SOME ASPECTS OF IRRIGATION TECHNOLOGY IN AFGHANISTAN

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Afghanistan is a variegated, landlocked country of high mountains, narrow fertile valleys, broad steppes, and deserts located at the heart of Central Asia (figs. 1,2). It is a harsh and austere land, the home of 12 million people[1] 80 to 90 percent of whom depend directly upon its soil for their livelihood. Still, in the words of an Afghan proverb, "Each man's country is his own Kashmir", and Afghanistan remains one of the few countries in Asia never to have been a European colony.

As a partial result of this distinction, it has no railroads, no heavy industry, and only rudiments of a banking and credit system. What it does have is a fiercely independent population and a highly specialized system of agricultural technology and social, political, and religious institutions evolved over centuries in response to relatively static conditions. This steady-state situation, however, no longer holds. One indication of this is the fact that Afghanistan has become a net importer of wheat, the staple food grain, and after centuries of rough balance between birth and death rates, now has a population that is increasing at about 2.3% per year.

This paper is an examination of the state-of-the-art of irrigation in Afghanistan and its effect in constraining increased national agricultural production.

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[1]Official government figures give a population of 17.6 million. A demographic survey currently being conducted by a State University of New York (SUNY) team, however, will probably show a figure of 11 or 12 million to be more realistic when it is released.

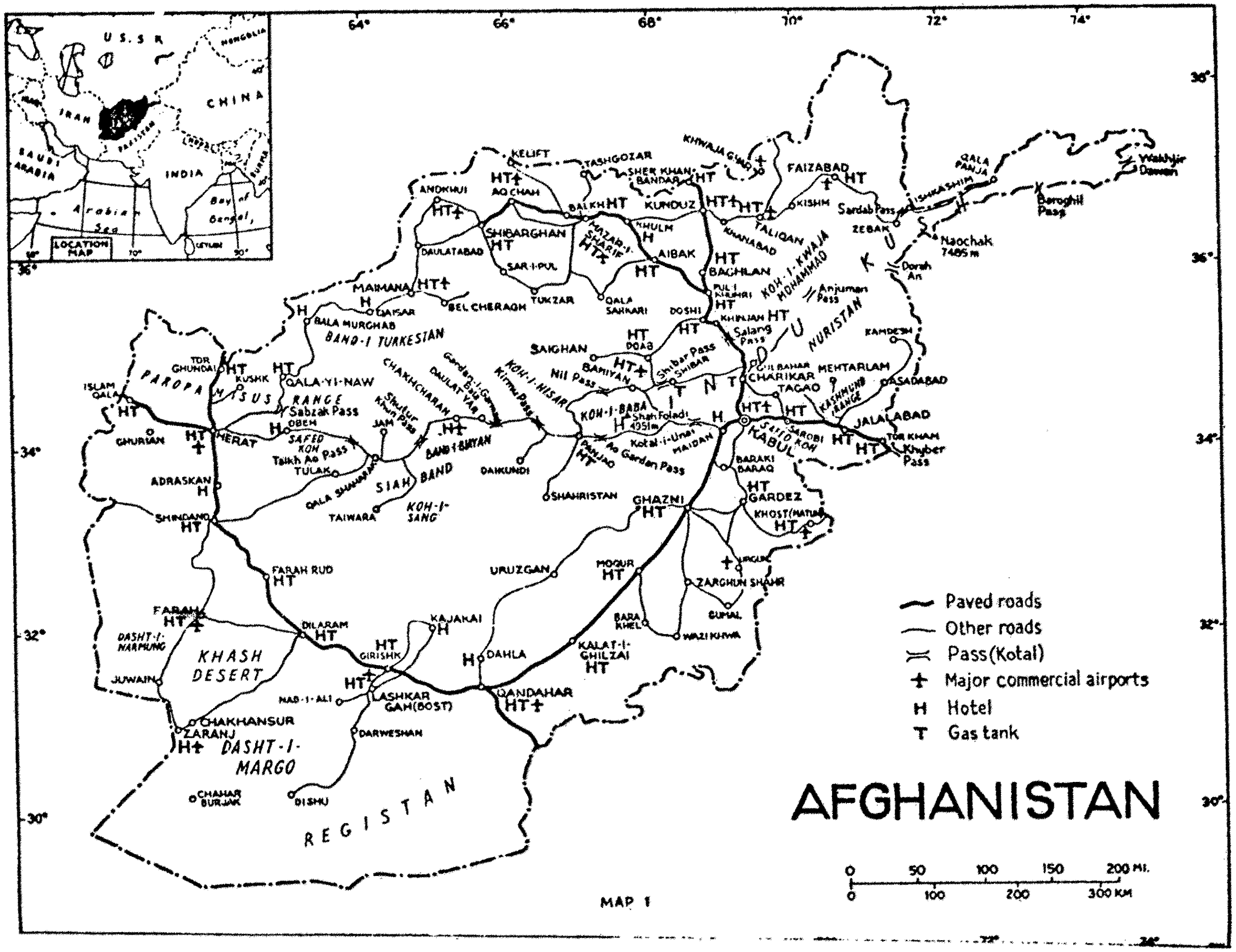

Fig. 1 Map of Afghanistan.

