mining

River Basins

- Kabul
- Helmand
- Western Flowing Rivers and Hari Rud
- Northwestern Rivers
- Amu Darya and its tributaries

River Basin Map



Major River Basins

- Kabul River – 54,000 km²
- Helmand - 300,000 km²
- Hari Rud - 39,300 km²
- Amu Darya - 205,690 km²

- Rigestan Basin - 28,600 km²
- Southeast Tributaries to Indus – 18,600km²

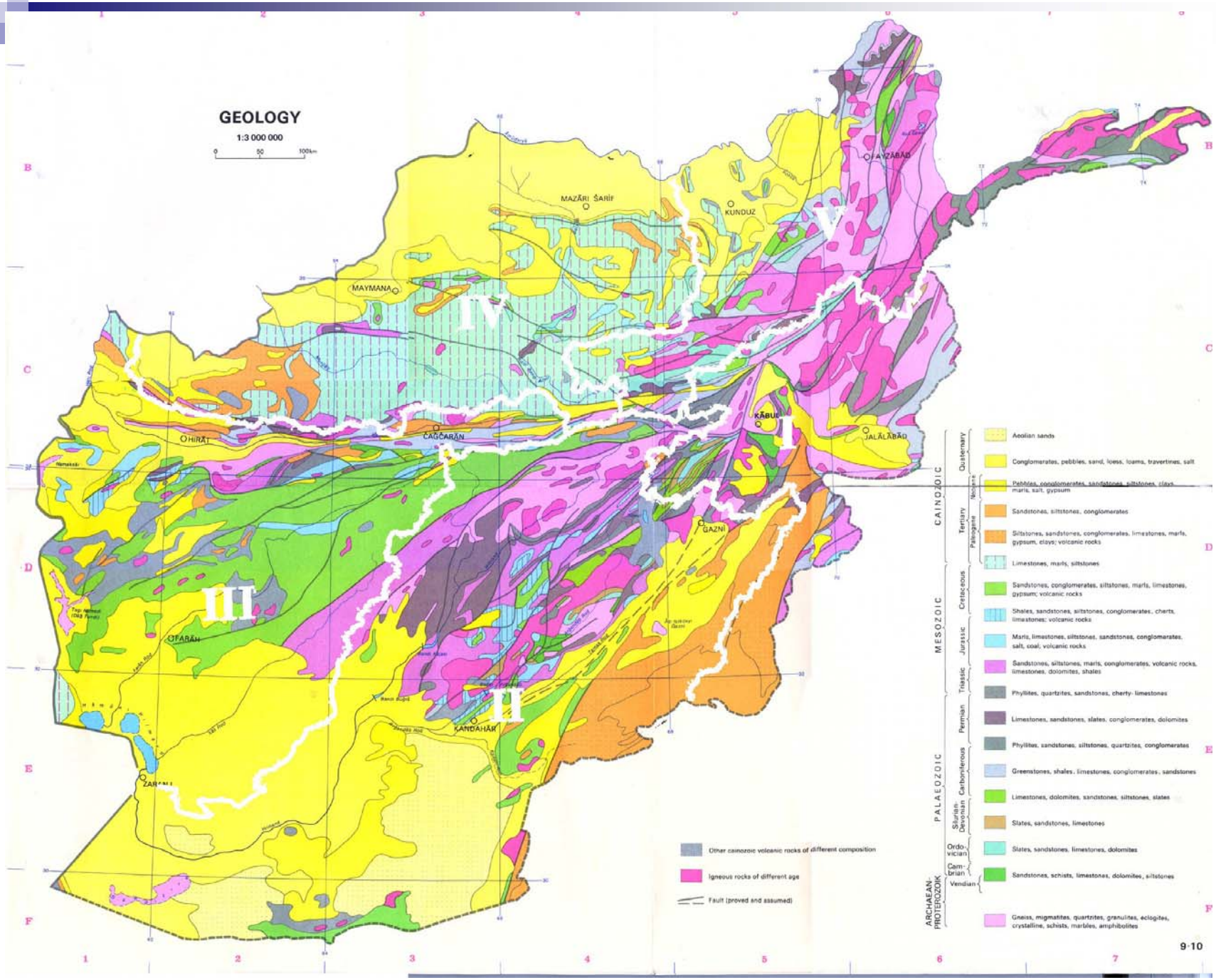
.Amu Darya River

Amu Darya River

Helmand River and Irrigation Canals

Principal Aquifer Systems

- Quaternary deposits in the major river valleys.
- Semi-consolidated Neocene Age deposits.
- Carbonate rock aquifer systems (largely unexplored).
- Sedimentary rock aquifer systems (largely unexplored).
- Crystalline rock systems – unexplored.


GEOLOGY
1:3 000 000
0 50 100km
MAZĀRI ŠARĪF
KUNDUZ
FAYZĀBĀD
MAYMANA
HIRĀT
ČAGČARĀN
KĀBUL
JALĀLĀBĀD
GAZNI
FARĀH
KANDAHĀR
ZARANJ
I
II
III
IV
V
CAINOZOIC
MESOZOIC
PALAEOZOIC
ARCHAEAN-PROTEROZOIK
Quaternary
Tertiary
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Silurian-Devonian
Ordovician
Cambrian
Vendian
Aeolian sands
Conglomerates, pebbles, sand, loess, loams, travertines, salt
Pebbles, conglomerates, sandstones, siltstones, clays, marls, salt, gypsum
Sandstones, siltstones, conglomerates
Siltstones, sandstones, conglomerates, limestones, marls, gypsum, clays; volcanic rocks
Limestones, marls, siltstones
Sandstones, conglomerates, siltstones, marls, limestones, gypsum; volcanic rocks
Shales, sandstones, siltstones, conglomerates, cherts, limestones; volcanic rocks
Marls, limestones, siltstones, sandstones, conglomerates, salt, coal; volcanic rocks
Sandstones, siltstones, marls, conglomerates, volcanic rocks, limestones, dolomites, shales
Phyllites, quartzites, sandstones, cherty- limestones
Limestones, sandstones, slates, conglomerates, dolomites
Phyllites, sandstones, siltstones, quartzites, conglomerates
Greenstones, shales, limestones, conglomerates, sandstones
Limestones, dolomites, sandstones, siltstones, slates
Slates, sandstones, limestones
Slates, sandstones, limestones, dolomites
Sandstones, schists, limestones, dolomites, siltstones
Gneiss, migmatites, quartzites, granulites, eclogites, crystalline, schists, marbles, amphibolites
Other cainozoic volcanic rocks of different composition
Igneous rocks of different age
Fault (proved and assumed)
9·10

