

Afghanistan Research and Evaluation Unit
Issue Paper Series

WATER MANAGEMENT, LIVESTOCK AND
THE OPIUM ECONOMY

**How the Water Flows:
A Typology of Irrigation Systems in Afghanistan**



Bob Rout

June 2008



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Glossary

<i>arbab</i>	village or community leader
<i>arhad</i>	traditional method using groundwater for irrigation of small plots, powered by animal draft (donkey, horse, camel or ox)
<i>badwan</i>	person responsible for operation and maintenance of intake canal
<i>chah</i>	access well in a <i>karez</i> system
<i>chak bashi</i>	water bailiff on secondary and tertiary canals (term used in Kunduz and Balkh)
<i>chak mirab</i>	water master responsible for main and secondary canal sections (term used in Kunduz and Balkh)
<i>darak</i>	water share controlled by a bifurcation
<i>hashar</i>	communal, usually unpaid, labour
<i>hawz</i>	traditional water tank, accumulated pool or small reservoir at the head of an irrigation system to permit delivery of larger unit flows or for irrigation during 12 hours of outflow using 24 hours of inflow
<i>jar</i>	temporary canal or dyke in river or wash bed to harvest subsurface water or springs during summer months (also known as <i>chow</i>)
<i>jerib</i>	unit measurement of land area equivalent to 2,000 m ² (5 <i>jerib</i> = 1 ha)
<i>juftgaw</i>	a variable measure of irrigated land used to allocate water according to established entitlements; flow share proportional to irrigated area and often estimated in <i>jerib</i> ; reflects the area ploughed by a pair of oxen
<i>karez</i>	underground canal system that taps aquifers by gravity through a series of subsurface tunnels; often extends for many kilometres before surfacing to provide water for drinking and irrigation
<i>karezkan</i>	<i>karez</i> specialist usually responsible for construction and maintenance of subsurface sections
<i>man</i>	measurement of weight that varies regionally; equivalent to 4kg in Herat but, for example, 7kg in Kabul, 4.5kg in Kandahar and 14kg in Balkh
<i>mirab</i>	water master responsible for main and secondary canal sections (term used in Herat)
<i>mirab bashi</i>	water master responsible for overall management of surface water system (term used in Kunduz and Balkh)
<i>nawbat</i>	water turn
<i>owkura</i>	the first point of access to water in a <i>karez</i> where drinking water is taken
<i>pau</i>	a variable measure of irrigated land area used to allocate water (term used in northern regions); see <i>juftgaw</i> for a description of a similar system of measurement
<i>qawala</i>	water rights or entitlement supported by ancient law
<i>qulba</i>	a variable measure of irrigated land area used to allocate water (term used in northern regions); see <i>juftgaw</i> for a description of a similar system of measurement
<i>roz</i>	day

<i>saat</i>	hour
<i>sarband</i>	intake canal for surface water irrigation systems, traditionally constructed with logs, gravel and sandbags
<i>sarchah</i>	the point-of-source access well located most upstream in a <i>karez</i> system; also known as mother well
<i>sehdarak</i>	structure for proportional water distribution in main and secondary canals
<i>ser</i>	measure of weight often used for grain; equivalent to 7kg in Kabul and 14kg in Mazar-i-Sharif
<i>shura</i>	local council, traditionally an assembly of clan-based, tribal or ethnic elders
<i>wakil</i>	individual responsible for overall management of surface water system (term used in Herat)

Technical terms

bund	a dam, barrier or weir
command area	gross area commanded by an irrigation system inclusive of irrigated area, infrastructure and non-productive areas
distribution efficiency	ratio of water flowing out of an irrigation system over water coming in
ETo	potential evapotranspiration
field application efficiency	efficiency of on-farm distribution and application of water to meet crop water requirements
isohyets	a line drawn on a map connecting points that receive equal amounts of precipitation
water use efficiency	ratio of unit measure of crop production per volume of system gross water intake, typically expressed as kilograms per cubic metre

Units

cumec	cubic metre per second
ha	hectare (area equivalent to 10,000 m ²)
km	kilometre
L/s	litres per second
L/s/ha	litres per second per hectare
m	metre
m ³	cubic metres
mm	millimetre
MW	megawatt

Abbreviations and Acronyms

ADB	Asian Development Bank
ADF	Abu Dhabi Fund
ADRBMP	Amu Darya River Basin Management Project
AIMS	Afghanistan Information Management Services
AREU	Afghanistan Research and Evaluation Unit
BBIWRMP	Balkh Basin Integrated Water Resources Management Project
CIDA	Canadian International Development Agency
DACAAR	Danish Committee for Aid to Afghan Refugees
DOI	Department of Irrigation, Water Resources and Environment
EC	European Commission
EIRP	Emergency Irrigation Rehabilitation Programme
EIRRP	Emergency Infrastructure Rehabilitation and Reconstruction Project
FAO	Food and Agriculture Organisation
GAA	German Agro-Action
JFPR	Japan Fund for Poverty Reduction
KRBP	Kunduz River Basin Project
MEW	Ministry of Energy and Water
MRRD	Ministry of Rural Rehabilitation and Development
NSP	National Solidarity Programme
RAMP	Rebuilding Agricultural Markets Programme
SWMA	Social Water Management in Afghanistan
UN	United Nations
URD	Urgence Réhabilitation Développement

Executive Summary

This paper develops and presents a typology of irrigation systems in Afghanistan. It is intended to enhance knowledge of irrigation methods and management with the aim of improving system performance and productivity. It is also intended to provide those involved in irrigation rehabilitation and natural resources management with a better understanding of the link between irrigation systems and livelihood sustainability. The importance of irrigated agriculture is undeniable since it is the mainstay of food security and income for the majority of the rural population, accounting for more than 70 percent of total crop production.

For the past 30 years, the rural sector has been severely impacted by war and civil unrest. The structures of irrigation systems have been damaged directly and sometimes deliberately. While many rehabilitation efforts by necessity have been emergency assistance, long-term strategies to improve the performance and reliability of irrigation systems are also required.

It is important to note that a great deal of information, resources and institutional capacity for accurate monitoring and reporting on natural resources were lost during the years of conflict. While significant efforts are underway to fill the information void, many inaccuracies and gaps remain.

National overview

The topography and climate of Afghanistan are the principal influences on the development of the type, range and distribution of irrigation systems. With predominantly dry continental climate, most of the country's cultivable area receives low or negligible rainfall during the irrigation season. Most annual precipitation occurs at high elevations in the Hindu Kush mountain range. The quantity, timing and distribution of precipitation chiefly determine water availability for irrigation.

Along with land allocation, the occurrence and distribution of water resources primarily determine the type and location of irrigation systems in the country. Average annual volume is estimated at 95 billion m³ of which 88 percent is surface water and 12 percent is groundwater.

While Afghanistan has five major river basins, nearly 60 percent of water resources come from the Amu Darya in the north. Surface water flows peak in the spring and early summer following snowmelt. The timing and duration of these flows presents both an opportunity to harvest water and a challenge due to the risk of floods.

Afghanistan's groundwater resources lie in a number of aquifers from which water has traditionally been extracted through *karez* and wells. To date, however, there appears to be little detailed research conducted on these water resources.

The cultivable area of Afghanistan is estimated to be 7.7 million ha, which is roughly 12 percent of the country's area. A land use survey from the 1990s estimated 3.2 million ha was irrigated of which 48 percent was intensively irrigated and 52 percent was intermittently irrigated with one or more crops. Of the five river basins, the Helmand supports the largest irrigated area (44 percent) in the country.

Irrigation Systems Typology

This paper presents a relatively simple classification system but one that may be a useful starting point for developing more detailed analyses.

This classification of system types is based on the following criteria:

- origins of development, distinguishing between "informal" traditional systems managed by local communities and "formal"

large-scale schemes supported by the central government;

- water source, which is categorised into surface water and groundwater; and
- system, which is classified by infrastructure related to primary water source such as large formal government schemes as well as systems involving surface “run-of-river” sources, *karez*, springs, wells, dams and harvest; these may be further divided into subsystems or specific schemes.

Informal systems

Traditionally developed and managed by local communities within the constraints of local resources, informal systems have existed for generations. They have undergone social and physical changes, expanding or contracting due to water availability or challenges arising from years of conflict. Informal systems account for 90 percent of the country’s irrigated area.

Surface water systems

Surface water systems make up nearly 30 percent of systems but supply 86 percent of irrigated area in Afghanistan. Their prevalence largely results from widespread availability of both water resources from rivers and streams as well as adjacent land suitable for development, usually along river terraces and alluvial plains. These systems vary but share some common infrastructural, organisational and operational features.

The systems are essentially supply driven, dependent on timing, rate and duration of the annual water supply. Communities use a water management strategy that maximises water harvesting potential during peak flow.

The key infrastructure typically found in surface water systems includes: diversion structures (*sarband*); main, secondary and tertiary canals (predominantly made of unlined earth); control

structures (weirs, *sehdarak* bifurcators, offtakes and spillways); conveyance structures (siphons, aqueducts, superpassages and culverts); protection structures (embankments as well as gabion and retaining walls); and access and ancillary structures (water mills, bridges and access points).

While the process and operation of organisations vary, surface water systems are largely locally managed as autonomous units. Regional variations in terminology exist but system organisation is generally based on a hierarchy of command headed by a *wakil* or *mirab bashi*. A *mirab* or *chak mirab* is usually responsible for main canal sections and the secondary canal. Concerned communities are represented by local or village committees.

Water is generally distributed based on water availability and a complex system of water entitlements but is also a function of water rights and system design, infrastructure and operation. Using proportional and rotational distribution is a part of system adaptation to changes in water availability and provides some equity in allocation for irrigation needs. System maintenance generally takes place in early spring to coincide with low or no-flow when labour is readily available. Under the *hashar* system, communal labour is traditionally supplied in proportion to water entitlements.

Other schemes using surface water for irrigation include small retention dams and water harvesting.

Groundwater systems

In Afghanistan, systems that tap into shallow groundwater include *karez*, springs and wells. There is great potential to develop both shallow and deep groundwater systems for irrigation and other uses, but precaution must be taken to avoid adversely affecting users of existing systems.

Karez

With origins dating back several millennia, *karez* extracts shallow groundwater by means of subsurface tunnels and canals to gravity-feed water to recipient communities and command areas. The tunnel can extend for several kilometres and is often evident from the spoil from access wells (*chah*) for construction and maintenance. An estimated 7,000 *karez* irrigate an area of 170,000 ha in Afghanistan. Average irrigated area per *karez* is 25 ha but ranges from less than 10 ha to more than 200 ha. Most *karez* systems are located within the Helmand river basin.

The components of a typical *karez* include: water collection from an unconfined aquifer through a subsurface canal section; water transport through a subsurface canal for transfer of water to the surface; water distribution by means of a surface network of unlined canals and conveyance structures; and, in some systems, temporary water storage (*hawz*) to improve distribution efficiencies.

Karez is organised and operated by local communities. This is traditionally under a *karezkan* specialist who is responsible for construction and maintenance of subsurface sections; a *mirab* oversees surface distribution operations. Water allocations, similar to surface water systems, are based on water entitlements and rotations. Customary rules apply to the rights and locations of access to water.

While *karez* provides sustained perennial flow and good quality water, its systems may commonly face problems such as vulnerability to collapse of subsurface infrastructure, water losses in canals, flood damage and groundwater depletion.

Springs

Many rural communities depend on the nearly 5,600 spring-fed systems estimated to irrigate approximately 188,000 ha. The relatively low

flow rates of springs mean systems are often supplemented with diverted surface water flows when available. The systems are commonly found in upper and tributary catchments and are concentrated in more mountainous central and southeastern provinces.

Spring-fed systems share many of the surface infrastructure of *karez*, including the use of unlined earth canals and *hawz*. Limited information is available on system organisation and operation. It is assumed, however, that water allocation is similarly based on water entitlement and rotational allocation systems.

Wells

Estimates from the late 1960s indicated that less than 1 percent of total irrigated area is supplied by water from wells. Traditionally, shallow groundwater has been abstracted from bores and shallow hand-dug wells using human labour or animal draft (*arhad*). The capacity of such systems is limited and confines the irrigable area per well to areas of less than 3 ha. In recent years, however, the use of modern well-drilling and pumping technology has been more widespread, considerably increasing the number of wells and their capacity.

Formal systems

Formal systems are large-scale irrigation schemes developed with central government assistance, financing, management, operation and maintenance. With additional support from bilateral and multilateral donors, most of these schemes were developed between the late 1940s and the 1970s.

Over the past 30 years, the schemes had become heavily degraded due to lack of funding and loss of technical and institutional capacity to support operation and maintenance. They are now operating well below capacity and require major rehabilitation and investment. Since 2003, a number of ongoing rehabilitation initiatives have been launched.

Afghanistan has ten formal schemes totalling an area of nearly 333,000 ha. The largest is the Helmand-Arghandab scheme (Helmand Province). The other systems are: Sardeh (Ghazni), Parwan (Parwan and Kabul), Nangarhar (Nangarhar), Sang-i-Mehr (Badakhshan), Kunduz-Khanabad (Kunduz), Shahrawan (Takhar), Gawargan (Baghlan), Kelagay (Baghlan) and Nahr-i-Shahi (Balkh). Several of the schemes have storage dams and capacity to generate hydropower.

Current Initiatives

Three decades of conflict have adversely affected the performance of irrigation systems and the ability of communities to sustain them. Since 2001, several initiatives have been launched to develop the irrigation sector and better manage water resources. The Ministry of Energy and Water, the lead government

institution for revitalising the irrigation system sector, receives support from international and bilateral donors. The major programmes are summarised in the table below.

Numerous other agencies have also contributed to rehabilitating irrigation systems among them: the Ministry of Rehabilitation and Rural Development; the Danish Committee for Aid to Afghan Refugees; German Agro-Action, Urgence Réhabilitation Développement and World Vision.

Future Direction

The long-term development of the irrigation sector should include consideration of the following key issues:

- improving system efficiency and productivity through enhancing infrastructure, increasing

Initiative	Funding Agency	Budget (US\$)	River basin
Emergency Irrigation and Rehabilitation Program	World Bank	\$75 million	all
Emergency Infrastructure Rehabilitation and Reconstruction Project	Asian Development Bank (ADB), Japan Fund for Poverty Reduction (JFPR)	\$15 million	Northern
Balkh Basin Integrated Water Resources Management Project	JFPR	\$10 million	Northern
Kunduz River Basin Project	European Commission (EC)	\$15 million	Amu Darya
Western Basins Project	ADB, Canadian International Development Agency, Abu Dhabi Fund	\$90 million	Hari Rod-Murghab
Amu Darya River Basin Management Programme	EC	\$5 million	Amu Darya

the equity of water allocations, and developing water storage systems;

- enhancing system operation and maintenance by improving the organisation of informal systems, financial self-sufficiency, design of structures to reduce de-silting, protection against water loss, and approaches to maintenance; and
- increasing sustainability of water resources through development of integrated catchment management plans and sustainable environmental management

Recommendations

This study of irrigation typology is the beginning of a systematic irrigation typology in Afghanistan and will hopefully provide the foundation for future surveys, studies and initiatives. The recommendations of this paper are:

System inventory and database To develop a national inventory and database of irrigation systems to support sector planning and implementation of interventions

Water entitlements and management To conduct more research on the relationship between water entitlements and irrigation management, which would complement current emphasis on infrastructure rehabilitation

Social water management To further study the structure and function of local water organisations, including variations between and among systems and regions; this information will provide a foundation to help integrate informal systems into a broader management framework

System monitoring To develop a system for routine monitoring of flow rates that will provide an indicator of system performance and annual variations in water availability

Distribution efficiency To research system performance to help identify ways that would improve distribution and water use efficiencies

Surface water development To identify technically and socially appropriate ways to improve structure type and operation for surface water irrigation systems, including developing intake structures, which is often excluded from existing rehabilitation programmes

Sustainability of interventions To evaluate the maintenance requirements for typical irrigation infrastructure and the capacity of communities to undertake them

Groundwater development policy To promote policies and plans for the protection and sustainable development of groundwater resources

Catchment and water basin studies To conduct research on hydraulic linkages between irrigation systems within surface water catchments and water basins, including identifying water-sharing agreements between communities

1. Introduction

This paper presents the findings of a study on the typology of irrigation systems in Afghanistan. It is intended to contribute to the knowledge of irrigation methods and management as well as to eventually improve performance and productivity. It is also intended to provide organisations and individuals involved in irrigation rehabilitation and natural resources management with a more informed understanding of irrigation systems and their link to livelihood sustainability in Afghanistan.

Irrigated agriculture is the mainstay of food security and income for the majority of the rural population in Afghanistan. It accounts for more than half of the country's GDP¹, 70 percent of total crop production, and provides a reliable and sustainable production base for many rural communities². It is estimated that approximately 42 percent of the 7.7 million hectares (ha) of cultivable land receives some form of irrigation. There is potential to improve productivity in existing irrigated areas as well as to increase the amount of land receiving irrigation where water resources are sufficient.

The rural sector in particular has been severely affected by war and civil unrest during the past 30 years. Since the fall of the Taliban in 2001, the international reconstruction and rehabilitation assistance has focused a great deal on the agricultural sector, aiming to improve rural productivity and livelihood sustainability. While there is considerable ongoing effort to rebuild and strengthen irrigated agriculture, most of this work by necessity has been emergency assistance, largely designed to meet immediate needs. In addition to fulfilling these needs, a better understanding of the physical and social

features of the variety of irrigation systems is also required. This will enable the development of long-term strategies to improve the performance and reliability of these systems, which in turn will enhance rural livelihoods.

The paper presents:

- a national overview, describing the national and regional irrigation context that includes a summary of topography and climate, water resources, and irrigated agriculture;
- a typology of irrigation systems, presenting the classification and description of system types and providing case study examples;
- an outline of current irrigation initiatives and future direction; and
- recommendations for future work related to the irrigation sector.

1.1 Study Scope

The purpose of this paper is to develop an irrigation systems typology for Afghanistan. The study defines and describes the major systems of irrigation water management in the country, including: their geographical distribution in Afghanistan; infrastructure as well as functional and social features; merits and constraints; and potential to improve irrigation water supply and support agricultural development. The study also presents various rehabilitation and development initiatives currently underway.

This paper is largely focused at the national level and water-basin level (i.e. major hydrological boundaries), providing an overview of major system types. It is acknowledged that considerable regional variations may exist

¹ Asian Development Bank, "Afghanistan Natural Resources and Agriculture Sector Comprehensive Needs Assessment," Final Draft Report (Manila, Philippines: ADB, 2002).

² Raj Khanal Puspa, "Irrigation Systems in Afghanistan: Typology and Development Considerations," unpublished draft (Kabul: FAO, 2006).

within system types. Where relevant, these are highlighted, but it is not possible to cover all existing differences. Hopefully providing a platform for future research, this paper should be viewed as a starting point for the development of a more detailed typology of irrigation systems in Afghanistan.

1.2 Methodology and Sources

The methodology for this study is based on the following:

- a 12-day country visit (7 days in Kabul and 5 days in Kunduz and Baghlan provinces) in February and March 2007 involving meetings with individuals and organisations for discussion and collection of information;
- collation of information, reports, data, drawings and photographs from these in-country individuals and organisations as well as other sources, including online publications and published reports on work in Afghanistan, Iran and Oman;
- review of relevant literature, including a wide range of reports and files, in particular, produced by and on behalf of AREU, the Ministry of Energy and Water (MEW), the European Commission (EC), the European Union, the Food and Agriculture Organisation (FAO), the Asian Development Bank (ADB) and the World Bank; and
- subsequent analysis of abovementioned data to support types of irrigation systems, including descriptions of case examples and production of maps and drawings.

One of the challenges in presenting information on agriculture and irrigation in Afghanistan is the reliability and accuracy of national data sets. Before 1980, data collection and reporting appears to have been reasonably systematic, with statistics published in a national yearbook. Unfortunately, a great deal of the information, resources and institutional capacity for accurate

monitoring and reporting on natural resources statistics were lost during the years of conflict. While significant efforts are underway to fill the information void, inaccuracies and many gaps in knowledge remain. This report has drawn on numerous information sources; it should be kept in mind, however, that some assessments of irrigated areas and distribution are no more than the best possible estimate within the constraints of available information.

Numerous organisations assisted with providing information including: ADB, Aga Khan Foundation, Afghanistan Information Management Services (AIMS), AREU, Danish Committee for Aid to Afghan Refugees (DACAAR), FAO, German Agro-Action (GAA), Kunduz River Basin Project (KRBP) and MEW.

2. National Overview

An overview of the context in which irrigation systems are situated allows for better understanding of why Afghanistan's particular range of irrigation system types has developed over several millennia. Rather than give in-depth description, this section is intended to be a summary of the most relevant features of topography and climate, water resources and irrigation development.