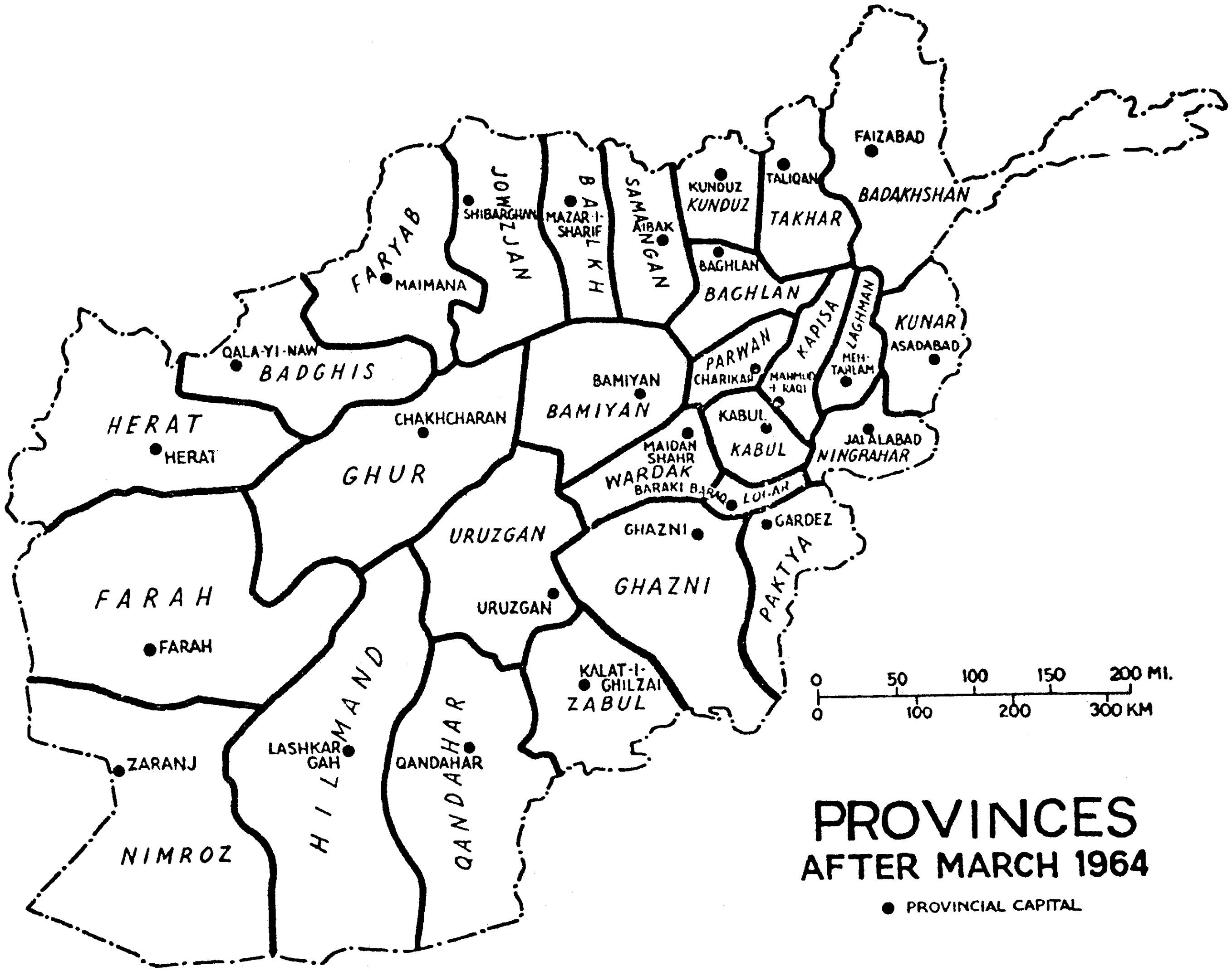

Fig. 2 Provinces of Afghanistan.

Water, of course, is not the only constraint operating to restrict increased production, but it is one of the more important ones. That the farmers themselves realize this is indicated by the fact that land prices for adjacent plots of irrigated and unirrigated land may be 100 times greater in the case of the former.

In the remainder of the paper, I will sketch briefly the context of the irrigation problem in Afghanistan and describe the three types of irrigation systems being used at the present time. I will also suggest modifications in some cases, based on experimental results and on my own experiences and observations. It should be noted at the outset, that data on all of the topics covered below are extremely sketchy and in many cases, simply rough approximations. It should also be emphasized that conditions and irrigation practices differ greatly throughout the country. I have not attempted to draw regional distinctions, as the basic data for this are simply non-existent. I have attempted to discuss practices and problems which are fairly widespread and have drawn examples to illustrate these points from different parts of the country.

Geography/Hydrology

Afghanistan is extremely varied in both topography and climate.[2] The nation is Texas-sized, with an area of about 250,000 square miles and ranges in elevation from over 24,000 feet in the extreme northeast to around 1000 feet in the northwest and south (fig. 3). A large

[2]See Arnold Fletcher, Afghanistan, Highway of Conquest, (Ithaca, NY: Cornell University Press, 1965), Chapt. I, brief description of the country, or Louis Dupree, Afghanistan, (Princeton, NJ, 1965), Part I, for a more comprehensive discussion.

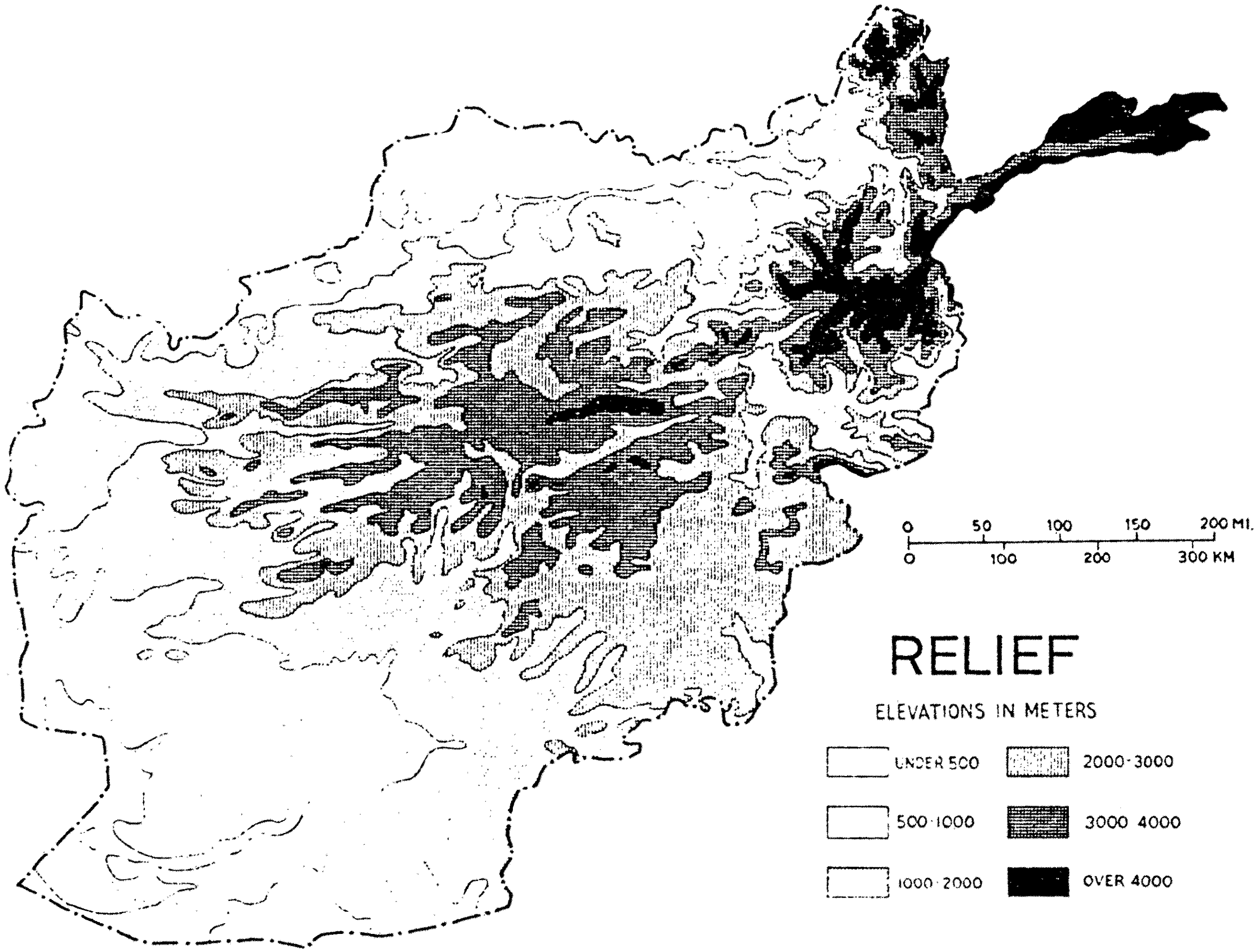

Fig. 3 Relief Map of Afghanistan.