Traditional Groundwater Sources for Irrigation and Drinking Water

- Karezes
- Springs
- Shallow hand dug open wells

Karez Diagram

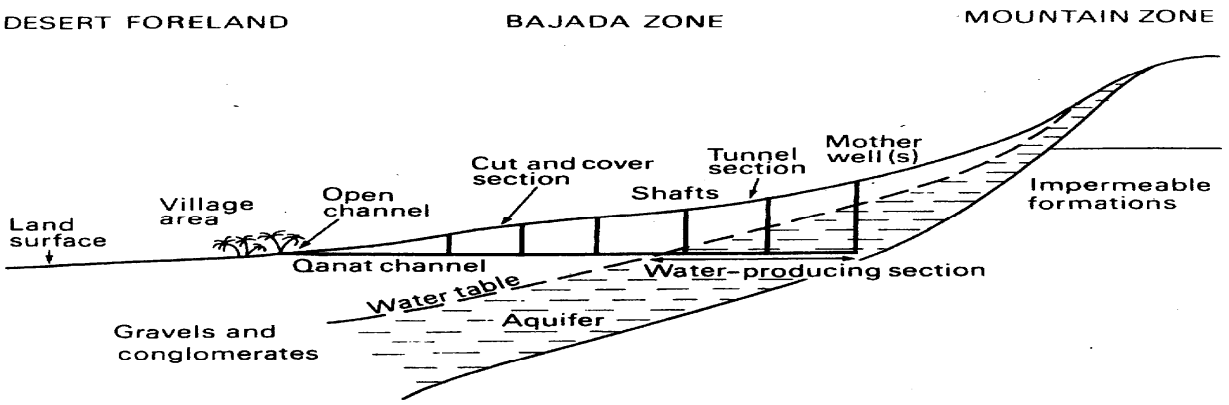
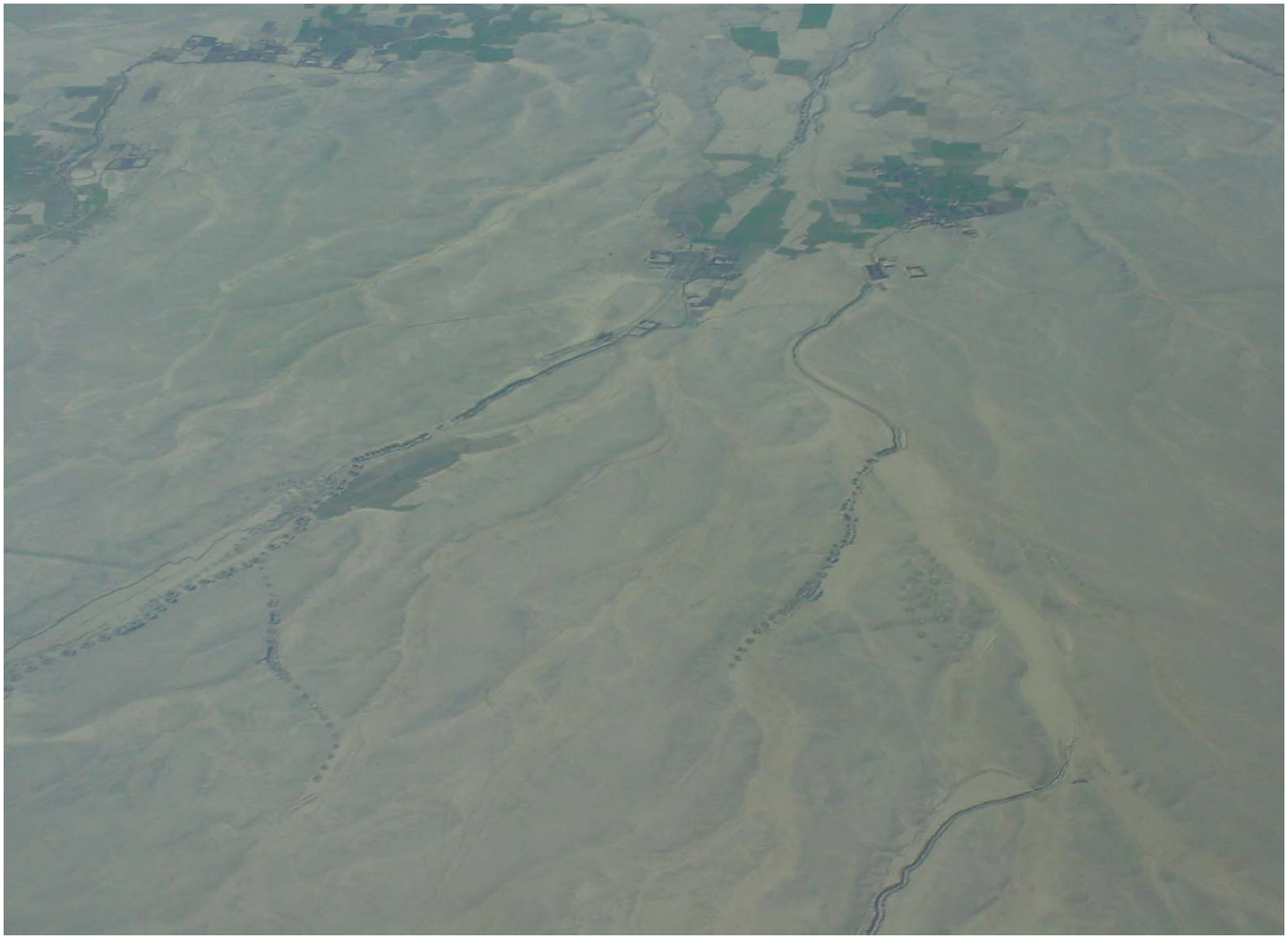