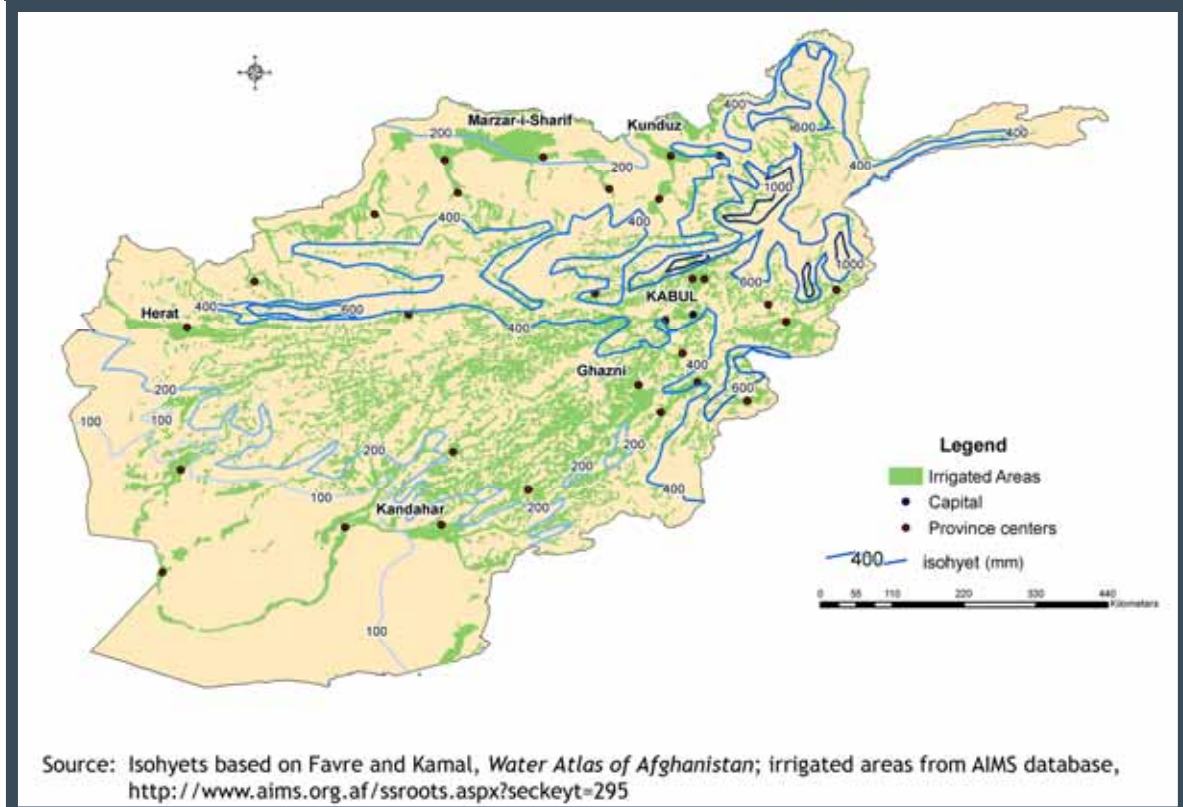
2.1 Topography and climate

The topography and climate of Afghanistan are the principal influences on the development of the type, range and distribution of irrigation systems. High mountain ranges characterise much of the topography; a quarter of the country's land sits at more than 2,500 m above sea level. The Hindu Kush range, the

westernmost extension of the Himalaya-Pamir mountain range, divides the country from west to east while the Suleiman and Karakoram mountains flank the southern border with Pakistan. From these mountains, major river valleys radiate to the north, west and south, creating fertile valleys along which most of the agricultural and irrigation development occurs.

Afghanistan has a predominately dry continental climate. The quantity, timing and distribution of precipitation are key factors in determining water availability for irrigation. Over 80 per cent of precipitation occurs as snow during winter in areas where elevation is greater than 2,500 m above sea level. While annual precipitation exceeds 1,000 mm in the upper mountains of the northwest, it is less than 400 mm over 75 percent of the country and virtually

Figure 1: Precipitation on irrigated lands



all of the cultivable lands. The timing and duration of snowmelt is a key factor in determining the quantity and duration of water availability in streams and rivers for irrigation in lower valleys. Figure 1 shows the distribution of irrigated lands and rainfall isohyets in Afghanistan.

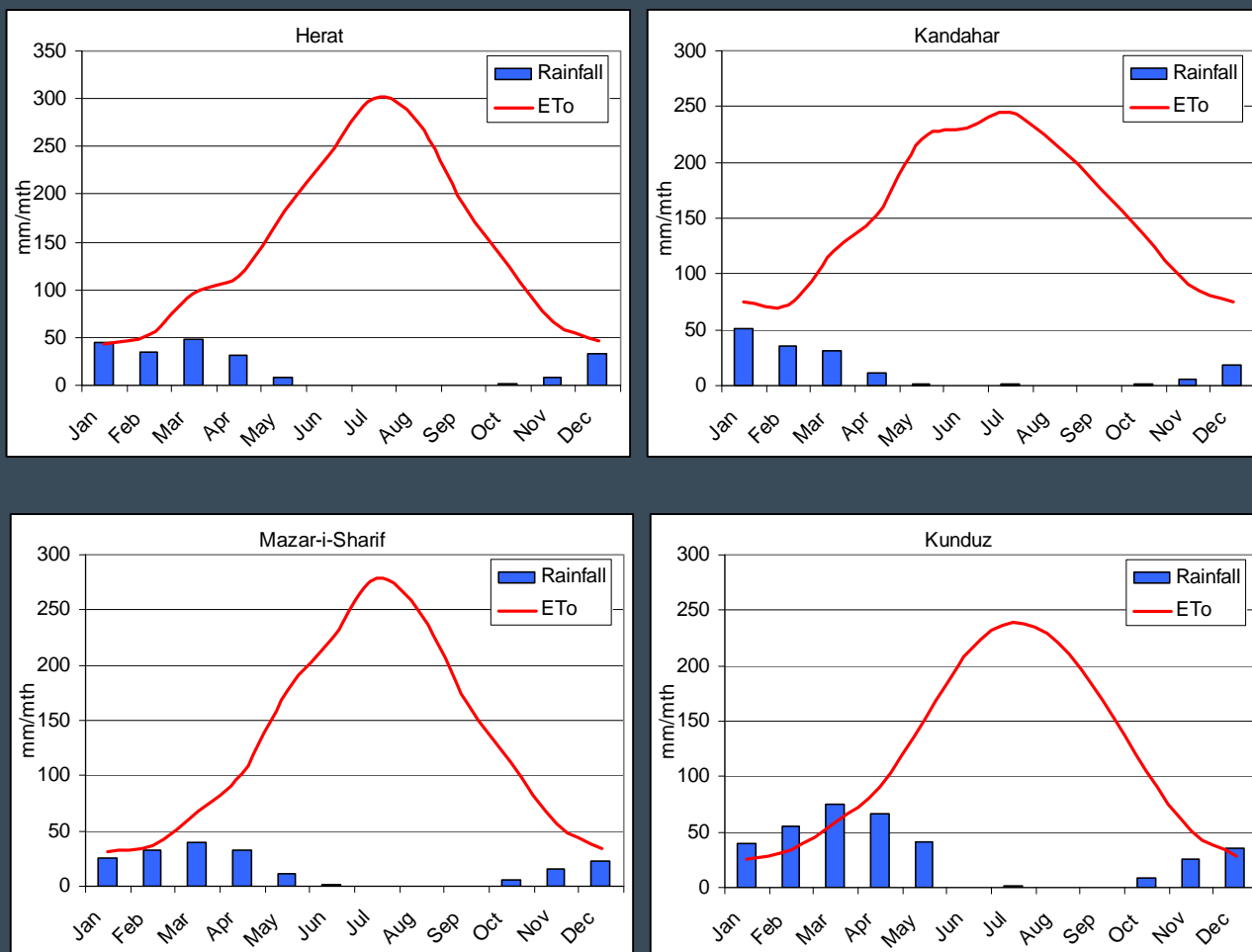
During the main growing period in the late spring and summer (May to September), a gap exists between the amount of rainfall and the demand for water, resulting in a dependence on irrigation to meet the majority of crop water

requirements. This is illustrated in Figure 2, which shows the average monthly rainfall and potential evapotranspiration at four locations with large irrigated areas (Herat, Kandahar, Kunduz and Mazar-i-Sharif). In the summer, irrigation demand peaks at about 250 mm to 300 mm per month while there is little, if any, reliable rainfall.

2.2 Water resources

Along with land allocation, the occurrence and distribution of water resources primarily

Figure 2: Rainfall and potential evapotranspiration (monthly values)



Source: Favre and Kamal, *Watershed Atlas of Afghanistan*

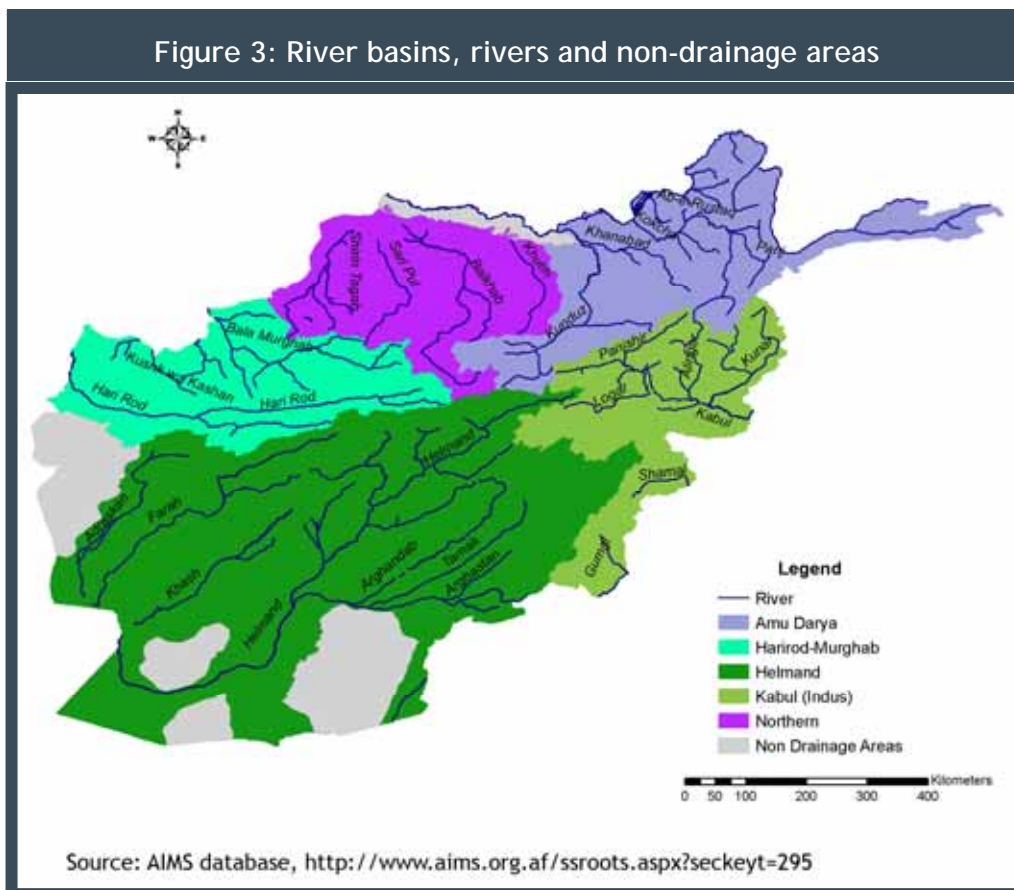
determine the types and locations of irrigation systems in the country. Average annual precipitation is estimated to be approximately 180 billion m³ of which 80 percent originates from snow in the Hindu Kush.³ While some of this water is lost to evaporation, the balance recharges surface and groundwater systems. Estimates of annual water resources vary among sources, which is not surprising given limitations in collecting hydrological datasets. A reasonable estimate, however, is based on FAO⁴ and groundwater studies⁵ that place annual volume at 95 billion m³, which consists of approximately

88 percent (84 billion m³) surface water and 12 percent (11 billion m³) groundwater⁶.

Surface water

Afghanistan has five major river basins – Hari Rod-Murghab, Helmand, Kabul (Indus), Northern and Amu Darya – as well as five non-drainage areas as shown in Figure 3. While the catchments of the other four basins originate entirely within the country, the Amu Darya is part of a larger transboundary catchment, which includes areas within neighbouring Uzbekistan and Tajikistan.

Figure 3: River basins, rivers and non-drainage areas



³ Food and Agriculture Organisation, "Promotion of Agricultural Rehabilitation and Development Programs in Afghanistan: Water Resources and Irrigation" (Islamabad: FAO, 1996).

⁴ FAO, "Promotion of Agricultural Rehabilitation and Development Programs in Afghanistan."

⁵ Vincent W. Uhl, "An Overview of Groundwater Resources and Challenges" (Washington Crossing, PA, USA: Uhl, Baron & Rana Associates, Inc., 2005).

⁶ Estimates of average annual renewable groundwater vary from 7 to 11 billion m³ per year.

Table 1: River basins in Afghanistan

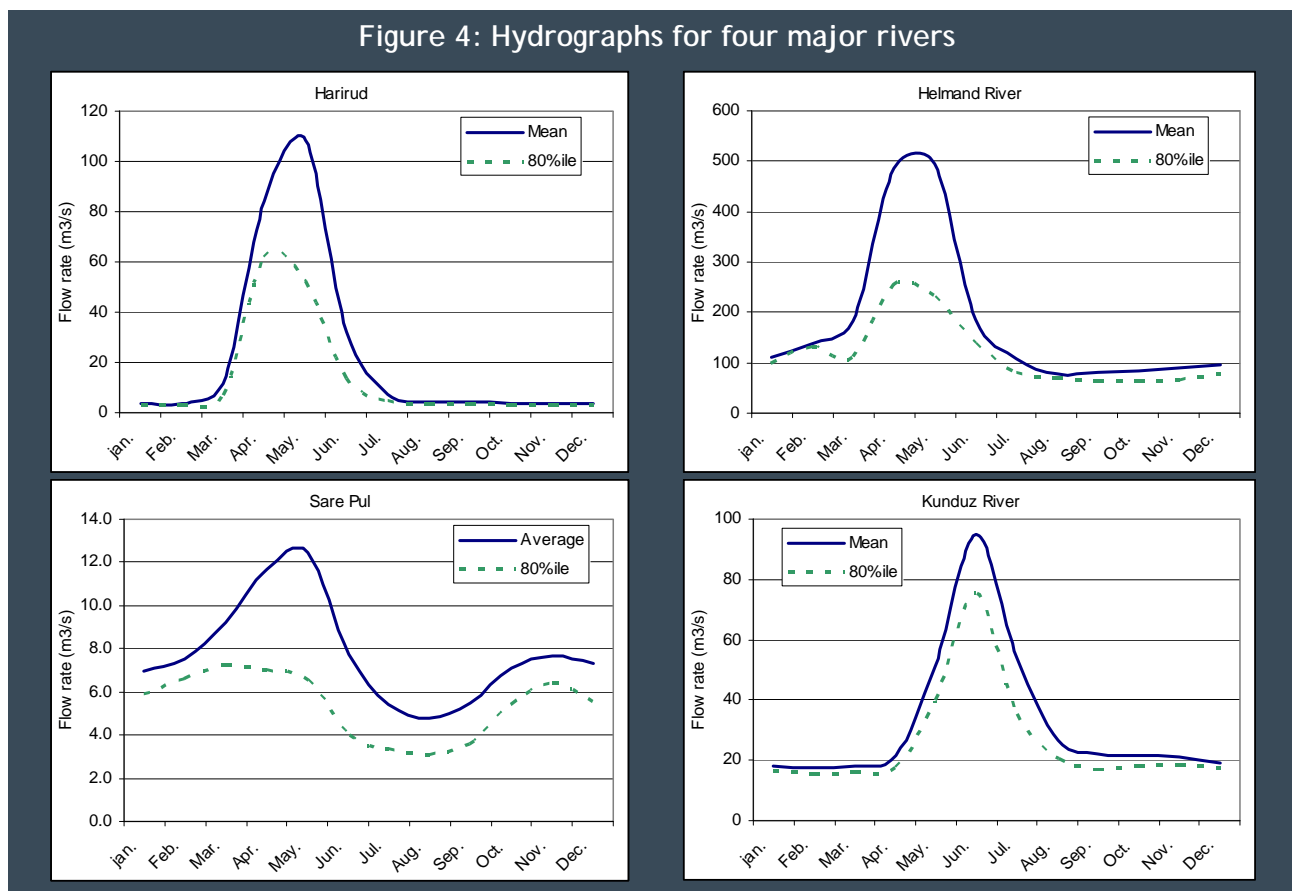
River basin	Area (%)	Water (%)	Rivers
Amu Darya	14	57	Amu Darya, Panj, Wakhan, Kunduz, Kokcha
Hari Rod-Murghab	12	4	Hari Rod, Murghab, Koshk
Helmand	41	11	Helmand, Arghandab, Tarnak, Ghazni, Farah, Khash
Kabul (Indus)	11	26	Kabul, Konar, Panjshir, Ghorband, Alinigar, Logar
Northern	11	2	Balkh, Sar-i-Pul, Khulm
non-drainage area	10		

Source: Favre and Kamal, *Watershed Atlas of Afghanistan*

The five basins are summarised in Table 1. The westward-draining Helmand and Hari Rod-Murghab river basins, while comprising more than half of the area of Afghanistan, account for only 15 percent of mean annual volume. Conversely, the Amu Darya basin makes up only 14 percent of total area but contributes 57 percent of annual volume due to the high catchment elevation and resulting perennial

flow in tributary rivers. Flow regimes for small tributary rivers and streams in many parts of the country are ephemeral – that is, temporarily following periods of rainfall or snowmelt. This offers a relatively narrow window of water availability for surface water diversion. There is, however, sustained subsurface flow that is harvested through a temporary canal or diversion bund, which is locally called *jar*.

Figure 4: Hydrographs for four major rivers



Source: Ministry of Energy and Water, Kabul

Groundwater

The principal aquifer systems in Afghanistan are: quaternary deposits in the major river valleys, particularly in the Kabul River Basin; the river systems in the Helmand River Basin to the east (Ghazni, Tarnak, Arghistan and Arghandab); the Hari Rod and certain river systems within the Northern and Amu Darya Basins; the semi-consolidated Neocene Age deposits in the Kabul River and other river basins; and carbonate rock aquifer systems on the northern flank of the Hindu Kush mountains and along parts of the Helmand River in Uruzgan Province.⁷

Estimations of groundwater average annual recharge and usage within the five river basins are shown in Table 2. The total recharge for confined and unconfined aquifers is roughly 10.6 billion m³ per year while usage is 2.8 billion m³ per year. Historically, usage has largely been limited to water from shallow unconfined aquifers abstracted through *karez* as well as through traditional wells from which water is drawn using animal power (*arhad*). More recently, deeper confined aquifers are being developed for domestic and municipal water supply using modern well-drilling techniques.

As will be discussed later, numerous irrigation systems in Afghanistan depend on shallow groundwater sources. Based on macro water balance estimates, water for irrigation, domestic and industrial use has potential to be further developed. To date, however, there appears to be little detailed research on groundwater resources. There is a need to better understand major groundwater systems as well as to develop policies and strategies aimed at sustaining current use and meeting future demand.

2.3 Irrigated agriculture

The cultivable area of Afghanistan is estimated to be 7.7 million ha, which is roughly 12 per cent of the country's area.⁸ Approximately 42 percent is intensively or intermittently irrigated. Much of this land lies in the fertile alluvium of major river valleys.

Table 2: Groundwater in Afghanistan
(in million m³/year)

River Basin	Recharge	Usage
Kabul	1,920	530
Helmand	2,480	1,500
Hari Rod-Murghab	1,140	460
Northern	2,140	210
Amu Darya	2,970	100
Total	10,650	2,800

Sources: Uhl, "An Overview of Groundwater Resources and Challenges"; FAO, "Promotion of Agricultural Rehabilitation and Development Programs in Afghanistan"

Taken from an FAO satellite survey conducted in the early 1990s, Table 3 lists irrigated land cover by river basin.⁹ It shows total irrigated area as 3.21 million ha of which 48 percent is intensively cultivated and 52 percent is intermittently cultivated with one or more crops each year. It is assumed that the survey covers both informal and formal irrigation systems; not listed, however, is area used for private gardens, vineyards and fruit trees, which totals more than 90,000 ha and likely receives some form of irrigation.

A survey of irrigation systems from the late 1960s usefully indicates the number of systems and water sources and is summarised in Table 4. It shows the existence of nearly 29,000 systems

⁷ Uhl, "An Overview of Groundwater Resources and Challenges."

⁸ *Provincial Landcover Atlas of Islamic State of Afghanistan*, FAO/UNDP project AFG/90/002 (Rome: FAO, 1999).

⁹ The irrigated areas are calculated using the AIMS dataset derived from the FAO land cover survey, which may be accessed from <http://www.aims.org.af>.

Table 3: Landcover survey by water basin

Water basin	Areas (ha)				Total %
	Intensively cultivated (2 crops/ year)	Intensively cultivated (1 crop/year)	Intermittently cultivated	Total	
Amu Darya	106,200	247,800	48,100	402,100	13
Kabul	62,000	244,000	178,100	484,100	15
Helmand	95,000	380,800	900,200	1,376,000	43
Hari Rod-Murghab	34,500	138,000	128,400	300,900	9
Northern	40,000	197,800	387,000	624,800	19
non-drainage area	3,880	10,000	6,700	20,580	1
Total	341,580	1,218,400	1,648,500	3,208,480	100

Source: collated from FAO land cover survey, AIMS website (<http://www.aims.org.af>)

of which 27 percent drew from surface water sources (rivers and streams) and the remainder from groundwater sources (springs, *karez* and wells). While surface water systems made up less than a third of the total number, they covered 86 percent of the irrigated area, confirming the importance of surface water as the main irrigation water source. Conversely, while a large number of systems are supplied from groundwater, they accounted for less than an average irrigated area of less than 20 hectares per system.