central plateau area has an average altitude of about 6000 feet. The interconnected ranges of the Pamirs, Hindu Kush, Koh-i-Baba, and the Parapomisus form a mountainous backbone for the country, running from the forbidding Wakhan corridor in the northeast to an area just east of Herat in the west. This impressive chain of mountains and a smaller range running along the eastern edge of the country are the source of virtually all of the nation's rivers which spread to its periphery in all directions. The hydrologic system is comprised of 10 river systems or major subsystems flowing into 4 basins. These are the Oxus (Amu Darya), Helmand, Kabul, and the Hari Rud (fig. 4). Only the Kabul finds its way to the sea; the rest being entirely inland systems. Indeed, it is difficult to classify some of the rivers of Afghanistan into systems because they debauch into desert wastes or swampy areas or dry up entirely during the summer months. Most, however, have two things in common: fairly steep gradients in all but the lower reaches, and transport of large silt loads during heavy runoff from rain and snowmelt.[3]

Meteorology

The climate of Afghanistan is continental, arid to semiarid; although a small area in the east near Jalalabad, affected by the monsoons of southern Asia, is sometimes described as subtropical. The daily temperature range is quite wide throughout the country, in both summer and winter. In the southern desert areas, temperatures sometimes reach 120° F during the day but may cool to 60° F at night. Winter

[3] A. O. Westfall and V. J. Latkovitch, Surface Water Resources Investigation Plan for Afghanistan, (Kabul: USAID, 1966), provide an overview of the climate, geography, and hydrology of the country, as do M. Z. Salem and F. D. Hole, "Soil Geography and Factors of Soil Formation in Afghanistan," Soil Science, 107, No. 4 (1969) pp. 289-295.

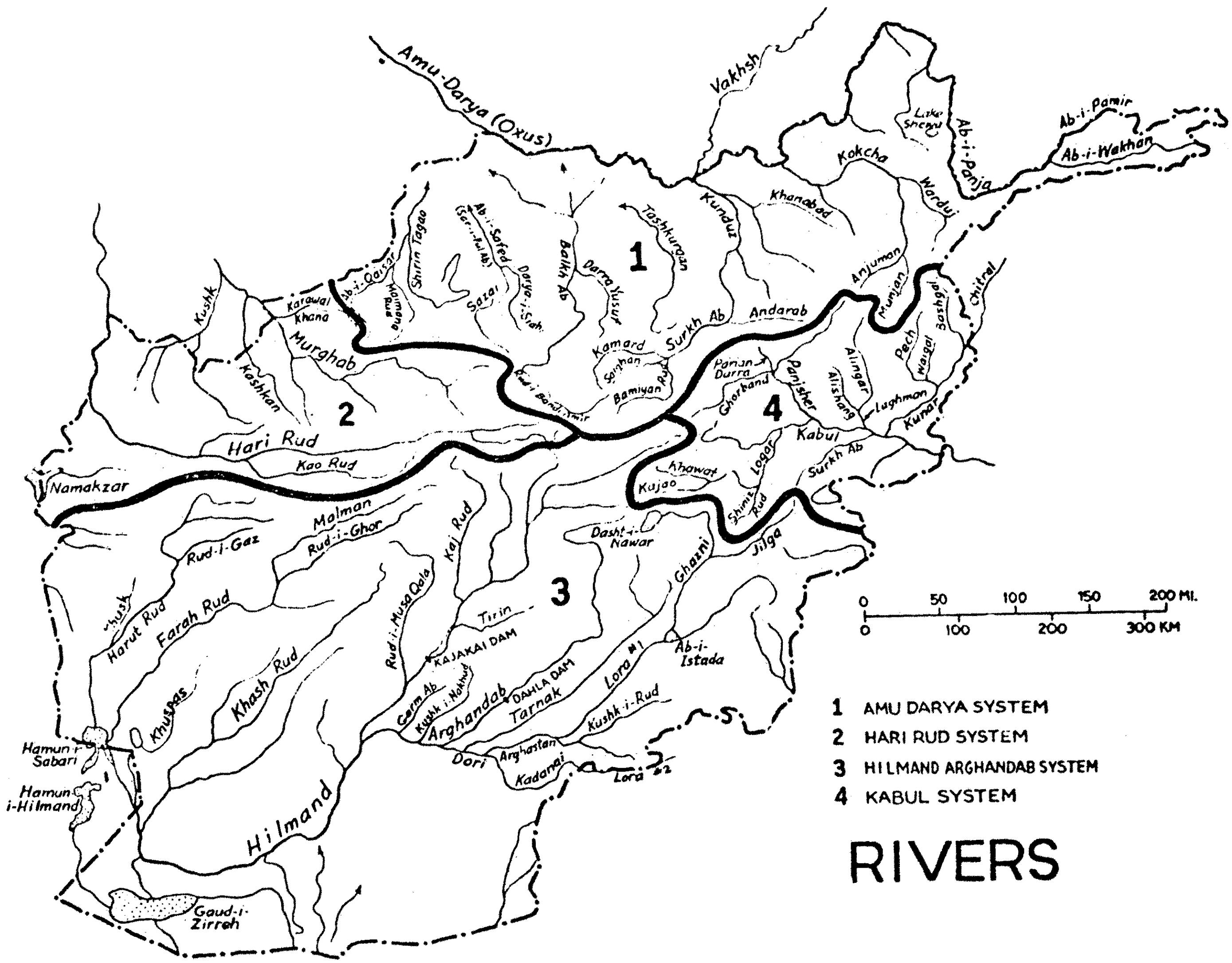

Fig. 4 The hydrologic system of Afghanistan.

temperatures in the northern deserts occasionally drop to -10° F at night but rise to 50° F under the clear skies and warm sun of the daylight hours. Mean temperatures at selected stations are given in table 1. Extremes of temperature and precipitation are shown in table 2.[4]

Precipitation usually occurs in the winter and spring and may range from 40 inches or more in the high reaches of the Hindu Kush to as little as 1 or 2 inches annually in the deserts of the southwest. The average is around ten inches annually. Most of this precipitation is received as snow in the mountains and its release throughout the summer months is the primary source of water for the nation's rivers. For this reason most seasonal fluctuations occur almost simultaneously throughout the country. Average precipitation at selected stations is given in table 3.

Because of its continental climate and seasonal clear skies, Afghanistan receives a larger share of solar radiation than do its neighbors to the east. Radiation inputs, in fact, may be among the highest in the world. A light intensity survey by Mathewson in the Helmand valley area from 21 May 1973 to 5 November 1973 showed maximum intensities in excess of 16,000 foot candles and average daily maximums between 13,000 and 15,000 foot candles. The average duration over this period of over 4000 f.c. intensity was 10.9 hours/day.[5] This high rate of solar radiation has important implications for both agriculture and irrigation.

