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WATERSHED ATLAS OF AFGHANISTAN
FIRST EDITION - WORKING DOCUMENT FOR PLANNERS

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DISCLAIMER

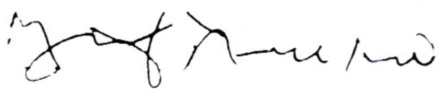
This atlas has been prepared to provide a broad appreciation of watershed issues in the Afghanistan context. In order to get the document into print and thus available as a reference for planners, final checks of every detail, in particular quantitative data, could not be accomplished. Improvements can be reflected in a future edition. Readers are invited to submit errata and suggestions for improvements to the Ministry of Irrigation, Water Resources and Environment or the Food and Agriculture Organization of the United Nations (FAO).

FOREWORD

Addressing water issues requires a multisectoral approach that recognizes the interdependence between competing demands and limited resources. Experience has shown that "integrated watershed management" is recognized as the best instrument for dealing with water and natural resources. Participation of all relevant actors and direct involvement of communities, of individual farmers and herders, are essential to successful water management in Afghanistan.

The first edition of the Watershed Atlas of Afghanistan is a working document for planners. The Atlas is a living and open source of information which will be updated, refined and completed with the contribution and experience of all actors involved. As a working document, there is scope for improving the accuracy and we must invest in further research and field actions. The Atlas provides baseline information for policy development, prioritization of initiatives on watershed management, coordination of actions and further assessments.

Future economic development of Afghanistan will result in an intensification of already limited water resources uses for irrigation, hydro-power or industries. Therefore, improving water use efficiency is essential to achieve sustainable development. The Watershed Atlas is a first step toward such an approach.



Ahmad Yusuf Nuristani
Minister of Irrigation, Water Resources and Environment

کابل بی زر باشد بی برف نی

"Kabul be zar basha, be barf ne"

"Kabul may be without gold, but not without snow"
Afghan Proverb

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INTRODUCTION

In Afghanistan, over 80 percent of the population relies directly on the natural resource base to meet their daily needs. Natural resources management is critical to improving livelihoods. However, the recent UNEP[1] environment assessment shows that two-and-a-half decades of war have resulted in widespread environmental degradation throughout the country, which poses a serious threat to future Afghan livelihoods. The major natural resource in Afghanistan is water - as expressed in a number of Afghan proverbs – and therefore sound water management is essential for the successful future development of the country.

The National Development Framework (NDF) drafted by the Government of Afghanistan considers that "river basin management is the best instrument for dealing with the management of water resources." Further, the NDF notes that "the government is therefore considering creating a Commission for management of each of the major river basins of the country." Linked with these institutional reforms, the NDF plans to improve the efficiency of natural resources use, improve catchments and on-farm water management, introduce more drought-tolerant farming systems, improve technologies for rainfed farming systems, improve agricultural services, increase crop diversification and cash crop enterprises, and improve pastureland management, productivity and successful animal husbandry systems.

Adopting a water catchment approach would involve integration of water resources management, rangeland and forestry activities, with the farming and urban development activities in the basin. "Integrated watershed management with participation of all the relevant key actors has become widely accepted as the approach best suited for sustainable management of renewable and non-renewable natural resources."[2]

The Watershed Atlas aims to support natural resources management and related monitoring activities (e.g. river flow, climatic data, agriculture production) with a planning tool in the form of geo-referenced river basin and watershed maps. It is an open source of information on rivers and watersheds of Afghanistan. The river basins and watershed maps have been prepared using ArcView 3.2 software and are fully compatible for area-based statistical analysis. They can be overlaid with any other geo-referenced maps and data on Afghanistan. The digital data can be downloaded from www.aims.org.af or www.fao.org/world/afghanistan websites. The Watershed Atlas is a first edition, and updating the Atlas will only be possible with the further contribution of interested parties – e.g. governmental, international and non-governmental institutions - working in the sector of water and natural resources management in Afghanistan.

[1]UNEP, "*Afghanistan. Post-Conflict Environment Assessment*", 2002.
www.unep.org
[2] Larry C. Tennyson, "*Review and Assessment of Watershed Management. Strategies and Approaches. Phase 1. Draft*", FAO, Rome, November 2002.

The Watershed Atlas is divided in five parts:

Part I

Overview of the climatic, water and natural resources context of Afghanistan.Several maps are presented on climate, mountain ranges and tectonics, snow cover satellite imageries, locations of (agro-) climatic and hydrological stations and existing and proposed dams. Also, tables on planned hydropower sector dam projects, sources of irrigation and formal irrigation schemes are presented. Finally, a brief discussion on watershed management in Afghanistan is made with a number of pictures illustrating major issues on watershed and natural resources management.

Part II

Discussion on methodology for the classification and delineation of river basin and watershed boundaries. This section proposes a terminology for four levels of water catchments areas for Afghanistan.

Part III

Description of the five river basins of Afghanistan. Includes discussions on the trans-boundaries riparian situation, hydrological infrastructures, environment and natural resources issues, agriculture patterns and main historical developments along water sources.

Part IV

Description of the 41 watersheds of Afghanistan. The description includes discussions on watershed features, sources of rivers and tributaries, land cover and the importance of agriculture land and graphs on water flow discharge based on the yearly Hydrological Book data compiled by the Ministry of Irrigation. These data have been recently entered by Asian Development Bank.

Part V

Conclusion and recommendations, acknowledgments and bibliography.

Annexes

Annexes, which include climatic data, location and codes of the historical hydrological stations and coordinates of the pictures presented in the Atlas.

Throughout the document, 142 pictures and panoramic views, taken during extensive field missions, illustrate features of river basins and watersheds. The geographical coordinates and the direction from where the pictures were taken (capital letters after the coordinates) are presented with each picture. These pictures and panoramic views provide a first database for monitoring of environmental changes in critical locations across Afghanistan.

This Atlas was produced thanks to one year of informal and voluntary collaborative work between FAO and AIMS staff that started in early 2003. FAO has contributed in defining the watershed boundaries based on existing literature, consulting with relevant governmental institutions (Ministry of Irrigation and Ministry of Water and Power), international organizations working in the water/natural resources management sector and through extensive field validation of boundaries in 2003. AIMS has contributed to the project with GIS work to delineate the boundaries and the provision of office facilities for the watershed consultant. The project could be finalized thanks to the financial support of Swiss Development Corporation and the administrative support of the Afghanistan Research and Evaluation Unit.

Finally, this presentation of river basins and watersheds is a discussion on geography, climate, valley systems, agriculture, Afghanistan's natural beauty and historical highlights of developments along water sources. Working on watersheds is setting oneself up for a journey into a fascinating country to which readers are invited!

> "Spatial variability is at the heart of geography, a field dedicated to understanding where things are and why. It is also a critical component in understanding many complex systems, particularly those which include interactions between wildly disparate sets of forces. Fortunately, the nature has given us a unit for analysis in which all of these components coalesce - the River Basin, but unfortunately, many analyses tend to ignore this hydro-centric unit, especially when including socio-economic or geo-political variables, in favor of units for which one can actually find data, notably the nation-state." (Wolf, 2003)

PART I

CLIMATE, WATER AND NATURAL RESOURCES

The context of Afghanistan

PICTURE 1
Lake and wetland in Samangan province, near Cheshma-i Hayat. 25 March 2003 (N36.54, E67.81, SW)

I. LOCATION AND CLIMATE

1. Location and geographic/geologic context

Afghanistan is a landlocked country of 652,000 sq. km. Over three-quarters of the land is mountainous. More than one-quarter of the national territory lies above 2,500 meters [3]. It is strategically located at the cross-roads of three main regions: the Indian sub-continent to the east, Central Asia to the north and the Middle East to the west. Afghanistan's neighbours are the landlocked Commonwealth of Independent States (CIS) countries (Turkmenistan, Uzbekistan, and Tajikistan) to the north, Pakistan to the east and south, the Islamic Republic of Iran to the west and China to the northeast. About 10 percent of Afghanistan's total land is arable, with less than 2 percent under forest cover and about 82 percent rangeland and bare land.

The Afghan landscape is mostly denuded – harsh desert. A group of students travelling from France by car in the 1970s stopped a geographer at work near the Maidan Shar in Wardak and asked, "But, tell us, how long all these deserts are going to last!"[4] – a reaction shared by countless visitors to Afghanistan. In the central highlands and the northeast, the Hindu Kush elevates its rugged, brownish and inhospitable slopes. Even when the relief smoothes down, nature is no more generous. Geographers distinguish the lut, arid steppes hostile to any cultivation, from the *dash*, steppes that turn green just after snow melt or rainfall in spring and attract nomadic livestock[5]. The most extensive flatlands are located in the southwest of the country, centred around the drainage of the Hilmand basin, and in the north of the country, between the northern foothills of the Amu Darya (Oxus) River (marking the border with Tajikistan and Uzbekistan). Both regions, the southwest in particular, include large areas of sand desert.

These desolate landscapes contrast sharply with the exuberant and fertile alluvial irrigated plains surrounding the Hindu Kush Mountains and the narrow irrigation strips bordering rivers that descend into sinuous mountainous valleys. In the north and the central highlands, low productivity lalm, or rainfed dry-land farming, is practised on mountain slopes.

Two mountainous arcs rising from the Iranian plateau spread across Afghanistan (see Figure 1):

1 The northern arc starts from northern Iran with the Elbourz Mountains and continues through the Hindu Kush in Afghanistan up to the Pamir and the Karakoram chains.

2 The southern arc starts in the Zarghos Mountains in Western Iran, continues through the Baluchistan Mountains, the Suleiman Mounts across Pakistan and Afghanistan, the Spingar (or Sefid Koh in Persian) of the Tora Bora area and ends with the northern arc in the Karakoram Mountains.

Geological rock composition and geological faults (by crushing rocks) have influenced the position of rivers and water catchment areas of Afghanistan. The Hari Rod fault traverses the country and extends in two branches: the Zebak fault up to the border to the Wakhan in Ishkashim, and the Badakhshi Markazi fault up to Darwaz district in the northeast (see Figure 2). This fault has defined east-west-oriented valley systems such as the Hari Rod valley, Bamyan and Shibar valleys, Ghorband (Picture 2) and Panjshir valleys, Zebak valley and Dara-i Shewa valley.

The geology of Afghanistan is a story of colliding landmasses that continues unabated - as demonstrated by recent devastating earthquakes in the north. Afghanistan is rich in minerals of economic value. Knowledge, however, is still fragmentary, and constitutes a promising field given that Afghanistan is at a geological cross-road between East Asia, the Middle East and Central Asia. The country's geologic mineral resources range from minerals such as lapis lazuli (Picture 3), emeralds and other fine gems to more standard metal ore deposits such as copper, iron or gold. The Hajigak iron ore deposit near the historical province of Bamyan has an estimated resource of two billion tonnes. Identified copper resources in Logar are estimated to be 240 million tonnes, making it a world-class deposit[6]. But Afghanistan's geological resources have been left largely untapped because of the difficulties of terrain, poor road networks and devastating civil war. It is hoped that these geological resources will one day be used to bring in foreign currency, provide jobs and help rebuild the country. USGS recently prepared an inventory of known mine resources of Afghanistan[7].

PICTURE 2
Abandoned meander of the Ghorband River that flows eastward along the Hari Rod geological fault in central Afghanistan. The fault cuts directly through and facilitates the meander neck cutoff. The river flows straight at the foot of the front mountain (background of picture). Ghorband, Parwan province, 5 June 2003 (N35.00, E68.81, N)

[3] Kapos, V., J. Rhind, M. Edwards, M.F. Price and C. Ravilious. 2000. "*Developing a map of the world's mountain forests*", from M.F. Price and N. Butt (eds.) "*Forests in sustainable mountain development: A state-of-knowledge report for* 2000". CAB International, Wallingford.
[4] Etienne, G., "*L'Afghanistan ou les Aléas de la Coopération*", PUF, Paris, 1972.
[5] Etienne, G., Ibid., 1972.
[6] H. Afzali, "*Les ressources d'hydrocarbures, de métaux et de substances utiles de l'Afghanistan: aperçu général*", Chronique Recherche Minière, No 460, 1961 and Schindler J. Stephen, "*Afghanistan: Geology in a Troubled Land*", February 2003. http://www.geotimes.org/feb02/feature_afghan.html
[7] G. J. Orris and J. D. Bliss, "*Mines and Mineral occurrence in Afghanistan*", USGS, Arizona, 2002.

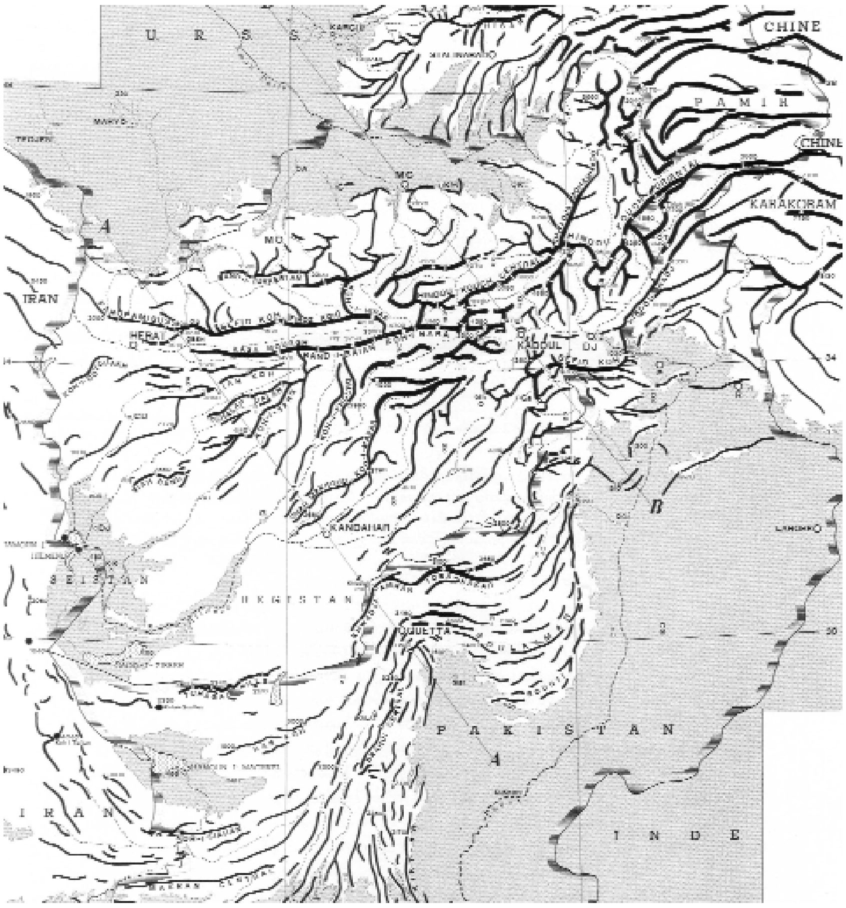


FIGURE 1
Main mountain ranges in Afghanistan. The thickness of the lines is proportional to elevation[8].

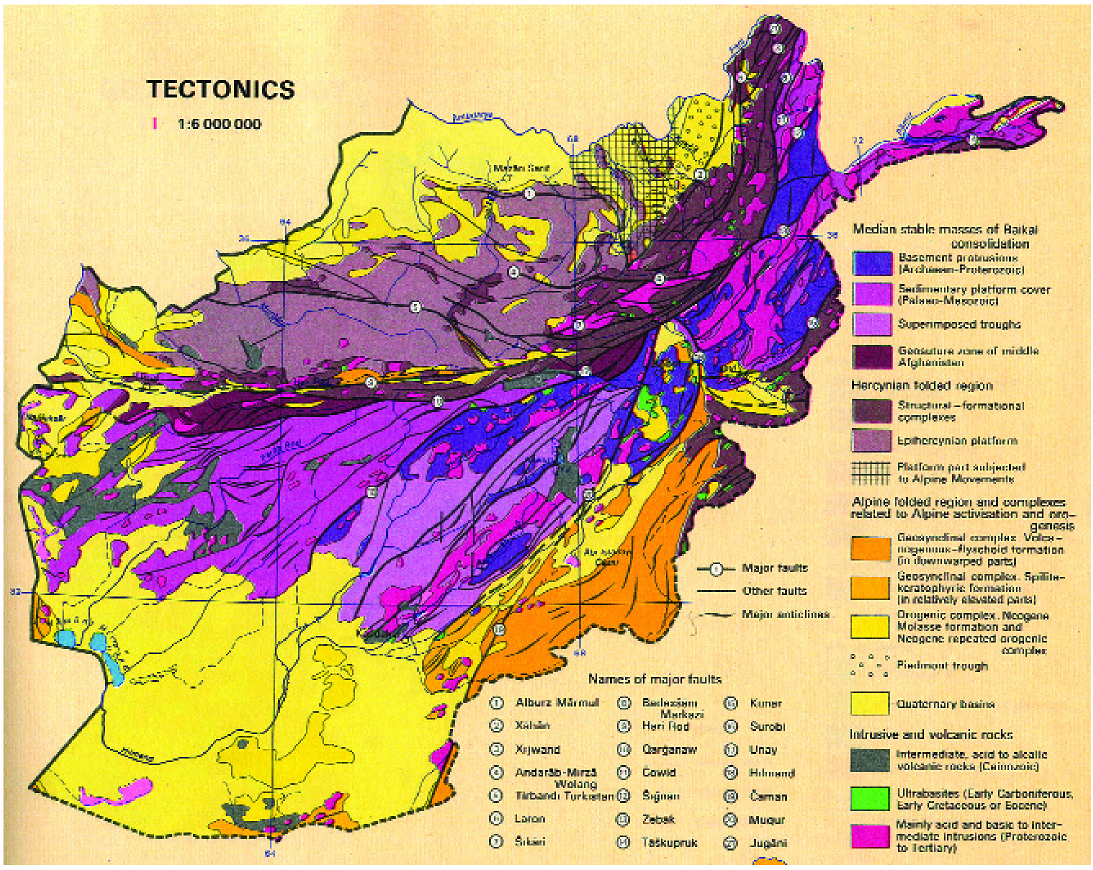
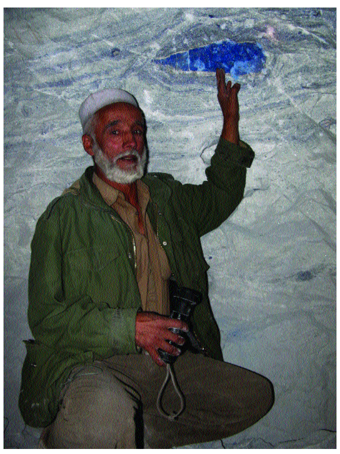


FIGURE 2
Tectonic map of Afghanistan[9].



