Case Study Series

WATER MANAGEMENT, LIVESTOCK AND THE OPIUM ECONOMY

Irrigation Systems

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This report is one of seven multi-site case studies undertaken during the first stage of AREU's three-year study "Applied Thematic Research into Water Management, Livestock and the Opium Economy".

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Glossaries

General terms

formal irrigation schemes	Schemes that have been developed using a formalised design with permanent diversion structures, well-defined water distribution structures and ordered water delivery methods. They are generally large- or medium-scale in size, and built by government. At present, the command area under such systems is 300,000 ha (about 10 percent of total irrigated area).
gross command area (ha)	total area that can be irrigated by a given canal; includes all infrastructure, houses and non-productive areas
hectare (ha)	measure of land equivalent to 10,000 m^2 or 2.471 acres
irrigation efficiency	percentage of intake used for crop production
net irrigated area (ha)	total area of land actually cultivated with crops; generally less than the command area by 12–15 percent
traditional irrigation schemes	Informal or traditional irrigation schemes are small- (<100 ha), medium- (100–2,000 ha) and large-scale (>2,000 ha) irrigation schemes developed by farmers on their own initiative. They have no formal design and have been developed over time and are operated and maintained by the farmers themselves. Gravity irrigation is used throughout these schemes, with most deriving water from rivers and streams by means of temporary (seasonal) diversion structures. About 90 percent of the country's irrigated land falls into this category.
water efficiency	percentage of net amount of water (intake minus return flow to river) used for crop production

Dari terms

ab, aw	water
arbab	village or community leader
arhat	traditional irrigation method using groundwater for irrigation of small irrigated plots (<1 ha) from shallow wells (3–10 m); powered by horse, donkey or camel
band	dam, barrier, weir
hashar	communal, usually unpaid, labour
hawz	traditional water tank; accumulating pool or small reservoir at the head of the irrigation system to permit larger unit flows to be delivered, or for irrigation during 12 hrs outflow using 24 hrs inflow
jangal	forest or scrub

jar	temporary channel or dyke in river or wash bed to harvest subsurface water or springs (during summer months)
jerib	unit of land measurement; 5 *jerib* = 1 ha (2000 m^2)
joy	irrigation channel (small or medium)
juftgaw	unit of irrigated land: flow/volume to area ratio under which water rights or turns are allocated on main canals; derives from a yoke of paired, ploughing oxen and reflects area ploughed by two oxen for different soil types and land slopes; directly proportional to irrigated area and often approximated by *jerib*; the entitlement of any particular community is the sum of all individual *juftgaw* of that community
karez	underground canal system that taps aquifers by gravity through a series of underground galleries or tunnels; often extends many kilometres before surfacing to provide water for drinking and irrigation; *karez* comprise three sections – water collection, water transportation and distribution
karezkan	*karez* specialist
kharwar	Kabul: equivalent to 80 *ser* at 7 kg per *ser* (560 kg) Mazar-i-Sharif: equivalent to 80 ser at 14 kg per *ser* (1,120 kg) Herat: equivalent to 100 *man* (400 kg)
kuchi	traditional name for Pashtun nomads (from Dari "to move from place to place")
man	measurement of weight equivalent to 7 kg (Kabul), 4 kg (Herat), 4.5 kg (Kandahar), 5 kg (Peshawar), 14 kg (Balkh)
mirab bashi	water master or bailiff responsible for all of a primary canal
mirab	water master, water manager, water bailiff, in some areas of Afghanistan such as Herat, assistant to *wakil* (equivalent to *chak bashi* or *kok bashi*)
paw-ab-daqiqa	local measure that relates seed application to land area, similar to *juftgaw* system in Herat (Nangarhar)
qarz	loan, debt
rod	river (Herat)
ser	4–7 kg of grain (location dependent)
shab o roz	24-hour irrigation flow, or night–day system; ratio of time-to-flow for traditional water allocation and water rights. Irrigators have rights to a number or fractions of hours of water in any one rotation series. For example, where the only crop is wheat, the rotation is 24 hours of water for every 20–30 ha of land in a 12.5 day rotation. If the land owner has more or less land then the water is adjusted

	proportionally. On Day 1 the *mirab* supplies water to top-end users and works downstream through the canal network. On Day 12.5, water is delivered to tail-end users and restarted at the top on Day 13. *Mirabs* deliver water throughout the 24-hour period, and farmers who receive their allocation during the night will receive their next allocation during daylight hours.
shora	local council, traditional assembly of elders (clan-based, tribal or ethnic) which runs community affairs
spingira	elder
wakil	water master or bailiff responsible for all of a primary canal (Herat); district representative (in cities)
woliswal	district governor
woliswali	district

Abbreviations and Acronyms

a.m.s.l.	above mean sea level
ACWUA	Atishan Canal Water Users Association
BCEOM	Le Bureau Central d'Etudes pour les Equipements d'Outre-Mer
DACAAR	Danish Committee for Aid to Afghan Refugees
DAI	Development Alternatives Inc.
DANIDA	Danish International Development Agency
DEW	Department of Energy and Water (formerly Department of Irrigation, Water and Environment)
DoA	Department of Agriculture (provincial level Ministry of Agriculture, Animal Husbandry and Food)
EC	European Commission
EIRP	Emergency Irrigation Rehabilitation Programme (World Bank-financed, FAO-implemented)
ET_0	evapotranspiration rate
EU	European Union
FAO	Food and Agriculture Organization
GAA	German Agro Action
GIS	Geographical Information Systems
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
IWRM	Integrated Water Resources Management
KRBP	Kunduz River Basin Project
MAAHF	Ministry of Agriculture, Animal Husbandry and Food
MEW	Ministry of Energy and Water (formerly Ministry of Irrigation, Water and Environment)
MMI	Ministry of Mines and Industries
MRRD	Ministry of Rural Rehabilitation and Development
NGO	non-governmental organisation
NSP	National Solidarity Programme
PID	Provincial Irrigation Department (provincial-level Water Management and Hydrology Department of the Ministry of Energy and Water)
PRT	Provincial Reconstruction Team
RBA	River Basin Authority
UN	United Nations
UNAMA	United Nations Assistance Mission in Afghanistan
UNHCR	United Nations High Commissioner for Refugees
WB	The World Bank
WB-EIRP	World Bank Emergency Irrigation Rehabilitation Programme
WUA	Water Users' Association

Contents

1. Introduction

This study was undertaken as part of the Afghanistan Research and Evaluation Unit's applied thematic research project "Water Management, Livestock and the Opium Economy" in cooperation with the Danish Committee for Aid to Afghan Refugees (DACAAR) in Ghazni and Herat and German Agro Action (GAA) in Nangarhar and Kunduz. This report presents the findings of initial fieldwork and describes current practices in the delivery of water to and within the four primary research sites. It suggests links between water and opium, and how farmers view crops in relation to the selection of cropping patterns and returns to labour. It also recommends areas for further study. Although the report touches on water management systems, full details of the primary *mirab* system in each research site is provided in the companion report *Social Water Management*.[1]

> ***The* mirab *system***
>
> *The tradition of* mirabs *in Afghanistan shows that farmers have been able to maintain their own systems without outside interference for hundreds of years. Collectively they have constructed, managed and maintained traditional irrigation systems, said to cover 90 percent of all irrigated area in Afghanistan, solving conflicts in water use and land in the process. This tradition was the basis for preparations by planners in the 1960s and 70s for large, state-managed formal schemes in Nangarhar and Helmand. However, the extended period of conflict has weakened the* mirab *system, exacerbated by subsequent outside intervention in the name of "emergency assistance" that fails to really understand how works will be perceived in the villages and their impact on social structures. During this time (the 1990s), traditional community and farmer tasks (*hashar*) have been replaced by paid interventions to the extent that communities now look for outside funding to solve problems first, before looking within their own community.*

1.1 Study methods

In each primary research site (see table 1), traditional irrigation systems were examined to identify current practices relating to water diversion, distribution and management and other related factors. Data and information were collected through discussions with farmers and communities, site observations, discussions with other organisations working in the area and secondary sources such as project documentation. The data collected at each site have been analysed to identify commonalities and differences between each. The intention is to provide information on the variations that exist between each area, and to indicate the factors that affect these variations. The period for field assessment was limited, and the findings will need additional examination and verification.