[4]Westfall, op. cit., pp. 7-8.

[5]James E. Mathewson, A Study of Light Intensity in the Helmand Valley, Afghanistan, mimeo, (Lashkargah, Afghanistan: HAVA, 1974).

Table 1.--Monthly Mean Temperature, in Degrees Celsius (Centigrade), at Selected Stations

Station and Altitude (meters)	Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Kabul 1,763	1960	2.1	4.1	5.4	9.7	17.0	22.4	25.7	24.7	19.5	12.2	4.7	-
	1961	-0.6	-1.0	6.2	11.1	19.0	23.3	25.7	24.7	21.8	12.3	4.1	0.0
	1962	-1.1	2.7	7.8	12.3	17.5	22.0	25.3	23.9	18.4	12.2	4.8	-1.8
	1963	-1.2	5.9	7.4	12.4	16.1	24.5	25.1	24.1	19.5	14.3	5.6	0.9
	1964	-11.2	-4.0	5.9	11.6	16.8	22.2	24.5	24.3	19.1	11.2	4.0	-1.2
	Ave	-2.4	1.5	6.6	11.4	17.3	22.8	25.2	24.3	19.6	12.4	4.6	-
Herat 975	1960	2.9	7.7	6.5	13.2	19.7	27.1	28.9	27.9	22.4	20.7	7.7	-
	1961	3.3	3.4	10.8	14.1	23.3	26.7	30.3	27.5	23.8	14.8	8.7	6.7
	1962	2.9	8.7	12.1	15.8	22.0	25.6	30.1	26.4	20.3	14.7	6.5	5.0
	1963	6.4	9.5	10.7	18.2	20.8	27.7	29.2	27.1	22.7	17.5	8.9	2.3
	1964	-6.7	4.9	12.8	15.4	21.6	26.7	29.5	28.1	22.1	11.5	7.9	-0.3
	Ave	1.8	6.8	10.6	15.3	21.5	26.8	29.6	27.4	22.2	15.8	7.9	-
Mazar-i-Sharif 325	1960	3.9	8.3	6.6	14.4	20.7	28.4	30.3	28.7	21.1	17.4	7.5	-
	1961	3.1	3.7	11.5	15.9	25.3	28.2	31.8	28.5	23.4	13.9	8.3	5.7
	1962	2.6	7.7	13.2	17.1	24.1	28.7	34.0	30.5	22.9	15.6	6.6	3.6
	1963	4.3	9.6	11.1	20.1	23.5	30.8	32.5	29.8	24.3	18.9	9.2	3.0
	1964	-3.7	6.1	12.2	16.1	23.9	30.1	32.6	30.6	24.8	13.8	9.1	0.1
	Ave	2.0	7.1	10.9	16.7	23.5	29.2	26.2	29.6	23.3	15.9	8.1	-
Maimana 900	1960	4.2	8.4	4.4	12.1	17.1	24.8	26.0	24.9	17.9	16.8	7.0	-
	1961	3.1	1.9	8.9	13.1	21.3	24.1	27.0	24.7	19.7	11.3	8.5	6.8
	1962	1.7	7.9	11.1	13.2	18.2	22.9	27.2	23.7	18.1	12.6	5.4	4.3
	1963	7.1	8.9	8.7	16.4	19.6	26.5	28.0	24.6	19.8	15.1	8.6	2.7
	1964	-3.3	4.7	10.6	13.2	18.7	24.2	27.1	25.2	19.7	10.1	9.1	-0.5
	Ave	3.1	6.3	8.7	13.6	18.9	24.5	27.0	24.6	19.0	13.2	7.7	-
Kandahar 1,007	1960	5.6	11.4	11.8	17.4	23.7	30.6	31.2	28.8	-	15.6	9.8	-
	1961	4.5	6.1	14.5	17.0	26.5	31.1	31.8	29.0	25.2	15.2	10.9	6.5
	1962	4.2	10.6	14.1	20.3	25.5	27.5	31.4	28.4	21.1	16.2	7.3	4.6
	1963	5.9	11.6	14.3	20.4	24.7	30.0	31.1	29.4	25.9	21.7	14.5	8.8
	1964	1.4	8.5	17.1	20.1	24.8	28.4	31.3	30.0	23.8	14.1	9.5	3.7
	Ave	4.3	9.8	12.3	19.0	25.0	29.7	31.3	29.1	-	16.5	10.4	-
Jalalabad 550	1960	-	14.6	14.4	18.6	27.2	-	33.4	33.8	26.5	-	-	-
	1961	7.7	-	-	19.1	28.6	33.6	34.4	-	30.9	21.4	12.0	8.4
	1962	7.1	11.9	16.5	21.5	27.8	32.2	33.4	31.6	26.8	21.5	13.9	7.9
	1963	7.5	13.8	15.4	20.7	24.6	34.6	34.4	32.5	28.8	22.2	14.7	9.1
	1964	5.6	10.0	17.4	21.4	28.1	32.4	32.5	32.9	28.2	20.9	12.3	8.6
	Ave	-	-	-	20.2	27.3	-	33.6	-	28.2	-	-	-
Farah 750	1960	-	-	-	18.4	24.8	32.1	-	31.7	26.5	19.4	11.3	-
	1961	6.7	7.6	15.3	18.3	27.6	31.3	34.9	31.4	27.3	18.0	11.9	9.7
	1962	6.8	12.8	17.0	23.2	26.2	30.0	34.2	30.2	23.6	18.9	9.8	9.9
	1963	7.9	12.8	15.3	21.9	23.8	32.2	34.2	31.6	26.9	21.6	13.1	8.2
	1964	2.4	9.4	16.1	20.3	26.5	31.3	33.2	31.1	24.0	14.8	11.6	3.5
	Ave	-	-	-	20.4	25.8	31.4	-	31.2	25.6	18.5	11.5	-

Table 2. Instantaneous Maximum and Minimum Temperatures, and Maximum Precipitation for 24 Hours, for Selected Stations During 1960-64.

Station	Instantaneous Temperature in Degrees Celsius (centigrade)		Maximum 24-hour Precipitation	
	Maximum	Minimum	(millimeters)	
Kabul	36.9 in 1961	-25.5 in 1964	35.2 in 1960	(1.39")
Herat	44.4 in 1960	-26.7 in 1964	35.2 in 1960	(1.39")
Mazar-i-Sharif	45.2 in 1964	-16.0 in 1964	36.0 in 1961	(1.42")
Maimana	42.5 in 1960	-18.1 in 1964	69.9 in 1960	(2.75")
Kandahar	43.9 in 1964	-12.3 in 1964 1/	46.3 in 1962	(1.82")
Jalalabad	48.4 in 1964	- 4.4 in 1962	67.2 in 1963	(2.64")
Farah	47.0 in 1964	-11.9 in 1962	35.9 in 1961	(1.41")

1/ A period in 1960-62 only.