PICTURE 3
Inside a lapis lazuli mine in Maidan-i Lajuar, Badakhsan province, 31 August 2003 (N36.23, E70.81)

[8] J. Humlum, "*La géographie de l'Afghanistan. Etude d'un pays Aride*", Scandinavian University Books, Copenhagen, 1959.
[9] GEOCART, "*National Atlas of the Democratic Republic of Afghanistan*", Warsaw, 1984.

2. Atmospheric pressure and wind

Afghanistan and the neighbouring areas of Central Asia and the Iranian highlands is a region with some of the lowest atmospheric pressures in the world. Comparable low pressures in July exist only in the Antarctic regions. In the capital city of Kabul, which is located at about 1,800 m above sea level, the atmospheric pressure is approximately 610 mm, and in the Sistan depression, 500-700 m above sea level, it is around 700 mm[10].

Dominant winds blow all year-round from the north and west. It is only in the eastern part of the country that the influence of the monsoons from the Indian sub-continent is present between July and September. In winter, cold air from the Mediterranean region can pass through Afghanistan up to the Suleiman Mount in Pakistan. Thus the eastern part of Afghanistan has two rainfall peaks, in January-February and July-September.

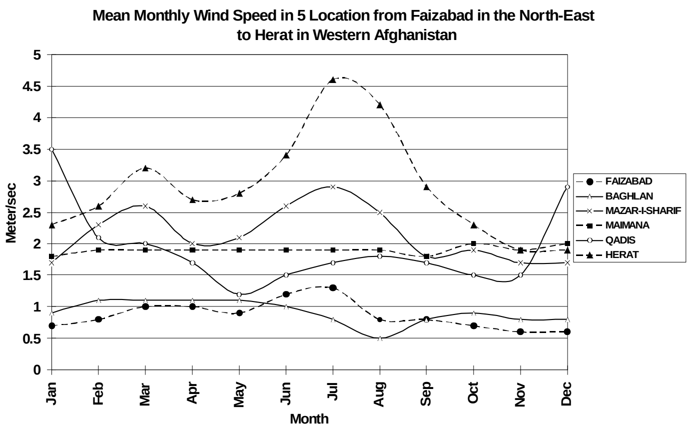
Generally, winds are not strong in Afghanistan and no air movements are common either in summer or winter. However, in Sistan, very strong dust winds blow in winter. One of the most famous winds in Afghanistan is the *bad-o sat o bist roz*, or the '120-days wind,' which blows strongest between early/mid-June and the end of September. Ephemeral dust winds throwing dirt and sand several hundred metres up in the air are common throughout the country during hot days in summer. Graphs 1 and 2 show that in Herat and Ghazni, monthly wind speed averages above 3 m/s.

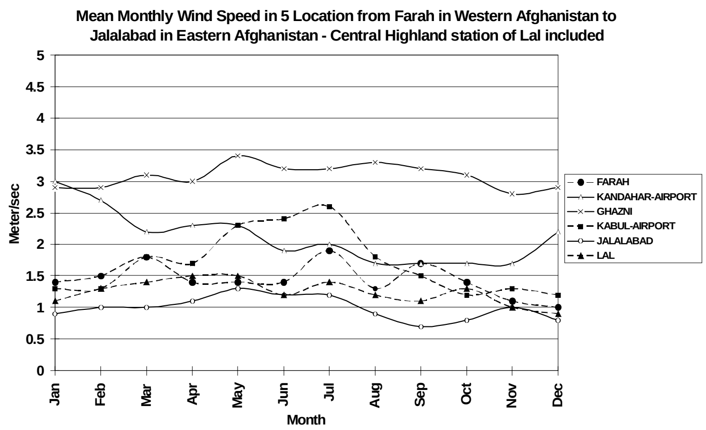
3. Precipitation

Afghanistan is an arid to semi-arid country receiving erratic rainfall over the years. Rainfall, which varies from a low of 75 mm in Farah to 1,170 mm in south Salang, occurs mostly in the winter months and particularly in the February-April period. The wet season is concentrated in winter and spring when the vegetative cover is low. In higher elevations, precipitation falls in the form of snow that is critical for river flow and irrigation in summer. From June to October, Afghanistan receives hardly any precipitation. These rainfall patterns result in high dependency on snow melts for irrigation (see satellite images in Maps 3-5). Figure 3 illustrates rainfall patterns for Afghanistan and surrounding countries.

The southern part of Afghanistan (the crescent from Herat to Ghazni) receives less than 300 mm of rain per year. The region south of Bust and Farah receives less than 100 mm of rainfall per year. The central highlands and northern Afghanistan receive between 300-400 mm of rain per year, while the highest mountains in these areas may receive more (Koh-i Baba range, Band-i Baian, Safid Koh, Tirband-i Turkistan). The Hindu Kush Mountains in the northeast and east (western edge of summer monsoon from the Indian continent) receive above 400 mm of rainfall per annum (Figure 4). Under these climatic conditions, the major limiting factor for agriculture production is water availability at critical growing periods.

Afghanistan is a drought-prone country. A severe drought generally equates to low winter rainfall in two consecutive years. Rainfall records suggest that low winter rainfall in two successive years occurs at least once every 10-15 years[12]. The last below-average consecutive years were 1963-1964, 1966-1967, 1970-1971-1972, 1999-2000-2001 and part of 2002 (in the southern part of the country).





GRAPHS 1 AND 2
Wind speed in northern and southern belts of Afghanistan[11].

[10] J. Humlum, Ibid., 1959.

[11] Source : Department of Meteorology, Department of Transport and Tourism. The data were entered by FAO Agro-meteorology department in Kabul under the supervision of Rabah Lekhal, FAO Agro-meteorologist.

[12] Berding, F.R., "*Promotion of Agricultural Rehabilitation and Development Programs. Land Management*", in Agricultural Strategy, FAO, Rome, January, 1977; a report part of the Afghanistan Agricultural Strategy, FAO, Rome, 1997.

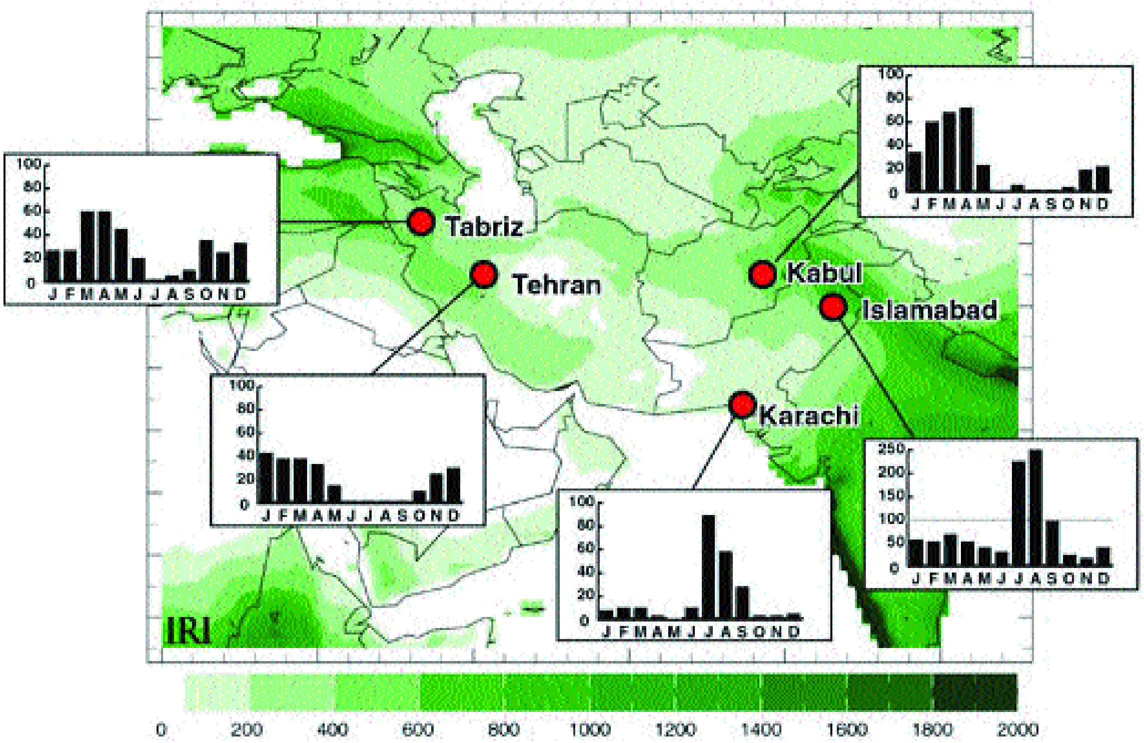


FIGURE 3
Regional rainfall patterns in Afghanistan and surrounding countries[13].

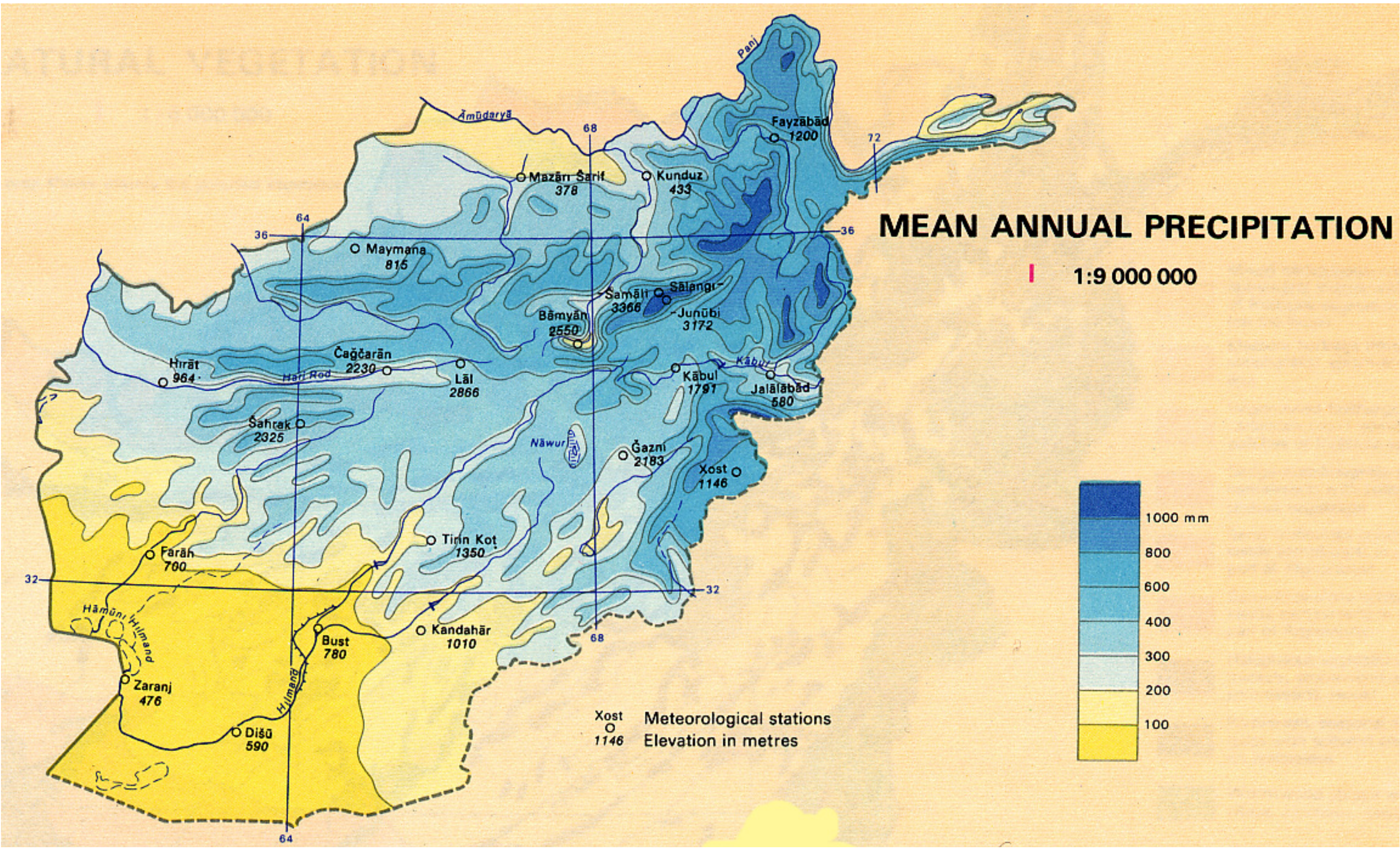


FIGURE 4
Annual precipitation in Afghanistan. The scale only indicates the printing size of the GEOCART Atlas[14].

[13] Source : www.iri.columbia.edu
[14] GEOCART, '*National Atlas of the Democratic Republic of Afghanistan*', Warsaw, 1984.

4. Temperature and potential evapotranspiration

The Afghan climate is continental, with temperatures ranging from 30° C in summer (Figure 5) to -20° C in winter (Figure 6). In spring, late frost can affect fruit production. Annual evapotranspiration (ETP) rates are relatively low (9,000-1,200 mm) in the Hindu Kush due to long and severe winters. They vary between 1,200 mm and 1,400 mm in the northern plains and reach values up to 1,800 mm in the southern and southwestern plains. However, summer ETP rates are high everywhere, showing a daily peak of 5-8 mm in June, July and August. Due to strong winds occurring particularly in Herat and in the southwestern plains (*bad-o sat o bist roz*, the 120-days wind), maximum daily ETP rates are over 10 mm in July and August (maximum of 11 mm in July).

Agriculture is practiced from 250 m to a little above 3,500 m altitude in the central highlands (Hazarajat) and the mountains of Badakhshan, mostly concentrated on plain and valley floor irrigation. Considerable differences in agricultural practices and cropping patterns exist both among regions as well as locally, between the troughs and peaks of valleys. Agriculture varies from sub-tropical areas such as Jalalabad (315 frost-free days), where citrus and sugar cane grow, to temperate cool areas, where only barley and wheat are cultivated (>180 frost days/year). Frost can cause damage to fruits (in spring – see Picture 4) and crops (in autumn).