Figure 5 shows irrigated area for the five river basins, using the above data combined with

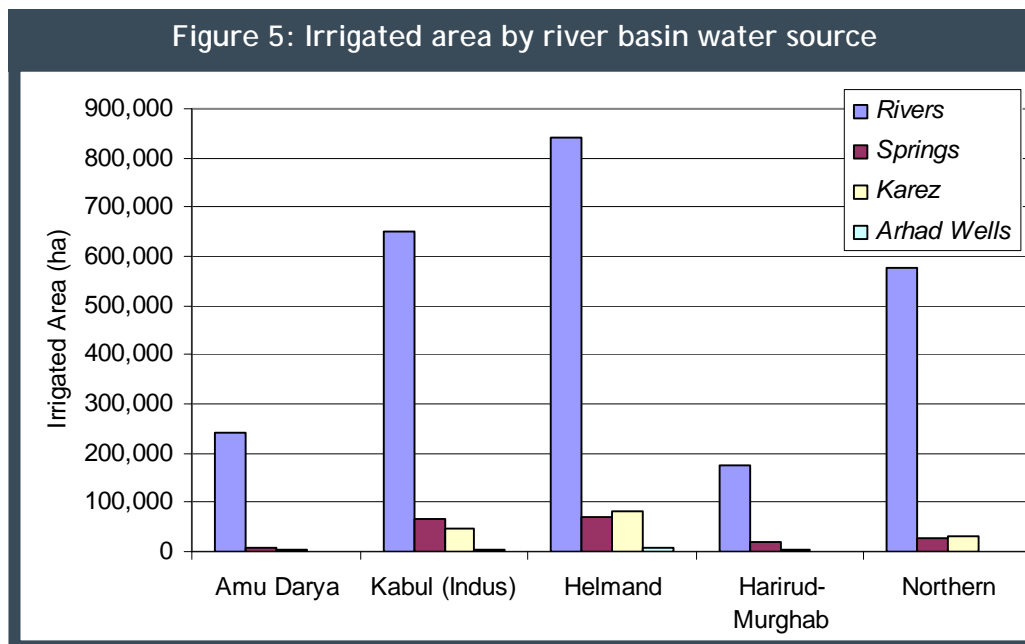
data on formal irrigation systems as well as estimated irrigated areas for four provinces not originally included. Again, it highlights the dominance of both surface water systems and the Helmand, Kabul and Northern river basins as sources for irrigation.

Some obvious differences, however, exist between this figure and the data reported in the FAO survey taken in the 1990s. In the late 1960s, irrigated area by water source was estimated to be 2.38 million ha, but this was based on only 28 of the 32 provinces and evidently does not include formal irrigation systems. The total is closer to 2.9 million ha

Table 4: Irrigation area by water source

System and area	Rivers and streams	Springs	<i>Karez</i>	Wells (<i>arhad</i>)	Total
systems (no. of)	7,822	5,558	6,741	8,595	28,716
systems (%)	27	19	23	30	
area (ha)	2,348,000	187,000	168,000	12,000	2,715,000
area (%)	86	7	6	<1	

Source: Favre and Kamal, *Watershed Atlas of Afghanistan*



Source: Government of Afghanistan, 1980 Statistical Yearbook in Anderson, "Rehabilitation of Informal Irrigation Systems in Afghanistan."

after accounting for approximately 180,000 ha from the missing four provinces (Khost, Nuristan, Paktika and Sar-i-Pul) and for formal systems (330,000 ha). After adjusting for the missing information, the survey provides reasonably good agreement with the FAO survey in terms of the percentage of systems within each water basin and province. This indicates that both surveys were probably reasonably accurate at the time they were conducted. Much of the variation in irrigated area may be due to factors such as neglect or damage due to conflict as well as natural processes including availability and development of water. In some cases, estimates also take into account a reduction in irrigated area during prolonged drought conditions between 2001 and 2004. Estimates on the operational status of irrigation systems and areas requiring rehabilitation also vary.

Average annual water use for irrigation in 1997 was estimated at 20 billion m³ of which 17 billion m³ was from surface water sources and

the remainder from groundwater¹⁰. With rehabilitation of systems and improved management, water use is estimated to increase to 35 billion m³ per year.

Given that the last survey of irrigated area is now more than 15 years old, there is a good case to update previous estimates. Current data is considerably out of date, incomplete and lack specific details on system type, area and management. A systematic inventory of systems would provide a sound basis for the planning of irrigation and water resource management policies and programmes.

¹⁰ Based on a total irrigated area of 3.3 million ha, this is the equivalent annual application depth of 600 mm.

3. Classifying Irrigation System Types

Given the importance of irrigation to the sustainability of rural livelihoods, there is a need for a pragmatic and systematic approach to define system types. This would enable a more effective approach for planning research and interventions related to system rehabilitation and development. The classification proposed below is intended to provide an objective approach to group systems according to common physical and social characteristics and one that may be further refined in the future.

Classification systems generally follow a hierarchical approach, linking system types by a series of criteria: physical, social, functional and financial. The selection of criteria generally relates to the intended use of the classification system. For example, Renault and Godaliyadda proposed a classification for surface water systems focused on improving operational management¹¹.

This paper presents a relatively simple classification system, but one that is a useful starting point for developing more detailed analyses. Well-suited to the intended audience, it provides an introduction to irrigation in Afghanistan and an understanding of the relationship between system types and their physical as well as social features. The adopted approach is similar to one presented in a recent FAO report on system typology¹² but develops a more defined structure based on water source. In particular, it draws on the link between, on the one hand, supply availability and reliability of various water sources and, on the other, such

features as system infrastructure, functionality and organisation.

As presented in the following sections, water source is a key determinant of where and how irrigation systems developed in Afghanistan. There are major differences between surface and groundwater sources in terms of quantity of supply, timing and quality. In turn, these influence: the area to be irrigated; crop types and intensities; infrastructure for water collection and distribution; water allocations; and, the organisation, operation and maintenance of systems.

For practical reasons, the proposed classification adopts some terminology currently used in Afghanistan. This will enable easier understanding of the system types, particularly using “informal” to describe traditional, community-based systems and “formal” to denote central government-supported systems.

This classification of system types is based on the following:

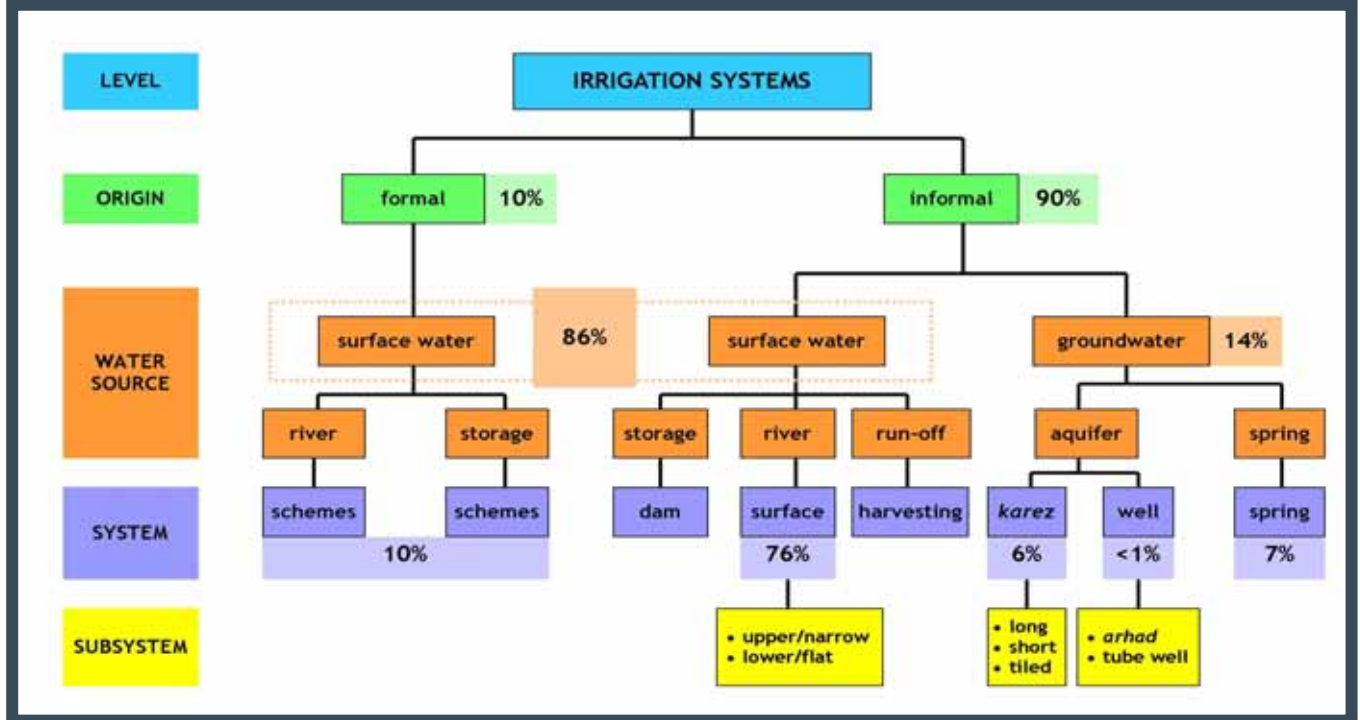
- the origins of development, distinguishing between informal and formal systems;
- water source, which is categorised into surface water and groundwater; and
- system, which is classified by infrastructure related to primary water source¹³ such as large formal government schemes as well as systems involving surface “run-of-river” sources, *karez*, springs, wells, dams and

¹¹ D. Renault and G.G.A. Godaliyadda, “Generic Typology for Irrigation Systems Operation,” Research Report 29 (Colombo, Sri Lanka: International Water Management Institute, 1999).

¹² Puspa, “Irrigation Systems in Afghanistan.”

¹³ While the classification is based on primary water source, it is recognised that, in some systems, cognitive use can result from more than one source; in particular, smaller *karez* and spring-fed systems may divert surface water during peak flow periods.

Figure 6: Classification of irrigation system types in Afghanistan (by area %)



harvest¹⁴; these may be further divided into subsystems or specific schemes.

The hierarchy of classification approximates share of total irrigated area for water sources and system types (Figure 6). It shows the importance of informal systems, which account for 90 percent of irrigated area, as well as the significance of surface water, which supplies 86 percent of irrigated area. Estimates of areas irrigated by small dams or diverted surface water run-off currently do not exist.

The following irrigation systems typology will highlight key features of informal and formal systems and case examples in Afghanistan. The section on informal systems covers distribution, infrastructure, organisation, operation, performance, merits, constraints and issues for

improvement; the one on formal systems is confined to key features, location, irrigated area and organisation. The following detailed sections focus a great deal more on community-based informal systems, which make up the majority of systems in Afghanistan, while formal systems supply less than 10 percent of the country's irrigated area.

¹⁴ Harvest includes all informal methods for diversion and spreading of surface run-off, e.g. flood spreading.

4. Typology of Informal Irrigation Systems

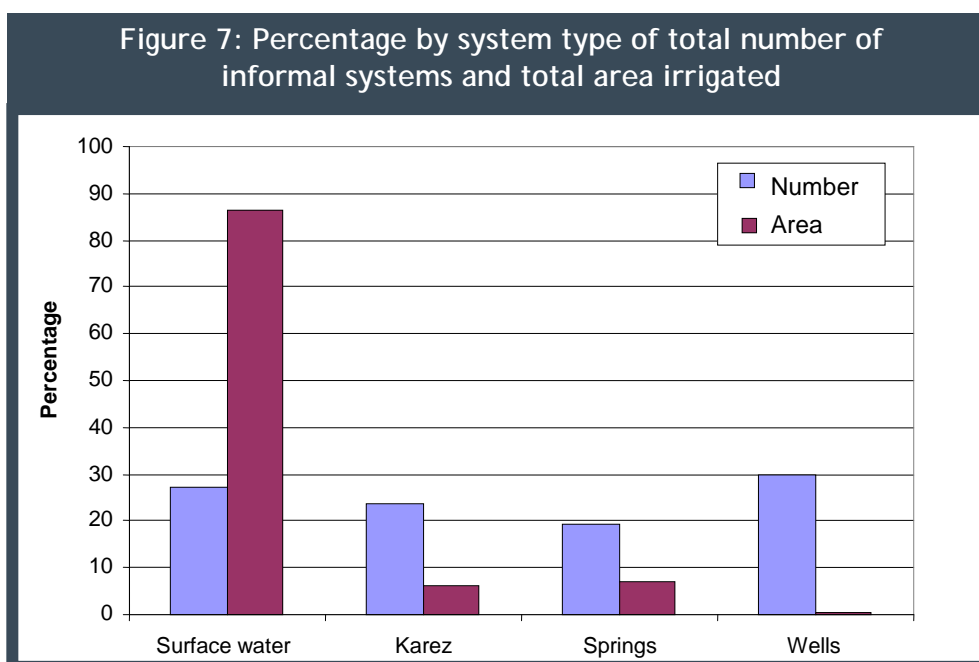
Informal systems are traditionally developed and managed by local communities, largely with local resources and knowledge. In most cases, these systems have existed for generations and have undergone many social and physical changes. They have expanded or, in some cases, contracted due to water availability or challenges arising from the last 30 years of conflict. Informal systems account for 90 percent of irrigated area in Afghanistan and virtually all (99 percent) of the country's irrigation systems by number¹⁵. Nearly 29,000 informal irrigation systems are estimated to be in Afghanistan¹⁶.

Contrary to their name, informal systems are generally well organised and have well-defined procedures for operation and maintenance. Over time, the construction and maintenance of these systems have required considerable

resources, materials, labour and the cooperation of neighbouring communities. The survival of the systems and their recipients largely depends on the ability of communities to operate and maintain systems—usually with limited or no outside assistance.

Within informal systems, irrigation is the main usage of water by volume but they also serve as a source for domestic and livestock water supply, either directly or through local recharge of shallow wells. These multiple uses of water are an important factor in system operation and maintenance. In larger systems, an additional issue is access to and across canals for the movement of people and goods by both foot and vehicle.

Construction methods vary according to local conditions. Traditionally, communities used



Source: Statistical Yearbook 1980 in Favre and Kamal, *Watershed Atlas of Afghanistan*

¹⁵ All estimates of the number of irrigation systems in subsequent sections are based on information presented in R. Favre, R. and G.M. Kamal, *Watershed Atlas of Afghanistan* (Kabul: Ministry of Irrigation, Water Resources and Environment, 2004).

¹⁶ Statistics from Yearbook (1980) in Favre and Kamal, *Watershed Atlas of Afghanistan*.

methods that were within their technical and financial capability. Particularly since the 1970s, however, the central government, international agencies and NGOs have contributed to interventions. Many have been emergency-oriented, focusing on replacing or rebuilding damaged structures. Compared to local approaches, the more recent design and construction approach usually involves more conventional methods and are intended to provide a more secure long-term solution.

Local communities use a variety of construction materials that are available, affordable and manageable, including dry stone, stone masonry, brick and timber. Canals are generally built with unlined earth wherever site and soil conditions are suitable and, when necessary, stone slab or stone masonry. Simple earth structures and bunds are constructed for water diversion from rivers and streams. Communities are very adept at using readily available resources; it is not uncommon to see war junk such as tanks and armoured vehicles in protection and diversion structures in rivers.

Figure 7 shows the percentage distribution of informal systems by area and number. Surface water systems make up less than 30 percent of systems but account for 86 percent of Afghanistan's irrigated area. While *karez* comprise 23 percent of systems, they account for 6 percent of irrigated area. The large number of wells (30 percent of all systems) irrigate a far smaller share (less than 1 percent) of area. It should be noted, however, that these estimates are more than 15 years old and an updated inventory is required.

4.1 Surface water systems

Surface water systems are the most extensive irrigation type in Afghanistan, estimated to account for 86 percent of total irrigated area and less than 30 percent of informal systems. Their prevalence largely results from widespread availability of both water resources from

rivers and streams as well as adjacent land suitable for development. While these systems considerably vary, they share some common infrastructural, organisational and operational features.

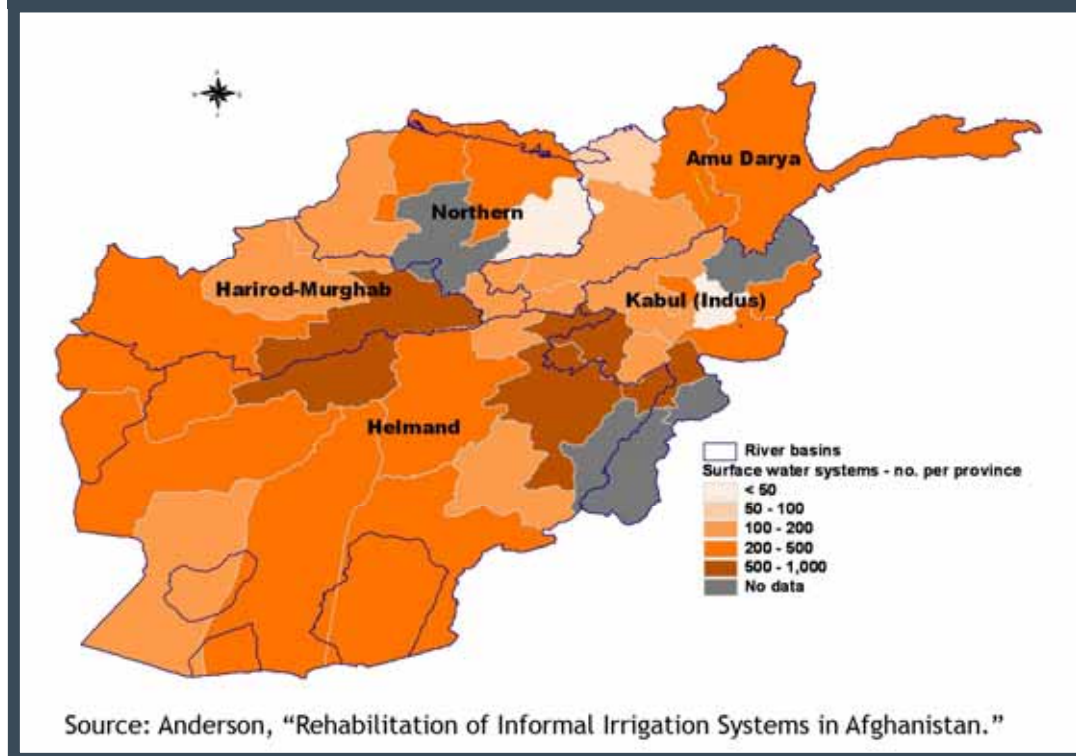
Along with rivers and streams, the water sources for these systems are washes and reuse of drainage water from adjacent upstream systems. The availability, reliability and quality of water source vary; the timing of peak flow and duration of flow are prime factors in determining the supply duration for surface water systems. Surface water resources are largely dependent on spring and early summer snowmelt that result in peak flows in the early to late spring, depending on the river morphology and location within the catchment. Particularly in northern catchments, perennial flow occurs in the larger rivers. In the southern and western catchments as well as small streams and washes, flow is largely confined to the spring and early summer months.

The systems are essentially driven by the timing, rate and duration of the annual water supply. Irrigation communities use a water management strategy that maximises harvesting potential from this variable supply. Water distribution and management is based on a system of water entitlements related to irrigated area. Using a combination of proportional and rotational allocations, the system has flexibility in adjusting irrigated area and cropping intensity to match water supply levels. In years of high water availability, irrigated area is increased while, in dry years, it is reduced.

Distribution

Surface water systems have existed in Afghanistan for hundreds, if not thousands, of years. Their development is ongoing; reports of improvements and new systems have emerged as recently as 80 to 90 years ago. For many rural communities, irrigation development is a prerequisite to community development and

Figure 8: Number of surface water systems per province



often has been affected by conflict and migration. For example, emigration from the newly-formed Soviet bloc in the 1920s influenced the expansion of irrigation systems in Kunduz Province.¹⁷

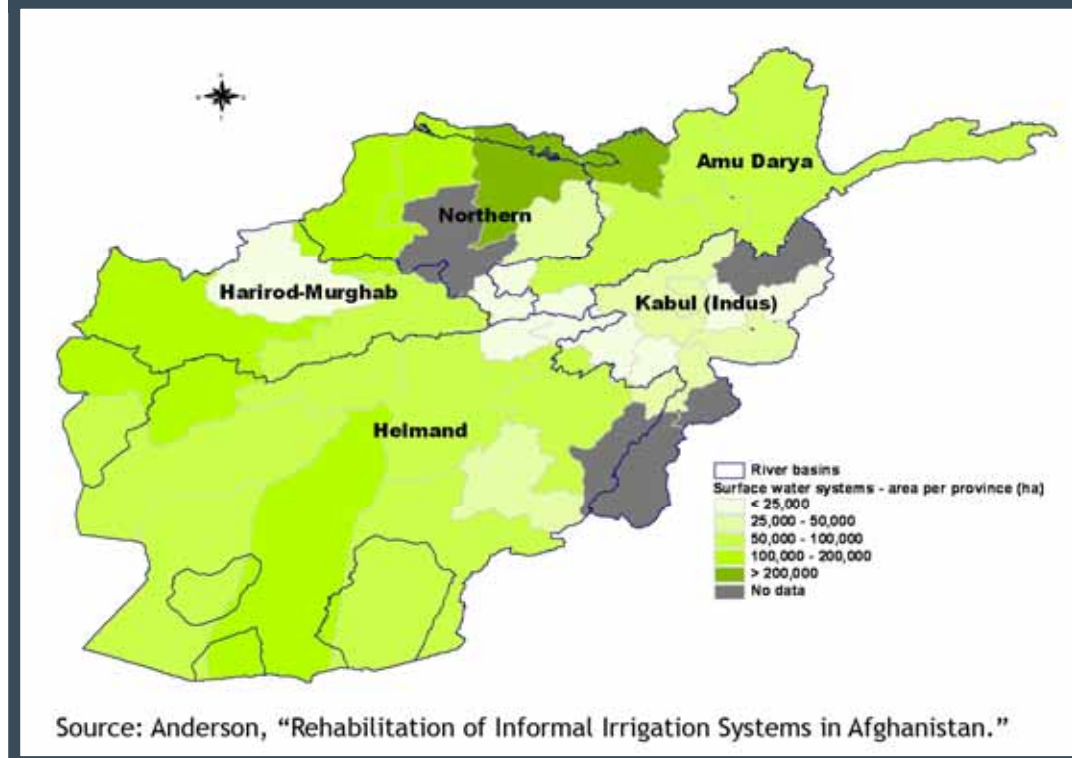
Systems generally develop along river terraces and alluvial plains. In some cases, small stand-alone systems are constructed, particularly in upper catchments where suitable land is limited and because of the confined nature of the river valley. In the lower catchment of larger river systems, however, infrastructure is often adjacent and hydrologically interlinked; drainage water from an upstream system may discharge directly or indirectly to downstream canals. This interdependence is an important consideration when evaluating overall irrigation and water use efficiency.