Table 1*. Primary research sites, GPS coordinates and elevations*

Province	**District**	**Settlement**	**Site coordinates from GPS readings** (* indicates readings taken from maps)		**Elevation (m)**
Nangarhar	Achin	Khawaji	N 34° 01' 00"*	E 70° 37' 37"*	~1700
		Otarkhel	N 34° 03' 17"*	E 70° 38' 46"*	~1470
		Sra Qala	N 34° 07' 38"*	E 70° 43' 00"*	~950
		Maruf China	N 34° 11' 45.5"*	E 70° 42' 24"*	~690
	Batikot	Janikhel	N 34° 15' 22"*	E 70° 44' 38"*	~550
Ghazni	Khwaja	Chel Gunbad	N 33° 43' 40.47"*	E 68° 23' 18.49"*	~2360

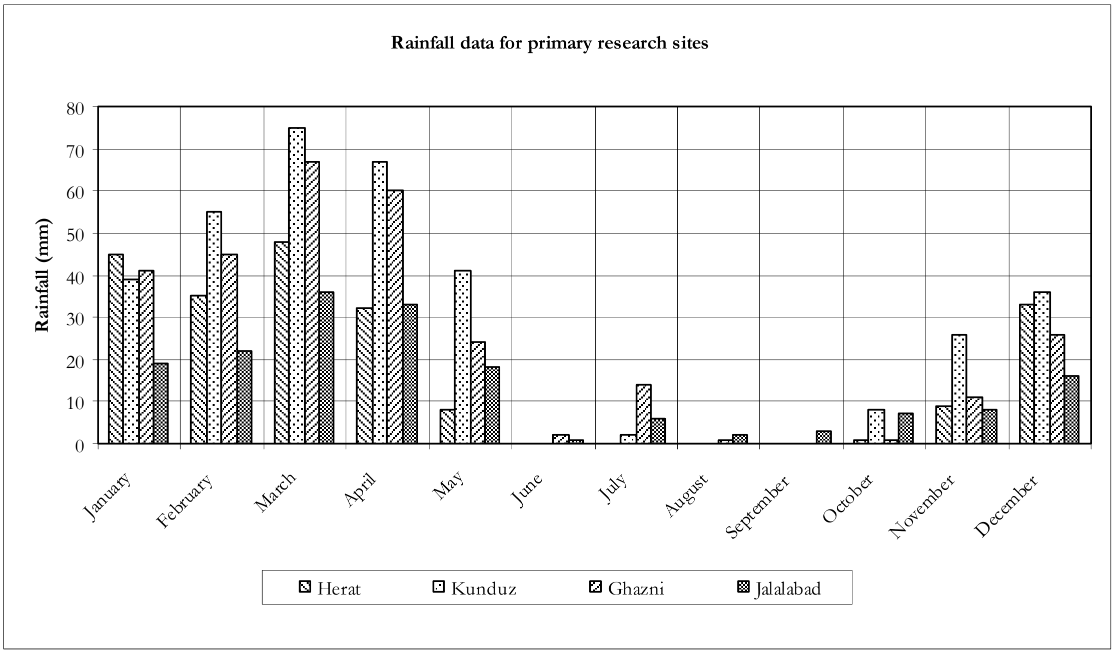
[1] J.L. Lee, 2006, *Social Water Management*, Kabul: Afghanistan Research and Evaluation Unit.

	Umari	Turmai	N 33° 41' 7.10"	E 68° 23' 56.0"	2300
		Qala-i-Naw	N 33° 38' 8.60"	E 68° 25' 12.50"	2255
		Zala Qala	N 33° 38' 49.3"	E 68° 18' 56.7"	2560
		Pyada Rah	N 33° 40' 26.2"	E 68° 20' 27.6"	2490
Kunduz	Qala-i-Zal	Dana Haji	N 36° 58' 24.50"	E 68° 31' 52.20"	335
		Afghan Mazar	N 36° 57' 41.80"	E 68° 34' 41.80"	340
		Wakil Jangal	N 36° 54' 52.70"	E 68° 34' 58.40"	345
	Khanabad	Alam Bai	unknown	unknown	~800
		Abdul Nazar	N 36° 34' 7.40"	E 69° 7' 29.00"	~800
Herat	Pashtun Zarghun	Gawashk	N 34° 17' 30.10"	E 62° 39' 41.50"	1090
		Tunian	N 34° 18' 22.20"	E 62° 31' 5.90"	1030
		Gharak	N 34° 20' 23.70"	E 62° 36' 12.20"	1165
	Kushk	Khalifa Rahmat-i-Ulya	N 34° 46' 10.40"	E 62° 17' 30.10"	1305
		Sir Zar	N 34° 44' 45.30"	E 62° 18' 57.40"	1490

1.2 Context

The research sites were chosen to cover a range of climatic and agro-ecological zones and water sources. Without exception, rainfall in all sites (from an average of 171 mm in Jalalabad to 349 mm in Kunduz, see figure 1[2]) is insufficient for crop production unless irrigation is provided – either from established irrigation conveyance systems or by utilisation of surface runoff. In the winter months this irrigation acts as a supplement to rainfall, but in the summer months full irrigation is required.

Figure 1*. Rainfall data for primary research sites*



Source: FAO Cropwat 4 Windows 4.3, CLIMWAT Climate and Rainfall Data Files

Traditional surface irrigation systems are used throughout the primary research sites and these are supplied from a range of water sources – some directly from perennial or seasonal rivers and dam storage, others from seepage from dam-stored water or

[2] Compared with mean annual ET_0 of 1,372 mm in Jalalabad (up to 1,736 mm in Herat).

from seasonal runoff and spring flow. Few were supplied by *karez*, as many had dried up in the recent extended drought (1999–2003). During these dry years, there was an increase in the number of shallow and deep wells drilled by farmers; such random developments are cause for concern as they influence local water tables, and if drilled without knowledge of groundwater characteristics they may lower seasonally high water tables and permanently affect water sources for tree crops on which many farmers rely.

All of the traditional irrigation systems have been developed over time, with many adopting alignments used by ancient systems and abstraction points being adapted to changing river morphology and the impact of annual floods. In all research sites, farming communities have, using contributed labour (*hashar*), developed efficient mechanisms for tapping water sources, both perennial and seasonal. These measures have, however, been badly affected by the significant periods of neglect during the years of conflict, when annual routine and preventative maintenance and repairs could not be carried out. At these times, rivers and streams were allowed to move unchecked, taking away permanently large and significant tracts of arable land and isolating canals from traditional intake sites (structures at the mouth of the canal which channel water away from the source). Some of the resulting damage has been so extensive and beyond the communities' capacity for repair that farmers have been forced to abandon all or parts of their systems. Some are still struggling to get water into their intakes. Donor aid has been used to support farmer efforts, but many of these interventions have significant weaknesses, whether from inadequate designs or poor construction. In the short term, some have proved beneficial, but their sustainability is in question in many cases as farmers have neither truly adopted them into their annual operation and maintenance plans, nor understood the need for preventative maintenance.

Crop production is aimed at food security, but in many cases family land holdings are too small to meet their needs and farmers are forced to cultivate either illicit crops or other higher value cash crops.[3] Decision-making is primarily based on returns to labour and available water, as plot sizes are small and families contribute significantly to their crop production with off-farm employment.

Most traditionally irrigated lands comprise good alluvial soils that have been systematically deposited over time. They are therefore suitably productive provided that adequate cultivation techniques are used, appropriate inputs including fertilisers are used, and drainage is provided for lower-lying lands. Where this has not been adequate, such as in lower Kunduz, drainage and salinity problems exist and are currently causing severe constraints for both crop production and yields. Although variations in cropping patterns do exist, the choice of crops in general reflects the elevation and location of the site. Major variations in irrigation methods and cropping patterns appeared to be related to the reliability of the water source, the place of agriculture in the farming system and the balance between required and available labour. These are discussed in more detail in the description of the research sites (section 3), where an overview of water infrastructures and irrigation systems in the research sites is presented along with the physical context of each site and its associated water management.

[3] See A.R. Fitzherbert, 2006, *Livestock Husbandry*, Kabul: Afghanistan Research and Evaluation Unit.

2. Policy Environment

Farming decisions reflect both the family and community situation and the national policy and enabling environment. Although this study examines the situation at the community level, many of the interventions made by farmers are directly affected by provincial and central government actions. Much of the aid that is currently provided to rural communities is managed at central level, often without adequate understanding of those issues of concern to farmers. Communities receive some assistance for their schemes, but quality control is poor as experienced international designers and implementers often do not or cannot visit the communities and sites for which they are providing assistance. Traditional decision-making and planning for annual and seasonal repairs is usually effective, but communities often do not have sufficient resources to carry out the work they know needs to be done. Traditionally farmers have contributed both to the repairs and to the salary of the water masters (*mirabs*), but with external interventions and the influence of local commanders in some cases, this has not been done as efficiently as before, and there has been a breakdown in traditional water management systems in many areas. Some of this is attributable to war, but some can be blamed on the struggle by donors to establish their "patches" before first defining the existing social water management arrangements in an area. This is gradually changing, but there is still a disbursement-driven mentality that assumes implementers know what communities need.