PICTURES 4 AND 5
Frost damage on vineyard in Spring 2003. Injil district, Herat province, 29 May 2003. Mulberry branches defoliated after a hailstorm in Herat, Koshan district. 30 May 2003 (Picture 4: N34.33, E62.28; Picture 5: N34.63, E61.24)

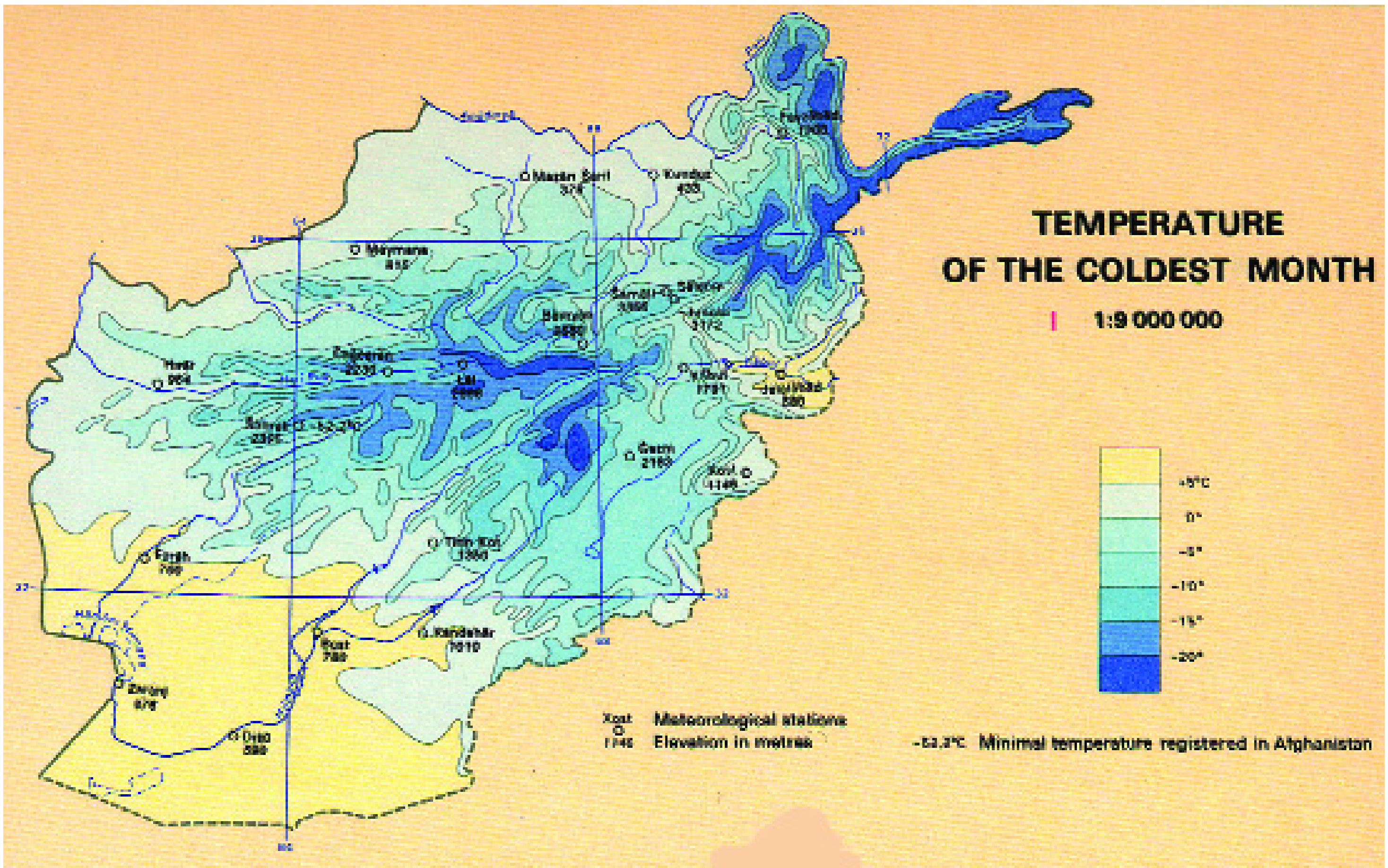


FIGURE 5
Temperature of the coldest month. The scale only indicates the printing size of the GEOCART Atlas [15].

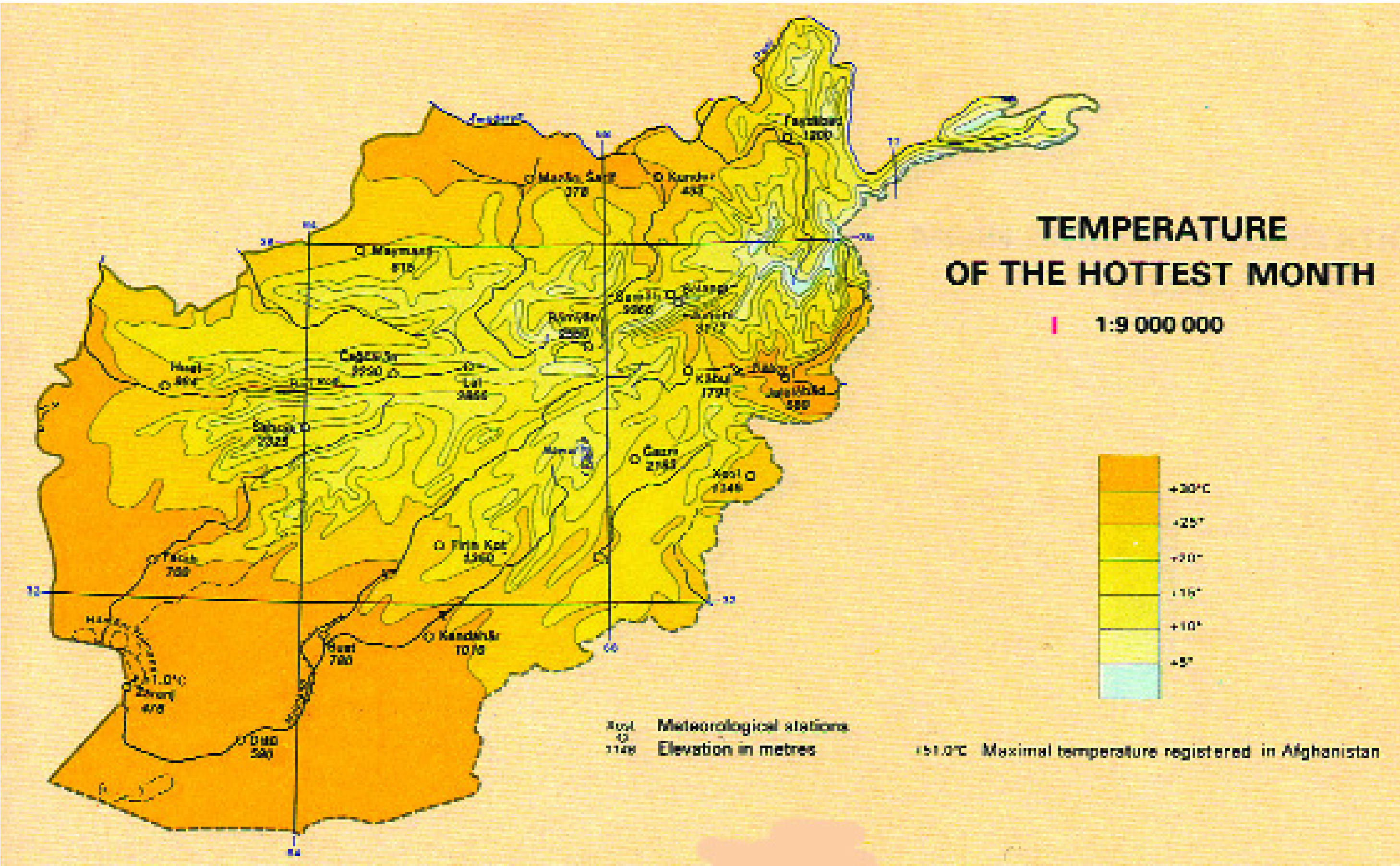


FIGURE 6
Temperature of the hottest month. The scale only indicates the printing size of the GEOCART Atlas [16].

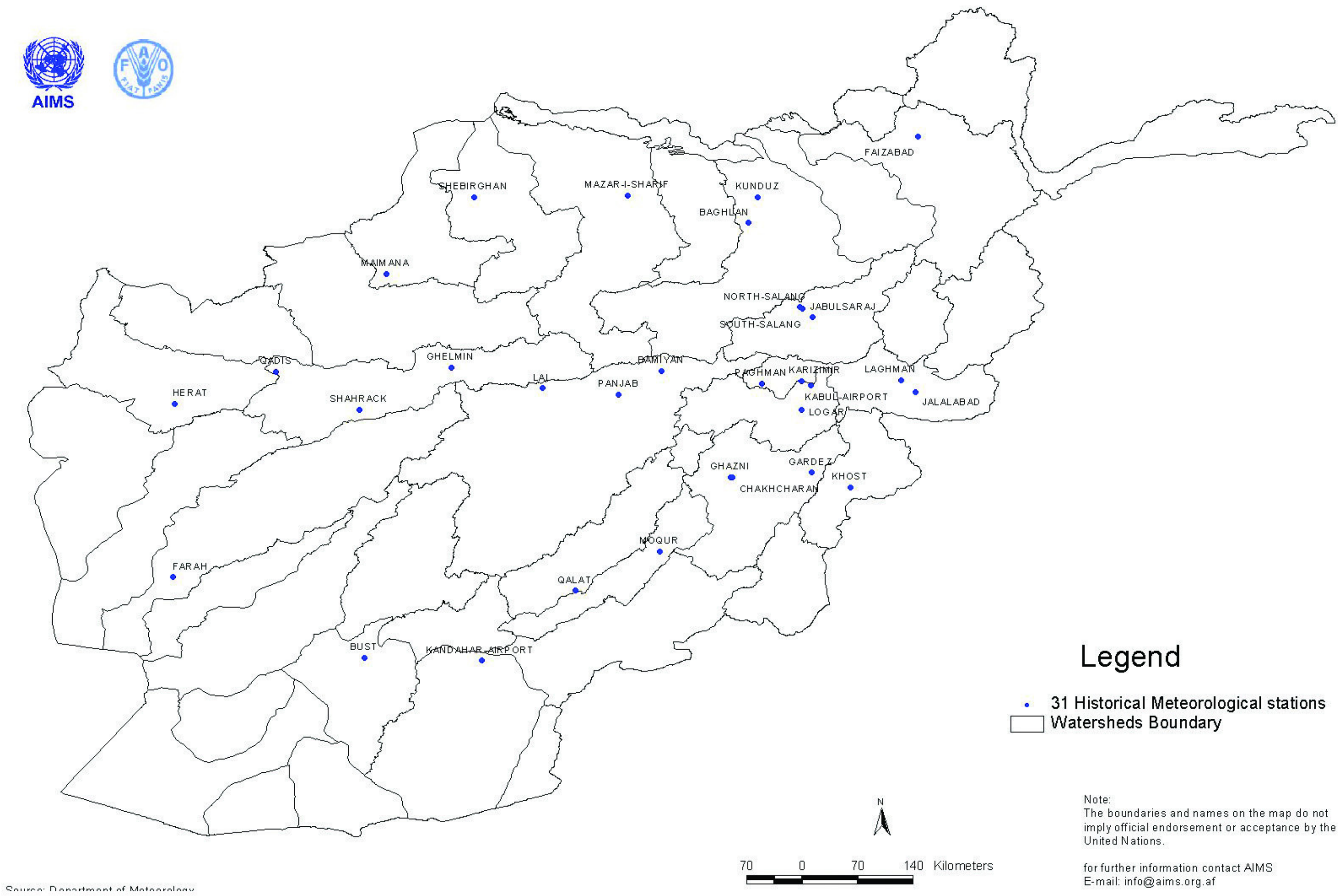
[15] GEOCART, "*National Atlas of the Democratic Republic of Afghanistan*", Warsaw, 1984.
[16] GEOCART, "*National Atlas of the Democratic Republic of Afghanistan*", Warsaw, 1984.

	Precipitation			ETP	ETP/Day*			Temp	Wind	Sunshine
	Max	**Normal**	**Min**	**Total**	**Mean**	**Max Month**	**Min Month**	**Mean**	**Speed**	**Mean**
STATION NAME	**Mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**°C**	**m/s**	**Ratio**
Baghlan				961	2.67	5.73	0.33	14.8	0.9	0.58
Bamyan	382.4	138.6	57.7					5.9		
Bust	196.0	92.7	32.4	1585	4.40	7.90	1.20	19.5	1.8	0.73
Chakhcharan	246.5	187.8	137.5					6.9		
Faizabad	791.0	501.3	300.1	925	2.57	6.07	0.27	13.2	0.9	0.54
Farah	193.0	90.1	38.0	1468	4.08	8.27	0.90	19.7	1.4	0.74
Gardez	521.1	319.3	141.2					9.3		
Ghazni	551.2	284.8	90.2	1359	3.78	7.57	*0.57*	9.5	3.1	0.73
Ghelmin	363.1	219.9	125.6	905	2.51	6.00	*0.37*	7.8	1.4	0.62
Herat	411.9	222.5	112.5	1737	4.83	11.03	0.87	16.3	2.9	0.62
Jabulsaraj	739.2	465.2	110.3	1409	3.91	8.40	*0.67*	15.0	2.5	0.69
Jalalabad	408.1	171.2	42.5	1274	3.54	6.80	0.70	21.5	1.0	0.68
Kabul Airport	547.8	316.0	164.9	1173	3.26	7.57	0.43	12.5	1.7	0.70
Qalat	461.3	281.3	144.8					13.4		
Kandahar Air	311.4	161.4	57.3	1644	4.57	8.27	1.30	19.0	2.1	0.78
Karizimir				955	2.65	5.77	0.47	10.5	1.1	0.70
Khost	657.3	449.9	206.2	1205	3.35	6.37	*0.93*	17.0	1.7	0.67
Kunduz	560.8	336.0	193.0	1285	3.57	8.13	0.43	16.5	1.8	0.58
Laghman	468.9	251.3	117.2					19.1		
Lal	429.3	227.4	168.0	695	1.93	4.33	*0.20*	2.9	1.2	0.69
Logar	372.2	222.0	101.4					10.7		
Mazar-i Sharif	379.1	189.1	87.4	1376	3.82	8.47	0.57	18.0	2.2	0.59
Maimana	582.1	353.6	200.3	1202	3.34	7.20	*0.63*	14.4	1.9	0.62
Moqur	451.1	239.5	49.3					10.2		
North Salang	1450.6	1018.5	376.5					-0.6		
Paghman	620.7	419.6	223.7					9.1		
Panjao	440.1	284.8	44.4					3.2		
Qaqis	450.5	344.8	210.9	1090	3.03	6.10	*1.03*	12.1	1.9	0.62
Shahrack	417.0	276.1	60.3					3.9		
Shebirghan	434.6	231.0	116.5	1364	3.79	7.90	0.73	16.4	2.2	0.60
South Salang	1354.0	1023.3	677.1					2.3		

* ETP/day maximum month: July, except Khost; June in Jalalabad
* ETP/day minimum month: December; italic numbers: January; and Qadis station: February

TABLE 1
Historical data on precipitation, temperature, potential ETP and wind in 31 selected stations in Afghanistan[17]

[17] Source : Department of Meteorology, Department of Transport and Tourism. The data were entered by FAO Agro-meteorology department in Kabul under the supervision of Rabah Lekhal, FAO Agro-meteorologist.



MAP 1
Locations of 31 selected Historical Stations for which climatic data was made available

5. Indigenous knowledge on weather conditions

Afghan indigenous knowledge on weather conditions has divided the climatic patterns during winter into two sub-seasons. The first sub-season, called Chel-i Buzurg (literally translated as 'The Big 40s') are the 40 days from 21 December to 31 January characterized by a cold winter climate (Figure 3). The second sub-season, called Chel-i Khord (literally, 'The Small 40s') are the 20 days from 1-20 February, when weather conditions are milder with some cold spells. After Chel-i Khord, the weather stabilizes and the temperature warms up steadily. In that period (beginning on the 21st of February), the spring climate is already set in the lowland areas throughout Afghanistan, while it is delayed by one month or so at 2,000 m elevation (and by two months at 3,500 m elevation).

As a general pattern, snow and rainfall occur during the first part of Chel-i Buzurg. Precipitation in that period is generally gentle and believed to be important for replenishing aquifers. After a first wave of rain/snowfall during the Chel-i Buzurg, it is locally observed that the rainfall reduces or stops for 5-7 weeks and starts again in springtime, toward the end of February. The shape of the clouds changes from stratiform to cumuliform. The second rainfalls (spring) are generally heavier but more erratic, and pose the risk of localized floods. In areas where dams have been built, the surface water from these spring rainfalls are retained and used to gently irrigate crops in summer. In other areas, the water is mostly lost (from an agronomic point of view). It is also in spring that hailstorms can occur, causing localized crop damage (see Picture 5).

6. Rehabilitation of the (agro-) meteorological network

The Government of Afghanistan once employed an extensive meteorological network. According to information from the president of the Afghan Meteorological Service, they had at one time 200 climatic posts, 50 synoptic stations and three upper-air recordings. This network was rendered inoperative during the two-and-a-half-decades of war. The long-term climatic data series of the Meteorological Service has been entered by FAO. Annex I present climatic data of Afghanistan. In 2003, FAO, Afrane[18] and ICARDA contributed to the rehabilitation of the agro-climatic network throughout Afghanistan. Map 2 presents the sites of (agro-) meteorological stations.