Based on a survey from the 1960s and 1970s, Figure 8 and Figure 9 show an extensive distribution of surface water systems by number and irrigated area per province. Higher concentrations of systems are located in the central and more mountainous provinces possibly explained by the existence of a large number of small systems. The largest irrigated areas per province (greater than 200,000 ha) are found in the northern provinces of Kunduz and Balkh. Average irrigated area is approximately 260 ha, but systems cover a range from less than 100 ha to more than 10,000 ha. As with data in general on irrigation in Afghanistan, an inventory will have to be taken to more accurately determine the number of systems and irrigated areas.

While this study does not adopt the subdivision, a recent FAO draft typology further classifies

¹⁷ Jonathan Lee, *The Performance of Community Water Management Systems* (Kabul: Afghanistan Research and Evaluation Unit, 2007).

Figure 9: Area irrigated by surface water systems per province



surface water systems into upper and lower catchment¹⁸. The rationale for the additional classification rests on the differences in water supply reliability, irrigated areas and land availability. Upper catchment (also known as narrow valley) systems are located in the narrower, upper catchment tributaries where surface flows are less sustained and irrigable land is constrained by topography. Lower catchment (or wide valley-flat plain) systems are located in lower catchment reaches that feature large extensive irrigable areas and more sustained surface and subsurface flow conditions. While the subsystems may differ in terms of size and water supply, they share many physical and social features; for this reason, the following subsections are applicable to both. At this stage, there is insufficient quantitative

information on surface water subsystems to present them as separate cases in this paper.

Infrastructure

Structures typically found in surface water systems were traditionally the product of local knowledge and experience, built with readily available and affordable construction materials. As part of emergency and rehabilitation efforts, recent interventions have introduced conventional engineering approaches with the aim of improving system performance and reducing maintenance requirements and cost. The descriptions of structures below are grouped according to function and standard engineering classification of canal structures. Where

¹⁸ Puspa, "Irrigation Systems in Afghanistan."

relevant and known, a locally used name is included.

Diversion structure

Water flow is diverted from the river or stream by a *sarband*, which is typically constructed from a combination of local materials such as timber, gravel and sand bags. The length and dimensions of a *sarband* are generally a function of river morphology, system flow requirements, available materials, and labour requirements for construction and maintenance.

The operation and maintenance of the *sarband* is critical to overall system performance and reliability, but it is, for most systems, the most difficult structure to maintain due to its vulnerability to flood damage. This damage can lead to drop-off in intake flows and premature decline in water availability. Repairs are difficult to undertake in high flow conditions and are often delayed until flow recession.

More than one intake is often constructed depending on river hydrology and flow characteristics. These may include a “spring” intake to divert high spring flows and a “summer” intake to supplement flows following the spring peak. The summer intake intercepts and diverts base flow from the shallow gravels to prolong water supply into the late summer months, albeit at lower supply levels.

Main canal

The main (or primary) canal conveys water from the intake structure to and through the command area. Depending on location and river gradient, the main canal may extend for several kilometres in order to command the irrigable area. With a few exceptions, main canals are hand-dug and made of unlined earth. The initial sections from the intake frequently run alongside the river or stream due to access and slope constraints. These sections are vulnerable to flooding.

Water flow into the main canal is traditionally unregulated. Depending on water source, canals have generally high capacities for accommodating large peak flows and providing a storage buffer to allow for variations between day and night irrigation demand. The canal serves as the water conveyor that supplies offtakes and secondary canals.

Secondary and tertiary canals

From the main canal to the farm turnout, water flows through an extensive network of secondary and tertiary unlined earth canals. Typically, the secondary canal is the responsibility of a village or group of villages and the offtake rate based on established water entitlement. It is not uncommon to see a number of secondary canals closely aligned in parallel, supplying separate villages.

Control structures

Most larger systems have a range of control structures for regulation and distribution of water from the main canal to secondary canals and offtakes. These include:

- cross regulators, which are weirs of various types and construction that regulate canal water levels, usually in conjunction with bifurcators and offtakes;
- bifurcators or *sehdarak*, which divide flow to secondary canals and offtakes according to a proportional distribution that serves water entitlement and system operation;
- offtakes, which are outlet structures from primary and secondary canals and the dimensions of which, in some cases, are proportional to the flow allocation; and
- spillways, which discharge excess water from the canal and protect the system and community from flooding—sometimes as formal structures and sometimes as breachable sections of the main canal adjacent to washes and drains.

Conveyance structures

For crossing of washes and cross drainage, most systems commonly have conveyance structures, including:

- inverted siphons of various capacities for crossing major drainage features such as washes, canals and drains;
- aqueducts, which are commonly used to cross washes and drainage features;
- super-passages, a more recently developed structure for passage of cross drainage from washes; and
- culverts for canal cross drainage.

Protection structures

A range of structures are used to protect systems from flood damage, including:

- embankments, which are for protecting canals and intakes and are constructed from not only stone and earth but also readily available materials such as war junk;
- gabion walls, a more recent adoption that is relatively easy to construct using local materials and labour; and
- retaining walls, which are large diversion structures built with stone masonry or reinforced concrete.

Water mills

Most medium and large systems have a number of water mills, which are usually privately owned and assigned water at night or times of low demand.

Bridges

Both foot and vehicle access across canals take place via a variety of bridges. Construction methods vary widely depending on canal width and available materials. In their simplest form, bridges are timber and earth structures.

Public access

Domestic and livestock water users can gain access to the canal at villages.

On-farm irrigation methods

These methods include basin and border irrigation for cereal crops (wheat, barley and rice) and furrow for vegetable and vine crops.

Organisation

The organisational structure of surface water systems varies depending on the history of the system, water availability and irrigated area. The size of an organisation generally relates to the size of the system; larger systems, for example, have larger organisations. Usually corresponding to system structure, management is split between the main canal, secondary canals and subsequent subunits. There are also regional differences in terminology used to describe various levels of management.

Table 5 presents a summary of organisational hierarchy for surface water systems. The overall organisational structure generally reflects the features of system infrastructure and water distribution. Primary structures (intake and main canal) and secondary canals (allocations to command areas) are managed separately.

Overall system management is led by a senior representative called *wakil* (Herat) or *mirab bashi* (Kunduz and Balkh). This individual is usually a well-respected community member and landowner with system experience and knowledge as well as influence on local government. In addition to system management, he also has the broader responsibility of liaising with adjacent irrigation communities, particularly over customary rights on the location and operation of the *sarband*.

In some locations, the *wakil* or *mirab bashi* may be supported by a main canal committee while in others by a *mirab* or *chak bashi*, but in both cases the supporting role represents the different upper, middle and lower sections of a

Table 5: Surface water system organisational hierarchy

	Level	Title	Responsibilities
MAIN SYSTEM	system	<i>wakil</i> (Herat) <i>mirab bashi</i> (Kunduz and Balkh)	<ul style="list-style-type: none"> • overall management • conflict resolution • scheduling annual maintenance • coordinating <i>hashar</i> and cash contributions • collection of annual contributions • coordinating emergency response • external coordination (e.g. with Governor, government and NGOs)
	intake (<i>sarband</i>)	<i>badwan</i> (Herat)	<ul style="list-style-type: none"> • intake construction and maintenance
	main canal	<i>mirab</i> (Herat) <i>chak bashi</i> canal committee (Kunduz and Balkh)	<ul style="list-style-type: none"> • managing system operation • supervising annual maintenance • supervising construction works • collection of annual contributions
SECONDARY SYSTEMS	secondary canals	<i>mirab</i> (Herat) <i>chak bashi</i> (Kunduz and Balkh) village committee	<ul style="list-style-type: none"> • management of branch water allocations and rotations • coordinating annual maintenance • conflict resolution
	tertiary canals	canal committee or village elder	<ul style="list-style-type: none"> • management of water allocations • provision of <i>hashar</i> labour for maintenance

system. In larger systems, a *badwan* is responsible for operation and maintenance of the *sarband* due to its importance and high maintenance requirements.

Through a *mirab* (Herat) or *chak bashi* (Kunduz and Balkh) or a village committee, the recipient community is usually responsible for the management of operation and maintenance of all canals and structures downstream of the secondary canals to farm turnouts. The *mirab* or *chak mirab* is typically a well-respected landless sharecropper who has working knowledge of system operation and maintenance. This official is usually elected by water right holders (landowners) or their sharecropping representatives.

Surface water systems are largely managed as autonomous units. While there are variations in structure, they essentially follow similar principles regarding election of representatives, payment for services, and contributions to maintenance and capital works. These organisations follow many of the concepts behind water user associations: stakeholder participation, community-based representation, financial independence and hydraulic integrity. Government involvement is generally minimal and largely confined to provision of emergency rehabilitation, dispute resolution and, in some instances, holding the register of water rights (Herat).

Payment for the services of system representatives is traditionally set as a unit weight of crop (e.g. wheat). The amount of payment received by an official depends on his level. Rates also vary between systems. In the Joy Naw system in Herat, the payment for a *mirab* is reported to be about 64 kg (locally, 16 *man*) of wheat per annum¹⁹. It is also reported that some landowners opt to pay the cash equivalent.

Operation

Water is generally distributed according to its availability and established rights and entitlements, but the adopted method is a function of these factors as well as system design, infrastructure and system operation. Water distribution methods include proportional, rotational, needs-based and a combination of all three methods.²⁰ Local and regional variations exist.

The management approach adapts to changes in availability and provides some form of equity in allocations to meet irrigation needs. During periods of high water availability, proportional distribution is extended down the distribution network according to entitlements, thus optimising the water harvesting potential of the system. During periods of low flow, rotational allocations are progressively moved up the distribution network.

Water entitlement is measured in flow units that irrigate a specified area; the terminology and values for these measures vary for different regions. Water allocations, based on cumulative entitlements, are distributed from the main canal to the secondary canals by use of a flow divider (bifurcator or *sehdarak*). Measures and terms for water entitlements vary between regions (*juftgaw* in Herat; *pau* or *qulba* in northern regions). A *juftgaw* is a flow unit

sufficient to irrigate an area of land approximated by number of *jerib*, which range from 40 to 120 *jerib* depending on differing water availability between the upper and lower system sections. The term is derived from the area worked by a yoke of paired ploughing oxen.

In northern regions, a system of allocation is similarly based on *pau* or *qulba*. A *juftgaw* is approximated by a specific number of *jerib*, a unit equivalent to roughly one-fifth of a hectare. Sections within systems range from 40 to 120 *jerib* (16,000 ha to 48,000 ha).

Nawbat, the rotational allocation system, is based on water entitlements, expressed as allocation in hours (*saat*) per return interval (measured in days or *roz*). Rotational allocation is practised on the secondary and tertiary canals and, during periods of low flow, on the main canal. The return interval, which varies widely among systems, can be as short as four or five days but during water shortages may be more than 20 days.

In some locations like Herat, water entitlements are supported by ancient law recorded in a *qawala* or title deed.²¹ From the main canal to offtakes and secondary canals, the allocation of entitlements may also be recorded by the system *wakil* or *mirab bashi* as well as by the Department of Irrigation, Water Resources and Environment (DOI).

There are well-established local rules on water allocated from the rivers and streams that serve as primary sources. Agreements between adjacent irrigation communities govern the location of the *sarband*. There may also be local agreements on sharing river and stream flows during periods of low flow, which could deter-

¹⁹ Jonathan Lee, "Mirab and Water User Association Report: Western Basins Project" (Kabul: ADB, 2005).

²⁰ Snowy Mountain Engineering Corporation, "Survey Report on Institutional Issues, Operation and Maintenance of Traditional Canal Systems in Lower Balkh Area: Balkh River Integrated Water Resources Management Project" (Kabul: ADB and Ministry of Energy and Water, 2006).

mine whether water is rotationally allocated between communities or released for a specified period.

While this summarises the general approach to water management and entitlement, the current literature evidently shows that the allocation and distribution of entitlements within systems is often complex. In some systems, entitlements vary between upper and lower sections of the main canal as a potential mechanism to compensate for inequities in water distribution.²² Disputes may also arise over allocations between communities within systems. There is clearly a need to better understand the structure and operation of water entitlements and allocation management as well as their impact on system water use efficiency and productivity.

System maintenance is a major activity that requires considerable organisation and mobilisation of resources. For many systems, peak flow presents a challenge to protect the system, irrigated land and village infrastructure from flooding. Flood flows are usually heavily laden with silt from surface run-off. While enhancing soil fertility, this is a major problem for canal maintenance, making de-silting a principal activity and cost.

Aside from de-silting, routine maintenance includes constructing one or more *sarband* and rehabilitating structures such as offtakes and *darak* (a water share determined as a flow rate passing through a *sehdarak* for a specified time). While there are regional variations, maintenance is generally timed for early spring during the months of Hamal and Hut (February to April) to coincide with the period of low or no flow when farm labour is readily available.²³

As with other informal systems, operation and maintenance of surface water systems are labour intensive. Labour is traditionally supplied for these activities under a system locally referred to as *hashar*. Landowners and sharecroppers provide labour in proportion to water entitlements or, when they are unable to contribute labour, the cash equivalent at a daily rate. The availability of local labour is a key element for sustainability, but it may be, at times, a constraint for landowners when maintenance conflicts with necessary on-farm and off-farm activities.

Illustration 1: Annual maintenance on Joy Naw main canal, Herat (Bob Rout photograph)



Main canal maintenance is organised by the *wakil* or *mirab bashi*; according to their water entitlements, landowners and sharecroppers contribute *hashar* or cash in kind. The number of labour units and duration of contribution is determined by a system related to either water entitlement or *nawbat*. Depending on the size of the system, maintenance works may be scheduled for each of the upper, middle and lower

²¹ Lee, *The Performance of Community Water Management Systems*.

²² Lee, "Mirab and Water User Association Report."

²³ Bob Rout, "Attachment 9" in *Western Basins Project: PPTA Report*, (Kabul: ADB and Ministry of Irrigation, Water Resources and Environment, 2005).

sections and the main intake structure, to be carried out by labour from recipient communities. Recipient landowners and communities are responsible for maintaining the secondary to tertiary canals, using contributions of labour and cash in kind for de-silting and reconstruction.

Performance

To date, there appears to have been little research conducted on the performance of irrigation systems in Afghanistan. While relatively low efficiency levels have been cited in the literature used for this study, it is often unclear how these values were determined or to which efficiency element they are referring. While analysis is often based on distribution efficiency of the canals, this can be too simplistic an interpretation of both system performance and overall efficiency of water use within the wider hydrology of the catchment.

The three measures relevant to system performance are:

- distribution efficiency, which calculates how efficiently water is distributed from source to farm turnout and measures the performance of canals, conveyance and control structures in transporting water;
- field application efficiency, which is the efficiency of on-farm distribution and application of water to meet crop water requirements and is a function of water entitlement, irrigation schedule and on-farm water distribution; and
- water use efficiency, which measures crop production per gross unit of water intake (typically kilograms per cubic metre).

Current estimates of distribution efficiency for surface water systems are 25 to 40 percent²⁴ based on typical canal and system parameters. Efficiency likely varies with intake flow rates; due to a lower proportion of losses, relatively high efficiencies gained during high flow decrease as flow rates decline²⁵.

Little is currently known about application or water use efficiency in Afghanistan. Given that both distribution efficiency and production per unit area are low, however, water use efficiency is also likely to be low. This area requires further investigation to determine the impact of water allocation and scheduling on crop productivity and to determine variability between upper and lower sections.

Merits, constraints and improvements

The principal merits of surface water systems in Afghanistan are:

- the simplicity of structures and use of local materials and labour;
- organisational independence as well as local representation and community participation in both organisation and maintenance; and
- the adaptability of system operations to variable supply levels using proportional allocation of water to maximise water distribution and storage as well as equity of water distribution.

The constraints of these systems are:

- the limited durability of structures and the lack of control of peak flows;
- the limitations of organisation, financing, technical support and inadequate transparency in election processes;

²⁴ I.M. Anderson, *Irrigation Systems* (Kabul: Afghanistan Research and Evaluation Unit, 2006).

²⁵ Rout, "Attachment 9."

- high maintenance requirements for intake and de-silting as well as the lack of flexibility in water allocation when facing changing land uses; and
- high canal losses and low efficiency at time of low flows.

There is potential for improvement in:

- controls, including regulation of intakes for protection and optimisation of water distribution, control gates, weirs, and check and drops;
- building better structures for flood protection;
- reducing maintenance costs of de-silting structures;
- canal cleaning performance while also reducing cost;
- the performance of canal alignment;
- canal design to enhance distribution efficiency and sediment transport to reduce sedimentation and scouring;
- intake design and structure through the use of intake galleries;
- organisation by upgrading skills for sustainable financial management; and
- water allocation by reviewing current practices.

Case example: Joy Naw, Herat Province

The Joy Naw, or “new canal,” is typical of lower catchment surface irrigation systems in many locations. Located on the right bank of the river Hari Rod in the Hari Rod-Murghab basin of western Afghanistan, it is the first in a series of intensive irrigation systems stretching over a 20 km reach of the river. The Joy Naw was probably built during the reign of the Timurid ruler of Herat, Sultan Husain Baiqara (1469-1506 AD).²⁶ The canal and command areas are upstream and border the more ancient Injil canal that flows through the city of Herat.

The Joy Naw system commands approximately 7,600 ha of which 5,100 ha are cultivated and the rest falls within military camps and urban areas. There are 20 villages within the command area inhabited by about 7,000 rural households of which 3,000 are landless.²⁷ Land ownership is heavily skewed; approximately 15 percent of medium wealth households²⁸ farm 40 percent of the area in small farms of roughly 2 ha. Another 40 percent of the cultivated area is held in small holdings of less than 1 ha by poor and very poor households. Landlords rent out the remaining 20 percent for sharecropping to poor, very poor and landless households.

Irrigated area varies between seasons depending on rainfall and water availability from the Hari Rod but is usually between 3,000 and 4,000 ha. Winter and spring wheat are dominant crops, covering at least 70 percent of the irrigated area and reflecting the food needs of poor households and the availability in the early spring. The remainder of the irrigated area consists of a combination of fodder crops (10

²⁶ Lee, “Mirab and Water User Association Report.”

²⁷ Snowy Mountain Engineering Corporation, “Western Basins Project Final Technical Assistance Report” (Manila, Philippines: Asian Development Bank, 2005).

²⁸ Wealth group classification is according to Andrew Pinney, “National Risk and Vulnerability Assessment 2003: A Stakeholder-Generated Methodology” (Kabul: AREU, 2004).

percent), orchards and vineyards (10 percent), vegetables, cotton and maize.

Water sources

The Hari Rod is the primary water source for the Joy Naw though there is also use of shallow groundwater to supplement domestic and livestock water requirements. Figure 10 shows the flow rate for the Hari Rod upstream of the Joy Naw intake and the peak intake rate for the system. The spring flow peak starts in late February and runs through to late June in a good year. Considerable variation can exist between "wet" and "dry" years, illustrated by the differences between the 1968-69 and 1970-71. Major challenges for the irrigation community are peak flow rates that may lead to flooding as well as possible water shortages resulting from short flow duration.

Following the recession of peak flow in June, the canal intake is switched from diversion of

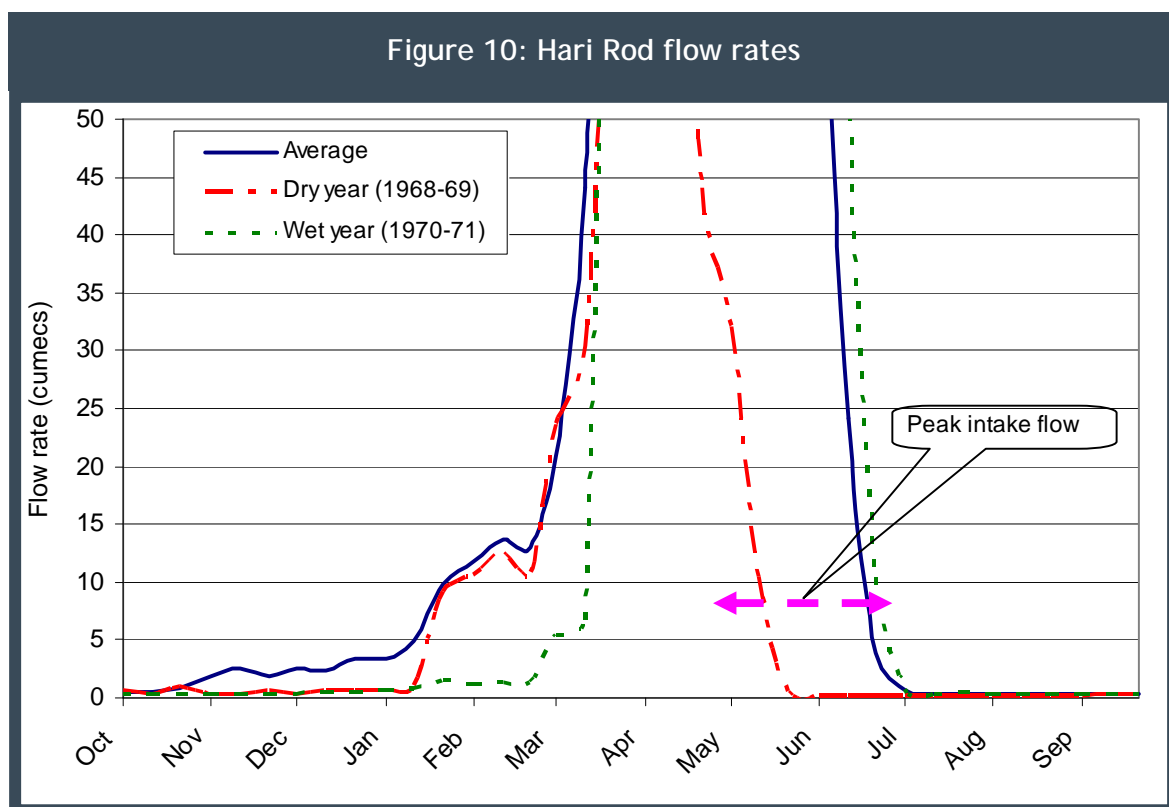
surface water flows to the diversion of spring-time flows from the shallow gravels. The ability to access water into the summer months, even if only by lower flows, is critical to supporting higher value second crops.