Figure 3: Cross-section of a Kariz

(Source: "The Warm Desert Environment" by Andrew Goudie and John Wilkinson, 1977)

Karezes



Karez History

- Also referred to as Qanat, Foggara, and Falaj
- Date back to 2nd millennium BC
- Ancient Persians – depths up to 100m and lengths up to 50 km.
- City of Tehran's water supply once supplied by Karezes.
- Diffusion of this technique thought to have been from the ancient mining areas of northwest Iran (Persia) into Central Asia, Balochistan, Arabia, the Sahara, and the Mediterranean world.
- Historically also in Madrid, Liege, Bavaria, and even South America.

Karez Uses

- Water Supply – Rural and Urban
  - Tehran
  - Quetta
  - And other major cities/towns
- Agricultural Irrigation

Principal Groundwater Recharge Mechanisms

- Direct infiltration of precipitation and snowmelt.
- Mountain front recharge – groundwater flux from bedrock systems to lower elevation Quaternary and Neocene aquifers.
- Infiltration of runoff and snowmelt into river sediments and large alluvial fans – major mechanism in some areas.

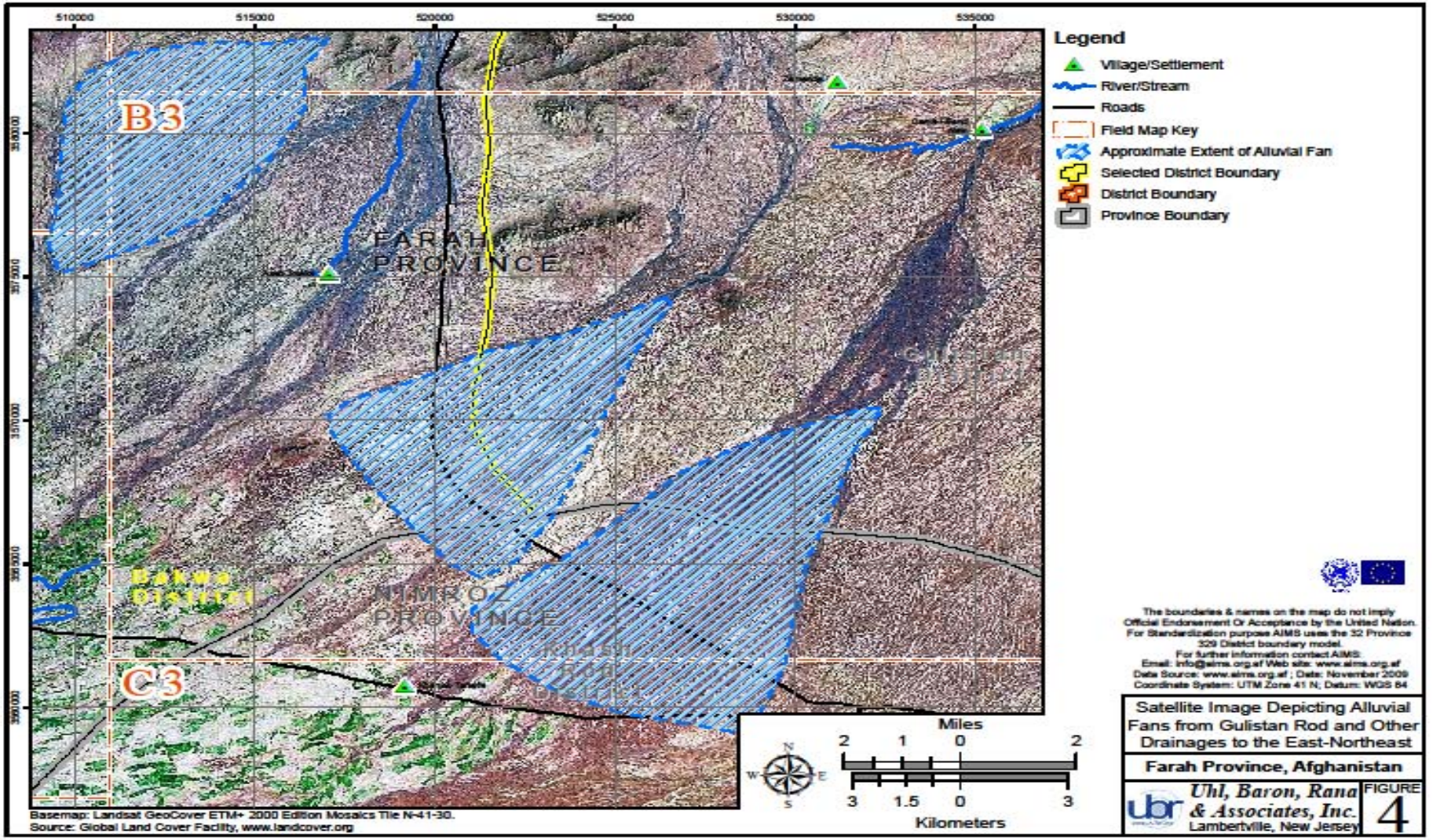
Groundwater Recharge

Farah Province Study – Case Study:

Mountain front recharge from the hilly/mountainous areas in the north/northeast.