Table 3. Afghanistan: Annual Cumulative Precipitation for the Years Ending Jauza 10, 1343-1352 (May 31, 1964-1973)

Stations	1343	1344	1345	1346	1347	1348	1349	1350	1351	1352	10-Year Average
	(millimeters)										
South Salang	1272.1	1409.7	1083.0	1255.1	916.9	1045.9	840.3	818.1	1168.5	1167.5	1097.7
North Salang	1241.4	1444.5	1153.1	1125.1	1280.8	991.1	532.0	418.0	945.0	1209.5	1034.1
Kabul	431.1	426.5	318.6	326.3	325.8	312.1	200.4	233.3	392.3	381.8	334.9
Jalalabad	139.0	370.1	247.2	157.9	289.3	181.2	91.0	110.2	180.9	251.2	202.8
Baghlan	343.9	356.3	282.5	301.9	343.6	434.1	259.8	240.3	335.3	355.1	325.3
Khost	410.2	726.5	503.6	630.3	331.5	215.6	122.8	273.7	537.3	366.0	411.3
Kunduz	382.2	397.5	242.7	261.9	313.7	456.0	229.9	231.5	284.5	332.2	311.2
Kandahar	168.7	109.9	171.6	120.7	185.2	117.0	132.8	47.3	186.1	102.9	119.0
Herat	263.2	188.1	245.4	259.6	205.8	350.8	184.5	111.8	375.9	187.9	237.3
Ghazni	468.0	536.4	353.8	84.5	335.8	210.1	253.9	172.1	439.6	329.1	318.3
Maimana	396.3	369.7	226.5	319.9	396.8	563.5	293.7	200.0	437.4	375.4	357.9
Mazar-i-Sharif	207.1	194.3	130.4	182.7	212.1	357.4	161.1	130.9	213.0	257.9	181.5
Sheberghan	143.6	191.6	158.9	219.8	219.7	185.6	113.3	113.3	315.5	351.2	201.3

Source: Compiled from data from the Climatology Section, Afghan Air Authority.

Agriculture

Afghanistan has a total area of about 250,000 square miles. Of this total area, about 19 million acres or 12% is cultivable. Only about 11 million acres or 7% of the total land area is in annual crops (fig. 5). It is interesting to compare this modern estimate with that of G. P. Tate writing in 1910 who visited Afghanistan in the early years of this century.[6] He estimated that 10% of the country's land area is cultivable and that only 1% was in annual crops. Even allowing for significant errors in the estimates, especially Tate's, it would seem that the area under cultivation has increased markedly over the past 60 years.

With regard to irrigation, it is estimated that about 13 million acres, or about two-thirds of the cultivable land is irrigated, though much of it receives only supplemental water. About half of the irrigated land is in annual crops, mostly wheat. Overall, 50-60% of the total amount of land in annual crops is devoted to wheat production. Of the total amount of land in wheat production, 56% is irrigated, but this land accounted for 77% of the total annual average output over the 1963-73 decade. This clearly establishes the central position of irrigated wheat production in the Afghan agricultural economy, and justifies the government's position in naming self-sufficiency in wheat production its number one priority. This, of course, means not only reaching parity with present demand, but achieving an annual increase in production of at least 2.3% annually.

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[6] G. P. Tate, The Kingdom of Afghanistan. A Historical Sketch, originally published at Bombay in 1911, (Karachi: Indus Publications, 1973), p. 8.

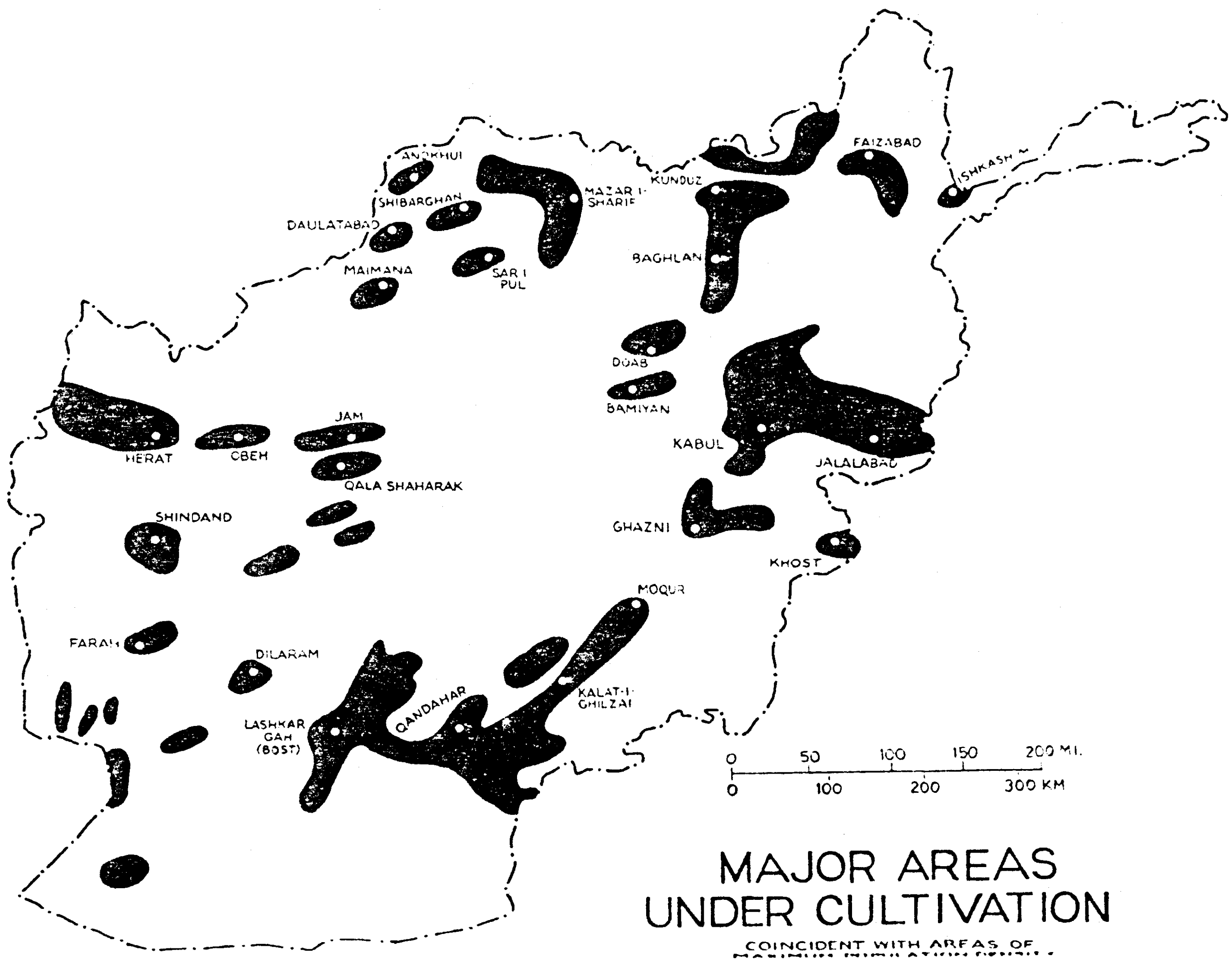

Fig. 5 Major areas under cultivation.