Infrastructure

The layout of the system, comprising numerous structures for intake and distribution as well as for associated community needs, is shown in Figure 11.

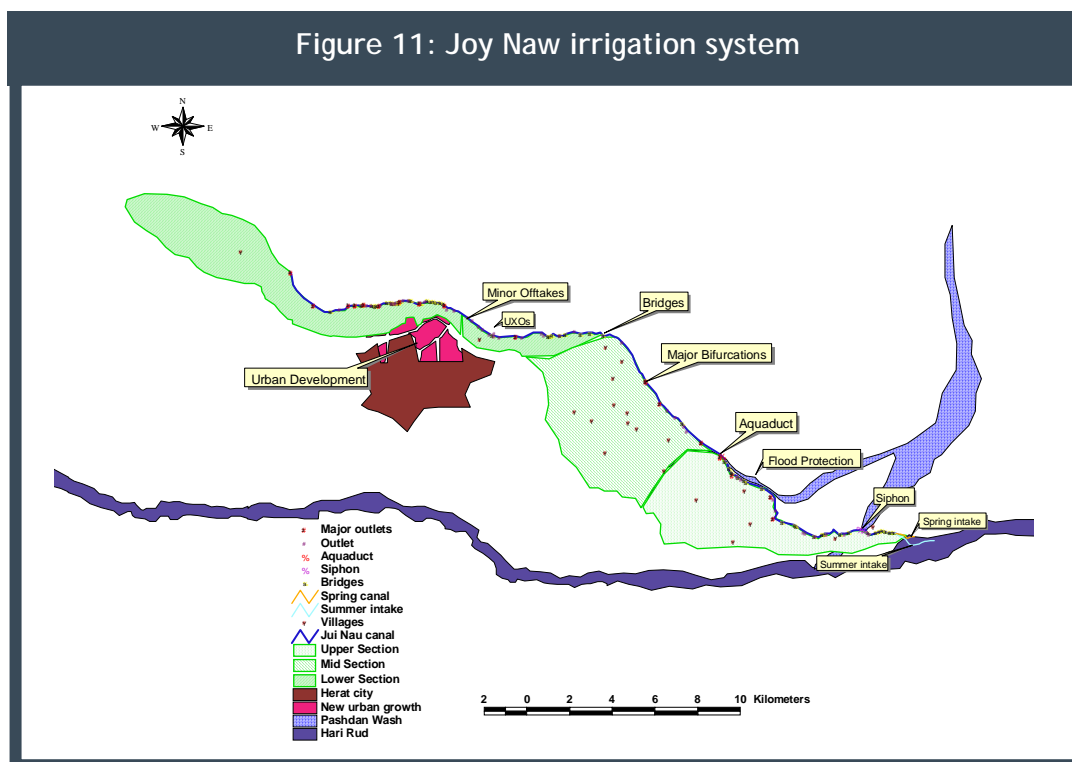
The system infrastructure includes (all photographs this section by Bob Rout):

- two sarband intakes, a springtime intake for diversion of high flows and a summer intake for diversion of base flows after the recession of river peak flows (Illustration 2);
- the main canal, which distributes water to a series of 17 secondary canals and offtakes; it



Source: Ministry of Energy and Water, Kabul

Figure 11: Joy Naw irrigation system



Source: Rout, "Attachment 9."

is constructed of earth (in-situ excavation) up to 10 m wide and 1.5 m to 2 m in depth with an average gradient of 1 m per kilometre and a maximum capacity at the intake of 8 cumec (Illustration 3 and Illustration 4);

- 17 *sehdarak* bifurcators with 45 offtakes accounting for 70 percent of flow (Illustration 5);
- 56 main canal offtake supplying minor canals and adjacent farms (Illustration 6);
- one formal spillway and several other locations designated for breaches in case of emergency (Illustration 7);
- one inverted siphon, 200 m long, crossing the left branch of the Pashtun Wash (Illustration 8);
- one aqueduct, 45 m long, crossing the right branch of the Pashtun Wash (Illustration 9);
- 84 foot and road bridges crossing the main canal as well as numerous smaller bridges crossing minor canals (Illustration 10); and
- flood protection structures built on the right branch of the Pashtun Wash to shield canal structures and farm land (Illustration 11).



Illustration 2: Sarband spring intake



Illustration 3: Main canal after de-silting



Illustration 4: Secondary canal



Illustration 5: Bifurcator



Illustration 6: Offtake



Illustration 7: Breach in main canal (April 2005)



Illustration 8: Siphon intake



Illustration 9: Aqueduct



Illustration 10: Foot bridge



Illustration 11: Protection structure

Organisation

The local community organisation for the Joy Naw system's operation and maintenance consists of:

- a *wakil* who is responsible for overall system management and liaising with the District Governor and the DOI; the position is filled by selection and acceptance of a suitable candidate;
- a *mirab* for each of the upper, middle and lower sections; and

- a *badwan* responsible for construction and maintenance of spring and summer diversion structures and canals.

Operation

The general operating principle is to harvest as much water for as long as possible during the irrigation season. A key element of system operation is the mix of allocation methods and the flexibility of the system to adjust to changes in water availability according to water intake levels. Proportional allocation is practised from the main canal to secondary canals and on major secondary canals. Rotational allocation according to water entitlements is practised on

the secondary and tertiary canals to maintain minimum flow rates.

During periods of high water availability and high intake rates, proportional distribution may be extended down the distribution chain so that water is distributed more widely and canals operate within flow capacity. As water availability declines, rotational allocation is extended up the secondary canal network. In periods of very low flow, this may be extended into the main canal, particularly to supply water to the lower section.

Water entitlements are based on the *juftgaw*, that is, a proportional allocation per unit area. The entitlements for the system are an estimated total of between 280 and 300 *juftgaw*. The distribution is split between the upper, middle and lower sections, as shown in Table 6. The unit area per *juftgaw*, however, increases down the main canal from 80 to 120 *jerib*. This increase effectively provides a higher unit allocation for the lower section, which may be a mechanism to compensate for distribution losses.

Table 6:
Water distribution by command section

Section	<i>jerib</i>	<i>juftgaw</i> per section	Total (%)	Irrigable Area (ha)
upper	80	86	28	1,978
middle	100	70	23	1,951
lower	120	146	49	1,404
Total	302			5,133

Figure 12 shows the distribution of water from the main canal over the three main sections at two flow rates, 4 cumec and 8 cumec. It shows that, based on offtake flow rates, 40 percent of the flow is distributed to the upper section, 30 percent to the middle, and 30 percent to the lower.

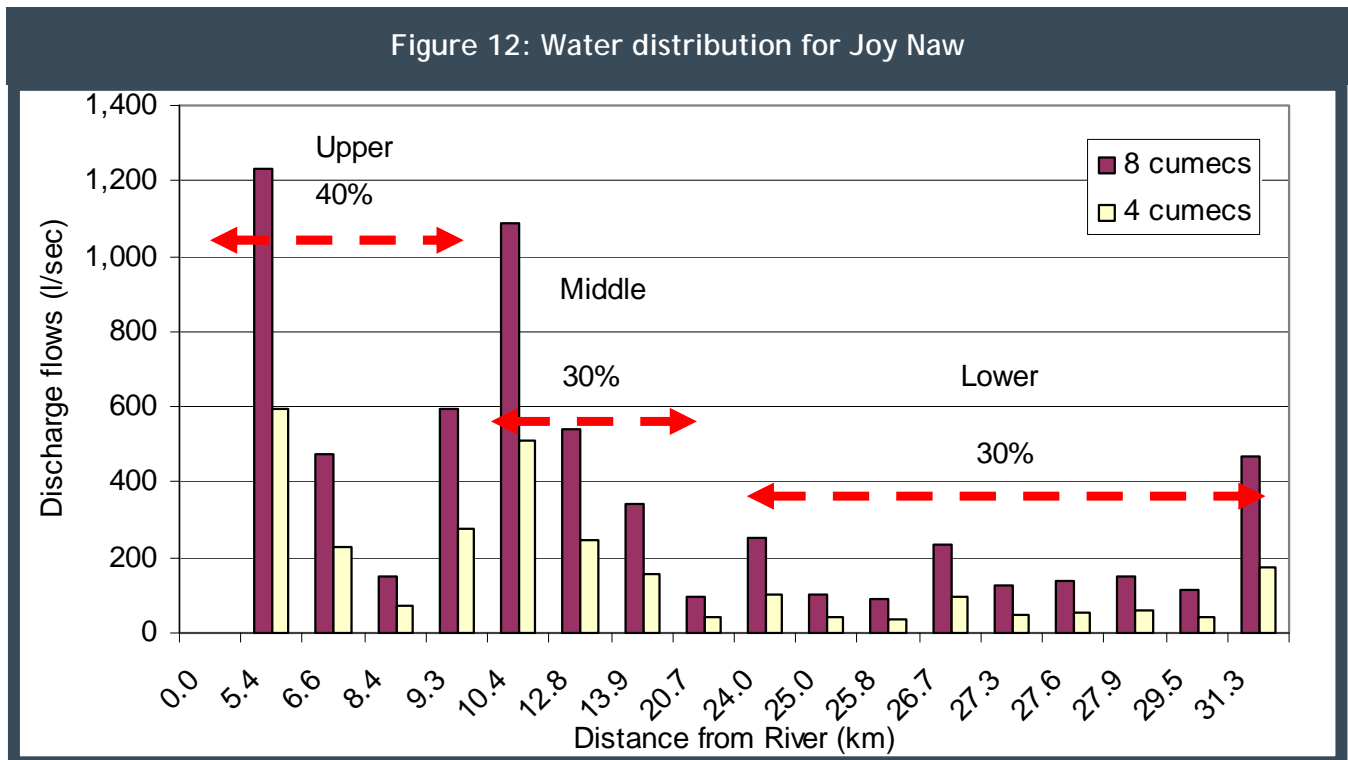
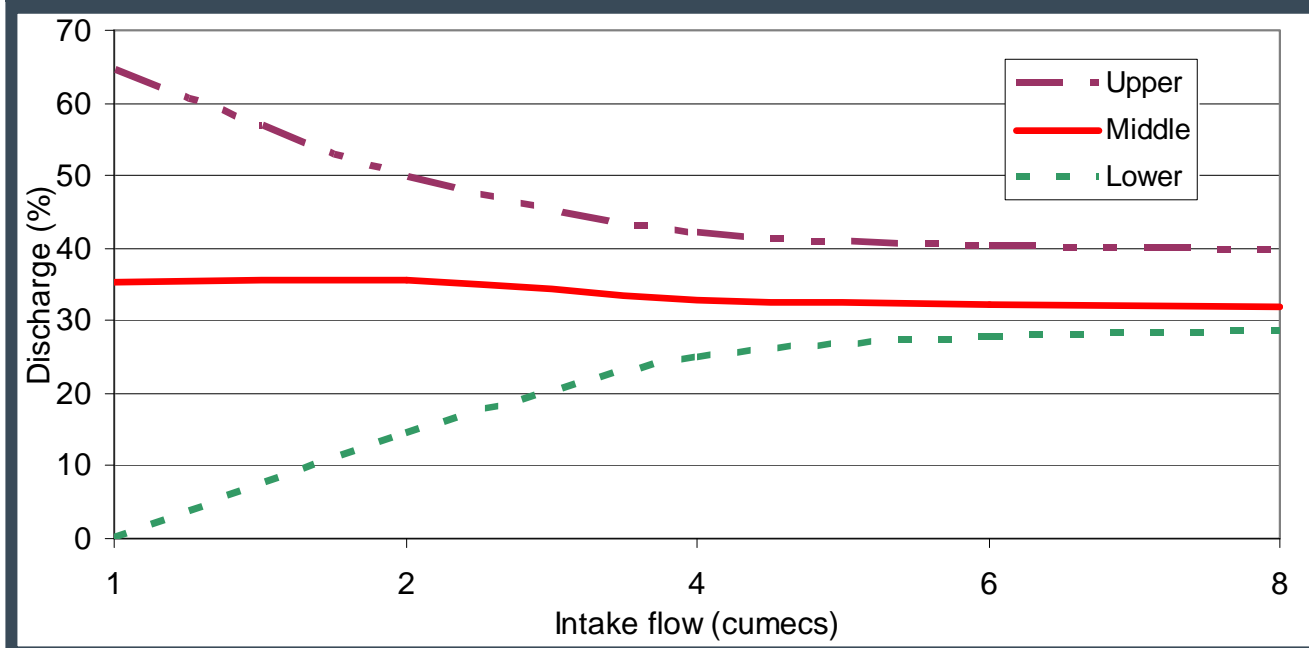


Figure 13: Joy Naw discharge distribution



Performance

In an unregulated irrigation system such as Joy Naw, the distribution of water from the main canal is a key determinant of overall system performance. Figure 13 shows the effects of changing intake flow rates on the distribution from the main canal to the upper, middle and lower command sections.²⁹ It shows that distribution between sections remains relatively constant at an intake of between 4 cumec and 8 cumec, however, when intake levels flow below 4 cumec, distribution is heavily skewed towards the upper reach and little, if any, water reaches the lower section.

Merits, constraints and improvements

The system's merits are:

- strong local participation with well-established community organisation;

- a relatively high intake capacity (up to 10 cumec), which enables harvesting of water during the short supply season;
- a well-defined system of water entitlements and allocation from the main canal; and
- a main canal system, with fixed flow dividers and offtake structures, that is simple to operate within the limits of infrastructure.

The Joy Naw canal system is constrained by:

- difficulties operating under high flow conditions, including no regulation of intakes and the potential for main canal overtopping and breaching;
- inequity of water distribution during periods of low flow as water users in the lower

²⁹ The figure is derived from modelled water distribution based on actual offtake locations, cross section areas and water levels. It correlates reasonably well with observed and reported seasonal trends in water distribution that shift due to changes in intake flow rates.

sections suffer disproportionately from water shortages;

- the vulnerability of the system canal and structures to flooding from the adjacent Pashtun Washes (Illustration 12);
- limited capability to harvest shallow ground-water during the latter half of the irrigation season; and
- high labour requirements for de-silting and maintenance of intake structures.



Illustration 12: Flood erosion
(Bob Rout photograph)

Proposed improvements to the system were identified as part of the Western Basins Project, a MEW initiative supported by ADB and the Canadian International Development Agency (CIDA). These include:

- rehabilitating structures for sustained canal performance;
- increasing water availability and the reliability of the system;

- improving distribution efficiency, particularly in the lower section at low water intake flows;
- reducing current operating and maintenance costs for de-silting; and
- protecting the canal infrastructure and other property from flooding.³⁰

Under the project, proposed works include: on-river works; intake galleries to increase water supply; flood protection of intake canals and adjacent farmland; control gates for regulation of intake flow rates and canal closure; the construction of an urban canal section; and the rehabilitation of main canal structures, bifurcation structures, minor offtakes as well as branch canals and structures.

Case example: Sufi-Qarayateem, Kunduz Province

Sufi-Qarayateem is in the northwestern province of Kunduz within the Amu Darya water basin. Because of its perennial water supply, it differs from many systems in other areas of the country. Information on the canal presented below is largely based on Social Water Management Reports³¹ and an AREU publication on community water management.³²

The irrigation system is located in Chardara District, diverting water from the Kunduz River, which is a major tributary of the Amu Darya. Due to river bank erosion, two separate systems, Sufi and Qarayateem, were joined to share an intake. The Sufi canal was reportedly constructed in the early 20th century by Pashtun tribesmen returning from Bukhara at the time of the 1916-1924 Bashmachi revolt.³³ The Qarayateem canal was constructed later during the 1933-1973 reign of Zahir Shah.

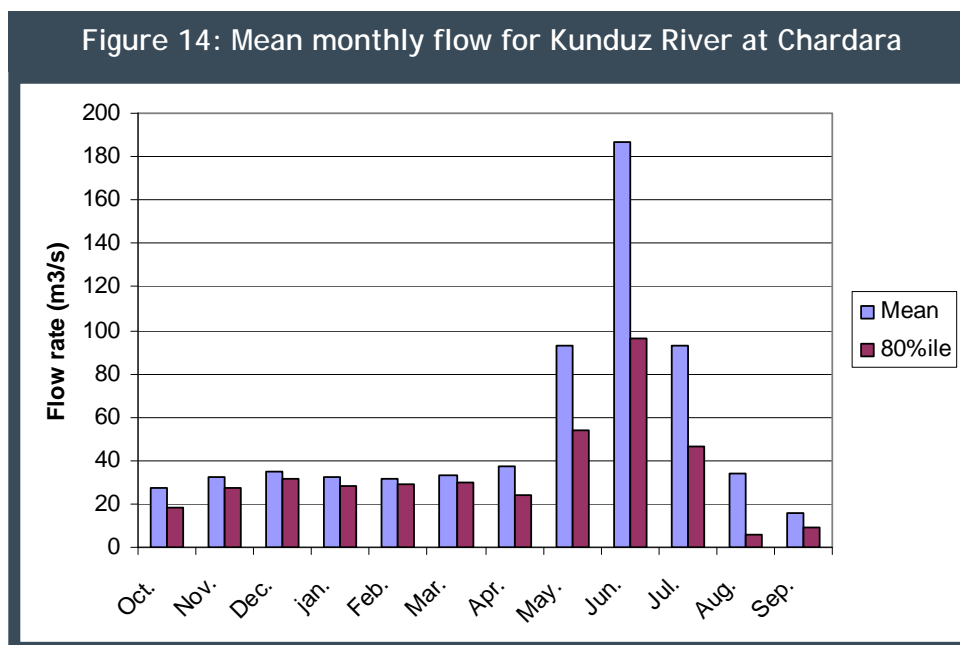
³⁰ Rout, "Attachment 9."

³¹ Bernie ter Steege, "Infrastructure and Water Distribution in the Asqalan and Sufi-Qarayateem Canal Irrigation Systems in the Kunduz River Basin," Field Report, Mar-June 2006 (Bonn, Germany: University of Bonn, 2006);

³² Lee, Performance of Community Water Management Systems.

³³ ter Steege, "Infrastructure and Water Distribution."

Figure 14: Mean monthly flow for Kunduz River at Chardara



Source: Kunduz River Basin Project

The system has a command area of approximately 3,000 ha, which is made up of the command areas of Sufi (1,000 ha) and Qarayateem (2,000 ha). The system involves a total of 15 villages (nine within Sufi and six within Qarayateem).

Water source

The Kunduz River is the system's primary water source. The monthly flow rate for the river at Chardara is shown in Figure 14. It illustrates a flow peak in June that is sustained into the late summer. The canal intake rate reaches a maximum of 7.5 cumec but, on average, is closer to 3 cumec.

Infrastructure

The range of structures in the system includes:

- a single intake sarband for flows from Kunduz River;
- a *sehdarak* bifurcator on the main canal to split flow between the Sufi and Qarayateem canals;

- the 8 km long Qarayateem canal, which supplies six secondary canals (Sorkhak, Wakil Sardar, Nary, Madrassa, Basama/Haji Juma Khan and Kulaba);
- an aqueduct crossing the main canal to supply the Chardara canal;
- a side spillway for the main canal;
- check structures at secondary canal offtake, which enable rotations; and
- two water mills at Chokani (Sujani) during the irrigation season, which is used only at night except during the winter when also used in daytime.

Organisation

Although within one system, the Sufi and Qarayateem canals each has its own *mirab bashi* due to their origins as separate canals. The *mirab bashi* is selected annually based on criteria such as knowledge of the system, availability and land ownership. This individual is traditionally elected in the months of Hut or

Hamal (February-April) before the start of the irrigation season. In each of Qarayateem's six and Sufi's three branch canals is a *chak bashi* managing water distribution and routine maintenance activities.

Shared between the *mirab bashi* and *chak bashi*, payment is based on water entitlement using the *qulba* flow unit and takes the form of rice or wheat measured in *ser* (a measure of weight varying regionally, e.g. 7 kg in Kabul but differs elsewhere). The rate varies for different canal branches from 10 to 30 *ser*; likewise, the proportion going to the officials varies for different branches. Funds are also collected to develop major works, for example, a levy of 270 Afs (US\$5.50) per *jerib* was raised in 2006 for the rehabilitation of the *sarband*.

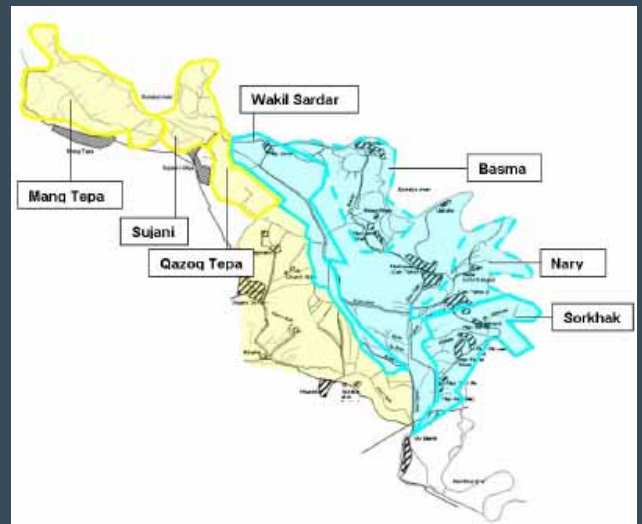
Operation

Water allocation is based on a flow unit called the *qulba*³⁴, which like the *juftgaw*, is proportional to an irrigable area. A *qulba* equates to 40 *jerib* (8 ha) which, at nominal water demand of 2 L/s/ha, is equivalent to approximately 15-20 L/s. Like Joy Naw, however, the area per *qulba* varies within the system between upstream and downstream takes, which may be due to changes in land ownership or a mechanism for differentiating between upstream and downstream distribution efficiency.