Over the last two years, efforts have been made to improve the enabling environment for both traditional informal irrigation and formal medium- and large-scale irrigation schemes. There is a clear need for an updated water law and a water sector policy that includes irrigation and not just potable water supply. In addition, communities need to be encouraged to make their own decisions, and to be shown that their concerns will be listened to. The Ministry of Energy and Water (MEW) has supported this through a series of actions:

- updated water law;
- draft water resources management policy;
- water sector policy framework;
- integrated water resources development and river basin approach; and
- legal authority and formalisation of water users associations.

From the initial examination of the primary research sites, it is clear that very important practical information and feedback about on-farm management and the role of village-based water users' associations can be provided to implementers to assist in the development of these vital legal interventions. The findings regarding the management of water and field-level requirements will provide useful insights into both water law and the Master Plan for Agriculture. Details on the sustainability of irrigation infrastructure interventions and how they are perceived by the beneficiaries will be impor-

The Master Plan for Agriculture

The proposed Master Plan for Agriculture, Animal Husbandry and Food was reviewed by cabinet in November 2005. It sets out the MAAHF's strategy over a five-year period, and prioritises high-value horticulture production, food security and domestic livestock development. It highlights improvement to water resources management and irrigation to achieve agricultural goals, and outlines the need for institutional strengthening. The plan also identifies a major role for the private sector in agricultural development. It is accompanied by an implementation document, setting out a schedule of actions and activities to achieve the goals identified.

tant in establishing and refining the role of Provincial Irrigation Departments (PIDs) and River Basin Authorities (RBAs).

2.1 National-level policy

The mandate for irrigation development currently rests with the MEW. There has been much discussion about whether it should be moved to the Ministry of Agriculture, Animal Husbandry and Food (MAAHF), and if so, how this should be done. There seems to be a general consensus that macro-level water management, planning and allocation of resources should rest with MEW, but that on-farm water management, including conveyance and on-farm water use, should be the mandate of MAAHF.[4] While this discussion continues, MEW continues to make the decisions relating to irrigation development and to establish the appropriate enabling environment in consultation with the other stakeholders. It is supported in this by a number of technical advisers in Kabul as well as international technical specialists from donor-supported projects at national and provincial levels. These advisers and specialists are endeavouring to provide a thorough understanding of the legal and technical basis for all interventions — whether they comprise large-scale formal projects or smaller, traditionally developed systems. Key issues relate to addressing equitability and sharing of water, payment for operation, maintenance and repair works and the legal framework for both decision-makers and water users.

2.2 Water law

The revised Water Law, approved by the National Assembly on 7 November 1988 and by the Senate Assembly on 7 April 1991, sets out Afghanistan's approach to water management. It defines, amongst other things, responsibilities for planning, investment and operation and maintenance. It was developed at a time when most larger systems were state managed and funded, and did not take sufficient account of the numerous informal farmer systems that existed and the fact that these systems had their own traditional systems of management. With the recent changes in the country's political direction, the need to recognise all levels of irrigated agriculture within the country has been recognised. The 1991 law has been reviewed by a group of lawyers and specialists, and a revised draft has been produced and circulated to relevant ministries and advisers.[5] The document is still to be finalised, but it is intended that it should pass into law in 2006.

There are a number of anomalies and ambiguities that remain, and these will need to be resolved if the law is to be effective. While the law provides a framework for future interventions, it does not yet recognise the importance of all farmers and traditional water users. Currently, most user groups in the country are informal and have no actual legal basis. Although the government would prefer that they established themselves as formal groups, there is little incentive for them to do this as many have been, or are being, assisted under various externally funded programmes with little or no requirement for reorganisation or obtaining contributions from the beneficiaries. The assumption in the current draft law is that all groups will want to formalise their Water User Associations (WUAs).

[4] This is effectively what is happening with the Nangarhar canal. It supplies a former state farm which is now under the jurisdiction of the provincial MAAHF, as most of this ministry's activities now relate to agriculture and water management.
[5] *Water Law in Afghanistan* 1991 (June 2005).

Provincial Irrigation Department (PID) support. It is acknowledged that some form of support and guidance will be needed at provincial level, or in the future at river basin level (see section 2.4), but there is currently no realistic approach to establishing the required capacity at this level. Many tasks and responsibilities have been assigned in the short term under donor programmes to the representatives of MEW at provincial level (PID), but these are not being carried out to the required standard as staff are neither professionally equipped nor rewarded to be able to undertake them. In the proposed Water Law, MEW has been given the overall mandate (Article 12) and wide-ranging responsibilities for water resource management, including the "implementation of operation and maintenance, repair and rehabilitation of irrigation systems" and the "assistance to cooperatives and users of the water related to implementation, maintenance and rehabilitation of irrigation systems". The revised law proposes that MEW "will establish an irrigation, construction and repair office with needed mAchinery and equipment for assistance to water users for repair, operation and maintenance, and rehabilitation of irrigation systems" (Article 13). However, this will not be free and for private irrigation systems it will be the user's responsibility (Article 14). There will be financial and technical assistance provided to users, but this will only be given if an agreement is produced defining the obligations and responsibilities of both parties (Article 15). Experience elsewhere has shown that it is far more cost effective for these services to be given to the private sector, with technical oversight provide by the relevant official organisation. The Emergency Irrigation Rehabilitation Programme (EIRP) has used this framework for construction, and this should be extended to also deal with resulting annual operation and maintenance.

Funding of maintenance works. The proposed Water Law clearly establishes a legal basis for the charging for maintenance (Article 9) and the protection of user groups (Article 10), and although it puts the emphasis on payment to the users, it states that it will "reward and will pay bonus for them" (Article 31). This would appear to put unnecessary burden on the government, and potentially create dependency. It does not, however, make any attempt to distinguish between formal and informal user groups. It recognises that user groups led by *mirab bashi* and *mirab* will be responsible for the management and maintenance of the systems (Article 17), and that requests for further water releases and the dividing of water between irrigation systems would be to MEW (Article 19). It also states that the "design and construction of structures or any installation adjacent to water resources, river banks and reservoir in the entire country must be approved by the Ministry of Water and Power (Article 20)".

Allocation of water. Under the section of the law dealing with water use in agriculture, it sets out how water will be allocated but does not appear to recognise traditional water rights. It states that these will be "fixed during land reform" but that "water will be distributed in accordance to local tradition" (Article 24). It also states that "water rights that exceed actual needs or without land will be considered the property of the government" (Article 25). This seems to be contradicted by the following Article (26) that states, "Water distribution will take place in according to fixed norms, considering traditional turns that are decided by User Group meetings". The *mirab bashi* and *mirab* is, however, required to follow the guidance of and cooperate with Irrigation and Agriculture Departments (MEW and MAAHF) regarding repair and distribution of water between users of irrigation systems (Article 28). The draft law is slightly confusing on the ownership of the improved works, and states that if "intakes, main structures and canals in existing irrigation systems are constructed or rehabilitated by the government...those structures will belong to the ministry...Repair and maintenance that is not done by the government is the responsibility of user groups” (Article 30).

2.3 Water sector policy framework

In parallel with work being done on the Water Law, a draft Water Resources Management Policy was produced in August 2004 by the then Ministry of Irrigation, Water and Environment (MIWE), now MEW.[6] This recognises the need for a revised version of the existing national Water Law and the establishment of new acts, laws and regulations. It has been developed in stages, elaborating on an overall Water Sector Policy Framework agreed by institutional stakeholders. This calls for an integrated water resources management (IWRM) based on the river basin approach that recognises the need for specific sub-sector policies and strategies, especially in the development of IWRM, irrigation, rural and urban water and sanitation, hydropower and other economic uses of water. A distinction is made between public and private institutions and calls are made for a clear division of responsibilities among these. The role of the government is to focus on controlling water demand through the development of policies, regulations and appropriate laws. This will be achieved through the promotion and establishment of viable independent WUAs, and active support for a vibrant private sector, both of which will be the main actors in the delivery of services and the management and operation of water resources.

Both the agriculture sector policy and the water sector policy emphasise the importance of WUAs, both traditional and new, in water management and irrigation. The challenge will be how each individual sector ministry should involve in the promotion, development and establishment of such associations. Effective coordination mechanisms will enhance the quality of activities between the two sector institutions, and should avoid duplications.