A NETWORK OF AGRO-CLIMATIC STATIONS SERVES THE FOLLOWING PURPOSES

1. Crop forecasting (rainfed production)

2. Rangeland and pastureland monitoring

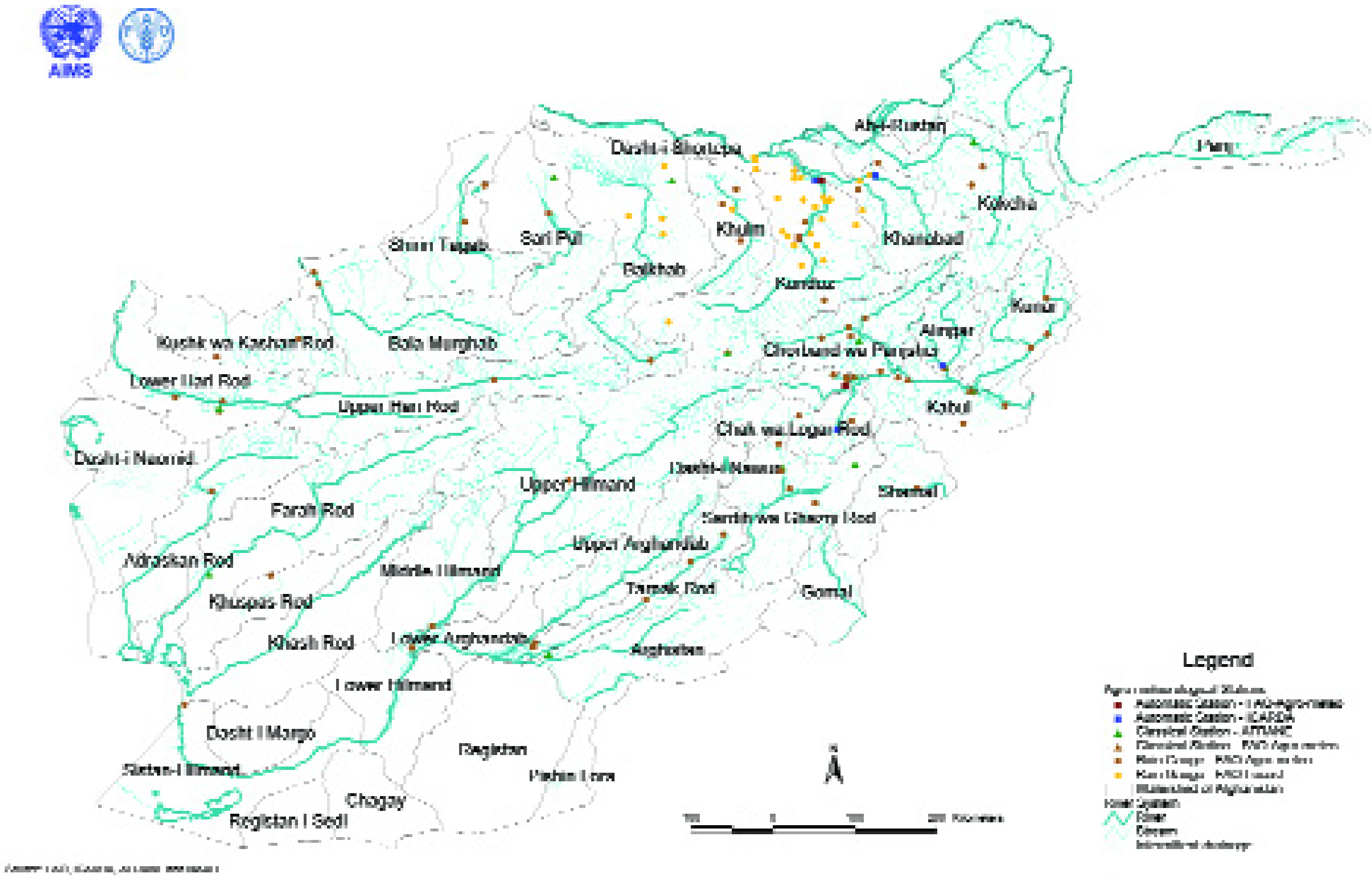
3. Satellite imagery ground verification for various natural resources monitoring models

4. Runoff forecasting system when used in conjunction with hydrological data[19]

5. Agriculture research programs

[18] French NGO.

[19] The Ministry of Water and Power (MWP) notes that meteorological data and forecasts are very useful in establishing run-off forecasting systems for improving reservoir operation for hydropower and irrigation purposes. Indeed, in order to operate existing and future reservoirs more optimally, it would be very useful to establish a model for run-off forecasting based on climate data from locations like Salang, as well as snow storage assessments based on aerial photos, satellite images or direct measurements. With a functioning forecasting system reservoirs such as Bandi Naghlu could be operated with smaller margins for flood storage and power production could therefore be increased. Government of Afghanistan, MWP, "*Power Sector Master Plan Update, Draft Final Report*", report prepared by Norconsult-Norplan for MWP, October 2003.



MAP 2
Map of the current agro-meteorological network

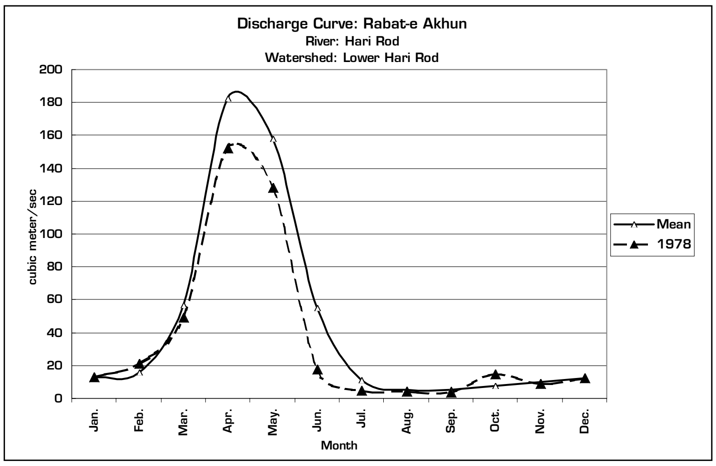
II. RIVER REGIMES

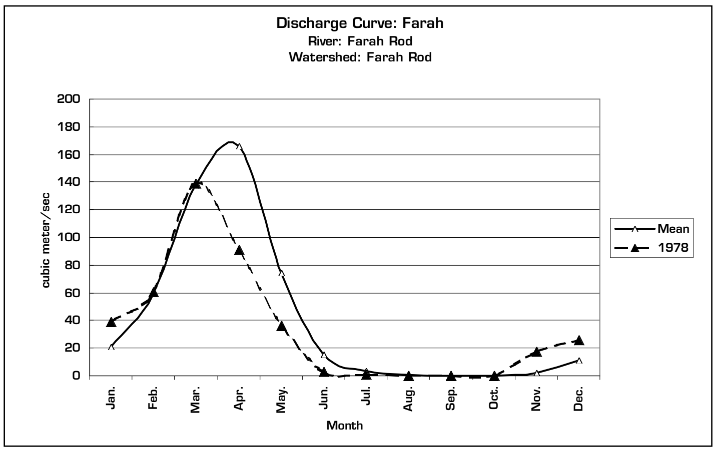
7. Rain/snow-fed rivers

Most of the river flows in Afghanistan depend on the success of annual rain and snowfalls. Maps 3, 4 and 5 illustrate snow cover extent in Afghanistan at different periods of the year (winter, early summer and autumn). When snow begins to melt in late winter and spring, the rivers rise. The rivers in Afghanistan generally have a peak of flow at the end of the winter and in spring, and a minimum flow in summer and autumn (Graphs 3, 4 and 5 and Pictures 6, 7 and 8). In many instances, minimum precipitation means the drying up or reduction of a river to a series of isolated pools in the streambed in summer and autumn/early winter. Also, there are myriads of seasonal streambeds carrying water for only a few hours, when torrential rains may occur in late winter or early spring and cause flash floods.

In many instances, the period when rivers carry water is shortened by one or two months as compared to natural flow due to human interventions for irrigation. In some cases, the river's length is considerably shortened, and the water runs out 50-200 km before the natural delta of the river in deserts (see northern and western oases below) [20].

In the southeast of Afghanistan, the rivers that drain water from the east of the Suleiman Mountains (Gomal and Shomal Rivers) have their flow affected by the furthest influence of the monsoon rainfall in summer (Graph 6). Located at a transition between the Indian sub-continent regime and the typical Afghan regime, these rivers have two maximum flows: one in January-March and a second one in July-September.

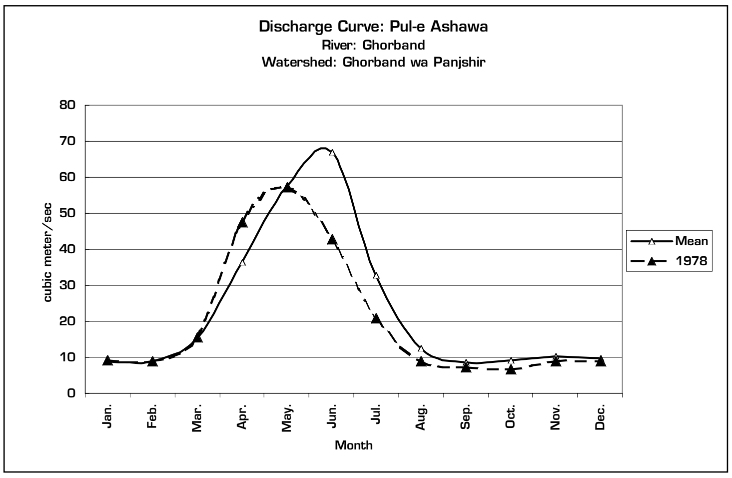




GRAPHS 3 AND 4

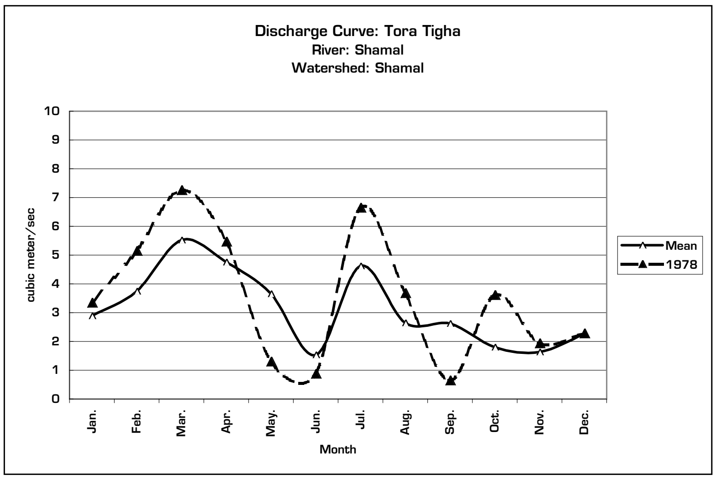
Discharge of two rain/snow-fed rivers, the Hari Rod and Farah Rod. The Hari Rod discharge flow peaks in April/May and then the flow reduces rapidly from July onward. The Farah Rod peaks in March/April and then the flow reduces rapidly from July onward. The river flow in both the Farah Rod and the Hari Rod increases slightly in winter during the planting season.

[20] See J. Humlum, *Ibid.*, 1959.



GRAPH 5 AND PICTURES 6, 7 AND 8

Discharge of a rain/snow-fed river, the Ghorband. The Ghorband water flow increases in March, peaks in April/May and reduces to a minimum from August onward. The picture shows the Ghorband River in Pul-i Matak in the Shomali plain (Jabulussaraj district) on the 11 May (top right; N35.09, E69.20, NW), 5 June (N35.09, E69.20, NW) and 27 August 2003 (bottom right; N35.09, E69.20, NW)



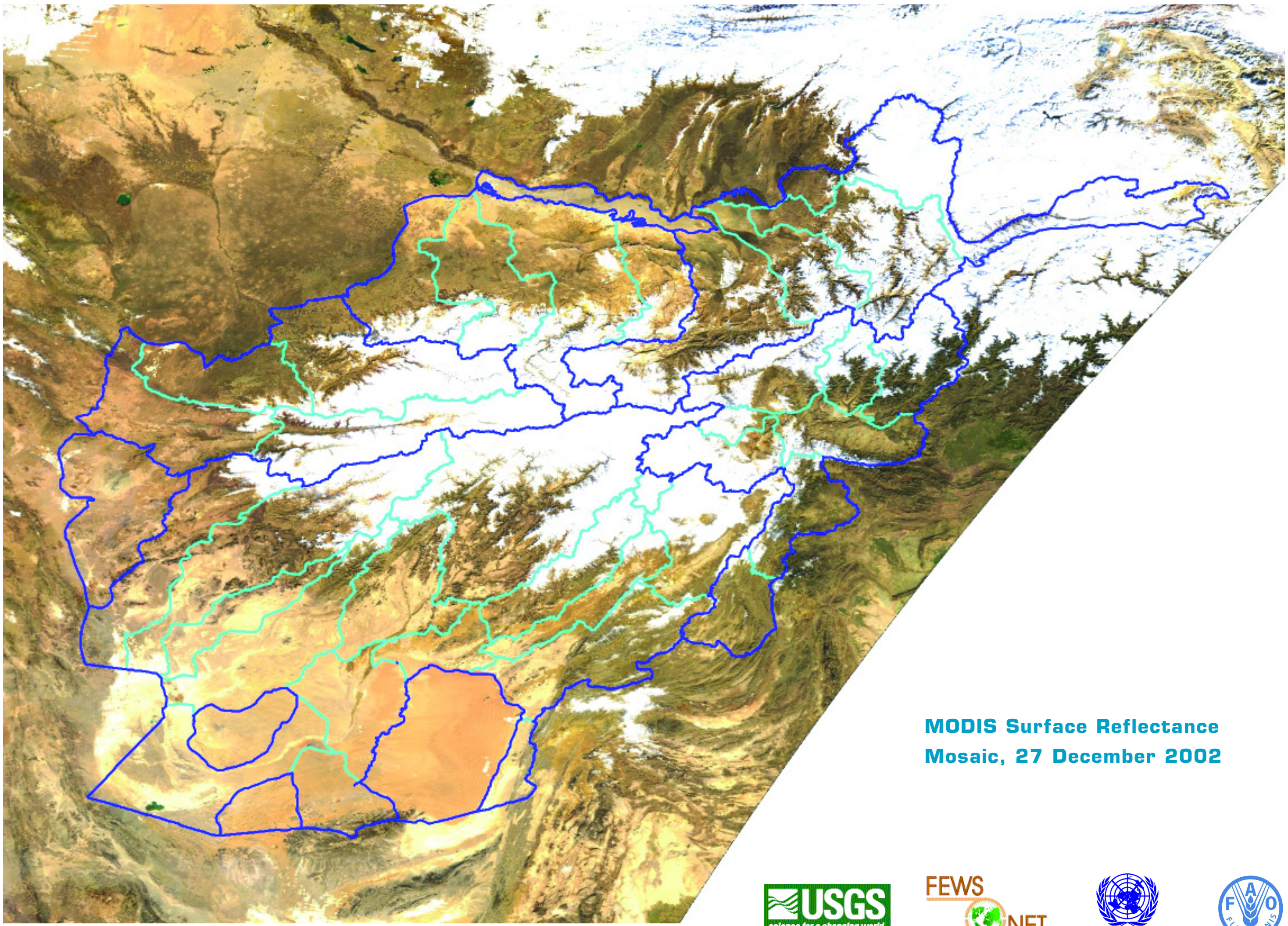
GRAPH 6

Discharge of a rain/snow-fed river, the Shamal, influenced by the monsoon rains in summer. The Shamal discharge flow peaks first in March; then the flow reduces in May/June before a second peak in July when monsoon rains cover eastern Afghanistan.

8. Snow/glacier-fed rivers

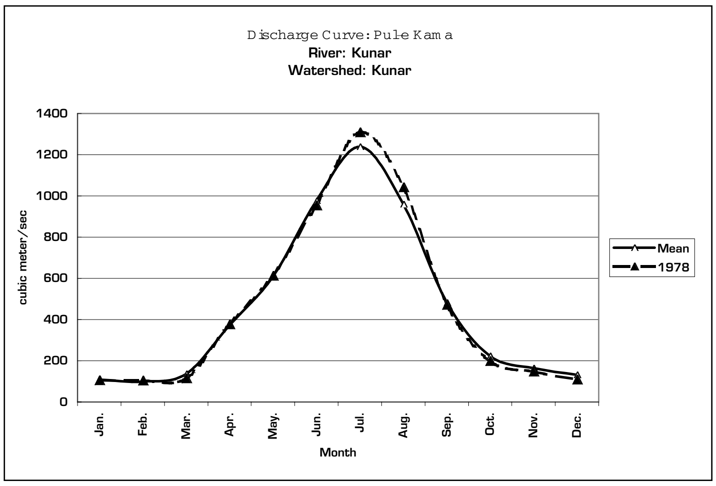
Several rivers in Afghanistan take their source from the high altitudes of the Pamir or Nuristan, where sizeable glaciers exist. Peaks above 5,550 m are permanently snow-covered (Picture 9). Map 4 illustrates the snow cover on the 25 May 2003. The image shows that it is in the northeastern mountains that sufficient snow is still available in May and June to sustain river flow throughout the summer. These rivers, namely the Amu Darya, the Kokcha, the Kunar and, to a lesser extent, the Alingar and Panjshir Rivers, sustain a good flow of water in summer months due to melting glaciers during the hot season. They have a minimal flow in winter and a maximal flow in summer when snow and glaciers melt (Graph 7 and 8). The glaciers represent an important ecological asset, stabilizing the water supply within and between years. The persistence of snow and ice are closely related to the prevailing temperatures, and therefore glaciers in Afghanistan are at risk from global warming.