The system is operated with proportional water distribution between the canals on the flow ratio of 3:2 in favour of Qarayateem. This diversion reflects the approximate ratio of both the command areas and the water allocations between the two canals.

Downstream of the main canal operation is based on a combination of proportional and rational distribution according to water availability. During periods of high water availability,

Figure 15: The Sufi-Qarayateem system



proportional distribution is extended down the system while rotational distribution is practised in the tertiary canals. Conversely, during periods of low water availability to maintain minimum flow levels, rotational distribution is extended up the system and the rotational interval is lengthened. The interval is reported to be ten days typically but may be extended up to 20 days during shortages.

The schedule of water rotations is decided in the month of Jawza (22 May-21 June) based on knowledge of winter snowfall in the upper catchment and probable river flows. In Qarayateem, canal water rotations start in Saratan (22 June-22 July) and run through to Mizan (23 September-22 October). The duration per *qulba* varies according to water availability, which may range from four to eight hours.

Maintenance activities include routine canal cleaning and de-silting, which is carried out in Hut (20 February-21 March) and can take up to 60 days. Labour is provided based on irrigated area with one labour unit per day for 30 *jerib* (6 ha), one person every two days for 20 *jerib* (4

³⁴ ter Steege, "Infrastructure and Water Distribution."

ha) or one person every three days for 10 *jerib* (2 ha).

Performance

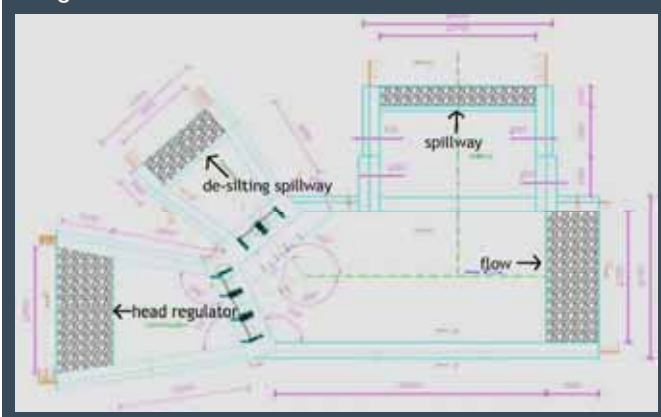
No specific information regarding performance was available to the author at the time of publication.

Merits, constraints and improvements

Specific information regarding the merits and constraints of this system was not available to the author at the time of publication.

Under the Kunduz River Basin Project (KRBP), some improvements have been proposed such as rehabilitating canal infrastructure to better control and distribute water as well as to reduce de-silting requirements and costs. The plan, shown in Figure 16, includes improvements such as: a head regulator with an intake and three head control gates; a double-gated de-silting channel and spillway for protection of the main canal; cross regulators for improved distribution and control to secondary canals; turnouts to improve operation of tertiary canals; a farm turnout operation; and a rehabilitated aqueduct crossing the main canal for access to a neighbouring canal.

Figure 16: Plan view of intake rehabilitation



Source: Landell Mills

4.2 Dams

Currently, there is little documentation of systems supplied by the large number of small traditional retention dams in Afghanistan. These vary in design, size and construction. Necessity and a lack of alternative sources and suitable sites primarily drive local communities to construct some form of water storage. Often, the principal aim of this system type is meeting domestic and livestock requirements, limiting water supply for irrigation. To improve community water supply and security, some NGOs have in recent years actively promoted small dam construction such as this project supported by World Vision in Golran District, Herat Province (Illustration 13).



Illustration 13: Dam under construction

Apart from dams constructed as part of formal irrigation and hydropower systems, one of the nationally better known, larger dams is Band-i-Sultan in Ghazni Province. The dam in place today was built in 1901, replacing a structure reputedly constructed more than 1,000 years ago during the reign of Sultan Mohammed Ghaznawi. Currently undergoing rehabilitation as part of the World Bank's Emergency Irrigation Rehabilitation Programme (EIRP), the dam

supplies an irrigated area of 6,250 *jerib* (1,250 ha).

4.3 Water harvesting

Harvesting is the diversion of surface water run-off to rain-fed cultivation areas. These systems, while extensive, are generally not grouped with irrigation systems. It is beyond the scope of this paper to investigate water harvesting in detail, but it is worthwhile to note its importance in improving food production and livelihood sustainability for many communities reliant on rain-fed agriculture.

Water harvesting of surface water run-off is widely practiced in many areas of Afghanistan. Typically, simple earth diversion bunds are constructed during cultivation to channel any surface run-off to irrigation borders. While the water contribution may be small compared to organised irrigation, it nevertheless may be significant enough to raise crop yields.

4.4 Groundwater systems

In Afghanistan, the groundwater system classification includes *karez*, spring-fed and well system types used for irrigation. Systems tapping into shallow groundwater (depths of less than 30 m) have historically been developed. More recently, development of deep groundwater systems is growing though mostly for drinking water rather than for irrigation.

A significant increase in groundwater use could potentially improve irrigation productivity. This may include using groundwater to supplement existing water supplies, particularly in the latter half of the irrigation season. In many surface water systems, the pumping of shallow groundwater is essentially the reuse of irrigation percolation losses, improving overall systems efficiency. Another improvement could come with the use of wells to supply new irrigated lands in lower catchment areas that are downstream of existing surface water systems.

There are, however, several issues that should first be addressed before more extensive groundwater systems may be developed.

- Any development should be undertaken with caution in areas where users of existing shallow groundwater systems (including *karez*, spring-fed systems and domestic supply wells) may be affected.
- Current knowledge of aquifers (e.g. their extent and yield) is limited, thus increasing risks for projects.
- The costs of development, operation and maintenance of wells and pumps are beyond the financial and technical capability of most small rural communities.
- In some areas, it may be strategic and necessary to protect resources for both current and future domestic and municipal use on the grounds of public health and other priorities.

There is a need for further research on the numbers, types and locations of traditional small dams in Afghanistan. Dam development holds considerable potential to improve water supply and security for small rural communities.

4.5 *Karez*

The *karez* is a traditional horizontal tunnel excavated into alluvium to extract shallow groundwater. Its origins are largely attributed to the expansion of the Persian Empire since similar systems are found in Iran (*qanat*), Oman (*falaj*) and North Africa (*foggaras*). These systems follow similar principles of extracting shallow groundwater through subsurface tunnels and canals, gravity-feeding water to the command area and recipient communities. Subsurface canals can extend for several kilometres and are often evident from the spoil from access wells (*chah*) for construction and maintenance.

Karez are typically located in areas of high alluvium deposits and colluvial deposits from washes. Their water supply comes from the abstraction of shallow, unconfined aquifers. The quantity and reliability of the supply is affected by local hydrogeology and the sustainability of groundwater levels during periods of low rainfall and recharge.

Karez may be classified into three types based on water source and location.³⁵ As shown in Figure 17, these are long, short and tiled.

Long karez: This long subsurface canal (up to 20 km) is excavated into high-yielding gravels and conglomerates in the lower catchment. Its flow rate is perennial and reliable, with long lag times between rainfall and flow effects.

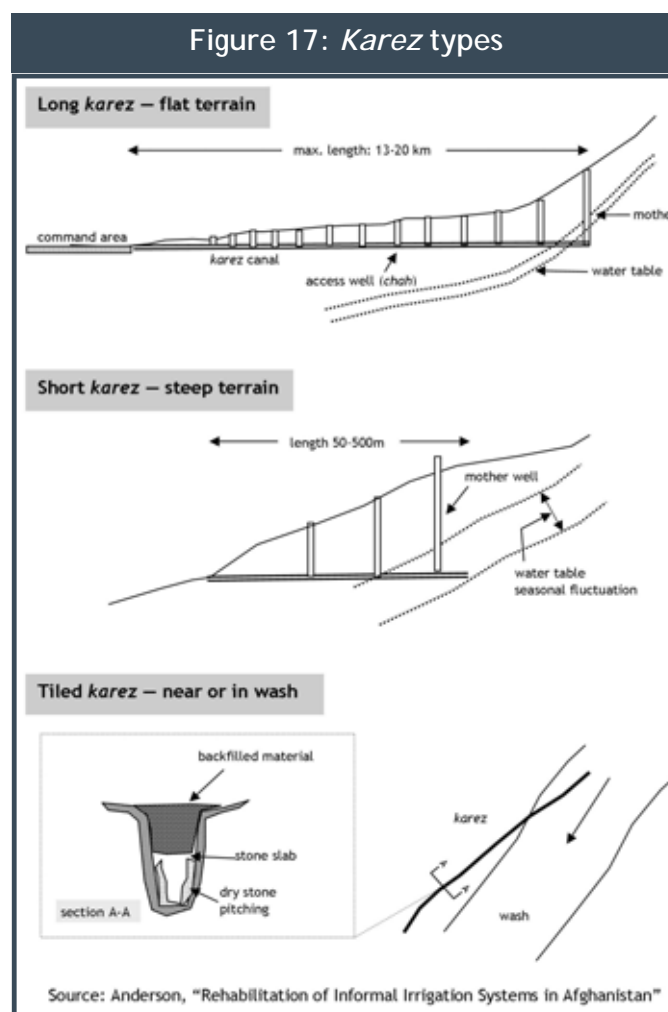
Short karez: This type is generally located at higher elevations and excavated into more stony, lower-yielding material. Subsurface canals are short but often more vulnerable to collapse. Compared to a long *karez*, flow rates are variable. A short *karez* also responds more rapidly to rainfall and snowmelt.

Tiled karez: Known locally as *jar* or *chow*, this *karez* is built adjacent or into washes to abstract subsurface-based flow. It is constructed by excavation of canals and protected with dry stone walls and slabs; it can be difficult and costly to maintain due to frequent flood damage.

Distribution

Based on estimates from the 1960s, there are roughly 7,000 *karez* systems irrigating approximately 170,000 ha in Afghanistan.³⁶ While few, if any, schematic surveys of *karez* have been conducted since, this is probably a reasonable current estimate given that any significant new

Figure 17: *Karez* types



constructions were unlikely to have been undertaken. Irrigated area per *karez* is, on average, approximately 125 *jerib* (25 ha), but it ranges from less than 50 *jerib* (10 ha) to more than 1,000 *jerib* (200 ha).

Karez-irrigated area and number of systems per province is shown in Figure 18 and Figure 19. The key point to note is the concentration of *karez* in the provinces within the Helmand river basin, which accounts for more than half of all *karez* and more than 70 percent of total *karez*-irrigated area. Most likely, this concentration is

³⁵ I.M. Anderson, "Rehabilitation of Informal Irrigation Systems in Afghanistan," design manual (Rome: Food and Agriculture Organisation, 1993).

³⁶ Government of Afghanistan 1980 Statistical Yearbook in Anderson, "Rehabilitation of Informal Irrigation Systems in Afghanistan."

largely due to suitable development conditions, such as extensive alluvial fans as well as limited potential for surface water systems.

Infrastructure

The *karez*, as illustrated in Figure 20, comprises three or four main components—for water collection, transport, distribution and storage.

Water collection: In general, a section of subsurface canal intercepts the unconfined aquifer. To improve water supply, there may be more than one section for water collection, including branches off the main canal. A mother well or *sarchah* is the access well located most upstream.

Figure 18: Number of *karez* per province

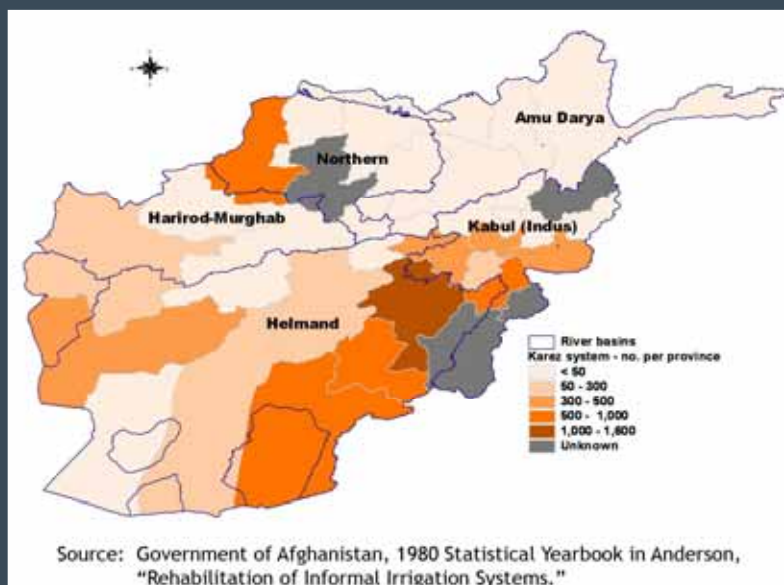


Figure 19: Area irrigated by *karez* per province

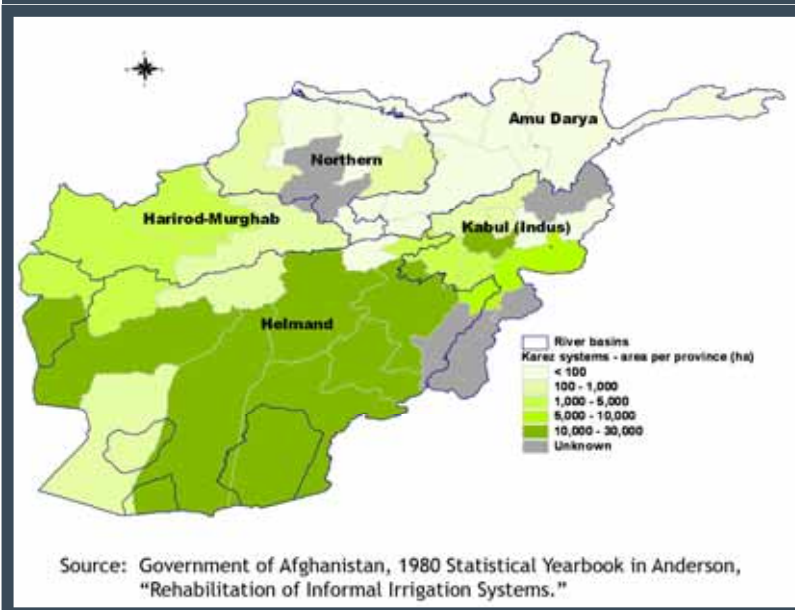
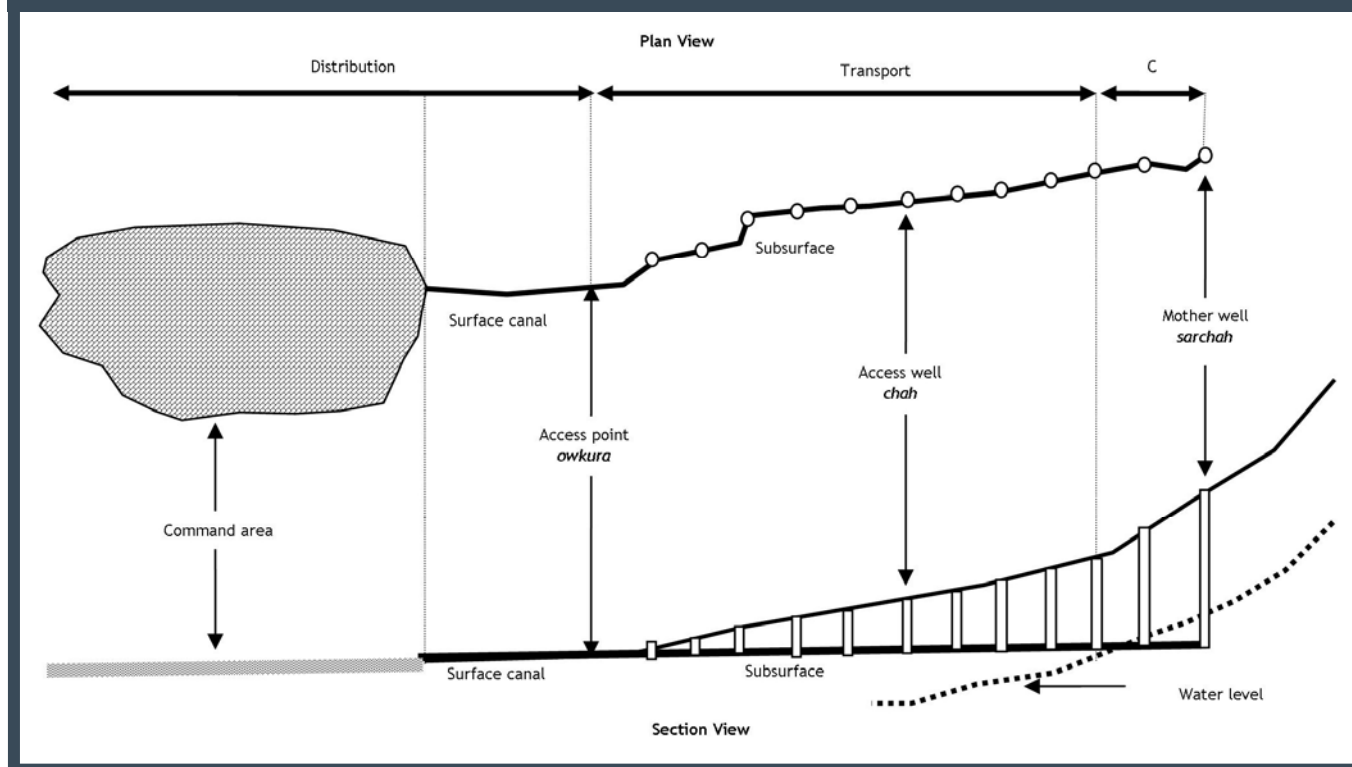


Figure 20: Karez sections



Water transport: A section of the subsurface canal transfers water to the surface. In some systems, this section may be up to tens of kilometres long. The subsurface canal is constructed by tunnelling while access and air supply are provided by a series of *chah* (access wells) often visible from surrounding deposits of spoil. Both the subsurface canal and access wells are prone to collapse and require reconstruction.

Water distribution: Conveyance and distribution of water to the command area is via a surface network of canals and structures, which are typically unlined earth canals. This network extends into the command area for distribution of water to the farm turnout. The first point of access to water is the *owkura* where drinking water is taken.

Water storage: Some *karez* incorporate water storage, locally called *hawz*, for night storage and to increase distribution flow rates. The

storage structure is located at the head of the distribution system into which flow is diverted during the night and released for daytime irrigation.

Organisation

The construction and maintenance of subsurface *karez* sections are traditionally carried out by a *karezkan*, a specialist who has knowledge of construction methods and conditions. The operation and maintenance of the distribution section are similar to those of smaller surface water systems, including water allocations and rotations falling under the responsibility for a *mirab*.

While this is the generally accepted understanding of *karez* organisation, it appears little research has been conducted into understanding issues of organisation and management.

Operation

Karez supplies water not only for irrigation but also for domestic and livestock consumption. Non-irrigation water access is based on local and customary rights of access to water for drinking, public use, livestock and non-drinking domestic consumption.

Allocations are based on water rights and rotations. The allocation is similar to the *nawbat* system, measuring a water take for a specified time in hours and rotation. Little research currently exists, however, on the various kinds of allocation within different *karez* types. There is a need to better understand water entitlements and management.

Performance

The efficiency of water distribution is affected by the performance of the transport and distribution canals. Open canal losses may be approximately 20 percent and subsurface canal losses 20 to 30 percent.³⁷ The subsurface canal sections may suffer high water losses due to the highly permeable gravels in the canal transport section and difficulties in construction.

Not much is currently known about application efficiencies for *karez* since little is understood about the efficiency of water allocations and on-farm water management. Water use efficiency, however, is expected to be higher than for many surface water systems because of perennial water supply sustained throughout the irrigation season, resulting in higher productivity.

Merits, constraints and improvements

The principal merits of *karez* are:

- its gravity-feed system;
- a sustained perennial flow;

- good water quality suitable for multiple use; and
- a community-based system that is similar to that of surface water systems and is headed by a community-selected *mirab* while its subsurface work is undertaken by a *karez-kan*.

Constraints of *karez* include:

- vulnerability to subsurface slumping and collapse as well as potential instability of tunnels and access wells;
- water losses in subsurface canals;
- flood damage to surface structures; and
- vulnerability to the groundwater depletion.

In addition, the lack of knowledge about efficiency of water allocations and the management of *karez* makes it difficult to comprehensively analyse this type of irrigation system.

Opportunities for improvements to *karez* systems may entail:

- lining subsurface canals to reduce water losses, improve water supply and reduce labour for maintenance;
- rehabilitation of access wells to improve access and water supply;
- rehabilitating subsurface canals;
- improving structures to protect canal structures and irrigated land from flooding;
- construction and rehabilitation of storage structures to improve system efficiency, distribution and application; and

³⁷ Anderson, "Rehabilitation of Informal Irrigation Systems."

- improving water allocation management based on irrigation demand.

Case example:

Bawran Karez, Herat Province

The Bawran Karez is located within the Pashtun Zarghun District, approximately 40 km southeast of Herat city. It was selected as a case example from *karez* that have undergone rehabilitation works by EIRP. It is typical of the type of *karez* included in the programme and provides an example of *karez* physical features, operation and maintenance issues. The information below is drawn from the EIRP, which included rehabilitating the subsurface canals and storage structures of the *karez*.