For the government to successfully implement the above principles, MEW acknowledges the importance of the promotion, initiation and strengthening of water management bodies at community level, such as the *mirab*, *karez* management and other water user associations – as initial steps towards IWRM.

2.4 River basin approach

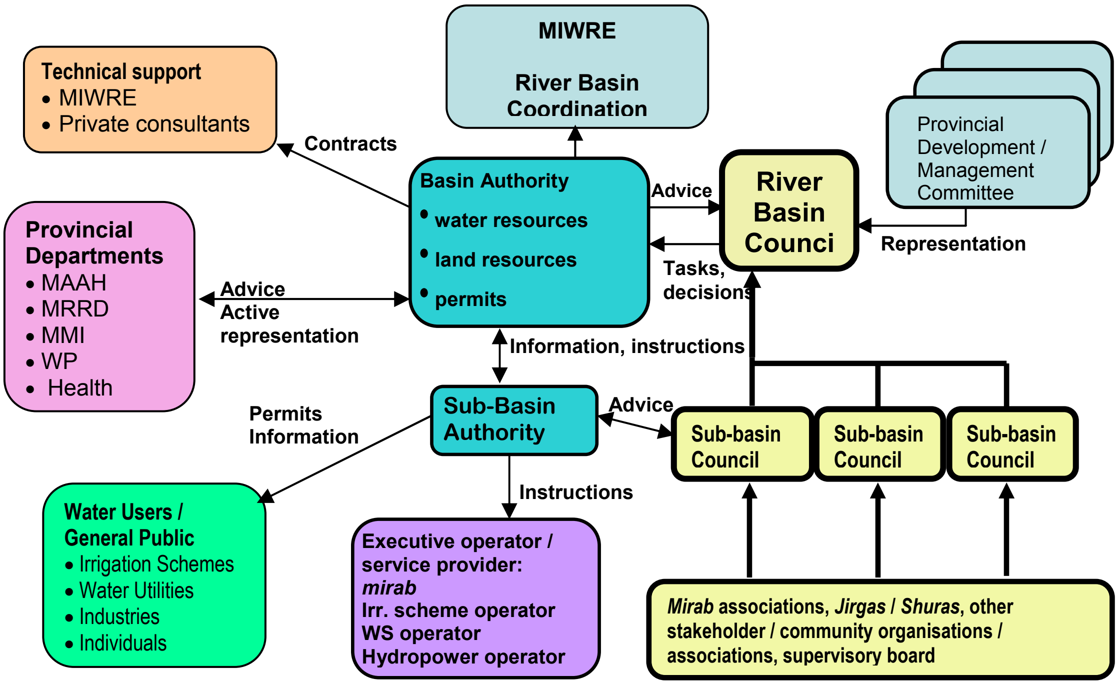
There seems to be a general consensus within the MEW that the future approach to water resource development under IWRM should involve the establishment of River Basin Authorities (RBAs) as semi-government institutions. These Authorities will be elected from WUAs and other stakeholders, and will become financially independent through the levying of fees and revenues. This change is in process, with the details being worked out with the various stakeholders over time. Although PIDs currently exist as the representatives of MEW, they will soon be absorbed into the RBAs.

RBAs will provide the River Basin Council (figure 2) with technical advice on water allocation, available water flows, ecosystem maintenance and potential energy, as well as general advice on planning, budgeting, the establishment or changes of water use rules, coordination of activities and policy preparation for water use and users in the river basin.

[6] Technical assistance is being provided under the Water Sector Reform project funded by GTZ.

The understanding of this approach and the functions of RBAs and WUAs varies greatly between the stakeholders, and this came to a head at an RBA workshop held in September 2004. Attempts have been made to keep the options open for both formal and informal schemes, and there is an underlying assumption that the *mirabs* will be responsible for implementation of RBAs at field level. This is a significant step that will take time and considerable training, as it assumes that *mirab* associations will be formed. The proposed arrangements for the institutionalisation the RBAs are shown in figure 2.[7]

Figure 2*. River basin institutional arrangements*



The Kunduz River Basin Project (KRBP), funded by the European Union, has been working on both the field-level aspects and links with the RBA using practical interventions to encourage *mirabs* and other representatives to meet and understand the process.

2.5 On-farm water management and WUAs

Due to the lack of clarity around responsibilities for irrigation, donors have provided little support for water management, and in particular on-farm water management. To date, all irrigation-related activities have been channelled through MEW, except those associated with National Solidarity Programme (NSP) which are through the Ministry of Rural Rehabilitation and Development (MRRD). A recent irrigation project funded by GTZ[8] to

> *Uncertainty about the "home" ministry for various aspects of irrigation has meant that the Master Plan does not treat the investment needs of irrigation rehabilitation and expansion except for the basic food crops, however it does treat farmer management systems of water management and watershed management.*
>
> ***Agriculture Master Plan, p. 11***

[7] Water Sector Reform Project, GTZ, 2005.

[8] Community-Based Irrigation Infrastructure and Institutional Strengthening of the Water Resources and Irrigation Sub-Sector in the Western Region, Phase II, funded by the German government, implemented with assistance of the FAO.

support on-farm water management was reduced in scope when the project was finally approved, with the software aspects giving way to mainly planning and infrastructural works. The MAAHF's draft Master Plan contains limited discussion of irrigation and even water management. It states that because of uncertainty about the appropriate "home" for various aspects of irrigation, MAAHF does not treat the investment needs of irrigation rehabilitation and expansion, except for the basic food crops for food security. It discusses the need to deal with watershed management and to integrate this with irrigation development, as well as the need to improve water efficiency – but little concrete details are provided.

2.6 Relevant project activities

Additional research to be undertaken at the primary research sites will explore and document how water is allocated at village level and how the actual delivery relates to this allocation. This will link in closely with research into the establishment of formal WUAs and RBAs, and will indicate how these formalised arrangements could assist the beneficiaries in achieving better and more equitable water allocations. It will also look at how to deal with other canal systems in times of water shortage. As has been seen at the Atishan canal in Herat, pre-existing agreements are not being honoured in practice, despite higher-level interventions. A basin-wide authority would assist in this, not only by providing a common forum for discussing these problems, but also by providing the technical and legal basis for sharing water between upper- and lower-level canals. To ensure that beneficiaries agree that this will benefit them, transparent mechanisms to select users must be assured at all levels – from village to RBA.

Crop production. Many communities are unable to cultivate a summer crop because of scarce or unreliable supplies of irrigation water. More efficient conveyance systems and better water delivery and use on farms would extend the areas that can be irrigated in this period. This may go some way towards reducing the reliance on the illicit crops, by increasing annual returns per hectare, as opium is not grown in the summer months. In addition to this, by working with communities to shorten the irrigation intervals and relating water supply to crops grown, more areas will be able to cultivate higher-value horticulture crops precluded by the current long irrigation intervals.

Social management of water. Current knowledge of traditional methods of water management is limited and needs to be researched and documented well in order to form a basis for organisation farming. It is essential for carrying out well-designed interventions in irrigation asset rehabilitation which will serve the needs of the beneficiaries. The first actions in the primary research sites should be to collect data on the needs for improvement (especially in relation to water distribution and control), and coordinate between the population in the irrigation schemes and the engineering teams working on asset rehabilitation. The next activities should aim to illustrate the importance of the process to beneficiaries, and to demonstrate how the process can be used to motivate stakeholders for properly planned, larger works.

Due to limitations of the current legal framework for water users and the absence of experience with maintenance of larger formal control structures, research from not only this project, but from others such as the KRBP, will contribute essential information required to change the current river basin institutional setup (figure 2) from the top down to the bottom up – arrangements that are essential for sustainability. This will enable proper user representation and adequate attention to arrangements for operation and maintenance of future water management schemes.

3. Description of Primary Research Sites

3.1 Nangarhar

These sites are all located in the west of Nangarhar province, near the border with Pakistan's North West Frontier Province. They are south of Barikot on the main road to Torkham, with Otarkhel, the furthest main village, about 30 km from Janikhel. The valley floor at Khawaji, about 7 km upstream from Otarkhel, is at about 1800 m and descends to about 1,500 metres as the wash enters agricultural land adjacent to Otarkhel and Johargar. Through these irrigated lands, the wash descends a further 200 m to Ahun Zarghun at an average slope of 0.001 (l m/1,000 m). The area cultivated by Otarkhel was the first to be developed, with more land upstream towards Khawaji being brought under irrigation as the population grew. Most people have small land holdings, but some have up to 10 *jerib*. As most land holdings are small, families supplement their incomes with off-farm work in Jalalabad and other areas of Afghanistan and Pakistan.