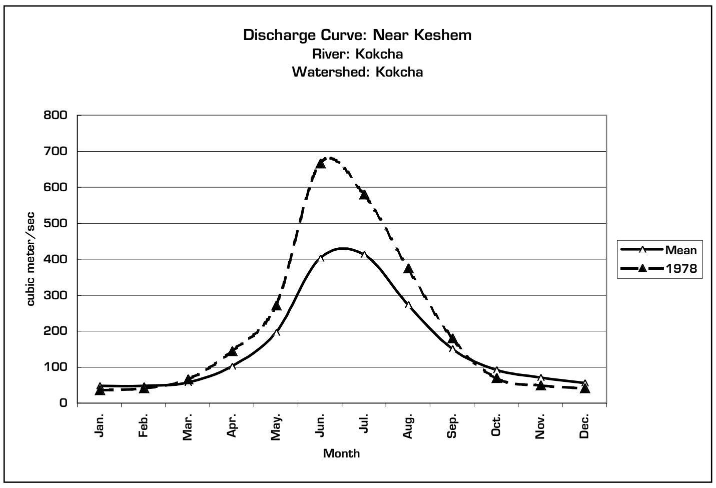
PICTURE 9
High mountains covered with glaciers in the Wakhan corridor. Badakhshan province, 2 September 2003 (N36.99, E72.45, S)



MAP 3

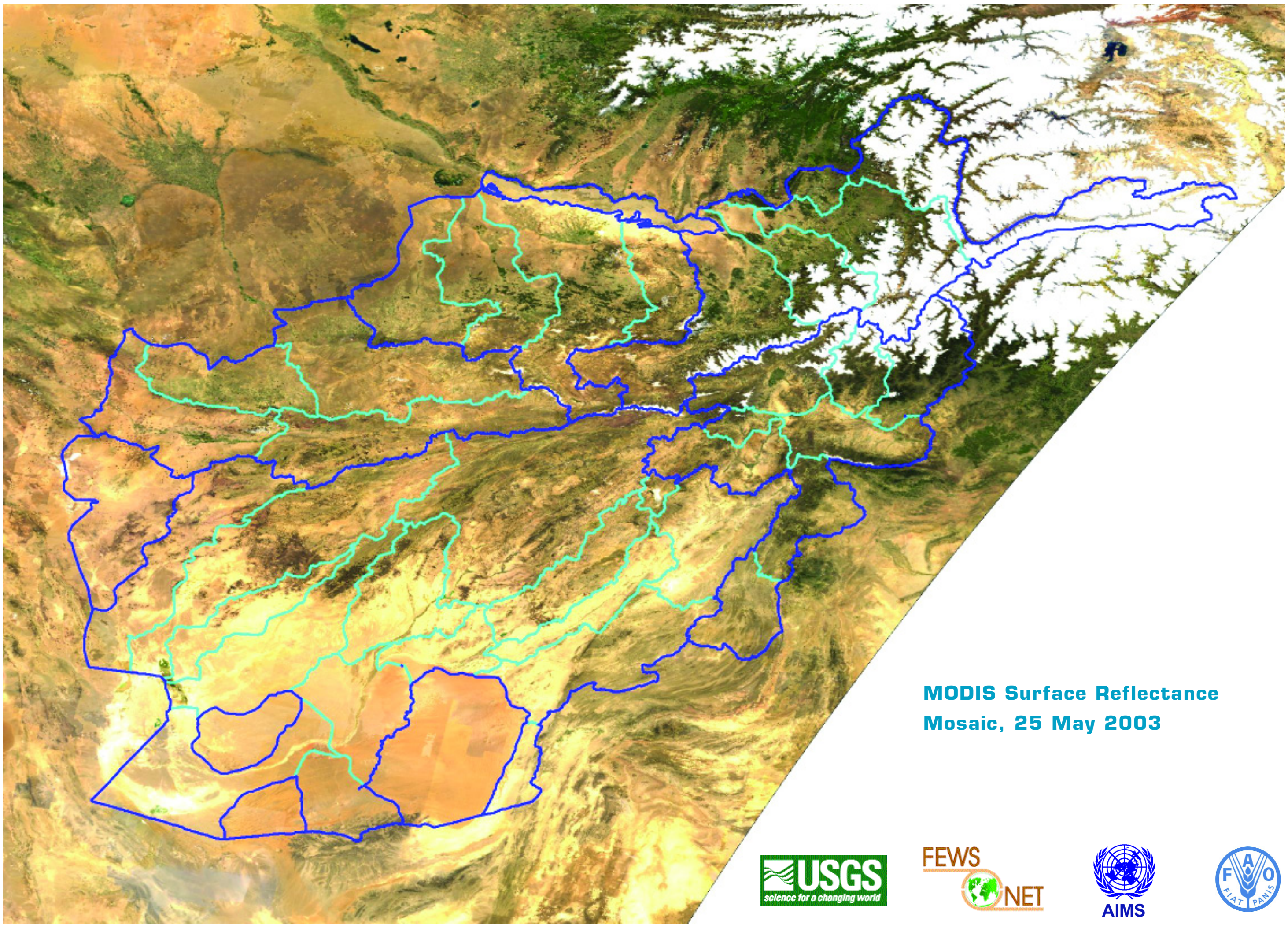
MODIS surface reflectance mosaic satellite image showing the snow cover extent (white colour) in winter on 27 December 2002. November-January is the planting time for the first winter crops in low and mid-elevation land. The dark blue lines show the boundaries of the river basins and the light blue lines show the watersheds. The river basin and the watershed delineated for the Atlas have been overlaid on the satellite image.





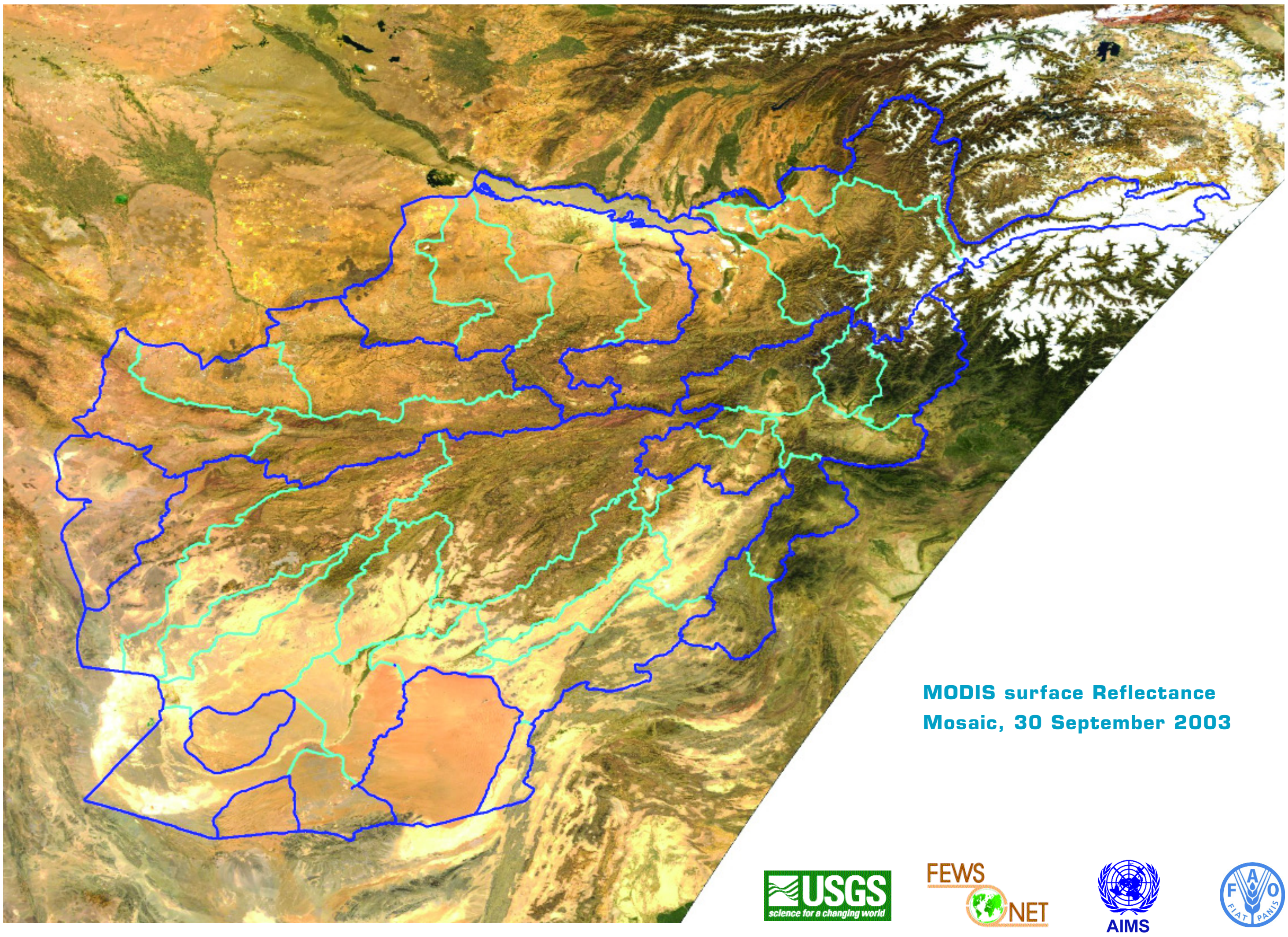
GRAPH 7 AND 8

Discharge of two snow/glacier-fed rivers, the Kunar and Kokcha. The water flow of the Kunar River increases in April, peaks in the summer month of July and decreases in September/October when the weather cools down in higher elevations. The lowest water flow occurs in the winter and spring months of December to March. The Kokcha River flow peaks in June/July and reduces in September/October to reach its lowest points in the winter months of December and January.



MAP 4

MODIS surface reflectance mosaic satellite image showing the snow cover extent (white colour) in early summer on 25 May 2003. April-June is the period with maximum river discharge in Afghanistan. It is also the harvesting time for the first crop and the beginning of planting for the second, summer crops in low- and mid-elevation land. Note that the main areas still covered with snow are the northeastern part of Afghanistan, feeding snow/glacier-fed rivers along which double cropping is generally practiced thanks to good water availability for summer crops. The dark blue lines show the boundaries of the river basins and the light blue lines show the watersheds. The river basin and the watershed delineated for the Atlas have been overlaid on the satellite image.



MAP 5
MODIS surface reflectance mosaic satellite image showing the snow cover extent (white colour) in early summer on 30 September 2003. September/October is the period with minimum snow cover and minimum river discharge for snow/rainfed rivers in Afghanistan. It is also the harvesting period for the first crops in the highlands and the second crops in low- and mid-elevation land. The dark blue lines show the boundaries of the river basins and the light blue lines show the watersheds. The river basin and the watershed delineated for the Atlas have been overlaid on the satellite image.

INFORMATION ON MODIS PRODUCTS

The MODIS surface reflectance mosaic -MOD09A1- image is a sample of the Level 3, 8-day composite of 500m Level 2G Surface Reflectance bands 1 (red), 4 (green) and 3 (blue). This product is computed from the MODIS Level 1B land bands 1-7. The 8-Day 500m product (MOD09A1) is an estimate of the surface spectral reflectance for each band as it would have been measured at ground level if there were no atmospheric scattering or absorption. This is achieved by applying a correction scheme to compensate for the effects of atmospheric gases, aerosols, and thin cirrus clouds. MOD09A1 is generated with input from Level 2G surface reflectance, observation pointers, and geolocation angles at each resolution. For more information, see http://lpdaac2.usgs.gov/modis/mod09a1v4.asp

The MODIS surface reflectance mosaic images (Maps 3, 4 and 5) presented here are a courtesy of USGS-FEWS/NET for the Atlas. The maps have been processed by Michael E. Budde, USGS/EROS Physical Scientist.

III. WATER RESOURCES IN AFGHANISTAN

9. Water resources overview

Natural storage of water in the form of winter precipitation (snow) at elevations above 2,000 m represents 80 percent of Afghanistan's water resources (excluding fossil groundwater). The amount of water received in these areas through precipitation is estimated to be in the order of 150,000 million m^3. The rest of the country receives only 30,000 million m^3 annually through rainfall, resulting in a total of 180,000 million m^3 for the whole country (FAO, 1996)[21].

The total annual surface water volume of 84,000 million m^3 (see Table 2), which corresponds to approximately 47 percent of the total precipitation, is shared with Afghanistan's neighbouring countries. Considering an estimated water use of 65 percent inside the country, approximately 55,000 million m^3 of surface water would be used in Afghanistan[22]. Surface waters in Afghanistan compare favourably with Iran and Central Asian republics, as the surface water per head in Afghanistan is estimated at 2,480 m^3/year (Iran: 1,430 m^3/head/year). Water catchments areas in Afghanistan are vast and settlements are generally concentrated along valley floor irrigation areas or river deltas opening in plain desert areas. Afghanistan has only 34 inhabitants/ km^2 [23]. Surface water is still largely underused.

According to the United Nations Commission for Asia and the Far East (1961)[24] there are about 50,000 million m^3 of runoff each year, of which about 30,000 million m^3 could be impounded. It should be noted that these figures were produced before the construction of the Bandi Naghlu and Darunta dams on the Kabul River. Water availability for irrigation purposes is a function of the seasonal variation of stream flow where no water is stored in reservoirs, too much water is flowing in spring due to snow melt and heavy rainfall, and often too little water is flowing in late summer when river discharges are low and crop water requirements are still high. As a result, the influence of the coverage and thickness of the snow cap is significant on crop results (see satellite images in Maps 3-5). Exceptionally good spring rainfall can compensate for low snow cover in lowland irrigation farming.

The annual volume of water used for drinking purposes (both humans and animals) is no more than 200 million m^3. Adopting a rate of 10,000 m^3/ha for a total irrigated area of about 2.4 million ha[25], the annual volume of water used for irrigation purposes is estimated to be in the order of 24,000 million m^3. Therefore, irrigation is the main user of water in Afghanistan, with an estimated 99 percent of the share.

The government of Afghanistan has divided the irrigated land into four classes according to the origin of the irrigation water: rivers and streams (84.6%), springs (7.9%), karezes (7%), and shallow and deep wells (0.5%). Table 3 presents the breakdown in various provinces according to the 1980 yearbook statistics of the Government of Afghanistan[26].

Assuming a conservative infiltration ratio of 10 percent of the total precipitation, the annual groundwater recharge in normal years would amount to about 18,000 million m^3. Groundwater is usually abundant in quaternary aquifers along all major river valleys where infiltration of surface water is high. Groundwater quality is generally good but varies from place to place. In lower reaches of river valleys, groundwater is frequently saline or brackish and not usable for either drinking or irrigation purposes. Considering the 1980s statistics (see Table 3) of 367,000 ha (or 15.4%) of land irrigated from alluvial groundwater aquifers[27] with karezes, springs and deep/shallow wells, the total groundwater extraction amounts to some 3,670 million m^3.

[21] Klemm, W., "*Promotion of Agricultural Rehabilitation and Development Programs in Afghanistan. Water Resources and Irrigation*", FAO, Islamabad, November 1996; a report part of the Afghanistan Agricultural Strategy, FAO, Rome, 1997.
[22] FAO assumed a 50 % share of the annual volume available from Panj River (18,200 million m^3), 30% from Kabul river (6,970 million m^3), Murghab (450 million m^3) and Hari Rod (530 million m^3) and 300 m^3 from the rivers in the southern and south-eastern basin. See Klemm, W., *Ibid*., 1996.
The population of Afghanistan is estimated at 22.2 million.
[23] Based on the CSO 2003-04 official population figures of 22.19 million people. CSO, "*Population Data* 2003-04", 2003.
[24] UN Economic Commission for Asia and the Far East, "*Multi-purpose River Basin Development, Part 2D, Water Resources Development in Afghanistan, Iran, Republic of Korea, Nepal. Flood control Series No.* 18", 1961; from: Ravi Costa, "*Literature Review on Afghanistan's Water Resources*", H2O Ray of Hope, Ravi_costa@yahoo.com, USA.
[25] In 2003, FAO estimated that 1.79 million ha of land was cultivated with a first crop - excluding vineyards, orchards and other trees- and 0.25 million hectares of second crops (rice and maize). Pulses represent approximately 0.1 million hectares. FAO estimates that 10% of the total irrigated land is orchards. Therefore, an estimated total of 2.4 million ha have been irrigated in 2003. Favre, Raphy; Fitzherbert, Anthony; Escobedo, Javier; "*MAAH/MRRD/FAO/WFP National Crop Output Assessment. First Phase. 10th May to* 5th *June* 2003", FAO, 25th July 2003; FAO/WFP Food and Crops Supply Assessment, 13 August 2003; FAO/WFP Food and Crops Supply. Assessment, 8 June 2001; and Maletta, Hector and Favre, Raphy, "*Agriculture and Food Production in Post-war Afghanistan. A Report of the Winter Agriculture Survey* 2002-2003", FAO, Kabul, August 2003.
[26] These statistics are indicative and intended for general description only.
[27] Data are not available on recently constructed deep and shallow wells for irrigation and the reduction of irrigated land via karezes and springs due to the drought and deep-well water extraction.