Constructed 300 years ago, this *karez* system is the principal water source for the villages of Bawran and Tagaw, which are inhabited by a

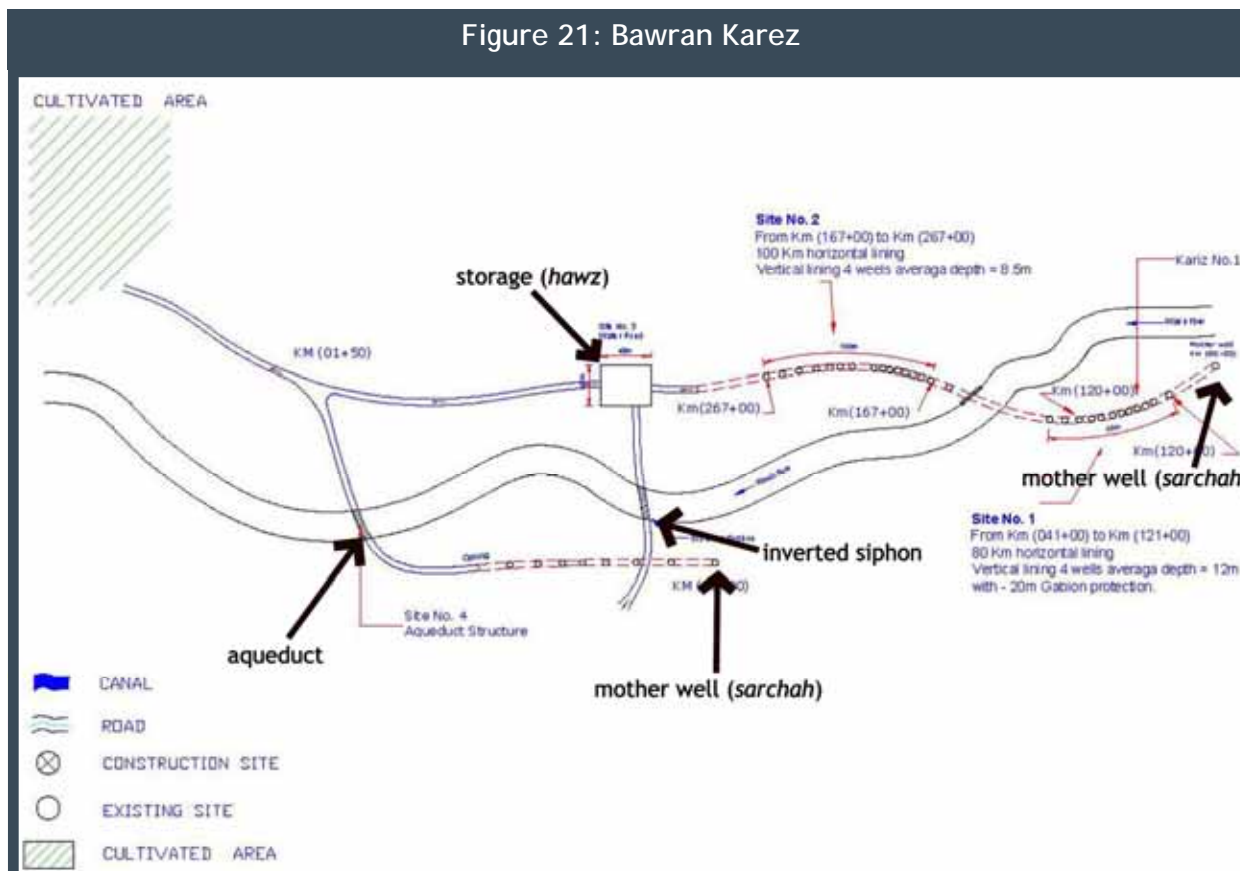
total of 220 households and a population of 2,240. It supplies an irrigated area of 200 ha that has a cropping intensity of 125 percent (200 ha summer cropping and 50 ha winter cropping). Irrigated crops include: wheat (150 ha), barley (30 ha), alfalfa (20 ha) and chickpea (50 ha).

The infrastructure of the system consists of two separate mother wells, associated access wells and subsurface canals as shown in Figure 21. In addition, surface water flow is diverted from the adjacent wash.

The system infrastructure includes:

- a 1,450 m long subsurface canal;
- 31 unlined access wells, each 1 m in diameter;
- an open canal stretching 5 km;

Figure 21: Bawran Karez



Source: EIRP

- an aqueduct crossing a wash; and
- an *hawz* tank holding a volume of 3,000 m³ for night storage.

The system is currently managed by a *mirab* who was elected by the *shura* or village council. Other information regarding organisation was not available to the author at the time of research.

Water is allocated on a 13-day rotation cycle, irrigating approximately 75 *jerib* (15 ha) per day. There was a lack of additional information regarding the operation of the system.

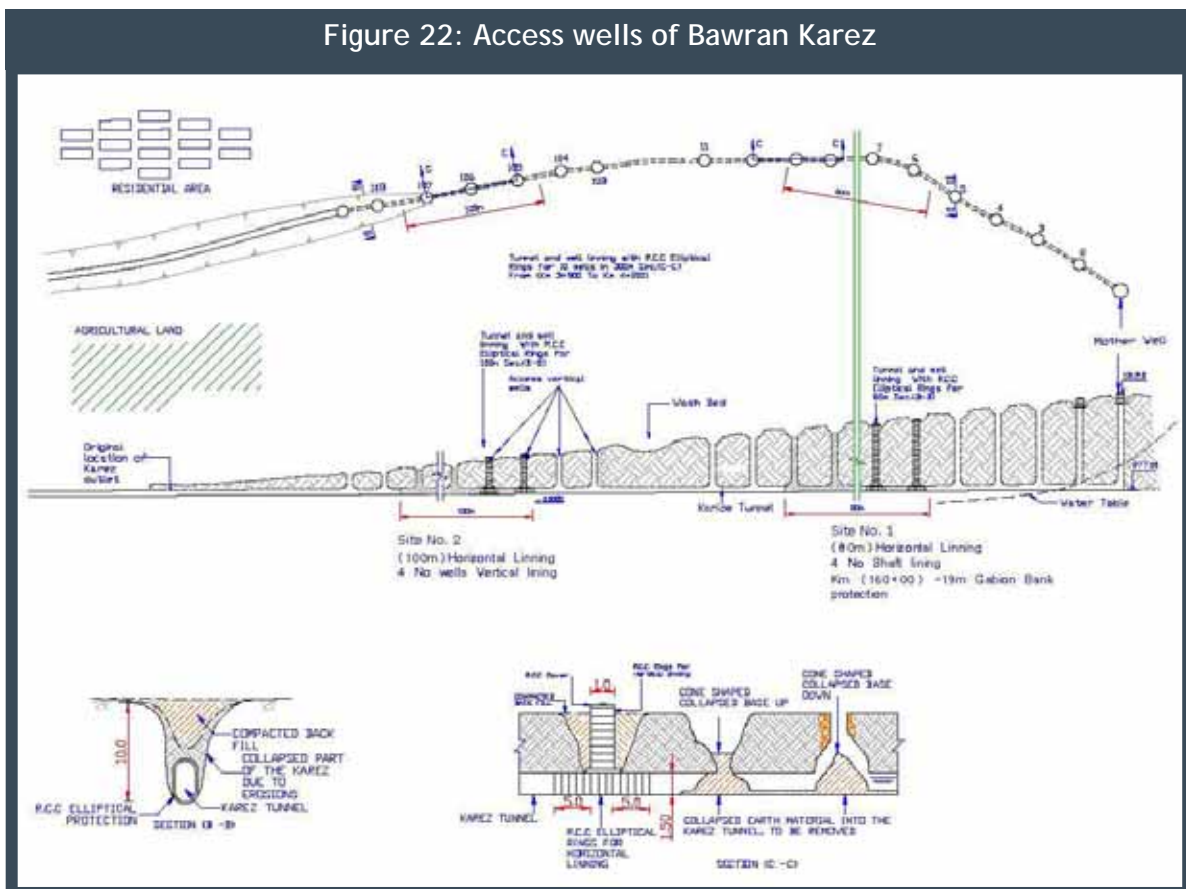
Merits, constraints and improvements

While information on the merits of the system were limited, EIRP identified system constraints including:

- possibly inadequate stability of tunnel and access wells (Figure 22);
- water losses in subsurface canals;
- water losses in *hawz* storage structure; and
- damage from the adjacent wash.

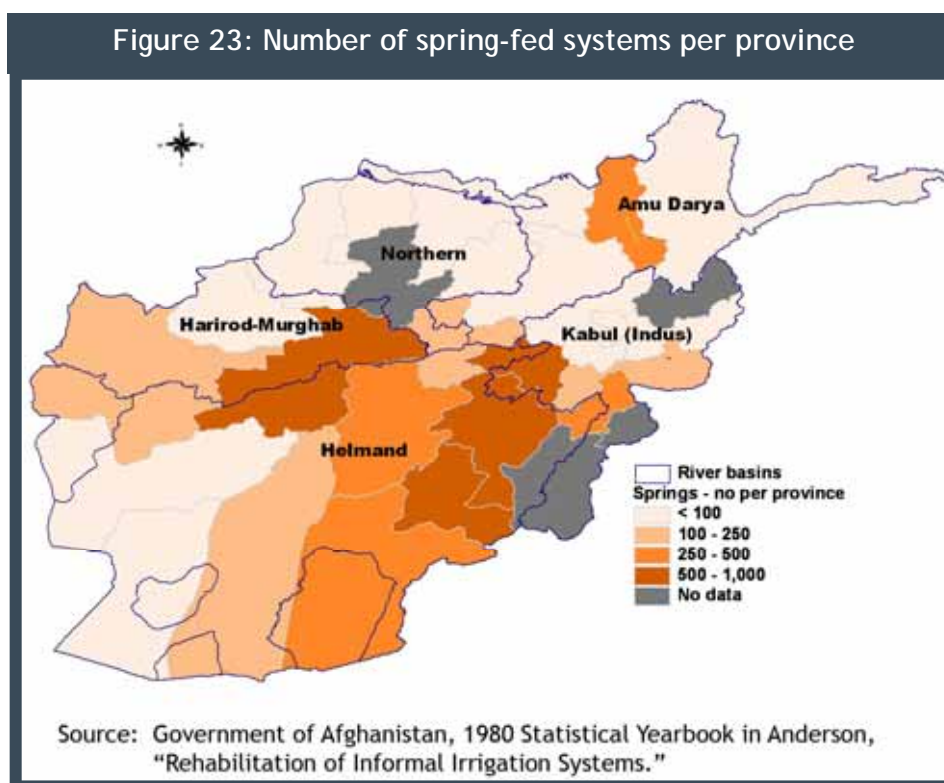
Rehabilitation and improvements included:

- lining of damaged tunnel sections and access wells;
- the construction of an aqueduct across a wash;
- the construction of a storage pond (3,000 m³ capacity) that takes 15 hours to fill at 60 L/s.



Source: EIRP

Figure 23: Number of spring-fed systems per province



4.6 Springs

Numerous rural communities depend on spring water for irrigation and other uses. For these communities, the spring is often the only perennial water supply and, therefore, essential to household and community sustainability.

In Afghanistan, the number of spring-fed systems and the area they cover are similar to figures on *karez*. Based on estimates from the late 1960s, the 5,558 systems accounted for 19 percent of all irrigation systems. Approximately 188,000 ha (7 percent of the then-irrigated area) were irrigated by springs.³⁸

The hydrology of springs is similar to *karez* since they are supplied by shallow unconfined aquifers and bedrock seepage in steeper, upper valley locations. Water supply reliability likely varies between locations. Flow rates, however,

are relatively low though probably more sustained than for surface water systems. When available and where possible, diverted surface water flows supplement the supply from shallow groundwater springs. Further research is needed regarding water supply characteristics and related issues for spring-fed irrigation systems.

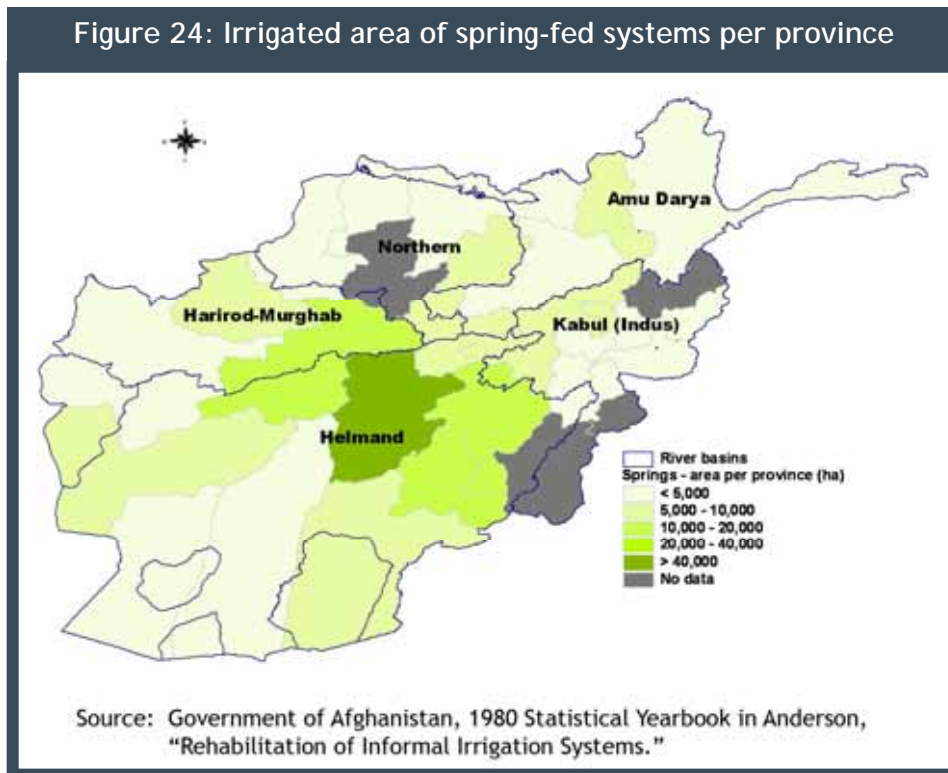
This section provides an outline of spring irrigation systems but existing knowledge gaps need to be filled. There is a need to better understand the resource and the system's technical, social and financial characteristics as well as development requirements.

Distribution

The number of spring-fed irrigation systems and associated irrigated area per province is shown in Figure 23 and Figure 24. Springs are commonly found in the upper catchment and tributary zones evidenced by the higher concen-

³⁸ Government of Afghanistan 1980 Statistical Yearbook in Anderson, "Rehabilitation of Informal Irrigation Systems in Afghanistan."

Figure 24: Irrigated area of spring-fed systems per province



trations located in more mountainous central and southeastern provinces. Irrigated area per spring averages roughly 30 ha but, similar to *karez*, ranges up to more than 200 ha.

The infrastructure of spring-fed systems is typically made up of simple canals and structures built and maintained by the local irrigation community. Sourced by one or more mother springs, these structures include:

- open, unlined earth canals similar to *karez* for transport and distribution;
- simple conveyance structures such as aqueducts and siphons;
- protection structures to prevent flooding from adjacent streams and washes;
- *hawz* for night storage and to improve distribution efficiency; and

- diversion weirs to supplement supply from streams and washes.

Stone masonry canals and support structures are at times needed because of difficulties in construction, resulting from the mountainous upper catchment location of many spring systems.

Literature available to the author provided limited information on system organisation and management.

Due to relatively low flows, water allocation is assumed to be rotational and based on water entitlements. Additional information on operation of these systems was not available to the author at the time of research.

System performance is likely to be similar to small surface water systems, including relatively high canal losses due to percolation. To date, however, there appears to be little, if any,

published literature presenting work on system performance.

Merits, constraints and improvements

Spring-fed systems share many attributes of *karez* related to water supply, which is sustained for much or all of the irrigation season over a year. Water quality is generally good, which makes the supply suitable for domestic and livestock consumption in addition to irrigation.

Constraints of the system type are:

- difficulties in construction and maintenance of canals;
- limited flow rates;
- the lack of water storage to improve distribution and application efficiencies; and
- a small command population to support system maintenance.

While a wide range of specific improvements can be proposed for these systems, they can be grouped into the following:

- reconstruction of the canal to reduce seepage losses and maintenance costs;
- rehabilitation of conveyance structures (aqueducts, siphons and super-passages) to improve supply reliability and distribution efficiency;
- spring development to improve water supply, including rate and sustainability of flow;
- construction of diversion structures for supplementary surface water supplies from washes;
- construction and rehabilitation of flood protection structures; and

- use of storage to improve distribution and application efficiencies.

Case example:

Cheshma Qulf Spring, Herat Province

The Cheshma Qulf Spring is located in the Hari Rod-Murghab river basin, approximately 140 km east of the city of Herat. The spring, which is reputedly 700 years old, is the sole water source for the irrigation and water supply system. In 2006, the system was rehabilitated as part of the EIRP from which the information below is drawn. The system was selected from those in the EIRP as a typical example of a spring system on the project.

The system supplies an irrigated area of 135 ha for cereal and fodder crops (80 ha of wheat, 40 ha of barley and 15 ha of alfalfa) and an additional 15 ha of garden area (tree and vegetable crops). The main recipient community of the system is the village of Qulf, which neighbours the district centre of Chest-i-Sharif. It has a total population of 1,020 and 144 households of which 78 are landowners and 66 are sharecroppers.

While limited, information on this system that was available to the author at the time of research has been included below.

Infrastructure

Illustration 14 shows the mother spring and discharge point to the main canal. Water is transported to the command area via an open, unlined canal approximately 4 km long. Within the command area, the main canal has three branches.

Organisation and operation

The system is managed by a *mirab* who was selected by the *shura* village council. Maintenance activities are carried out under the *hashar* system, which typically requires the labour contribution of 30 farmers for a period of 23 days per year. The spring flow rate averages



Illustration 14: Chesma Qulf Spring (courtesy of EIRP)

approximately 40 L/s to a maximum of 90 L/s. Water is distributed on a 13-day rotation with allocation duration based on water entitlement.

Merits, Constraints and Improvements

The EIRP addressed some key issues such as water losses in unlined earth canals and, due to low discharge rates, the need for night storage to improve efficiency. The project also rehabilitated the canal and turnout structure as well as constructed a night storage reservoir (Illustration 15).

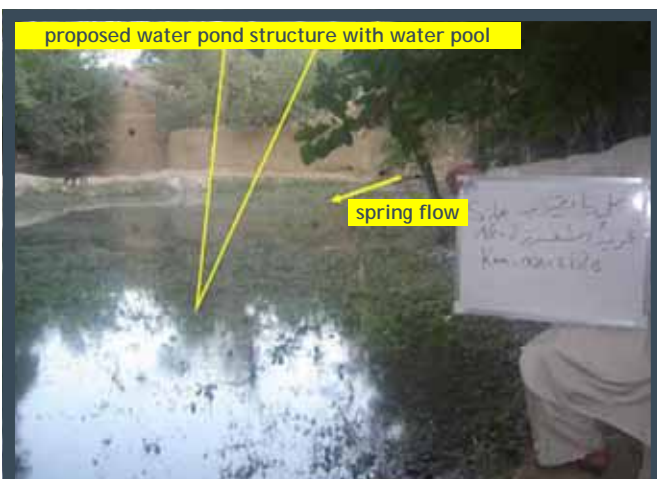


Illustration 15: Hawz for the Chesma Qulf Spring system (courtesy of EIRP)

4.7 Wells

Estimates from the late 1960s indicated that less than 1 percent (12,000 ha) of total irrigated area is supplied by water from wells. Traditionally, groundwater supply in Afghanistan has been abstracted from bores and shallow hand-dug wells using human labour or animal draft (*arhad*) for water lifting (see Illustration 16).



Illustration 16: Well handpump (Bob Rout photograph)

These systems are largely limited by water depth and lifting capacity; the irrigable area per well, therefore, is confined to less than 3 ha.

Well construction using traditional methods is shown in Illustrations 17 and 18. In recent



Illustration 17: Internal access to well (Bob Rout photograph)



Illustration 18:
Well construction traditional
method
(Bob Rout photograph)

This includes adapting traditional well-drilling techniques, including combining them with concrete lining rings as well as the use of drilling in the construction of deep tube wells. The adoption of modern pumps also greatly increases the pumping rate and potential irrigable area per well.

times, the general development of groundwater has considerably expanded to meet both irrigation and growing domestic water demand. Modern well-drilling and pumping technology has been adopted in Afghanistan (see Illustration 19).



Illustration 19:
Modern well-drilling
(Bob Rout photograph)

5. Typology of Formal Irrigation Systems

In this study, formal systems are defined as large-scale irrigation schemes developed with central government assistance, financing, management, operation and maintenance as well as technical and financial support from bilateral and multilateral donors. Created largely from the late 1940s to the 1970s, these schemes combine “green fields” and traditional systems. They were aimed at expanding the agricultural production base by developing new irrigated lands as well as conglomerating and improving existing informal systems.

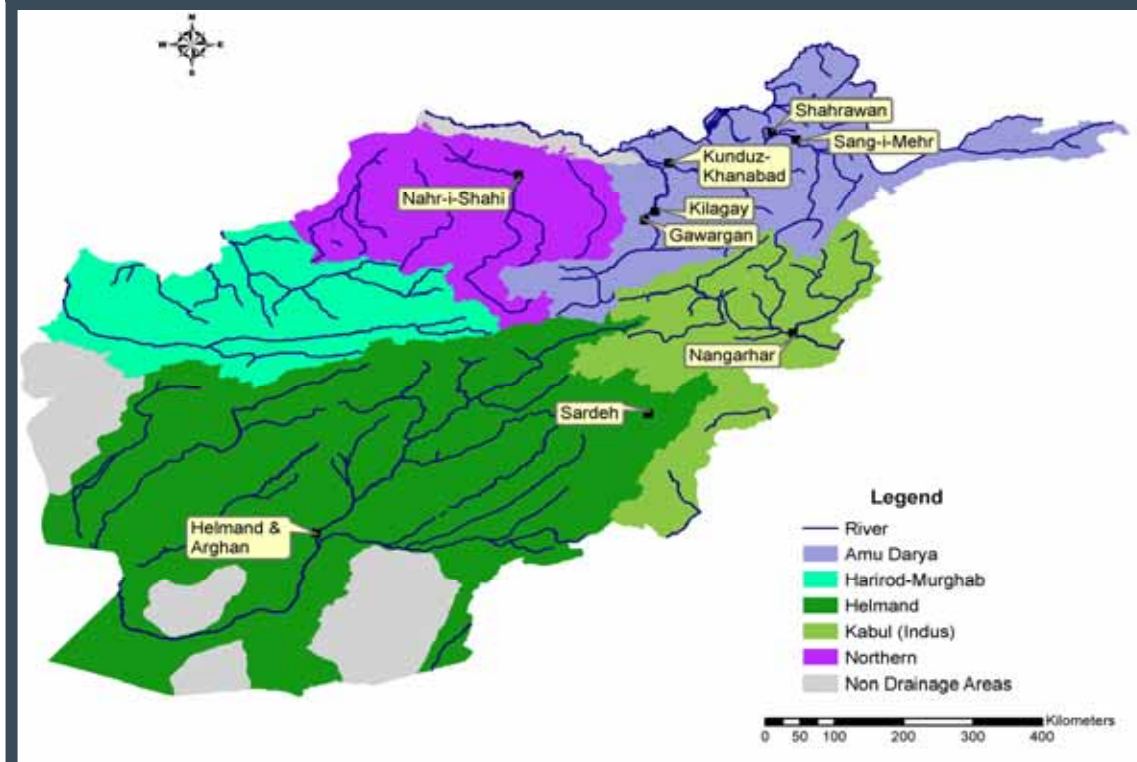
5.1 Key features

By constructing storage and diversion dams,

lined canals and control structures, the schemes were designed to overcome the water supply and distribution problems inherent in informal systems. Some storage schemes also had hydropower production capacity. The structure of scheme operation and management entails strong government support, leaving farmer responsibility largely confined to the lower levels of distribution.