Irrigation water and canal systems

Evapotranspiration rates (ET_0) are high in these areas, exceeding rainfall in all months (table 2). Crop production is therefore only possible with irrigation. Some moisture for crop production is provided by direct rainfall in the winter months, but this is supplemented with irrigation from seasonal wash flows resulting from rainfall runoff and snow melt. In the upper parts of the catchment near the Spin Ghar mountains, this runoff extends into the spring and summer months, and in most years there is sufficient water for winter and spring crops.

***Table 2**. Jalalabad climate data*

		Temp (Celsius)		Hum-idity (%)	Wind (Km/d)	Sun-shine (hrs)	Solar rad. (MJ/m2/d)	ET_o (mm/d)	Rain-fall (mm)
		Max	Min						
Jalalabad	Jan	16	2.6	67	78	6.2	10.4	1.33	19
580 m (a.m.s.l)	Feb	18.6	6	61	86	6.6	13	1.99	22
Latitude	Mar	22.9	10.9	70	86	6.7	15.9	2.78	36
34.26 N,	April	27.4	15	69	95	7.1	19	3.84	33
Longitude	May	34	19.2	56	112	9.1	23.2	5.55	18
70.28 E	June	40.6	24.8	43	104	11	26.4	6.87	1
	July	39.8	27.1	53	104	10.7	25.7	6.69	6
	Aug	38.3	26.7	59	78	9.7	23.1	5.63	2
	Sept	35.5	22	59	60	9.5	20.5	4.35	3
	Oct	30.4	14.7	63	69	8.6	16.2	2.98	7
	Nov	22.9	6.5	72	86	7.1	11.8	1.81	8
	Dec	17.2	2.9	69	69	6.2	9.7	1.17	16
	Av.	**28.6**	**14.9**	**61.8**	**85.6**	**8.2**	**17.9**	**3.75**	**171**

Source: FAO Cropwat 4 Windows 4.3, CLIMWAT Climate and Rainfall Data Files

Only in the upper parts of the flood plain near Otarkhel is there sufficient water for a summer crop on the commanded arable land (the total area that can be irrigated from a canal). In Otarkhel, farmers plant much of the area for the second crop and take the risk that they will only be able to irrigate some of what they have planted. At times of shortage water is reduced, but the share time is kept the same. Water may be reduced for only those plots that have a large water share so that the poorer sections of the community can at least achieve a minimum amount of irrigation.

The three upstream sites of Khawaji, Otarkhel and Sra Qala use runoff from the same seasonal Pirkha wash for their irrigation water. At Khawaji, the wash is still within the steep valleys of the lower Spin Ghar mountains and although the water is available as surface flow in most places, the irrigable lands are not extensive and are vulnerable to flooding at times of high flow, both after large rain storms in the spring and during the period of peak flow of snow melt (April–May). Flow data are not available for the Pirkha wash, but examination of available data shows that at Otarkhel, the wash is starting to enter its flood plain. As it proceeds downstream from here, longitudinal slopes become less and the course of the wash becomes wider, but not yet too braided. Once the Pirkha wash reaches the village of Sra Qala, flows are much more unreliable as most of the flow is subsurface except for peak runoff. In this area farmers tap what they can for the irrigation of their spring crops, obtaining water from "springs" – sites where the subsurface flow is pushed to the surface. In summer, there is very little surface or subsurface flow at these sites, so only a very small area, if any, is irrigated at this time.

For **Khawaji** and **Otarkhel**, a series of traditional diversion weirs collect the wash water and convey it into the canal systems, irrigating an area of about 2,500 *jerib* (500 ha) on both left and right banks. Khawaji is the most upstream irrigated area, with two canals that run close to the hills on each bank supplying about 50 *jerib* in the valley floor and seven grinding mills. Otarkhel is the next command area and is supplied on the left bank by the Shah Toot canal as well as three smaller canals with their own diversion weirs further downstream. The command area ends at the villages of Garwegh and Ahun Zarghun. The Shah Toot diversion weir is located on the left bank of the Pirkha wash about 1–2 km upstream from the village of Otarkhel, and is thus able to command all of the arable land which is approximately 10 m above the level of the wash. On the right bank opposite Otarkhel is another irrigated area that is fed by four canals taking water from the Pirkha wash. These irrigate land that belongs to Johargar village. All canal intakes are being repaired under interventions from the NSP.

In **Sra Qala** village, two channels with separate diversions serve about 550 *jerib* of community-irrigated land and 85 *jerib* of government farm. These canals take their names from the leading people on each channel and share the water with six upstream communities.

Maruf China obtains its water from a neighbouring sub-catchment with similar characteristics to the Pirkha wash. The village is far from the foothills of the Spin Ghar mountains and receives only infrequent supplies of surface water. It therefore relies on four short *karez* that extend into the wash for 1–2 km. Available flows are small and allow the spring irrigation of only about 150 *jerib*. In summer only one *karez* has water and this is used primarily for livestock. Some summer irrigation is practised using three new 15 m deep private wells equipped with pumps. Recharge is slow, permitting continuous irrigation for only about half an hour. The wells have been developed by poor farmers with very little land who sharecrop other neighbours' land – providing their water and labour in return for two thirds of the crop.

Janikhel is the last village in the system supplied by the Nangarhar canal. This was built in 1972 under Russian assistance as a government state farm for olives and citrus, but the formal conveyance network was never completed in the downstream reaches used by the five villages of Janikhel, Shomakhel, Alikhel, Nassirkhel and Badlukhel. Water supply has therefore been very problematic and farmers have developed their own systems of water management. They cultivate a wide range of crops on about 2,000 *jerib* (400 ha), with the Nangarhar canal as their only source of irrigation water.

Water management, and system operation and maintenance

Otarkhel and **Khawaji** only use a *mirab* for the summer crop when water shortages occur and disputes are more likely. In spring and early summer, sufficient water is available to meet all farmers' demands in most years. The current *mirab* has been in the post for two years, succeeding his late uncle[9] with whom he had previously worked. He took over after election by the community and is responsible for all eleven canals in the command area. When he is busy or otherwise occupied, his brother assists him. The water share is based on a 24-hr turn (*shab o roz*) and rotation normally takes place every four to five days. The *mirab* ensures that water is delivered to the main canals according to the allocation plan, and it is up to the villages to then distribute the flows within their area according to size of land holding.

The general cleaning is done annually at the beginning of the new year (21 March). This is before the first irrigation of the season, and is intended to rectify damage and siltation resulting from the winter rains. Maintenance is planned by the *mirab*, but supervised by an appointed person from each village, and all canals are cleaned at the same time. This takes two to three days on average. All farms that benefit from the irrigation water are required to contribute one labourer per holding or water right, depending on size and duration of flow. This is to assist not only with routine maintenance, but also with emergency repairs whether within the irrigation system or at the diversion structure on the wash. During the snow melt period, communities must repair the diversion weir frequently, and for this it is quite common for one village to ask another for help and to repay the service.

Sra Qala shares its irrigation water with six upstream communities. These villages have rights to 20 *shab o roz* compared with one *shab o roz* for Sra Qala. There is also a government farm near to the *woliswali* and it has rights to four *shab o roz* for its 84.5 *jerib* of land. Downstream users (Kayi village) have further a water right of five *shab o roz*. In practice, they receive their water turn only once a month and this varies alternately between day and night with adjustments for different lengths of day and night.

Maruf China has a total water right of 12 *shab o roz*. They have a *mirab*, but he is only used in spring as there is virtually no water in summer. *Karez* maintenance is carried out by all land holders contributing labour in proportion to their land holding. Before the water supply diminished so much, they used to obtain the assistance of *karezkan* from Logar; they now do not feel this is justified.

Janikhel has developed its own water management system together with the other four benefiting villages. During the times of Zahir Shah and Daud, rights for water distribution from the Nangarhar canal were fixed, and were divided between the upper and lower villages. They calculate the water rights in units of *shab o roz* and the informal system seems to work without too many problems. To oversee the

[9] Anyone from the same extended family can take over the *mirab* role, provided that the community agrees. In this way, the *mirab*'s knowledge is passed down through the generations.

water management, the villages have appointed a *mirab* who is paid 40 *man* of wheat for winter crops and 40 *man* in maize for the summer irrigation.