RIVER BASIN	RIVER NAME	RIVER REGIME	MEAN ANNUAL VOL. (mtn m3)	% TOTAL
Amu Darya	Ab-i Panja*	Snow/glacier-fed	36,420	43
Amu Darya	Kokcha	Snow/glacier-fed	5,700	7
Amu Darya	Kunduz	Rain/snow-fed	6'000	7
TOTAL Amu Darya			48,120	57
Kabul (Indus)	Gomal	Rain/snow-fed	350	0
Kabul (Indus)	Margo, Shamal, Kuram	Rain/snow-fed	400	0
Kabul (Indus)	Panjshir	Rain/snow-fed	3,130	4
Kabul (Indus)	Kunar**	Snow/glacier-fed	15,250	18
Kabul (Indus)	Kabul (without Panjshir & Kunar)	Rain/snow-fed	2,520	3
TOTAL Kabul (Indus)			**21,650**	**26**
Northern Basin	Tashkurgan (Khulm)	Rain/snow-fed	60	0
Northern Basin	Balkhab	Rain/snow-fed	1,650	2
Northern Basin	Ab-i Safid	Rain/snow-fed	40	0
Northern Basin	Shirin Tagab	Rain/snow-fed	100	0
Northern Basin	Amu Darya desert	Rain/snow-fed	30	0
TOTAL Northern			**1,880**	**2**
Hilmand Basin	Farah Rod	Rain/snow-fed	1,250	1
Hilmand Basin	Adraskan Rod (Harut Rod)	Rain/snow-fed	210	0
Hilmand Basin	Khuspas Rod	Rain/snow-fed	40	0
Hilmand Basin	Khash Rod	Rain/snow-fed	170	0
Hilmand Basin	Kaj Rod	Rain/snow-fed	60	0
Hilmand Basin	Ghazni Rod	Rain/snow-fed	350	0
Hilmand Basin	Hilmand at Kajaki dam	Rain/snow-fed	6,000	7
Hilmand Basin	Musa Qala	Rain/snow-fed	220	0
Hilmand Basin	Arghandab	Rain/snow-fed	820	1
Hilmand Basin	Lower Hilmand	Rain/snow-fed	110	0
Hilmand Basin	Southern river basin	Rain/snow-fed	70	0
TOTAL Hilmand			**9,300**	**11**
Harirod-Murghab	Murghab	Rain/snow fed	1,350	2
Harirod-Murghab	Kashan and Kushk Rod	Rain/snow fed	110	0
Harirod-Murghab	Hari Rod river	Rain/snow fed	1,600	2
TOTAL Harirod-Murghab			**3,060**	**4**
Grand Total			**84,010**	**100**

TABLE 2
Mean annual volume of river discharge by river basin.
Based on MIWRE hydrological data (FAO, 1996)[28].

No.	Province	Areas irrigating by various sources in (1000 Ha)				
		Surface Water	Alluvial Ground Water			Total
		Rivers & Streams	Springs	*Karezes*	Shallow & half-deep wells	Irrigated area
1	**Badakhshan**	57.83	3.84	-	0.09	61.76
2	**Badghis**	20.25	8.66	4.39	-	33.30
3	**Baghlan**	80.02	0.16	-	-	80.18
4	**Balkh**	224.25	0.20	-	0.05	224.50
5	**Bamyan**	17.26	5.35	-	0.54	23.15
s6	**Farah**	88.84	7.35	28.48	1.06	125.73
7	**Faryab**	116.70	4.25	0.38	0.27	121.60
8	**Ghazni**	74.32	14.53	23.96	4.68	117.49
9	**Ghor**	55.92	15.99	0.71	0.24	72.86
10	**Hilmand**	135.44	4.32	22.83	0.13	162.72
11	**Herat**	159.85	0.83	1.65	1.37	163.70
12	**Jowzjan**	182.42	2.06	0.02	0.10	184.60
13	**Kabul**	38.88	3.30	14.76	0.66	57.60
14	**Kandahar**	96.05	5.31	15.86	0.70	117.92
15	**Kunar**	22.59	0.72	-	0.01	23.32
16	**Kunduz**	209.05	-	-	0.54	209.59
17	**Laghman**	23.52	0.06	-	-	23.58
18	**Logar**	21.86	0.17	4.38	0.24	26.65
19	**Nangarhar**	28.52	4.36	9.45	0.01	42.34
20	**Nimroz**	59.74	-	0.32	0.24	60.30
21	**Paktia**	45.74	4.68	5.86	0.07	56.35
22	**Parwan & Kapisa**	62.77	10.34	1.98	0.05	75.14
23	**Samangan**	37.61	5.84	0.41	0.47	44.33
24	**Takhar**	53.55	8.15	-	0.36	62.06
25	**Uruzgan**	52.67	56.28	17.55	0.08	126.58
26	**Wardak**	14.93	8.69	1.98	-	25.60
27	**Zabul**	37.67	11.99	12.78	0.10	62.54
Total		**2'018.25**	**187.43**	**167.75**	**12.06**	**2'385.49**
Percentage %		***84.6***	***7.9***	***7.0***	***0.5***	***100.00***

*Yearbook statistics of the government of Afghanistan, 1980

TABLE 3
Irrigated area by surface water and alluvial ground water (1967-68)*

[28] Klemm, *Ibid.*, FAO, 1996.

10. Hydrological stations network

Hydrological analyses are based on river discharge measurements that began in Afghanistan in the mid 1940s across a few sites. The number of sites increased steadily over the years until the late 1970s. Measurements were discontinued soon after the Soviet invasion of Afghanistan. No records have been kept since September 1980, and the river gauging stations are not operable. Until 1978, Afghanistan had a network of approximately 160 river gauging stations. Map 6 shows the locations of the hydrometric stations. Continuous recording of hydrological data is a prerequisite for efficient and reliable planning of irrigation programs, hydropower and water/natural resources management. The World Bank, in collaboration with FAO, is intending to re-establish the hydrometric network of Afghanistan over the next several years.

The Panj River and Shewa River in the northeast, the Gomal River in the east, the Khuspas Rod and the Pishin Lora Rod in the south were not included in the hydrological network of Afghanistan, and thus are not shown on Map 6.

11. Use of water resources for developing Afghanistan, or, The development dilemma

Formally organized large-scale irrigation systems were developed in Afghanistan between the 1950s and 1970s (see Table 4). By the late 1970s, three large-scale modern irrigation systems had been built and were in operation: the Hilmand-Arghandab schemes in the southwest (Kandahar and Hilmand provinces), the Ghaziabad farms near Jalalabad in the east (Nagarhar province), and the Kunduz-Khanabad scheme in the northeast (Kunduz, Baghlan and Takhar provinces). At the time, their operation and maintenance was highly structured. After 25 years of conflict and the almost total breakdown of formal government institutions, only a small part of these schemes is operational.

Currently, Afghanistan cannot meet its energy demands, even though present consumption is low by global standards. The Ministry of Water and Power (MWP) anticipates that the energy requirements of Afghanistan in 2020 will increase between 2.5 and 5 times, depending on the region. The increase in energy requirements will be partly filled by further development of the hydropower capacity of the country. Map 7 shows the current status of hydropower stations and the proposed development by the MWP Draft Master Plan (projection up to 2020). Table 5 summarizes the hydropower projects of the draft Power Sector Master Plan[29].

Afghanistan's economic rehabilitation will require the increased use of water resources for irrigation and hydropower purposes. However, UNESCO highlights the dilemma on increased use of water resources for Afghanistan's development: in order to develop its own water resources, Afghanistan will need to establish regional cooperation with the downstream countries of Tajikistan, Turkmenistan, Uzbekistan, Iran and Pakistan. Further studies will be needed to determine whether the Kabul, Hilmand and Amu Darya River projects can be realized without harming the interests of neighbouring countries[30].

[29] Government of Afghanistan, MWP, "*Power Sector Master Plan Update, Draft Final Report*", report prepared by Norconsult-Norplan for MWP (Ministry of Water and Power), October 2003.
[30] UNESCO, "*Afghanistan on the (rocky) road to recovery*", July 2003. http://portal.unesco.org/en/ev.php@URL_ID=13582&URL_DO=DO_TOPIC&URL_SECTION=201.html

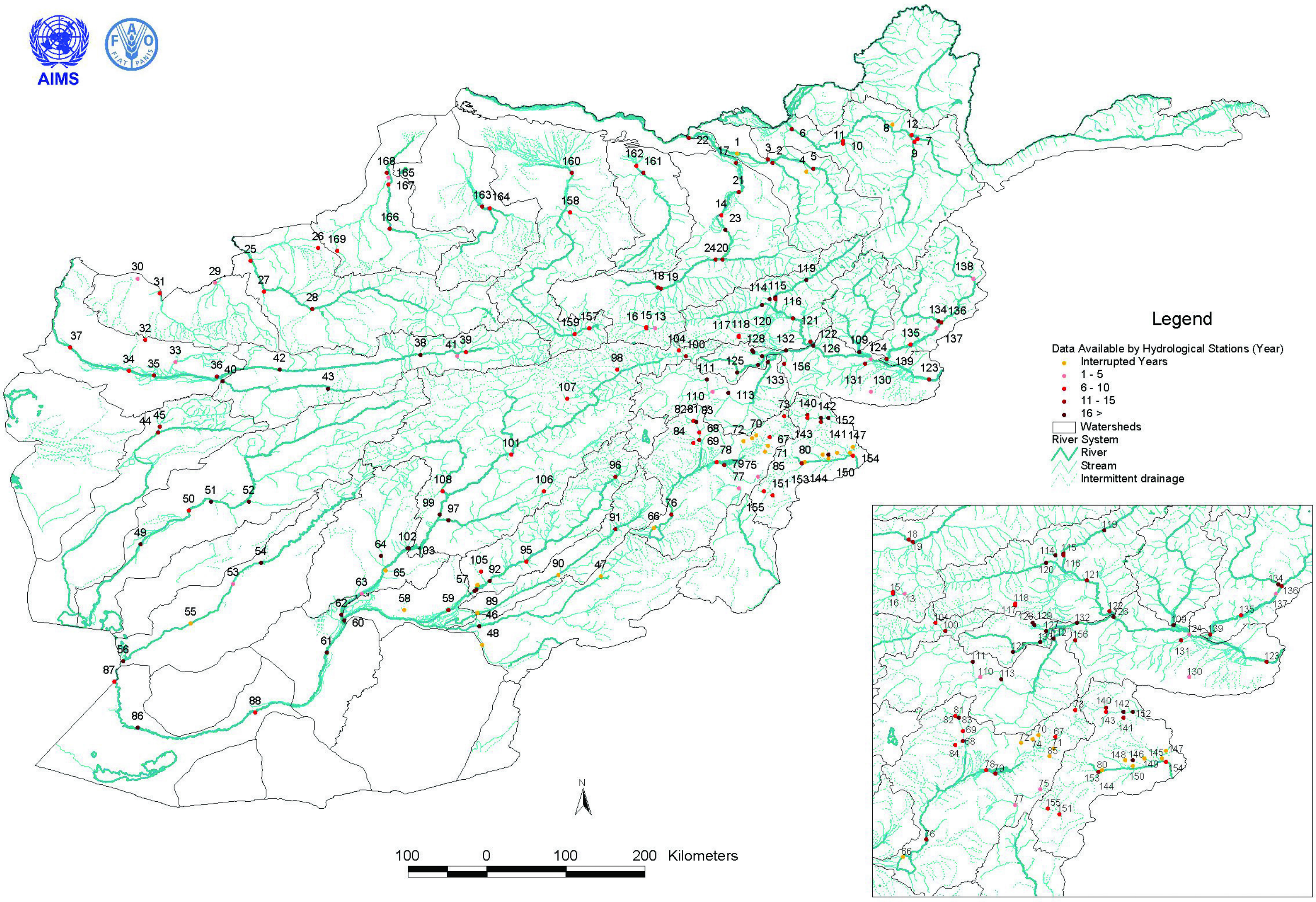
No	Name of schemes	Province	Area under Irrigation	**Main structures**	**Remarks**
1	Hilmand & Arghandab project	Helman & Kandahar	103,000 Ha	Kajaki & Dhala Dams, Diversion of Boghra, Main canal of Boghra, Shahrawan, Shamalan, Darweshan and Baba Walee	Water flow managed by Government, Maintenance by NGOs
2	Sardeh	Ghazni	15,000 Ha	Reservoir (164 m.m^3), Left and right canal (15 m^3)	Water flow managed by Government, Maintenance by NGOs
3	Parwan	Parwan & Kabul	24,800 Ha	Diversion, Main canal (27 m^3), Eastern and Southern canals, Pumping Station, Power House (2.4 Mega W)	Water flow managed by Government, Maintenance by NGOs
4	Nangarhar Irrigation system	Nangarhar	39,000 Ha	Darunta dam and Power Station, Main canal Qmax=50m^3, Pumping Station, state farms	Water flow managed by Government, Maintenance by NGOs
5	Sang-i Mehr	Badakhshan	3,000 Ha	Intake and main canal Q=2,5m^3	Run by community, Maintenance by NGOs
6	Kunduz-Khanabad	Kunduz	30,000 Ha	Diversion, left and right canal, regulators	Not completed, not operational
7	Shahrawan	Takhar	40,000 Ha	Intake, main canal	Water flow managed by Government, Maintenance by NGOs
8	Gawargan	Baghlan	8,000 Ha	Intake, main canal	8,000 out of 20,000 ha currently cultivated Water flow managed by Government; Maintenance by NGOs
9	Kilagay	Baghlan	20,000 Ha	Intake, main canal	Water flow managed by Government, Maintenance by NGOs
10	Nahr-i-Shahi	Balkh	50,000 Ha	Diversion, main canal and division structures	Run by Government and community
Total			332,800 Ha		

TABLE 4
Formal irrigation schemes built by the Government of Afghanistan [31],

#	**PROJECT**	**Province**	**District**	**River Basin**	**Watershed**	**Assessment required**	**Resettlement > 200 pers.**	**Brief Description and Critical Issues**
1	**BAGHDARA**	Parwan	Panjshir	Indus	Ghorband wa Panjshir	Full EIA	Yes	New 90 m-high reservoir dam with a crest length of 125 m. Site is located 4 km downstream from Alekozi settlement. - Large resettlement component.
2	**SURUBI 2 & 3**	Kabul	Surobi	Indus	Kabul	Full EIA	No	Development of the head between Surubi and Sarkando
3	**KUNAR Alternative A**	Kunar	Bar Kunar	Indus	Kunar	Full EIA	Yes	New 160 m-high earth-filled dam with a crest length of 1080 m. The site is located 7 km upstream of Asmar settlement. - Large resettlement component.
4	**KUNAR Alternative H**	Kunar		Indus	Kunar	Full EIA	Yes	New 105 m-high earth-filled dam with a crest length of 670 m. The site is located 22 km upstream of Asmar and 1 km below Chunek village.
5	**GULBAHAR**	Parwan	Panjshir	Indus	Panjshir	Full EIA	Yes	New 200 m-high rock filled dam with a crest length of 173 m. The site is located 2 km north of Gulbahar at the entrance of the Panjshir valley. - Large resettlement component.
6	**KAMA**	Nangahrar	Kama	Indus	Kunar	Full EIA	Yes	New 5-6 m diversion weir from the river with a headrace channel 16 km long. The site is located close to the Kunar River near its confluence with the Kabul River.
7	**KAJAKI (extension)**	Hilmand	Kajaki	Hilmand-Sistan	Upper Hilmand	Full EIA	Yes	Installation of 11 m-high radial gate in the spillway and increase of the dam height by 2 m. Water availability for Iran and biodiversity in Sistan are to be considered.
8	**OLUMBAGH**	Uruzgan	Dihrawud	Hilmand-Sistan	Upper Hilmand	Full EIA	Yes	New 55 m-high rock-filled dam about 75 km upstream of Kajaki dam. The site is located near Olumbagh village. - Large resettlement component. Water availability for Iran and biodiversity in Sistan are to be considered.
9	**KAMAL KHAN**	Nimroz	Chahar Burjak	Hilmand-Sistan	Sistan Hilmand	Full EIA	No (?)	Completion of diversion dam on the Hilmand River to prevent water to the Gaod-i Zirreh lake in flood period through the Beyeban channel. Water availability for Iran and biodiversity in Sistan are to be considered.
10	**KHANABAD**	Kunduz	Khanabad	Amu Darya	Khanabad	Environment Review	No	Completion of the hydropower dam located near Khanabad town. Possible conflict with irrigation requirements.
11	**KILAGAY**	Baghlan	Pul-i Khumri	Amu Darya	Kunduz	Full EIA	Yes	New earth-filled dam upstream of Pul-i Khumri town. More study on irrigation impact required. Large resettlement component.
12	**UPPER AMU**	Badakh-shan		Amu Darya	Ab-i Panj	Full EIA	Yes	New 30 m-high dam downstream of the confluence of the Panj and Vakhsh Rivers (in Tajikistan). Large resettlement component. Water for downstream countries and the Aral Sea revitalization. Land covered in both Afghanistan and Tajikistan territory. Irrigated area to be defined.
13	**SALMA**	Herat	Chesth-i Sharif	Turkmen Oases	Hari Rod	Full EIA	Yes	New 104 m masonry dam with a crest length of 430 m. Excavation of the dam foundation had reached a relatively advanced stage, but foundation cleaning was not completed. No work on the dam or on penstocks had started. Water availability for Iran and Turkmenistan is to be considered. No water treaties exist.
14	**BAKHSHABAD**	Farah	Bala Buluk	Hilmand-Sistan	Farah Rod	Full EIA	No (?)	New 87 m-high concrete buttress dam with a crest length of 265 m. Located 3 km below the village of Sangak.Water availability for Iran and Turkmenistan where no water treaties exist.