Actually, "agricultural economy" might be a misnomer here. Over the past decade, only about 40% of the total wheat production of the country has moved through the market system, either by sale or barter. The rest was retained by farmers for consumption and seed. This seems to indicate that a substantial share of the nation's wheat is grown on small farms by individual farmers.[7]

The implications of this for a national irrigation policy are several. The subsistence nature of agriculture in Afghanistan, and the virtual lack of government food reserves, makes assured deliveries of irrigation water to farmers extremely important.

Tate in 1910 writes that "Years of scarcity are not infrequent, but severe distress is confined to those districts in which cultivation depends chiefly on the rainfall. It rarely becomes very general or develops into a famine."[8] As more marginally irrigated land is brought into production to meet the demands of a rapidly increasing population, however, this may no longer be true. The severe drought of 1969-71 is a case in point. Massive starvation was averted only by large infusions of American relief wheat into the central highlands, and the extreme northeast and northwest portions of the country. An improving national transportation net and a growing urban population demand that agricultural production and irrigation policy be viewed from a national perspective as well as a regional one.

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[7]All of the figures used above are derived from Nathan Koenig and Harold V. Hunter, <u>A Wheat Stabilization Program for Afghanistan</u>, (Kabul: USAID, 1973), Chapt. I. Koenig and Hunter emphasize that these figures are very approximate. There exists no regular, comprehensive system for gathering agricultural information in the country nor has there ever been a complete cadastrial survey or an agricultural census taken.

[8]Tate, op. cit., p. 6.

In addition, a strong agricultural base for national development schemes is a necessity in a country so lacking in industrial infrastructure.[9] Periods of drought also have the following secondary effects which are detrimental to national development aspirations.

1. A consolidation of land holdings through mortgage and sale.
2. Out-migration from the region affected and the nation.
3. Resulting high wheat prices prevent the raising of cash crops necessary for the production of capital and foreign exchange currency.

Thus a key ingredient in any agricultural development scheme, and therefore the development of the economy as a whole, must be the provision of an assured supply of irrigation water to the nation's farmers and measures to insure efficient use of that water.

The Riverine System

By far the most common irrigation scheme in the country consists of a diversion structure in a watercourse with canals and laterals leading water to fields downslope. Once the water reaches the fields, basin irrigation is almost universally practiced. Distribution is gravity powered[10] and ditch gradients, especially in hilly regions, are quite steep. This results in substantial amounts of potentially irrigable land being left above the ditch and lost to cultivation.

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[9] See Edgar Owens and Robert Shaw, Development Reconsidered, (Lexington, MA: Lexington Books, D. C. Heath & Co, 1972), Ch. 5 and 6. This is one of the better books to appear on development in recent years and is strongly recommended for anyone interested in development.

[10] In one village I observed a type of Persian wheel lifting water 10 or 12 feet which was powered by the current in the canal. This was said, however, to have been designed by a German engineer at a nearby textile plant and is probably unique in the country.

Diversion structures are typically made from rock, soil and wooden pilings and placed nearly parallel to the current flow so as to offer minimum resistance to the main channel flow. Nevertheless they are often carried away by spring floods. Cross stream diversion structures are built after spring flood crests have passed and must be completely reconstructed annually. The Provincial Development Department has experimented with rock-filled gabions as an alternative, more-permanent construction, but has been hampered by the high cost of imported gabion sections and a lack of technical expertise on the part of its personnel. Still, this represents a promising approach and warrants further investigation.

Canals are hand-dug and exhibit various cross-sections. The high gradients mentioned above often cause scouring and bank erosion, necessitating frequent repair. Ditches leading through hilly terrain follow a serpentine path from the river to cropland, and sections crossing gulleys and washes are swept away each spring during the rainy season.

Protection against this sort of damage would be difficult without engineering works which are beyond the capability of villagers and provincial officials. In any case, the cost of such protection would probably be prohibitive. For the time being, the present, labor-intensive approach is probably the most efficient. The laying out of canals with more moderate slopes, however, would seem to be a relatively inexpensive way of bringing substantial amounts of new land under irrigation. Kabul University has an excellent engineering faculty which produces a number of competent engineers very year. The country's three technical high schools also train surveyors who would be capable of doing such work. Finally, the moribund National Cadastrial Survey employs a number of surveyors who, theoretically at least, could be released for this work.

Seepage and evaporation losses are also important factors in reducing the quantity of water available for irrigation. Although little or no quantitative research has been done in these areas, estimates from the Helmand Valley Region suggest seepage losses of 25% for canals and 15% for laterals.[11]

Evaporation losses are also high, particularly in the longer canals, which may be 30 miles in length, and from impounded bodies of water. In the intensively cultivated Helmand Valley Region these losses run to 9 or 10 feet per year. As an extreme example, evaporation rates in the southwest corner of the country may reach 16 feet per year, second only to the nitrate flats of Northern Chile.

The reasons for this high evaporation rate may be found in the high solar energy inputs mentioned earlier, the extremely low prevailing humidity, and the strong, steady winds which blow across large sections of the West during the summer. These are quite regular and are called the "120-day wind" by the people of the region. All of these factors, of course, affect the transpiration rates of agricultural plants in a similar way.

The problem of high evaporation rates and the perhaps more serious problem of siltation are serious deterrents to the construction of water storage facilities in many parts of the country. High stream gradients and the absence of vegetative cover on hilly watersheds add large silt loads to the runoff which rapidly fill impoundment structures.

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[11]Louis L. Mitchell and David A. Garner, "A Collaborative Survey of the Helmand-Arghandab Valley Region" (draft report, USAID/Afghanistan, 1974), p. 9.

Some small earth dams constructed in Paktia province (see map, fig. 2) with foreign assistance, it is now expected, will have a life expectancy of only eight to ten years before becoming completely silted in. German advisors with considerable experience in that province state that the only way to control siltation and riverbed erosion is to stop the water on hillsides through range management programs before it reaches the rivers.[12]

To this end, they have conducted several interesting experiments involving the digging of trenches and contour furrows on barren hill-sides. These techniques have been almost completely effective in halting runoff erosion. In addition, the resulting increase in infiltration has made it possible to grow grasses and fruit trees on the hillsides which was previously barren.[13] These techniques, and the slightly more elaborate technique of micro-catchment basins, seem exceedingly promising and certainly warrant further attention.[14] They have the added advantage of being highly labor-intensive and require a minimum of capital investment.

The Karez

A second means of obtaining irrigation water is the "karez". Called "qanats" in Iran, where about 50,000 of them are still in operation, they were known there well before the time of Christ. Ruins of these ingenious structures have been found in the Negev desert

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[12]David A. Garner, "Trip Report to Paktia Province" (internal communication, USAID Afghanistan, 1972), p. 6.