Crops and cropping patterns

In Achin the preferred crop is poppy, and given a free hand, farmers would plant 100 percent of the land with this winter crop. They grow a little wheat, clover and winter vegetables, but these occupy only a small part of the land and are mainly for home consumption. Wheat is followed by 90-day maize planted at the end of May and harvested in September. Onion, eggplant, tomato, spinach, radish, okra, chilli and cabbage are grown in summer for their own consumption. The amounts grown depend primarily on where they are located in the irrigation systems and the availability of water.[10]

Programmes in the area

NSP is assisting the villages of Otarkhel and Khawaji with intake improvement and road access across the canals. This involves the construction of masonry weirs (4 m in width) across the wash with the sill invert at wash level (foundations 2 m below wash) and 10 m long upstream and downstream guide walls 2–3 m high either side of the wash. The offtake to the main canal is an ungated pipe through the wing wall. To date, it is reported that the first four canals have been completed with a further two nearing completion. Diversion structures were the villagers' first priority before schools, clinics and a bridge. Drinking water is not a problem as all villages have piped water from springs and wells.

3.2 Ghazni

Sites within the Jaghatu valley

The Ghazni River flows due south from the Banda-e-Sultan dam through the relatively narrow Jaghatu valley in which the five primary research sites in Khwaja Umari district of Ghazni province are located. The river has an average slope of about 0.01 (1 m/1000 m) and descends from 2400 m at the dam to 2200 m at Ghazni around 25 km away. An all-weather gravel road connects the dam to Ghazni town. The climate in the valley is characterised by hot summers and harsh winters. Rainfall is less than 300 mm per annum and exceeds ET_0 in only two months. Irrigation is essential for crop production, although in the lower part of the valley, tree crops are being grown using locally high groundwater tables resulting both from irrigation and seepage water from the dam and side valleys.

Table 3. *Ghazni climate data*

		Temp (Celsius)		Humidity (%)	Wind (Km/d)	Sunshine (hrs)	Solar rad. (MJ/m2/d)	Et_o (mm/d)	Rainfall (mm)
		Max	Min						
Ghazni	Jan	1.6	0	75	251	5.6	10.1	1.02	41
2183 m (a.m.s.l)	Feb	3.9	-8.1	77	251	6.7	13.4	1.4	45
Latitude 33.32 N,	Mar	11.1	-1.1	70	268	7.7	17.4	2.51	67
Longitude 68.25 E	April	17.1	3.5	67	259	8.4	20.9	3.69	60
	May	23.1	7.2	57	294	9.4	23.7	5.32	24
	June	28.8	11.7	48	276	11.5	27.2	6.82	2
	July	30.8	14.5	54	276	11.2	26.5	6.85	14

[10] For more details, see Fitzherbert, *Livestock Husbandry*.

	Aug	30.3	13.9	47	285	11.2	25.3	6.74	1
	Sept	26.8	8	44	276	10.7	22.3	5.62	0
	Oct	19.9	1.9	54	268	8.9	16.8	3.65	1
	Nov	12.2	-3.1	66	242	8.3	13.3	2.03	11
	Dec	5.3	-7.5	68	251	6.9	10.6	1.32	26
	Av.	**17.6**	**3.4**	**60.6**	**266.4**	**8.9**	**19**	**3.91**	**292**

Source: FAO Cropwat 4 Windows 4.3, CLIMWAT Climate and Rainfall Data Files

Irrigation water and canal systems

The existing 200 m long Band-i-Sultan stone masonry structure is 32 m high, with a crest elevation of about 2,400 metres a.m.s.l. It was constructed in 1901 using lime mortar on the same site as the original dam built some 1,000 years before during the Sultan Muhammad Ghaznavi period. The remains of this dam can be seen just upstream of the current dam. It commands 6,250 *jerib* of irrigated land between the dam and Ghazni town and further seasonally irrigated land south of Ghazni, and has a dominating influence on the water availability, use and management in the valley through large direct water releases, seepage and regular small-base flow releases.

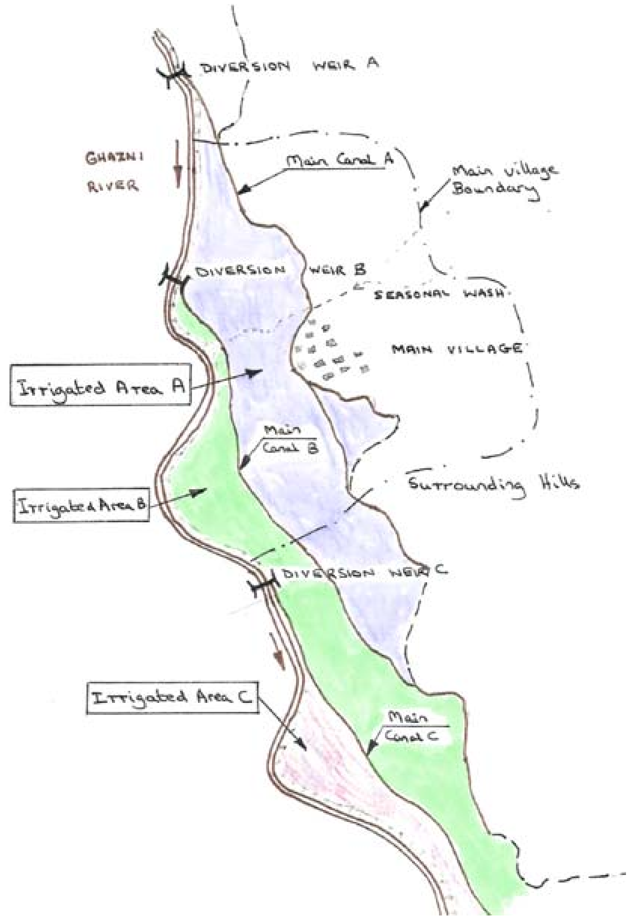
The storage reservoir behind the Band-i-Sultan dam is supplied by the Sarab and Barik Ab rivers, both of which derive their flows from a combination of rainfall and snow melt. Historical data from two gauging sites upstream of the dam (1968–1980) indicate that the mean and maximum recorded flow of the Sarab River was 1.3 m^3/sec and 35.2 m^3/sec respectively. Similar data for Barik Ab are 0.07 m^3/sec. and 15.1 m^3/sec. Currently the reservoir is empty as a 60 m breach occurred on the left shoulder of the dam in early 2005. This caused about two thirds of the stored water to be lost, and as it flowed down the valley in a tidal surge, it caused damage to standing or planted crops, houses and some structures, and flooded Ghazni for a short period. Repair works are being carried out by MEW and are ongoing. To facilitate the repairs works, the river inflow of about 0.5 m^3/sec is passing through the irrigation outlet to the Ghazni River.

The main source of irrigation water for the Jaghatu valley floor command areas is the surface flow in the Ghazni River. This comprises regular large water releases from the dam,[11] periodic smaller releases,[12] seepage from the dam and inflow from the aquifers within the colluvium that occurs on both sides of the valley for its entire length. Over the year, the groundwater table in the valley floor varies from about 2–10 m below ground level, although during the drought period of 1999–2003, it is thought to have gone much deeper. Groundwater was traditionally accessed in this area using *arhat* irrigation with animal power to drive gear wheels to extract the water from shallow open wells. Since the emergence of low head centrifugal pumps located in wider concrete shafts 2–3 m below ground level,[13] this method has gradually become redundant. During the drought period, the number of wells increased and several deep tube wells (60–80 m) were introduced. Although these are currently banned,[14] new drilling was reported to be continuing in the middle and

[11] These are made into the river in October and June to supply water to the seasonally irrigated lands on the large alluvial and colluvial fan downstream from Ghazni town.
[12] These are made regularly and determined on the basis of irrigation demand within the Jaghatu valley upstream of Ghazni town (dry spring/summer period) and the build-up of water behind the dam (rainy/snow melt season).
[13] These small pumps operate efficiently down to 6 m suction head. Most pumps are located 2–3 m below ground level indicating that groundwater depth in the main summer irrigation period is about 10 m.
[14] This is according to the head of the PID in Ghazni.

lower valley north of Ghazni. This could have a serious affect on the groundwater depth in the valley, and impact on both the river recharge and the tree crops that depend on the shallow table in summer months.

Figure 3. *Typical canal layout*



River water is diverted to the irrigated areas by masonry and concrete diversion weirs that extend across the whole river (10–20 m) and supply canal intakes located either on the left or right banks. Few of the original traditional weirs exist, with almost all having been replaced by improved weirs built by NGOs since 1992. These weirs normally supply only one canal and are of similar design and capacity since the course of the Ghazni River from the dam to Ghazni town is very stable and lined in most places by willow and poplar trees. Some structures have minor erosion problems, probably caused by flood surge from the failed Band-i-Sultan dam.