During years of conflict in Afghanistan, the schemes became heavily degraded due to lack of funding and loss of technical and institutional capacity to support operation and maintenance. As a result, they are now operating well below capacity and require major rehabilitation and

Figure 25: Location of formal irrigation schemes



³⁹ Ministry of Irrigation, Water Resources and Environment, “Irrigation Policy” (Kabul: Government of Afghanistan, 2004).

Table 7: Summary of formal irrigation schemes

	Location (province)	Irrigable area (ha)	Main structures
Helmand-Arghandab	Helmand, Kandahar	103,000	Kajaki and Dhala dams; diversion of Boghra; main canals: Boghra, Shahrawan, Shamalan, Darweshan and Baba Walee
Sardeh	Ghazni	15,000	Reservoir (164 million m ³), left and right canals (15 cumec)
Parwan	Parwan, Kabul	24,800	Diversion weir; main canal (27 cumec); eastern and southern canals; pumping station; power house (2.4 MW)
Nangarhar	Nangarhar	39,000	Darunta dam; power station; main canal (Q _{max} = 50 cumec); pumping station; state farms
Sang-i-Mehr	Badakhshan	3,000	Intake and main canal (2.5 cumec)
Kunduz-Khanabad	Kunduz	30,000	90 percent completed infrastructure; entire scheme under rehabilitation including diversion weir; main right and left canals
Shahrawan	Takhar	40,000	Intake; main canal
Gawargan	Baghlan	8,000	Intake; main canal
Kelagay	Baghlan	20,000	Intake; main canal
Nahr-i-Shahi	Balkh	50,000	Diversion weir; main canal; division structures
Total irrigable area		332,800	

Source: Favre and Kamal, *Watershed Atlas of Afghanistan*

investment. Since 2003, a number of ongoing rehabilitation initiatives for the schemes have been launched. For most, improvement works are planned over the next decade, largely financed by bilateral and multilateral donors.³⁹

5.2 Location

Figure 25 shows the location of the ten formal systems. When classified by river basin, two are in Helmand (Helmand-Arghandab and Sardeh); two in Kabul (Nangarhar and Parwan); five in Amu Darya (Gawargan, Kelagay, Kunduz-

Khanabad, Shahrawan and Sang-i-Mehr); and one in Northern (Nahr-i-Shahi).

5.3 Irrigated area

According to estimates, the schemes serve a combined irrigable area of 332,000 ha.⁴⁰ Because no reliable estimates currently exist, the irrigated area may be considerably lower than this value. Table 7 summarises the irrigable area and main structures of each scheme, three of which include large structure dams and hydropower production.

⁴⁰ Favre and Kamal, *Watershed Atlas of Afghanistan*.



Illustration 20: Main canal, Kunduz-Khanabad
(Bob Rout photograph)



Illustration 21: Diversion weir, Kunduz-Khanabad
(Bob Rout photograph)

5.4 Organisation

The management of schemes with and without storage differ and are summarised below.

Systems without storage These systems—with permanent intake structure—are operated and maintained by DOI. Management of the system follows the rules of large-scale traditional systems, but regulation of water flow depends on a functioning interaction between government authorities and village communities.

Systems with storage Also known as dams, these systems are completely managed by government authorities. Land tenure practices differ from those in traditional systems; some parts of the scheme are operated under private land ownership agreements while others are operated as state farms.

5.5 Case examples

Helmand-Arghandab scheme

This is the largest scheme in Afghanistan with

an irrigable area of more than 100,000 ha. Constructed in the 1950s and 1960s largely with US government support, it was intended to be a model of modern irrigation and water resources development. It has, however, suffered from numerous problems including institutional and financing difficulties. It has also encountered technical problems in drainage and salinisation resulting from degradation during years of conflict. Since 2003, US agencies⁴¹ have been engaged in ongoing scheme rehabilitation and remediation.

Kunduz-Khanabad scheme

The construction of Kunduz-Khanabad was nearly complete when the outbreak of conflict in the late 1970s stopped further work (Illustration 20 and Illustration 21). The concept behind the scheme is to link and develop 11 existing informal systems on the right and left banks of the Taluqan River resulting in a common intake source and main conveyer canals. As part of the KRBP, the assessment phase of a plan to complete and rehabilitate the scheme is currently underway.

⁴¹ These agencies are the Rebuilding Agricultural Markets Programme (RAMP), and the US Agency for International Development.

Parwan scheme

Constructed in the 1970s with assistance from the Chinese government, this system irrigated a substantial area of the Shamali Plain, north of Kabul. During the later years of conflict, both the scheme and command communities suffered

considerable damage. Since 2003, some infrastructure has undergone rehabilitation and additional works have been planned with US assistance. Some of the scheme's infrastructure is depicted in Illustration 22 and 23.



Illustration 22: Main conveyor canal, Parwan scheme (Bob Rout photograph)



Illustration 23:
Tertiary control gate,
Parwan scheme
(Bob Rout photograph)

6. Current Initiatives and Future Direction

This section presents a summary of current irrigation initiatives and addresses potential issues and developments related to the future direction of the irrigation sector in Afghanistan.

6.1 Current irrigation initiatives

Of the nearly 30,000 irrigation systems in the country, few are large schemes. The vast majority are small systems each covering less than 200 ha but together total most of the country's irrigated area.

Considerable potential exists to enhance performance and productivity of irrigated agriculture, thereby improving food security and livelihood sustainability in rural communities. This may be achieved through rehabilitation of existing irrigation systems as well as, in the longer term, through improved development of water and land resources.

Three decades of conflict have adversely affected the performance of irrigation systems and the ability of communities to sustain them in traditional ways. The impact includes destruction of infrastructure, the lack of maintenance and loss of labour due to migration. In 2003, the FAO estimated that, as a result of conflict and drought, approximately half of the irrigated area (and presumably systems) required rehabilitation.⁴²

Since 2001, several initiatives have been launched to develop the irrigation sector and better manage water resources along with natural resources and the environment. Undoubtedly, this huge task requires a long-term strategy and investment. MEW, the lead government institution for irrigation system rehabilita-

tion and development, receives support from international agencies and bilateral donors. The Ministry of Rural Rehabilitation and Development (MRRD) also implements a number of NGO-supported programmes for irrigation rehabilitation as part of the National Solidarity Programme (NSP). Other government stakeholders include the Ministry of Agriculture, Animal Husbandry and Food (responsible for on-farm irrigation development and management) and the Ministry of Mines and Industry (responsible for groundwater management).

Emergency Irrigation and Rehabilitation Program (EIRP)

EIRP is the most extensive initiative with national coverage aimed at the rehabilitation of irrigation systems, the hydrometeorological network and institutional capacity. It is funded by the World Bank and implemented by FAO and MEW by means of local contractors. The programme is limited to physical emergency rehabilitation work, particularly conveyance structures.

Coverage: national; administered by a central and five regional offices (Jalalabad, Kunduz, Mazar-i-Sharif, Herat and Kandahar)

Funding: US\$50 million

Duration: three years (scheduled for April 2004-March 2007)

Project elements:

- Targeted rehabilitation covering a total of 280,000 ha of irrigated area in 1,280 irrigation systems defined by size as small (100 ha), medium (750 ha) and large (2,500 ha) and including canal, *karez* and springs
- Rehabilitation of hydrometeorological network

⁴² A.S. Qureshi, "Water Resources Management in Afghanistan: The Issues and Options", Working Paper 40, Pakistan Country Series 14 (Colombo, Sri Lanka: International Water Management Institute, 2002).

- Preparation of feasibility studies and monitoring
- Institutional development

As of June 2008, the rehabilitation of 634 schemes had already been completed or is in progress. The EIRP faced constraints during its start-up phase and a need to build up its institutional capacity and establish procedures. Its work programme may also be seen as ambiguous.

Emergency Infrastructure Rehabilitation and Reconstruction Project (EIRRP)

The objective of EIRRP is to rehabilitate traditional irrigation systems and key irrigation infrastructure while also developing the capacity of MEW. It is the Traditional Irrigation Component of a larger US\$150 million infrastructure and reconstruction project and is funded by the ADB and the Japan Fund for Poverty Reduction (JFPR). EIRRP is being implemented by MEW through consultants from PCI Asia.

Coverage: Northern Basin sub-basins of Khulm, Balkh, Ab-i-Safid and Shirin Tagab, with emphasis on Balkh River and Jawzjan irrigation systems

Funding: US\$15 million

Duration: entire project ten years (2003-2013); irrigation component to be completed in 2008

Project elements:

- Rehabilitation of irrigation civil works (\$11.1 million)
- Implementation and support for infrastructure improvement (US\$2.9 million) and technical support to MEW
- Enhance MEW capacity to implement improved infrastructure (US\$1 million)

Balkh Basin Integrated Water Resources Management Project (BBIWRMP)

This project is aimed at improving water management and associated agricultural productivity to reduce rural poverty of local

communities. Funded by JFPR, it is being implemented by MEW through Snowy Mountain Engineering Corporation as a technical consultancy.

Coverage: Northern, Balkh sub-basin

Funding: US\$10 million

Duration: 3.5 years (2004-2008)

Project elements:

- Rehabilitation of irrigation infrastructure (US\$5.0 million)
- Institutional strengthening and development (US\$2.66 million)
- Capacity development (US\$2.34 million)

Kunduz River Basin Project (KRBP)

The objectives of this project are: to assist rural farming communities with improving irrigation schemes; to implement new institutional and policy framework for one river basin to draw lessons for extending the integrated river basin management approach; and, to develop and test technical and social solutions for an efficient, equitable and sustainable management of the water and other natural resources. The KRBP is funded by the EC.

Coverage: Amu Darya sub-basins of Kunduz and Khanabad

Funding: €12.5 million (US\$15 million)

Duration: four years (2007-2011)

Project elements:

- Preparation of a river basin management plan and setting up of a river basin authority
- Improvement of infrastructure and water management in ten to 15 small and medium irrigation schemes
- Increasing operational efficiency of water use from irrigation schemes
- Enhancing capacity of three MEW provincial offices and river basin councils including water user associations

- Regeneration of selected upper catchments

Western Basins Project (WBP)

The WBP is aimed at improving rural livelihoods through the strengthened integrated water resource management, improved irrigation service delivery, enhanced agricultural practices, and increased productivity of irrigated agriculture.

The project is funded by ADB, CIDA and the Abu Dhabi Fund (ADF).

Coverage: 32 systems in the Hari Rod-Murghab river basin covering a total irrigated area of 52,000 ha

Funding: US\$90 million

Duration: seven years (2007-2014)

Project elements:

- Integrated water resource management
- Water resources and irrigation development, including civil works and machinery accounting for approximately 50 percent of the project budget
- Agricultural and livelihoods support services
- Project management and capacity-building

Amu Darya River Basin Management Programme (ADRBM)

The objective of the ADRBM is to enhance sustainable development and the river basin water management approach in watersheds of the Amu Darya river basin. The programme is funded by the EC.

Coverage: Kokcha and Panj watersheds of the Amu Darya river basin

Funding: €3.83 million (US\$4.97 million)

Duration: five years (commencing in 2007)

Project elements:

- Development of a river basin water management plan for the two watersheds of the Amu Darya river basin (similar to the KRBP)

- Irrigation asset rehabilitation and development (provisionally for 14 systems)
- Design of river training works
- Upper catchment conservation works
- Institutional and local capacity-building

Other programmes

In 2006, the Afghan government initiated the National Sustainability Fund (NSF) to support rural communities. Under the NSF, communities can request financial support for a wide range of activities and services, including rehabilitation of irrigation infrastructure. The fund is administered by the MRRD, which subcontracts NGOs with relevant expertise to implement the irrigation projects. These are generally for rehabilitation or improvement of small structures. A number of other bilateral and NGO programmes have supported the irrigated agricultural sector.

The US-led **Rebuilding Agricultural Markets Programme** has produced studies on the Helmand-Arghandab irrigation scheme and undertaken efforts for its rehabilitation.

An NGO active in the sector in Afghanistan for several years, **DACAAR** provides technical and financial assistance for rehabilitation of irrigation infrastructure. It also supports the MRRD in implementing irrigation reconstruction works under the NSP.

Another NGO, **GAA**, is active in the agricultural sector and provides services to investigate and improve social water management as well as develop water user associations as part of national and river basin strategies.

The international NGO **World Vision** supports the construction of small-scale projects for irrigation and rural water supply, including small retention dams and irrigation infrastructure.

The French NGO **Urgence Réhabilitation Développement** is involved with European

Union- and EC-funded projects in the irrigation sector. These include research of agrarian systems and participatory management of water in Baghlan and Takhar provinces.

Table 8 summarises current major irrigation initiatives. Much of the support to the sector, by necessity, has come as emergency efforts to rehabilitate existing systems, improving operation and addressing immediate food security needs. A conservative estimate indicates that US\$200 million is scheduled for investment in the sector for the next five to seven years. While much of this is in infrastructure rehabilitation, some will be in capacity-building of national and regional institutions and technical support for water resources and irrigation management.

6.2 Future direction

While current initiatives enhance the irrigation sector in the interim, it is essential to consider its long-term development. A number of key areas should be marked for improvements in the future.

System efficiency and productivity

- Improving water diversion and control structures of surface water systems to increase water supply reliability and reduce operation costs and maintenance labour requirements
- Increasing water distribution efficiency of all systems by renovating distribution canals as well as control and conveyance structures
- Making water distribution more equitable within systems by reviewing water entitlement and allocation methods
- Developing water storage systems to improve water availability and supply reliability

System operation and maintenance

- Strengthening organisation of informal system through technical support from central and regional agencies and the adoption of transparent organisational and operational structures
- Modifying financial mechanisms to strengthen system financial self-sufficiency (e.g. formalised accounting and cash contributions for operation and maintenance)
- Developing technical measures to reduce canal de-silting requirements and costs
- Protection against groundwater depletion and pollution for systems that are particularly vulnerable to these factors such as *karez*, springs and *arhad*
- Improvement of current maintenance approaches for *karez*, such as adapting those used for *qanat* (equivalent system type in Iran)

Sustainability of water resources

- Optimising water resource development and environmental sustainability by developing integrated catchment water management plans as part of plans for sub-basins and river basins
- Sustainable development and management of groundwater resources, particularly in the lower catchment, for increasing irrigated areas and productivity

Table 8: Current initiatives for irrigation development and rehabilitation

Initiative	Agency	Budget	Sched-uled Duration	Water basin Sub-basins	Components
EIRP	World Bank	US\$75 million	3 years	all	<ul style="list-style-type: none"> Rehabilitate 1,280 irrigation systems (280,000 ha) Rehabilitate hydrometeorological network Prepare feasibility studies and monitoring Institutional development
EIRRP	ADB JFPR	US\$15 million (irrigation component)	10 years (entire project including irrigation component)	Northern Khulm, Balkh, Ab-i-Safid, Shirin Tagab	<ul style="list-style-type: none"> Rehabilitate irrigation civil works Implement and support for infrastructure improvement Enhance MEW capacity to implement improved infrastructure
BBIWRMP	ADB JFPR	US\$10 million	3.5 years	Northern Balkh	<ul style="list-style-type: none"> Rehabilitate irrigation infrastructure Institutional strengthening and development Capacity development
KRBP	EC	€12.5 million (US\$15 million)	4 years	Amu Darya Kunduz, Khanabad	<ul style="list-style-type: none"> Prepare river basin management plan and set up river basin authority Improve infrastructure on 10 to 15 small and medium systems Improve operational efficiency of water use from irrigation systems Develop capacity of three MEW provincial offices and river basin councils including water user associations Regenerate selected upper catchments
WBP	ADB CIDA ADF	US\$90 million	7 years	Hari Rod-Murghab Hari Rod, Murghab, Khush	<ul style="list-style-type: none"> Integrated water resource management Water resource and irrigation system development (52,000 ha) Agricultural livelihoods support Capacity-building and project support
ADRBMP	EC	n/a	5 years	Amu Darya Kochoa, Panj	<ul style="list-style-type: none"> Develop river basin water management plan for the watersheds Irrigation asset rehabilitation and development Design river training works Upper catchment conservation works Institutional and local capacity-building

7. Recommendations

This paper is the beginning of a systematic irrigation typology for Afghanistan, using existing information and previous research on the subject. Many gaps in knowledge remain, however. Nevertheless, this study of irrigation types will also hopefully provide the foundation and framework for future surveys, studies and initiatives of both informal and formal systems. The following are recommendations to improve the understanding of irrigation systems in Afghanistan.

System inventory and database

Current knowledge about the number, type and distribution of irrigation systems in Afghanistan is incomplete, inaccurate and outdated. Given the importance of the irrigation sector to livelihoods as well as national economy and security, this lack of knowledge is a major weakness in planning and development. A national inventory and database of systems should be established, possibly including the use of satellite imagery integrated with existing information on system type and location. This would serve as a foundation and focal point upon which national and international agencies could draw for planning support and interventions. The approach to developing the inventory should be pragmatic and consider current technical and institutional constraints. There is, however, a considerable body of existing information (e.g. initiatives, studies and surveys) that could form the starting point.

Water entitlements and management

Existing information provides a general understanding of the principles of water entitlements and allocations, but considerable variation between the complex systems and system types exists. More research is needed to understand the relationship between water entitlements and the efficiency of water use within systems. Current support for systems is greatly focused on improving system distribution, but it is also necessary to increase understanding of how

effectively systems currently allocate water and to identify constraints and areas for improvement.

Social water management

Often under adverse conditions, traditional organisational structure of informal systems has stood the test of time maintaining and operating systems. In the development of integrated catchment and river basin management, it is widely acknowledged that these organisations formed the basis of formalised water user associations and community representation. More research is needed, however, to better understand the structure and function of traditional organisations to determine how they may be strengthened and better integrated into a broader management framework.

System monitoring

A significant gap exists in information on key issues of system performance, water availability, reliability and water use efficiency. Current literature does not appear to provide any records on system flow rates. As part of developing catchment and river basin management programmes, it is recommended that routine flow monitoring be conducted for representative system types and major systems. Monitoring requirements include: establishing gauging stations (ideally in the upper reach of the main canal); routine gauging (daily during the irrigation season); and data collection, storage and processing.

Distribution efficiency

For informal systems, current knowledge of distribution efficiency is largely limited to estimates based on assumed parameters for canal construction, dimensions, gradient and flow rate. Finding ways to improve distribution and water use efficiency will require quantitative research into distribution efficiencies. This work may be conducted on a sample of systems and system types as a part of evaluating system

performance pre- and post-implementation of rehabilitation programmes.

Surface water development

A key constraint for developing surface water irrigation systems is the construction and maintenance of on-river intake structures because of limited technical and financial resources. This is further complicated by issues of water rights and access to resources shared by adjacent irrigation communities. For these reasons, many existing rehabilitation programmes exclude substantial development of intake structures. The performance of these structures, however, is pivotal to overall system performance and sustainability and, therefore, requires identifying technically and socially appropriate ways to improve structure type and operation. This may call for a fundamentally new approach such as the development of large cross-river dams and weirs to service downstream systems and, similar to the Kunduz-Khanabad scheme, shared conveyor canals and de-silting structures.

Sustainability of interventions

Since 2001, MEW and several international agencies have made a concerted effort to implement emergency rehabilitation programmes, which have largely focused on improving irrigation infrastructure. To improve performance and durability of structures, the engineering approach to design and construction is often based on adopting conventional irrigation structures, materials and construction methods. Generally, responsibility for the long-term maintenance of the new structures rests with the recipient community. In some cases, structures prematurely fail due to the technical or financial inability of the community to plan and carry out preventative and routine maintenance. An evaluation should be undertaken regarding maintenance required for typical irrigation infrastructure (e.g. control gates and protection walls) and the capacity of communi-

ties to maintain it.

Groundwater development policy

There is considerable potential to develop groundwater resources. In some areas, this is being exploited through rapid construction of new wells for irrigation and domestic water use. This expansion, however, could also adversely impact existing users of shallow groundwater systems, especially *karez*. Experience in other countries indicates how difficult—if not, impossible—it is to recover from over-exploitation of groundwater. To ensure adequate protection for these users, it is thus crucial that Afghanistan develops groundwater policies and plans along with enhancing institutional capacity.

Catchment and water basin studies

There is a need to better understand the hydraulic linkage between irrigation systems within surface water catchments and water basins. Water is shared and recycled between systems and any changes in water use are likely to impact on downstream systems and communities. The KRBP provides an example of an integrated approach to river basin management; similar approaches should be developed for other major catchments and river basins. Future research should include identifying customary agreements between communities on water sharing.

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