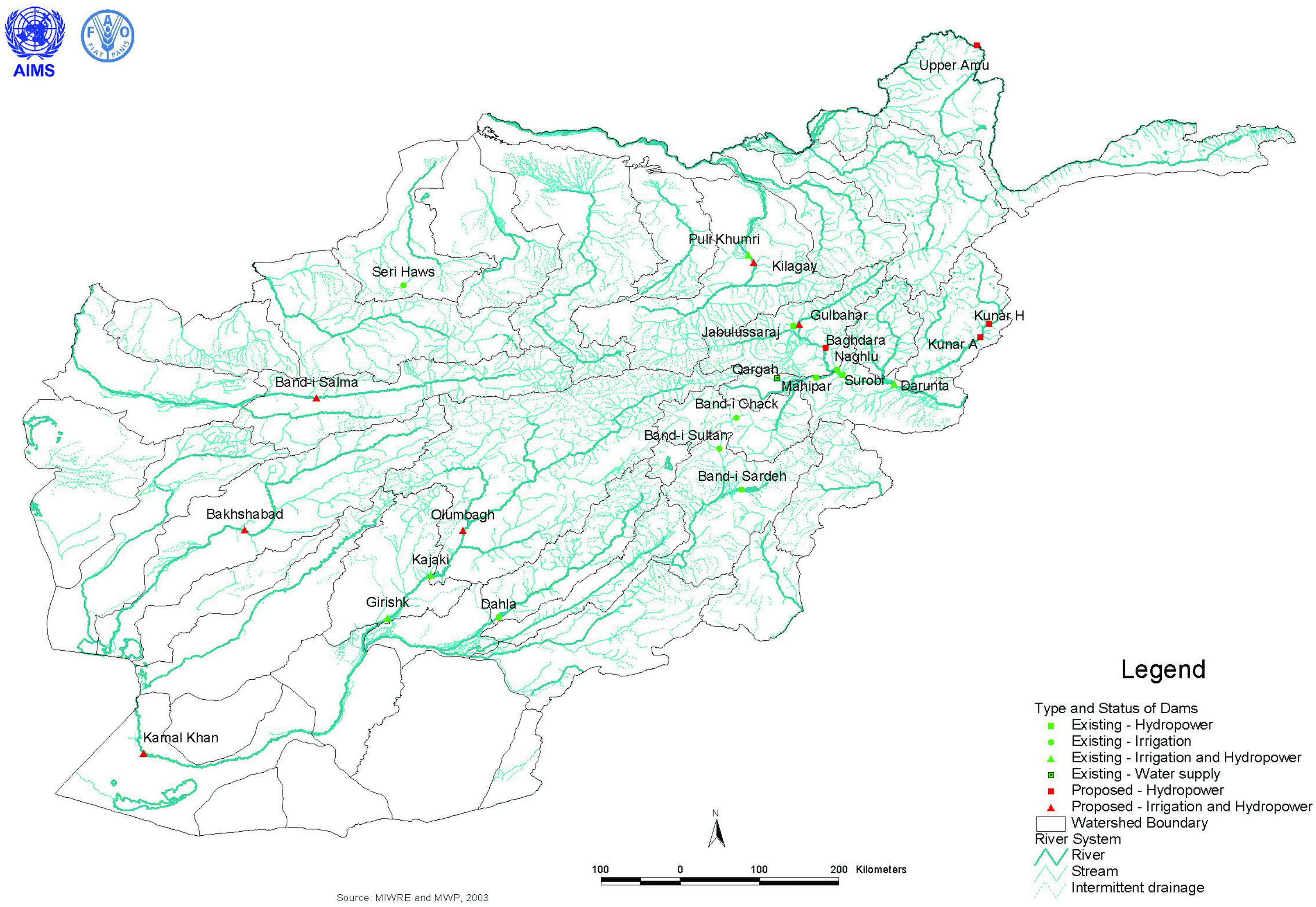
TABLE 5
Summary of hydropower project of the Draft Power Sector Master Plan. Environmental Impact Assessment (EIA).

[31] Source: MIWRE, 2003



MAP 6

Location of historical hydrological stations



MAP 7
Existing and proposed dams of Afghanistan

12. Water bodies

There are very few lakes and marshland areas in Afghanistan. Due to their rarity, existing wetlands are particularly valuable for people as sources of water, resources such as reeds and habitats for wetland species, notably for breeding and migrant water birds. The wetland ecosystem of Afghanistan is created by rivers that have no natural outlet to the sea, and hence they drain into a series of depressions, forming large shallow saline lakes and marshes. The beds of these wetlands are made of the sediments transported by the rivers, which makes them the most biologically productive ecosystems in the country, and therefore constitute viable waterfowl habitats.

Of the seven wetlands in Afghanistan, there are three considered by ornithologists as being of international importance for migrating and wintering waterfowls. The Ab-i Istada and Dasht-i Nawur are important habitats for migrating or wintering waders and ducks. They also support large breeding colonies of greater flamingos (Phoenicopterus ruber). In addition, Ab-i Istada has the distinction of being regularly visited by the entire migrating populations of the highly endangered Siberian crane (Grus leucogeranus). The third important wetland is the Kole Hashmat Khan on the outskirts of Kabul, which used to be rich in bird biodiversity, hosting a large number of ducks and coots during winters[32].

Besides these seven main wetlands, there are a number of small wetlands of environmental and recreational interest in various parts of Afghanistan. The FAO 1990/93 Landcover Atlas classified water bodies and marshlands; these are reflected in the statistics by river basin and watershed (see Parts III and IV). Pictures 1, 10, 11 and 12 illustrate some of these small wetlands of Afghanistan.

Any further development of irrigation system on rivers that have no natural outlet to the sea may be at the expense of these delicate wetland ecosystems.

PICTURE 10
The Andkhoi salt lake is filled in the winter and spring from water infiltrating the upper lands and resurging in the lowlands of Andkhoi Lake (elevation of 255 m above sea level). The water dries in summer and the salt dissolved from deep soil layers crystallizes, to be harvested in autumn. Faryab province, 17 May 2003 (N36.62, E65.05, NE)

[32] Anonymous, "*Migratory waterfowl likely to be hit by war in Afghanistan*", Wildlife in India, October 2001. http://www.wildlifeofindia.com/artafghanwar.htm

PICTURE 11
Vegetation in saline soil conditions near Andkhoi salt lake. Faryab, 17 May 2003 (N36.56, E64.99, NE)

PICTURE 12
Wetlands in Lal wa Sarjangal district (near Lal district center) of Ghor province. 2 June 2003
(N34.47, 66.24, NE)

IV. A WORD ON WATERSHED MANAGEMENT

'NOTE ON THE WATERSHED MANAGEMENT SECTION'

The purpose of the Watershed Atlas is not to be prescriptive in terms of approaches to watershed management and descriptions of the benefits of local watershed management, as the issue is complex and all aspects cannot be captured in a brief outline. Below, some of the main issues in watershed management in Afghanistan are presented based on available information to the authors. However, further elaboration and studies are required in the watershed management sector.

"Watershed management in its truest form is the conservation management of the soil-plant-water resources of a catchment in order to benefit man. It involves managing the land and human resources of the drainage in a manner that sustains adequate level of water, soil, food and fibre production"[33]. This is reflected in the UNCED Agenda 21, Chapter 18: Protection of the Quality and Supply of Freshwater Resources, which calls for integrated water resources management, including the integration of land and water-related aspects to be carried out at the level of the catchment, basin or sub-basin.

"The watershed part of watershed management implies management of these resources, to the extent possible, within a defined physiological boundary within which it is possible to identify and monitor the components (e.g. inputs, storage and outflows) of the watershed system, i.e. the hydrologic cycle. However, from a land management perspective, these physical boundaries are considered to be simply a topographic demarcation within political and administrative boundaries that usually overlay a series of watersheds"[34]. Wolf (2002)[35] notes that the fact that water and natural resource issues manifest themselves within basins, while analyses are often based on country boundaries, can lead to fundamental misunderstandings.

This is fully verified in Afghanistan, as watersheds do not necessarily correspond to administrative boundaries. However, at the micro-level, preliminary observations on *manteqa*, the social organization of rural Afghanistan below the district level, tend to show that there is some degree of overlapping between micro-watersheds (valley systems) [36]. This suggests a positive convergence of social and geographical factors for the development of a watershed management approach. Indeed, 'integrated watershed management through people's participation' has become widely accepted as the approach that insures sound sustainable natural resources management and a better agricultural economy for upland inhabitants as well as people living in downstream areas. However, as of yet neither the watershed nor the inner sub-district social organization of the manteqa is recognized in Afghanistan.

"Degradation of natural resources is considered to be the largest constraint to sustainable agricultural development in most of the developing countries"[37]. Afghanistan is no exception, and the last two-and-a-half decades of war and failed governance has had a huge and partly irreversible negative impact on natural resources. Massive destruction of forests, degradation of rangeland through fuel collection and encroachment of pastureland for rainfed cultivation have resulted in soil erosion, increased incidence of flash flooding and low biomass production on rangelands. Saba (2001) asserts that "Afghanistan is in a state of severe environmental crisis, unprecedented in its history"[38]. Pictures 13-36 illustrate some of the main environmental degradations and watershed management issues in Afghanistan.

Water conservation and harvesting through rehabilitation of land/soil cover (pasture, forest) and construction of water management infrastructures such as check dams and contour bunds are necessary to conserve water and enhance groundwater recharge in all watersheds. Sheladia Associates, Inc., notes that "global experience has demonstrated in a wide range of arid environments similar to Afghanistan that water harvesting measures, combined with pasture restoration and reforestation, can a) improve water management, b) increase water available for drinking, livestock and for irrigated farming, c) strengthen livelihoods and d) reduce their vulnerability"[39].

[33] Tennyson, L. C., "*Review and Assessment of Watershed management. Strategies and Approaches. Phase* 1. *Draft*", FAO, Rome, November 2002.
[34] Tennyson, L. C., *Ibid*, 2002.
[35] A. T. Wolf, "*Thematic Maps: Visualizing Spatial Variability and Shared Benefits*", Oregon State University, in FAO/UNEP, "*The Atlas of International Freshwater Agreements*", 2003. http://www.transboundarywaters.orst.edu/publications/atlas/
[36] On the *manteqa*, see Monsutti, A., author of "*Guerres et migrations: réseaux sociaux et stratégies économiques des Hazaras d'Afghanistan*", Neuchâtel: Faculté des lettres et sciences humaines (thèse de doctorat), Switzerland, 2003, 492 p. and Favre, Raphy, "*Interface between State and Society. An Approach for Afghanistan. Final Draft*", 30 October 2003
[37] FAO, "*Preparing the Next Generation of Watershed Management Projects/Development Programmes. Concept Note*", Rome, 2003.
[38] Saba, D. S., "*Afghanistan: Environmental Degradation in a Fragile Ecological Setting*", Int. J. Sustain. Dev. World Ecol. No 8, P. 279-289, 2001.
[39] Sheladia Associates,Inc., "*Draft Final Report for Rapid Assessment and Draft Report for Framework of Water Resources Management*", Submitted to AACA, October 2003.

PICTURES 13 AND 14
Depredated land cover is a major problem of water resources management in Afghanistan. The picture on the left shows soil erosion caused by surface water in a rainfed field (N35.92, E64.69, SE). Marks of surface soil erosion are erased when the land is ploughed (right). Almar district, Faryab province, 19 May 2003 (N35.91, E64.68, SE)

'MANTEQA'

The *manteqa*, which literally means 'area' or 'region', is a group of settlements or hamlets of hetrogeneous sizes (qaria, âghel, deh, keli, bonda or qishlaq) that are commonly identified by their inhabitants or other communities under a single name. Somewhere between the district and settlements or hamlets, the manteqa do not have administrative recognition but represent the social and territorial unit of rural Afghanistan. The manteqa may sometimes refer to lineages, but not necessarily as solidarity can also be maintained by the proximity of various people living in the same area (Monsutti, 2003). The manteqa refers to a group of people sharing a common identity that shapes the solidarity space. Afghans generally refer to the manteqa as their place of living. (Favre, 2003)

Rangeland management is an important part of watershed management, as rangeland represents 45 percent of the national territory (based on the FAO Landcover Atlas)[40] and both livestock rearing as well as nomadic movements are essential components of rangeland management. Dupree in 1973[41] described the nomadic movements and grazing patterns in Afghanistan. These patterns were established under the rule of the Afghan King Abdur Rahman in the late 19th century who, after conquering the central highlands [41 bis] and the northern Khanates [42], transmigrated the Pashtuns into the northern and central areas, thereby ensuring him control over these regions. It was at this time that the central and northern grazing areas were opened up to Pashtun pastoralists, or *kuchis*. Over the years, through the monarchy period of Afghanistan, documents were handed to kuchis giving them rights of pasture or agricultural land in different areas. In some cases, this was land already used by other people, which caused conflict, whereas in other areas the lands were either unused or shared amicably. The migratory patterns presented by Dupree were disrupted during the war and particularly with the independence of various ethnic groups from the central government. The nomadic migration patterns are renegotiated at local levels every season based on the socio-political power balance of Afghanistan. Furthermore, the tumultuous history of Afghanistan has resulted in a situation of intricate land tenure insecurity issues across the country[43], leading to inadequate management of natural resources[44].

PICTURE 15
Pastureland encroachment for rainfed cultivation is causing widespread changes in soil covers in most parts of Afghanistan. Here, Dasht-i Laili. Jawzjan, 25 March 2003 (N36.72, 65.68, N)

[40] FAO, "*Provincial Landcover Atlas of Islamic State of Afghanistan. Utilization of Remote Sensing for the Inventory and Monitoring of Agricultural Land in Afghanistan*", based on 1990/93 Landsat TM data in 1990/93, March 1999.

[41] Dupree, Louis, "*Afghanistan*", Princeton University, 1973.

[41 bis] See Musavi, S., Askar, "*The Hazaras of Afghanistan: an historical, cultural, economic and political study*", Ed. Curzon, 256 p., 1988.

[42] Maimana, the last of the Uzbeq Khanates of Afghan Turkestan, submitted to Abder Rahman in April 1884. On the Pashtun colonization of Northern Afghanistan, see Tapper, Nancy, "*The Advent of Pashtun Maldar in North-Western Afghanistan*", Bull. School Oriental and African Studies, No 34 (1), p. 55-79, 1974 and Tapper, Nancy, "*Abd Al-Rahman's North-West Frontier*: *The Pashtun Colonisation of Afghan Turkistan*", in: "The Conflict of Tribe and State in Iran and Afghanistan", Edited by Tapper, Richard, Ed. Croom Helm, NY, 1983.

[43] On Land Rights issues, see Wily, L. A., "*Land Rights in Crisis*: *Restoring Tenure Security in Afghanistan*", Issues Paper Series, AREU, March 2003.

[44] For a recent case study of misuse of rangeland, see Favre, Raphy, "*Grazing Land Encroachment. Joint Helicopter Mission to Dasth-i Laili. 25-27 March* 2003", FAO, Kabul 23 July 2003.