About 30 main villages have irrigated lands within the valley floor, and each is supplied by one or more canals. Larger villages like Qala-i-Naw are supplied by several canals, each with their own diversion weir, and the longer canals supply more than one village (see figure 3). In some cases the weirs are located within the bounds of the village and in others they are located on the upper village's land. For the three research sites, Chel Gunbad is supplied by one canal that also supplies other downstream villages, Turmai by two canals (upper and lower Turmai canal) with the upper canal being quite long and supplying three further villages, and Qala-i-Naw by three canals (Balai, Sokhta Jangal and Jangalak).

All systems use the main canal as the conveyor, with water diverted into secondary canals to supply irrigation units (small plots of land) within which water is channelled to the farmer's fields either directly from the secondary canal or through tertiary and/or field channels. The further downstream from the intake, the more complex the secondary and tertiary systems become, as the canal moves closer to the surrounding high land and further from the irrigated areas. For the upper half of the Jaghatu valley, water does not seem to be a constraint and this is reflected in the cropping patterns and fewer tree crops. Further down the valley, below Qala-i-Naw, surface water shortages do occur and this is reflected in the greater proportion of tree crops that are probably using the relatively high groundwater levels. Within each command area, shallow wells are used for supplementary irrigation. Some of these are new wells; others have been built on former *arhat* sites.

Within the valley floor, the soils comprise deep silty clay loam with some gravel, which have their origins in the material deposited over the many hundreds of years of irrigation. The area is typical of irrigation in quite steep land, comprising:

- Terracing from the main canal towards the river;
- Canals traversing the agricultural land at an angle to the river to gain as much command as quickly as possible and thereby dividing the land owned by a village into diagonal parcels (see figure 3);
- Canal command areas forming the boundary between upstream and downstream villages;
- Intakes for lower villages channelling water from the river within the boundary of the upper village;
- Some land from the upper village being supplied by the lower canal within its own boundary.

Water management, and system operation and maintenance

Although each canal was reported to have a *mirab*, it was found that only in those lower villages below Qala-i-Naw, where water is a constraint, were *mirabs*[15] appointed. In the upper villages, including in the primary research sites, water issues and operation and maintenance are decided by a forum of elders within each village. Water is allocated by rotation within the canal systems using the *shab o roz* system. In winter and spring there is usually no shortage, and farmers take water as and when they need it. Long summer cycles were reported by the villagers,[16] however, considering actual cropping patterns, either farmers are trading in water or they are able to obtain it at 4–5 day intervals at peak periods of demand for water. This would require closer examination.

A system of informal exchange or loan (*qarz*) of water exists for users at the downstream ends of canals during peak demand periods. Requests from tail-enders to upstream users for additional water to supply suffering crops will be agreed to on individual bases. The repayment is also in water, with the farmer who allows additional water to flow down to the petitioner then having the right to take the same amount of water from the irrigator when he needs it. Water is also sold from the pumped wells for 200–300 Afs per hour, and this water is conveyed into the existing secondary or tertiary canal network. Such arrangements will explain why farmers are able to grow vegetables in the summer in some areas. *Hawz* are used on some of the canals, but the small sizes of these indicate limited storage and perhaps other uses such as livestock watering.

Annual cleaning is organised and supervised by the head of the village *shora*. The number of days required from the users for this cleaning is variable and depends upon the state of the canal. If particular problems are encountered, additional labour will be requested from the land owners and sharecroppers. When a breach occurs in the canal, or emergency cleaning or repairs are needed, land owners and sharecroppers are again requested to provide more help. Structural repairs are also the responsibility of the community. According to head of the *shora*, the structures built by DACAAR and CARE both in the river and at the offtakes are all owned and maintained by the community and not by DEW (which also claims it owns and

[15] The *mirabs* from lower Jaghatu valley (eighteen below Qala-i-Naw) meet with the PID every two weeks to discuss water demands and shortages.
[16] Both upper and lower canals were reported to be on an 8–10 day rotation system.

maintains them). Selected farmers have been trained by some NGOs in structural inspection and repair, but as the permanent structures are relatively new, no major maintenance is anticipated in the short to medium term.

Crops and cropping patterns

Wheat, fodder,[17] potatoes, some barley[18] and vegetables[19] are the main crops, with apples, plums, apricots, some pears and peaches, and potatoes being important cash crops. Fruit trees are mostly grown in the lower part of the valley and the produce is sold either in advance to merchants who are then responsible for guarding, picking, packing and transporting the crop, or directly into markets[20] by the owner. In this case, the owner picks, packs, transports and markets the crop.

Programmes in the area

NSP is assisting Turmai and Qala-i-Naw, with DACAAR as the implementing partner. Prior to these interventions, DACAAR worked with the same communities on an integrated rural development programme. Earlier still, CARE and IRC assisted some villages with irrigation infrastructure. The result of this past assistance has meant that almost all river diversions have been rehabilitated with permanent structures, and many more permanent on-farm structures have also been built.

Sites located in the side valleys

Two primary research sites (Pyada Rah and Zala Qala) are located in small side valleys in the foothills to the west of the Jaghatu valley. The climate is similar, but water is much scarcer, with irrigation relying on flow from *karez* and springs. In both areas, *karez* are most important and include one main long *karez* serving the main village areas, probably the oldest and at a lower elevation than the others, and supplemented with flow from several short *karez*. These short *karez* have smaller flows and are upslope from the village and the main *karez*, but they tap the same seasonally fluctuating aquifer. In Pyada Rah, DACAAR has been assisting with the construction of improved *hawz* and other related works.

Irrigation water and canal systems

Pyada Rah village has five *karez* that derive their water from the colluvial material above the village and one improved spring collection system supplying a total of about 100 *jerib* of irrigated land (table 4). Each *karez* has a *hawz* for both night storage and flow accumulation that is located near where the *karez* first emerges. These supply gravity canal distribution systems through a gated outlet and also receive return water from higher irrigated areas and canal systems. Farmers mainly grow a winter or spring crop; few grow summer crops as water is insufficient. Even winter flows suffered in the drought period, but they have now recovered well following good winter snow and spring rain in early 2005, and the assistance provided by DACAAR for *karez* cleaning.

[17] Lucerne (up to 6 years, 3–4 cuts per annum); clover (3 cuts per annum).
[18] Sown in spring for grain, and in summer for an autumn cut as green forage.
[19] Onions, carrots, tomatoes, eggplant and spinach.
[20] Such as Ghazni or Jalalabad, and Mazar-i-Sharif where local apple production is not possible due to climate.

Table 4. *Names and brief details of Pyada Rah* karez *(north to south)*

No.	Name	Remarks
1	Khinjakak	Privately owned. Small working. 3 shafts. Short *karez*.
2	Said	Dry and collapsed. Landlords living in Kabul.
3	Abi Qol	More like a *karez* that collects water from within a wash. Built with the help of DACAAR in 2000–01. Flows about 1–2 L/s and the best noted in the area. The overflow from this canal system flows into the *hawz* of the Sakob *karez*.
4	Sakob	Traditionally shaped *karez* tunnel. Flows about 1 L/s. *Hawz* about 80 m from where *karez* first appears. 10 days rotation.
5	Butawak	Privately owned. Small.
6	Shewan Ab	The largest and lowest of all the *karez*. Flows 2–4 L/s and seems to be a stable *karez*. 30 shafts. 10 days rotation.

It seems that the larger Shewan Ab *karez* is the oldest with the others having been built later to accommodate increases in village size and the need for more irrigated land. The shape of the *karez* tunnel at its outlet shows a narrow cross section with traditional stone-lined construction and a top slab placed across the side stones. Pyada Rah is a small village with obvious sources of support from outside farming. This was confirmed during discussions with the elders.

Table 5. *Names and brief details of Zala Qala* karez *(north to south)*

No.	Name	Remarks
1	Khordi	Only the Nokai *karez* was visited, which is reported to be the main *karez*. It was quite small in cross section and not visibly larger in flow than the main *karez* in Pyada Rah. From the description received, it would seem that most if not all of the other *karez* are "short" – less than 1 km. There will be at least one "long" *karez*, the village's original *karez*.[21] This will need to be investigated further.
2	Nokai	
3	Kuli Bahud	
4	Qulali	
5	Sakawa	
6	Siyanaw	
7	Passinab	
8	Small Yaksi	
9	Yaksi	
10	Lower Dawlat	
11	Upper Dawlat	
12	China	
13	Lara	

Zala Qala village has thirteen *karez*, of which two are larger than the rest with one of each located in the two main sub valleys (table 5). As with Pyada Rah, these are the older *karez* and the main sources of water for the irrigated land in the village. The origins and layout of the *karez* appear similar to Pyada Rah, with the greater number of smaller *karez* reflecting the larger village and the need to accommodate the growing population.