[13]Ibid., pp. 3-5.

[14]For an excellent discussion of micro-catchment and other collection techniques see Michael Evenari, The Negev, Challenge of a Desert (Harvard University Press, 1971).

of Israel and as far west as North Africa. The number of operating karez in Afghanistan at the present time is unknown, but they are by no means uncommon. In many locations they provide the only year-round source of water for both irrigation and domestic use.

In theory, the karez is an extremely simple construction. It consists of a series of wells connected underground by a tunnel that gently leads the water from the uppermost well in the series to a point downslope where it can be reached by a ditch dug downward from the surface. The water is then led onto the fields in a conventional manner. The wells provide access during construction and cleaning operations to the tunnel which serves as an infiltration gallery. The first well, which may be 100 feet deep, is usually sunk at the base of a hill where the land slopes away to the fields below. Water is "raised" to the surface by bringing it downslope at a shallower gradient than that of the land surface above (see figure 6). This sometimes requires several miles to accomplish.

In practice, construction is difficult and dangerous work and a single karez may require two or three years to complete. The tunnel and wells are seldom lined and cave-ins are frequent. In addition to the hazard posed to the men who dig these tunnels, the cave-ins often block the tunnel resulting in the need for periodic cleaning or, in extreme cases, abandonment.

Because the water spends a large share of its time underground, evaporation losses are greatly reduced. Flow rates, however, are typically low[15] because of low infiltration rates, seepage after the

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[15]U.S. Geological Survey hydrologists, in the country on temporary assignment from Pakistan during the 1965 Indo-Pak War, conducted an investigation of several karez systems in the Helmand Valley area. Their findings were published by USAID/Afghanistan in an Administrative Report, c. 1966.

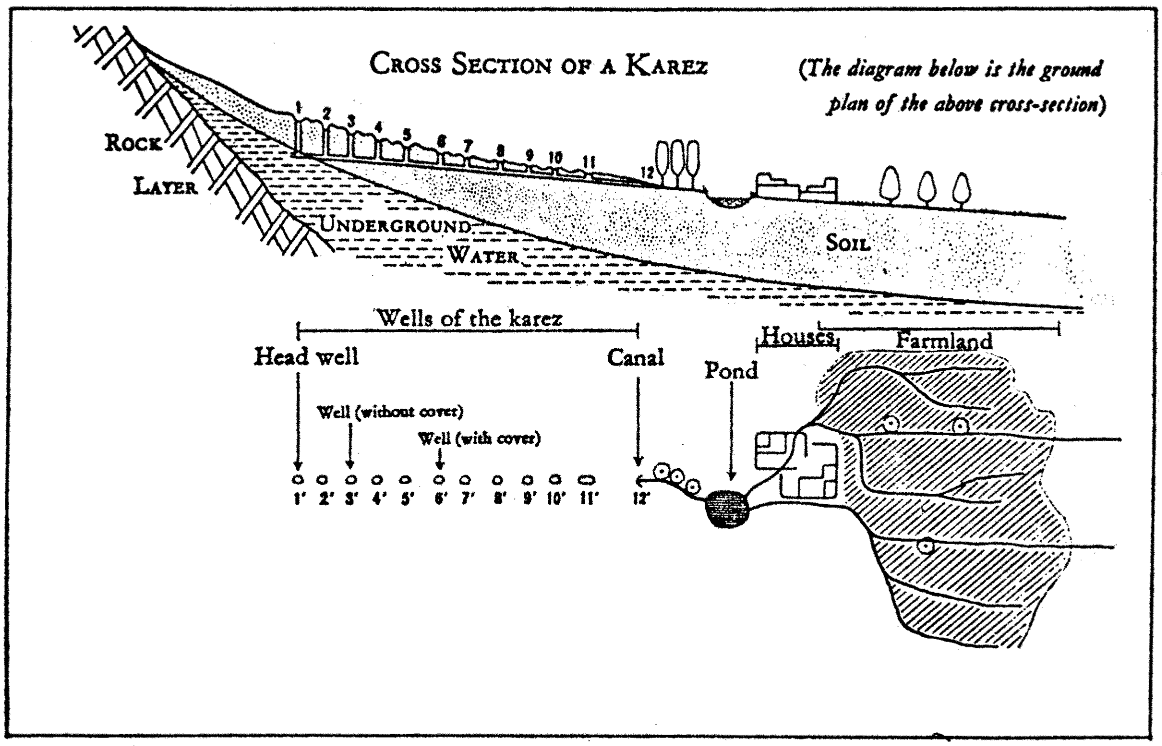

Fig. Cross section of a karez.
From: Masatoshi Konishi, Afghanistan, Crossroads of the Ages, (Tokyo, 1969), p. 49.

tunnel rises above the aquifer, and the fact that the tunnel cannot be driven very far into the aquifer by the men working in the tunnel.

An interesting application of the karez technique is its attempted use for interbasin water transfers. On two occasions I was told by villagers of karez-like tunnels which had been driven through hills to bring water to valleys with less abundant supplies. Neither tunnel was still operational in 1972, if indeed either ever was, but the fact that the attempt was made says much about the value of water, indigenous engineering capability, and willingness to experiment.

Finally, two modified systems based on traditional karez technology, deserve mention. Both were developed by the West German aid mission working in the Paktia area. The first, designed by Dr. Chris Hasselbarth, seems most useful where the aquifer to be tapped lies reasonably close to the surface at a point not too far distant from the village. When water is located, a trench is dug from the test well to the fields below. The trench replaces the collection tunnel in the traditional karez and has a similar gradient. It is then roofed over with flat stones, which are found in abundance in many sections of the country, and refilled. This greatly reduces the problem of cave-ins and of dirt entering the tunnel via the wells. Hasselbarth estimates the average life of such a karez to be as long as 50 years.

Although construction costs would be considerably higher than for more traditional construction, maintenance costs are virtually eliminated and initial investment would go almost entirely for labor which is still relatively cheap in Afghanistan. To become practical on a self-sustaining basis, what is needed is a mechanism for spreading these construction costs out over the life of the structure. As might be expected, planning horizons are often restricted to one generation.

The second karez-variation is an attempt to tap water flowing beneath dry or nearly dry riverbeds during the rainless summer months. Sections of porous concrete pipe are buried in the sand of the riverbed. If the bed is wide, feeder pipes branch out at regular intervals from the main collection pipe. The drainfield then empties into a surface canal at some point downslope. One experimental system which was being installed in Paktia province in 1972 consisted of a main collection pipe 1000 meters long and 50 centimeters in diameter with feeder pipes every 20 meters. When completed, the system was expected to yield 30 to 50 liters per second. Construction costs were estimated at $10,000.

This type of construction has all of the advantages of a traditional karez with the additional advantage of receiving runoff and effluence from the entire natural drainage basin of the river. It would be almost maintenance-free assuming no siltation problems. Some capital investment in the concrete pipe sections would be required, however these are being cast locally in most sections of the country at the present time. Locally produced cement is widely available at about $1.50 per bag.