PICTURES 16 AND 17
Pistachio forests have been dramatically destroyed during the past 25 years. However, where pistachio trees have not been uprooted, rejuvenation is possible provided the rangeland is protected. Above, hills that were covered with pistachio forests in recent years. Left, rejuvenation from pistachio stock in the same location (N34.96, E63.07, S). Qala-i Naw district, Badghis province, 22 May 2003

PICTURES 18, 19 AND 20
Extensive destruction of forest covers took place over the past 25 years in Afghanistan. Top left, a truck exporting wood from southern Afghanistan forests in the mid 1990s. Paktia July 1994. Top right, wood market in Ghazni town, July 1994. Below, a wholesale market of cedar wood in Kunar province. July 2003

PICTURE 21
Demand for fuel wood for cooking and heating has increased as a result of widespread livestock decimation during the past drought. The practice of uprooting plants and enlarging the number of species collected due to increased demand aggravates land cover degradation, which in turn increases the time necessary for fuel wood collection. Above, storing fuel and fodder material for winter in Sherghan, Badakhshan, 4 September 2003

PICTURE 22
Flash flooding is a direct consequence of land cover degradation. There is a general consensus amongst Afghan farmers interviewed in 2003 that flash floods have increased over the past 25 years. Flash flood in Mazar-i Sharif (Balkh province) in Spring 2003. 26 March 2003 (N36.65, E67.07, NE)

PICTURE 23
Degraded forest above the Qorawa (left) and Zamamkor (right) village close to the entrance of the Panjshir valley. Parwan province, 27 August 2003 (N35.21, E69.31, S)

PICTURES 24, 25 AND 26
Isolated trees testify to the presence of forests in the past. There is the possibility of re-forestation in many parts of Afghanistan. On the left, in Jurm district, Badakhshan province, August 2003 (N36.67, E70.85, E). On the right, isolated *Pistacia khinjuk* along the Hari Rod River. Cheshti Sharif Herat province, 1 June 2003 (N34.36, E64.19, N). Sometimes trees can be seen in unexpected locations, such as desert areas in southern Afghanistan. Below, tamari trees traditionally planted on graveyards in Qala-i Qah district, Farah. 26 May 2003. (N32.30, E61.65, S)

PICTURES 27 AND 28

Most of the plants growing on the Afghan rangeland are annual. They offer only limited topsoil protection and have a low biomass production, as annual grasses explore only a few centimetres of the topsoil. Perennial fodder grass with deep rooting systems, such as alfalfa, are of high interest, as they explore deep layers of the soil. They therefore have a strong soil stabilization effect, producing more biomass. Farmers in Lal district of Ghor province have started seeding Lucerne on the rangeland with success. The alfalfa on the rangeland below reportedly continued growth during the 3-4 years of recent drought. Lal wa Sargangal district,
Ghor province, 2 June 2003 (N34.49, E66.68, SE)

PICTURES 29 AND 30

Meandering rivers are beautiful sites for visitors, but they increase water loss by evaporation, rendering potential farming land unavailable. River channelling along with a delineation of protected areas would allow the achievement of both environmental objectives (stabilization of wetlands and forests) and economic objectives (increase of land under cultivation). Here in Chaman valley, Yakaolang district, Bamyan 3 June 2003 (Picture 29, N34.73, E66.87, W; Pictures 30, N34.73, E66.88, E)

PICTURES 31, 32, 33 34 AND 35
Along meandering rivers, one finds bushes, forests, pastureland and gravel. From the top left: Kokcha River (Jangal-i Marzu forest) in Kuran wa Munjan district, 30 August 2003 (N36.03, E70.72, SE); pastureland between meanders of the Warduj River (N36.65, E71.35, S); gravel along the Warduj River and alluvial cone created by a steam in Ishkashim, 1 September 2003 (N36.66, E71.37, SW and N36.67, E71.38, E). Below, panoramic view of the Kokcha River below the junction of the Anjuman and Munjan Rivers, Kuran wa Munjan district, 31 August 2003 (N36.04, E70.72, NE).
River engineering training material has been developed for Afghan engineers by SDC and UNJLC. [45]

[45] Staempfli, H. and Hunzinger, L., "*River Engineering for Engineers in Afghanistan*", SDC and UNJLC, January 2004

PICTURE 36
Building concrete irrigation channel intakes along meandering rivers is challenging. Therefore, most of the intakes in Afghanistan are traditional and need to be rehabilitated every year after the peak of water flow. The amount of water available to a certain population group depends on the maintenance of the intake. Rehabilitation of intakes by humanitarian agencies may change the water availability among population groups within the same watershed. Here, traditional intake irrigation canal using local material in Doshi. Baghlan province, 12 September 2003 (N35.60, E68.69, NW)


UN

METHODOLOGY AND TERMINOLOGY PART II

I. WATER CATCHMENT TERMINOLOGY

II. METHODOLOGY

PICTURE 37
FAO conducted extensive field verifications of watershed boundaries. Here, a bridge over the Kokcha River in Kuran wa Munjan, 30 August 2003 (N35.99, E70.59, E)

I. WATER CATCHMENT TERMINOLOGY

There are as many water catchments [1] classifications as there are aims for which the classifications are used. A classification for the purpose of hydropower generation will look different from one dealing with forestry and agriculture or international riparian issues. The following terminology of catchments areas is defined based on various needs for Afghanistan (see Table 6) that have been identified through consultation with various agencies working in the water and natural resources management sector in Afghanistan as well as the Ministry of Irrigation, Water Resources and Environment (MIWRE).

River basins: Includes five large catchments areas that were delineated in Afghanistan considering the definition of the International River Basins of Asia of the "Trans-boundary Freshwater Database" (see Figure 7)[2]. The river basins map of Asia was reviewed with the Ministry of Irrigation for the definition of river basin names for Afghanistan[3]. The five river basins delineated for the Atlas differs from the 2003 contemplated basin management units of the MIWRE due to non-permanent factors such as access and security issues (see Map, Annex III).

Watersheds: Includes 41 meso-catchments areas delineated in Afghanistan. These are individual rivers or meso-catchments that contribute to larger river basins (e.g. Hilmand). The size of the watersheds was limited in order to retain 'meso-units' suitable for hydrological and agricultural/agro-meteorological monitoring and analysis and watershed management activities.

Micro-catchments: Includes catchments that can be managed by local communities. The number of micro-catchments has not been yet delineated in Afghanistan, but these could probably be in the range of 3,000 to 4,000[4].

Community water point areas: Includes local water catchments areas defined by any community-based water or conservation project (e.g. drinking water points and surface water harvesting structures)

From the four levels of classification for Afghanistan, this Atlas presents maps and statistics for the first two layers of classification, namely the river basins and the watersheds. Further work and studies are required to identify the micro-catchments and their communities.

DEFINITION

'River basin' is defined as the area that contributes hydrologically (including both surface- and groundwater) to a first-order stream, which, in turn, is defined by its outlet to the ocean or to a terminal (closed) lake or inland sea. Thus, 'river basin' is synonymous with what is referred to in the US as a 'watershed' and in the UK as a 'catchment'. There are currently 263 rivers basins defined in the world, including 57 in Asia, that either cross or demarcate international political boundaries. The absolute numbers of international basins, as well as the nations through which they traverse, changes over time in response to alterations in the world political map.

LEVEL	TERMINOLOGY	DEFINITION IN AFGHANISTAN	TYPE OF USE
International	River Basins	5 basins	Transnational Treaties Large reservoirs/dams for irrigation/hydro power water/natural resources planning and protection Aggregation at river-basin level of watersheds planning and coordination
National	Watersheds	41 watersheds	River flow monitoring Agro-meteorology monitoring water balance analysis water/natural resources management planning and coordination
Community	Micro-Catchments	3,000-4,000 micro-catchments [5]	Community participatory approach in natural resources management Land rights and land use issues
Micro-projects	Community Water-point Areas	Varies with the number of project implemented	Special protection of micro-catchment areas (e.g. drinking water, local salt extraction, protected water resources, etc.)

TABLE 6
Level of interventions and terminology on water catchments

[1] Water Catchment is used as a generic name here.
[2] FAO/UNEP & OSU, "*The Atlas of International Freshwater Agreements*", 2002. http://www.transboundarywaters.orst.edu/publications/atlas/.
[3] The definition is from A. T. Wolf, "*Thematic Maps: Visualizing Spatial Variability and Shared Benefits*", Oregon State University, in FAO/UNEP & OSU, "*The Atlas of International Freshwater Agreements*", 2002. http://www.transboundarywaters.orst.edu/publications/atlas/. The history of international water treaties dates as far back as 2,500 B.C., when the two Sumerian city-states of Lagash and Umma crafted an agreement ending a water dispute along the Tigris River (Wolf, 1998). Since then, a rich body of water treaties has evolved. The Food and Agricultural Organization of the United Nations has documented more than 3,600 international water treaties dating from from 805 to 1984 AD. M. A. Giordano and A. T. Wolf, "*The World's International Freshwater Agreements. Historical Developments and Future Opportunities*", Oregon State University, in FAO/UNEP, "*The Atlas of International Freshwater Agreements*", 2003, http://www.transboundarywaters.orst.edu/publications/atlas/
[4] Based on preliminary work on social group definition in Afghanistan made by the author. See Favre, Raphy, "*Interface between State and Society. An Approach for Afghanistan*", 30 October 2003.

FIGURE 7
International River Basins of Asia[6]

[5] Based on preliminary work on social group definition in Afghanistan made by the author. See Raphy Favre, "*Interface between State and Society. An Approach for Afghanistan*", 30 October 2003.
[6] FAO/UNEP & OSU, *Ibid.*, 2002. http://www.transboundarywaters.orst.edu/publications/atlas/.

II. METHODOLOGY

1. Main references used for classification

The detailed work of the geographer Humlum[7], published in 1959, was the main reference source on which the watershed maps have been developed. The works of other authors and institutions, such as the Ministry of Irrigation (MIWRE) in 1979[8], Louis Dupree[9] in the 1970s, FAO in 1965 [10] and 1996 [11], the GEOCART Atlas of Afghanistan[12] and the FAO/UNEP/OSU Atlas of International Freshwater Agreements [13] were given due consideration. Also, extensive field observations conducted in 2003 by FAO in the framework of a food security program provided first-hand field material to fine-tune the watershed boundaries.

2. Factors considered for the water catchment classification

2.1 River basins

The following factors were used to classify river basins and watersheds:

Terminal drainage area: River basins regroup rivers that flow to the same terminal drainage area. The main terminal drainage areas for rivers originating in Afghanistan are the Sistan depression, the Garagum desert (Turkmenistan), the Turkistan plain in northern Afghanistan, the Aral Sea in Central Asia and the Indian Ocean (Indus River).

National boundaries have been considered, particularly in the north, to differentiate between rivers drying in irrigation canals or deserts within the national boundaries of Afghanistan and rivers draining into neighbouring countries. This significantly influences water resource management and farming systems along these rivers.

The "International River Basins of Asia" of the Transboundary Freshwater Dispute Database was consulted for river basins units and names [14].

2.2 Watersheds

The following factors were used to classify river basins and watersheds:

Size of the watershed: Water catchments larger than 40,000 sq. km were divided when natural features (e.g. junction of tributaries) or human-made structures (e.g. dams or irrigation structures) significantly influenced the river regimes. The watershed of Upper Hilmand is the largest of all and, due to its homogeneity, the catchment area was not sub-divided.

Human intervention: Major dams, such as Kajaki dam, Dahla dam or Bandi Naghlu dam, that have significantly reshaped both the flow of water as well as farming practices, have been considered for the demarcation of watersheds. Similarly, irrigation has in places significantly transformed the river flow and thus was considered to demarcate watersheds (e.g. irrigation system on the Hari Rod, along the Hilmand valley or the non-drainage area in the north).

3. Methodology used for water catchment boundary delineation

With the water catchments classification for Afghanistan prepared by FAO, GIS deskwork was conducted at the AIMS offices in Kabul and Mazar-i Sharif to delineate the actual boundaries of the defined watershed and river basins. An initial water catchment map (including river basins and watersheds) was produced in early 2003. The boundaries were drawn manually on a computer, using as the background a DTED elevation model at 500 m. The work was operated on Arc-View 3.2 software. These initial coarse maps were taken to the field for verification during extensive agriculture field surveys organized by FAO in 2003. Revisions and fine-tuning of the maps were made based on field observations and with the availability in late 2003 of a DTED elevation model at three arc degree intervals (100 m elevation). Also, a number of other available digitized maps and satellite images of Afghanistan were used to fine tune the boundaries (see Table 8). A similar method of delineating boundaries was retained. Figure 8 illustrates the process of classification and delineation of river basins and watersheds of Afghanistan.

[7] J. Humlum, *Ibid.*, 1959.
[8] Government of Afghanistan, MIWRE, "*Classification and Numbering of Hydrological Stations*", Kabul, 1976.
[9] Louis Dupree, "*Afghanistan*", Princeton Uni, 1973.
[10] Jidikov, A.P., "*Hydrology*", volume III, in FAO, "*Report on Survey of Land and Water Resources. Afghanistan*", Rome, 1965.
[11] Klemm, W., *Ibid.*, 1996.
[12] GEOCART, "*National Atlas of the Democratic Republic of Afghanistan*", Warsaw, 1984.
[13] UNEP/FAO and OSU, *Ibid.*, 2002.
[14] UNEP/FAO and OSU. *Ibid.*, 2002

SOURCE	TYPE	INFORMATION
1:50,000	Topographic Map (Russian)	✓ Detailed topographic information ✓ High-resolution elevation data ✓ 20m contour interval ✓ Irrigation systems
1:100,000	Topographic Map	✓ Identify major river systems ✓ Name of rivers ✓ Location of structure s
Landsat 7 & TM	Satellite Images	✓ 15m-30m ground resolution ✓ Detailed river features ✓ Physical features, relief and valleys ✓ Lakes and water bodies
100m Contours	ArcView Shapefile	✓ High-resolution elevation information ✓ River system distribution
DTED1	100m	✓ Slopes and gradients of the topography ✓ 100m resolution of elevation

TABLE 7
Types of GIS data used for the definition of the river basins and watershed maps

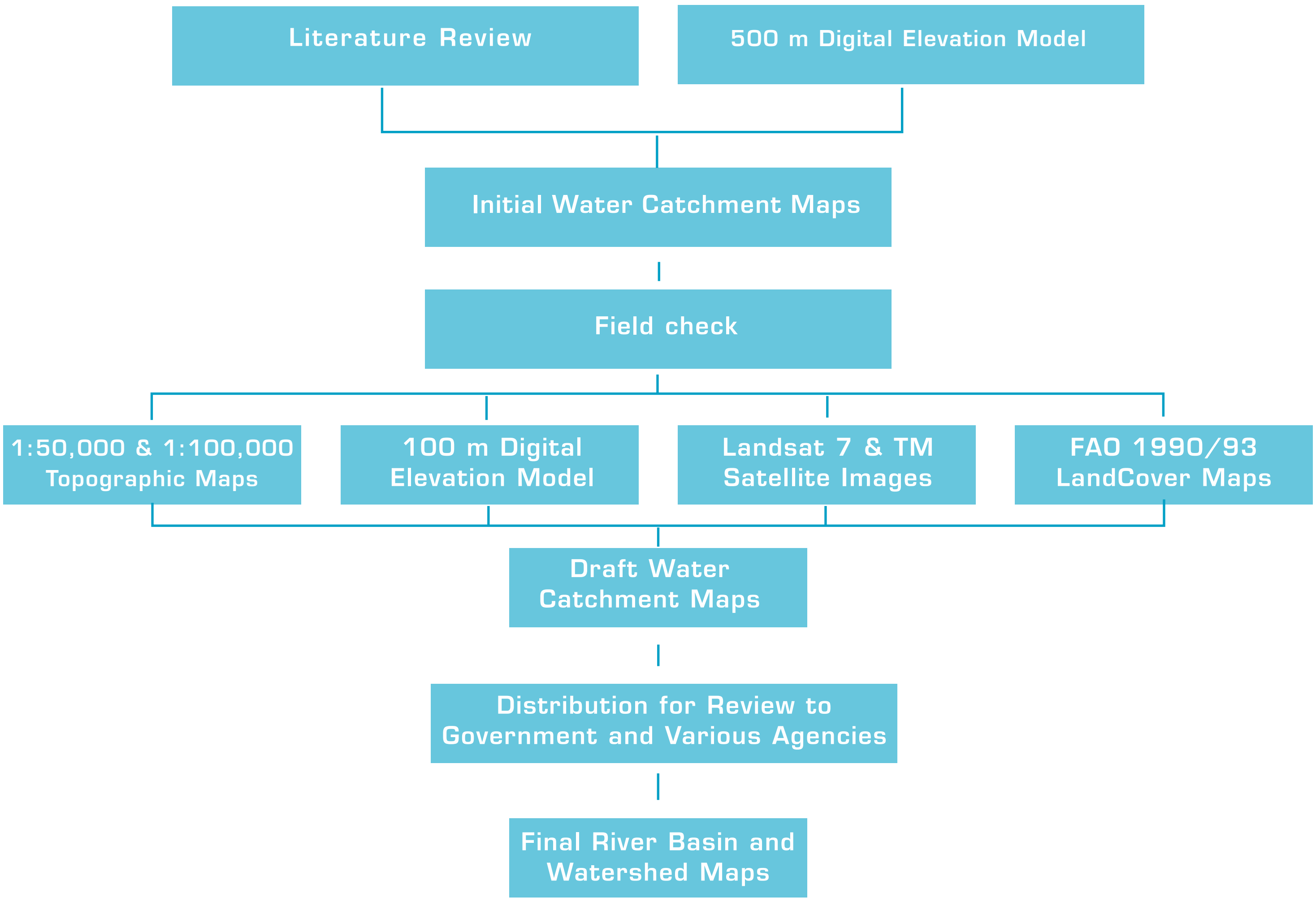


FIGURE 8
Flowchart on the process of the watershed boundary delination for Afghanistan