Infiltration of runoff from rainfall events and snow melt into the large number of seasonal drainage pathways in both the upland and lowland areas.

This includes **Recharge** over large permeable alluvial fans - the most prominent being the Gulistan Rod fan to the east - northeast**.**


510000
515000
520000
525000
530000
535000
B3
C3
FARAH PROVINCE
NIMROZ PROVINCE
Legend
Village/Settlement
River/Stream
Roads
Field Map Key
Approximate Extent of Alluvial Fan
Selected District Boundary
District Boundary
Province Boundary
Miles
2 1 0 2
3 1.5 0 3
Kilometers
The boundaries & names on the map do not imply Official Endorsement Or Acceptance by the United Nation.
For Standardization purpose AIMS uses the 32 Province 329 District boundary model.
For further information contact AIMS:
Email: info@aims.org.af Web site: www.aims.org.af
Data Source: www.aims.org.af ; Date: November 2009
Coordinate System: UTM Zone 41 N; Datum: WGS 84
Satellite Image Depicting Alluvial Fans from Gulistan Rod and Other Drainages to the East-Northeast
Farah Province, Afghanistan
Uhl, Baron, Rana & Associates, Inc.
Lambertville, New Jersey
FIGURE 4
Basemap: Landsat GeoCover ETM+ 2000 Edition Mosaics Tile N-41-30.
Source: Global Land Cover Facility, www.landcover.org