Wells

Of lesser importance than the riverine and karez systems, shallow wells nevertheless provide irrigation water in some regions. Here again, no figures showing the numbers of such wells or the area they irrigate are available. Almost all are hand-dug and rely primarily on the Persian wheel to bring water to the surface. Thus depth is strictly limited by the distance water can be raised using the animal-powered device. Wells generally penetrate the water table by only a few feet as dewatering equipment is not generally available and must be deepened when the water table drops below the bottom of the well. Most wells are unlined, though pre-cast concrete rings are beginning to come into use in some areas. Afghans are accomplished at this work. In the Northern part of the country, where thick beds of loess cover large areas, wells have been dug down as much as 200 feet to find water. Their use, however, is limited to domestic purposes and the water is drawn up in buckets.

Since being chartered around 1970, the Agricultural Development Bank of Afghanistan (AgBank) has been active in granting loans for irrigation well construction and diesel pump sets. The bank is a quasi-government organization funded by the IDA, a branch of the World Bank, and should play an increasingly important role in the financing of small, private irrigation development projects. The AgBank is also marketing, on a cash basis, a type of Persian Wheel fashioned from old truck differentials. These were developed by the German-sponsored Paktia Development Corporation and are markedly more efficient than the traditional wheels employing ring and cog gearing.

The AgBank has also made a start at gathering some farm economic information. Preliminary results show that for many farmers, particularly those with small holdings, animal powered pumping is less expensive than motorized pump sets. This will be even more true in the wake of the recent world-wide increases in petroleum prices.

Finally, it should be noted that the ground water reserves of the country have never been mapped in any comprehensive way. Survey work that has been done in Herat province, however, shows extensive aquifers at relatively shallow depths, underlying the city of Herat and the surrounding area. Interstinglv, an engineer for ERCON, a British consulting firm which did the survey work, indicated that although they had not exploited them systematically, farmers, over hundreds of ye of trial and error, had located virtually all of the shallow aquifers in the survey region.

Distribution

As was mentioned earlier, irrigated crops are grown in basins which are flooded when ones water turn comes around. In addition, a small amount of furrow irrigation is practiced, as in the case of potatoes which have been recently introduced as a cash crop. A typical village distribution system is shown in figure 7. The source of water in this case is a karez, though it could have been wells or a canal from a nearby watercourse. The distribution system would be little changed in either case. Often in hilly regions, the village itself will be built on unirrigated land above the highest canal so that every available foot of irrigable land can be cropped.

The three methods of obtaining and transporting water to croplands described above are common to the entire country. Social systems affecting the control and allocation of water, however, while almost always based on a rotational system, vary widely throughout the country. In some areas farmers cooperate closely in sharing water turns and even in collective production practices. In other areas rivalries between kinship groups or villages are strong, and each will have its own canal leading down from a common river. This naturally results in an inefficient use of water and often reduces the amount of land which might be irrigated.

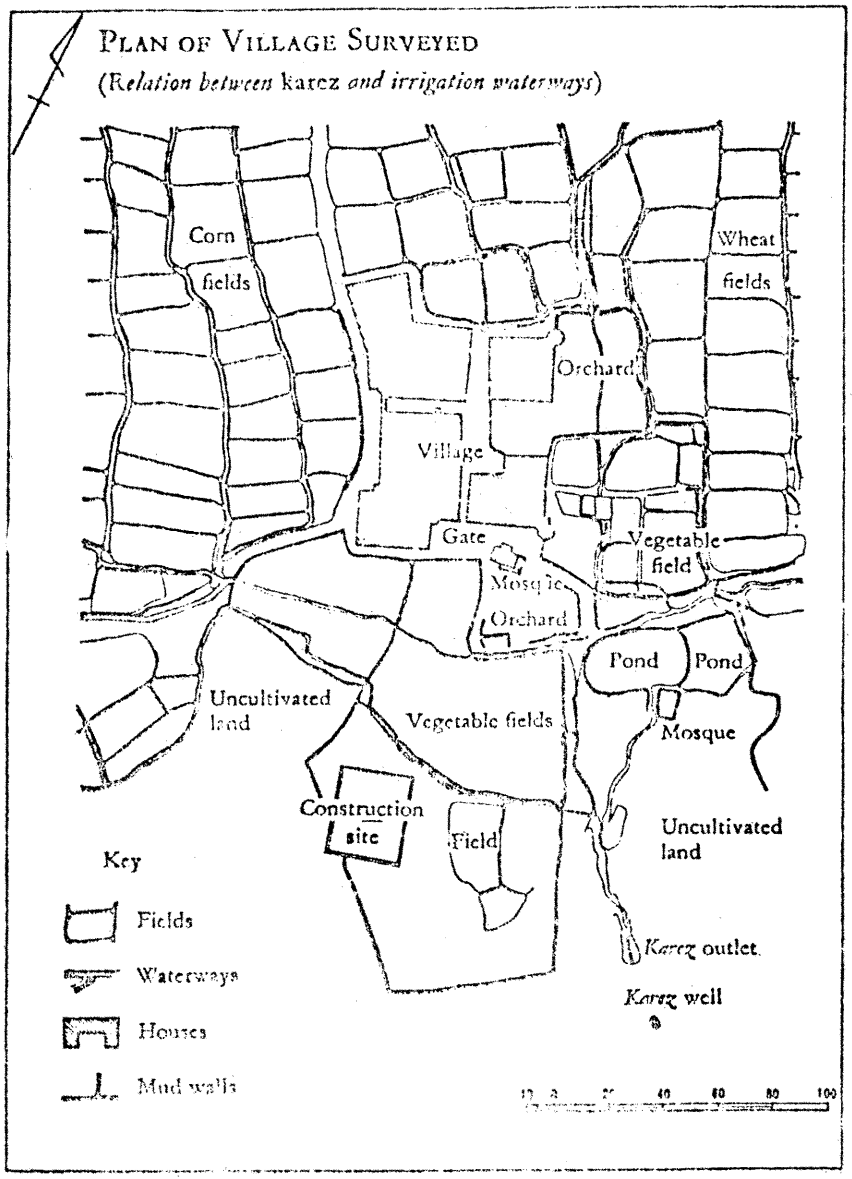

Fig. 7 A typical village distribution system.

Common to most situations, at least those where water rather than available land is a limiting factor, a "mirab" or water controller will be elected by the farmers to supervise allocation of water and maintenance of facilities, and to adjudicate disputes. This is an important position as might be expected and the mirab's income will usually be substantial. Needless to say, complete impartiality is not always achieved, but often this system does work surprisingly well.

There are, of course, scores of variations on the basic pattern sketched above and before changes in irrigation structures and practices are attempted, a thorough understanding of the non-technical context of a project is imperative. The history of development in Afghanistan is replete with examples of projects which have failed to achieve their objectives because no attempt was made to develop this understanding.