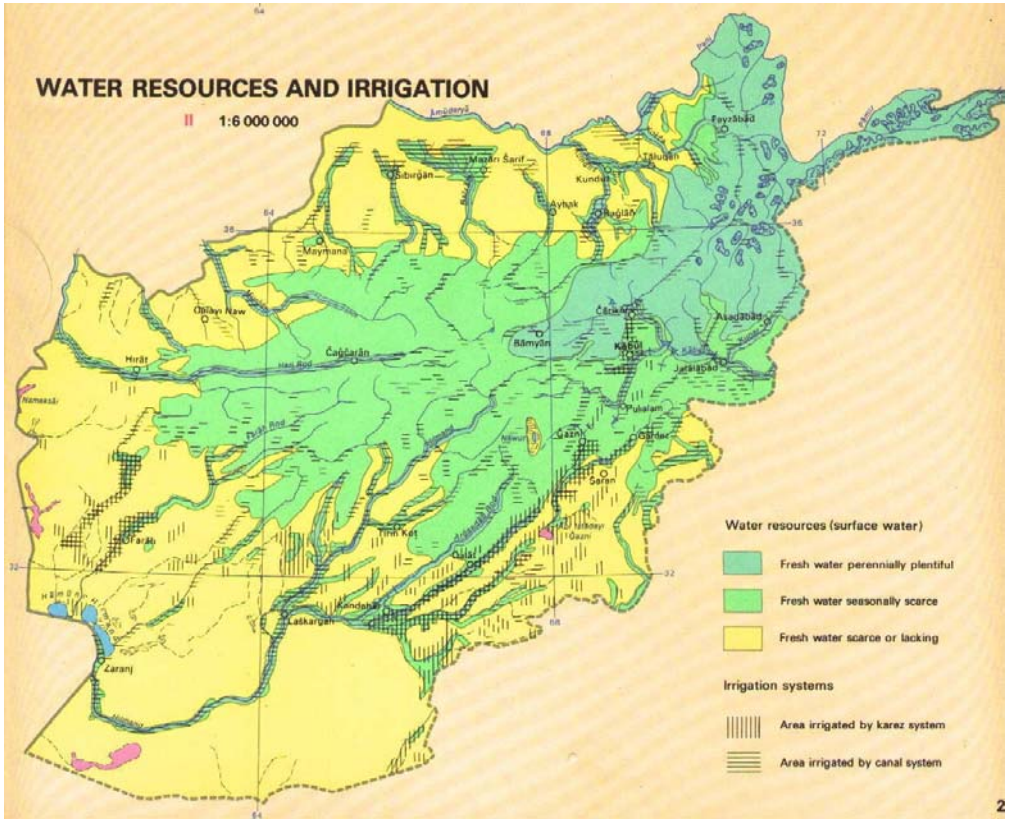
Regional Estimates of Groundwater Recharge

- Recharge as a percent (%) of annual precipitation for a river basin or sub-basin taking into account:
  - Water balances (groundwater recharge determinations) from investigations in similar settings.
  - Geology (e.g. unconsolidated vs. crystalline rock systems).
  - Climate (precipitation quantities and temperatures)
  - For Afghanistan around 5%.
- Water Balance: Prec. – runoff – ET = GWR

Recharge Estimates - Afghanistan

River Basin	GW Usage-FAO-MCM/yr.	FAO Recharge Estimate MCM/yr.	UBR Recharge Estimate – MCM/yr
Kabul	436	2,830	1,920
Helmand	1,380	5,280	2,980
Hari Rud	126	980	640
Amu Darya	241	7,450	5,120
Totals	**2,183**	**16,540**	**10,660**

Water Resources Overview



Major Impacts

- Reduced groundwater recharge due to deforestation and land use practices.
- Water level impacts in certain river basins due to over pumping.
- Drying up of shallow wells and karezes.
- Undocumented water quality impacts particularly in urban areas.

Issues to Resolve

- Traditional Sources (gravity fed Karezes) vs. Deep Wells.
- Over-abstraction in some river basins.
- Management and regulatory approaches
  - National, Regional, and/or local.
  - Local acceptance and participation.
  - Traditional water management practices.

Forward Looking Practices

- Basic groundwater data compilation and aquifer/river basin studies.
- Abstraction regulations.
- Well permitting and construction guidelines particularly for drinking water wells.
- Integrated River Basin Management approaches.
- Watershed management protection, reforestation and recharge enhancement.

Lessons Learned

- Lessons can be learned from nearby arid and semi-arid countries where over abstraction is occurring.
- Put management and regulatory policies in place and in advance of drilling and pumping equipment technologies that can result in aquifer depletion.

Recommended Actions

- Initiate practically oriented scientific studies by river basin that focus on groundwater availability, recharge characteristics/sustainability, and management alternatives.
- Begin to consider and develop the elements of some form of regulation for well drilling and groundwater abstraction.

Recommended Actions Cont.

- Develop a focus on education related to conservation, watershed care, and reforestation.
- Initiate groundwater recharge enhancement through the application of local small scale technologies.

Village in the Hindu Kush Mountains