The cropping systems are similar in both villages, and both suffered badly during the years of hostilities and also in the recent drought. Most of the *karez* are now running close to full capacity and this has enabled almost all of the land to be brought back into production. There is a problem with land mines on some of the rainfed land and a small part of the irrigated land, and this affects about 70–80 *jerib*. Land holdings

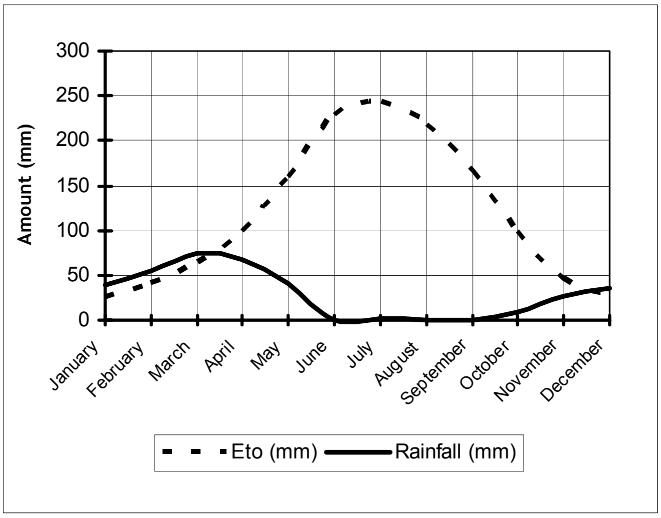
[21] See I.M. Anderson, 1991, *Report on UNDP Support to* Karez *Cleaning*, UK: Agrisystems.

are small, 1–4 *jerib* per household, and this limits the amount of food that can be grown for home food security – necessitating additional off-farm employment. The main crops are winter wheat sown in Tir Mahi, and spring crops of barley, clover (*shaftal*), lentils (*adas*), *shokhal*, field pea (*mushing*), vetch (*shakhal*) and potato if there is enough water. Some apples, apricots and mulberries are grown with fodder crops also cultivated in the orchards. Up to four cuts per year can be achieved, depending on the amount of irrigation water available, with clover being cut green for both livestock and human greens in spring. Neither village has a *mirab*, with the *karez* in both villages being managed by their respective *spingira*. All villagers know their water rights and these are based on *shab o roz* allocation of water in both villages. Cleaning of *karez* is not needed every year, but when it is required the village elders organise contributions from the benefiting farmers.

3.3 Kunduz

Qala-i-Zal district of Kunduz province is located in the lower flood plain of the Kunduz River Basin, one of Afghanistan's major river basins. It features two main rivers, the Baghlan and the Khanabad, that meet just north of the town of Kunduz and it contains significant areas of irrigated agriculture. Below this confluence, the combined flow is called the Kunduz River. In this area, the river has meandered extensively, exacerbated by insufficient protection and repair works during the period of civil strife from the 1980s to the early 90s. All three primary research sites are located on the right bank of the Kunduz River. As with other provinces in this study, crop production without irrigation is not possible. A better balance between Et_0 and rainfall exists in this area (figure 4), but the variability of the rainfall combined with the hot spring and summer months (table 6) means that supplemental irrigation is needed from early April for the spring months and full irrigation is needed in the summer.

***Figure 4**. Moisture deficits, Kunduz*[22]



Irrigation has been practised in this area for many hundreds of years, and during the last century, additional, more marginal lands have been brought under irrigation by the settlers who have come from both within Afghanistan as well as from across the border in the former Soviet Union. Although canal alignments and irrigated areas have been well established, uncontrolled river movements and heavy siltation in some canals have created significant problems for farmers in maintaining the sites for their intakes and retaining the extent of their irrigated lands. During the 1970s before the Soviet invasion, plans were in place to provide irrigation water for all the right bank irrigation command areas by means of a high-level canal taking off from the Khanabad barrage. Unfortunately these have not materialised and the problems experienced by the canal systems

[22] Mission estimate from CLIMWAT climate and rainfall data files.

persist. Under the KRBP it has been recommended that these options are revisited. In the meantime, immediate works for improving the intakes of some of the major canals are being planned. These include: reduction of damage by flood flows; limiting the silt that enters the canals; and improvements to structures whose repair and cleaning consume considerable time and effort of the benefiting communities.

***Table 6**. Kunduz climate data*

		Temp (Celsius)		Hum-idity (%)	Wind (Km/d)	Sun-shine (hrs)	Solar rad. (MJ/m 2/d)	Et_o (mm/d)	Rain-fall (mm)
		Max	**Min**						
Kunduz 433 m (a.m.s.l) Latitude 36.4 N, Longitude 68.55 E	Jan	7.3	-2.4	84	121	3.4	7.3	0.81	39
	Feb	10.6	0.9	82	147	4.5	10.2	1.3	55
	Mar	16.1	5.7	82	147	5	13.4	2.05	75
	April	22.2	10.9	80	156	6.4	17.7	3.23	67
	May	29.6	14.9	65	156	8.8	22.6	5.14	41
	June	37.1	20.5	36	173	10.6	25.7	7.4	0
	July	38.7	23.1	35	190	10.7	25.5	7.85	2
	Aug	37	21.4	35	181	10.6	24	7.05	0
	Sept	31.8	15.9	38	173	9.8	20.4	5.4	0
	Oct	24.2	9.9	52	156	7.1	13.9	3.18	8
	Nov	15.5	3.5	69	121	5.8	9.9	1.48	26
	Dec	9.5	-1	83	121	3.7	7	0.83	36
	Av.	**23.3**	**10.3**	**61.8**	**153.5**	**7.2**	**16.5**	**3.81**	**349**

Source: FAO Cropwat 4 Windows 4.3, CLIMWAT Climate and Rainfall Data Files

Irrigation water

Irrigation water for two of the primary research sites (Afghan Mazar – Char Gul canal and Wakil Jangal) is obtained from the Khanabad River, just upstream from its confluence with the Baghlan River. The third site (Dana Haji – Aq Tepa canal) is supplied from the Kunduz River just downstream from the confluence. Initially it was thought that the three sites were on the same canal, but further investigation showed that they are on three different canals.[23] Although the catchment area of the Khanabad River (~10,000 km^2) is less than half that of the Kunduz River (~24,000 km^2), both tributaries have similar mean monthly flows (table 7). Part of this may be due to the limited runoff from the intermediate catchments of the Baghlan River and part due to Khanabad River's physical characteristics (steep longitudinal gradient, smaller cross sectional area, less meandering) that influence the passage of runoff down the system. Average monthly flow data masks the pattern of daily and flood flows and more particularly the water availability for abstraction for irrigation.

***Table 7**. Average river flows (m^3/sec)*

River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baghlan	32	31	31	40	97	235	148	60	39	37	36	34
Khanabad	30	28	32	53	91	186	149	70	36	36	36	35

Source: KRBP, River Training and Control Structures, *first mission report (6 December 2005)*

[23] A similar mistake was initially made by KRBP when interpreting the satellite imagery. It is not unusual in Afghan irrigation systems to have several canals very close together and more or less parallel but at different elevations, giving the impression of one large canal.

Data from KRBP indicates no significant difference in base flow between the two rivers, but considering the more braided and wider cross section of the Baghlan River, it is likely that the flow records underestimate minimum flows due to subsurface movement of water and the difficulty of accurately measuring such flow.

***Table 8**. Maximum and minimum flows for the Kunduz River (m^3/sec)*

Ref	Station	Minimum flow (m^3/sec)		Flood flow (m^3/sec)		Remarks
		Average	80% Probability	Average	Design (1:20 years)	
13	Chardara	10.0	4.8	282	707	Baghlan river just upstream from confluence with Khanabad
8	Pul-i-Chugha	10.72	5.14	245.50	466.44	Khanabad river just upstream of confluence with Baghlan river

Source: KRBP, River Training and Control Structures*, first mission report (6 December 2005)*

Canal systems

Land slopes in the Kunduz plain are relatively flat, giving large river meander widths that affect large areas of land each year and continually change local river grades. Despite this, conveyance distances from canal intake to command area are still quite long-ranging, from 8–10 km for the larger older canals such as Aq Tepa up to 22 km for more recently developed irrigated areas such as Afghan Mazar. The older canals were able to adopt the most suitable alignment, slope and cross sections, whereas the newer canals had to adapt these to available land. For this reason, cross sections and grades for the larger canals seem suited for keeping silt in suspension[24] whereas the smaller canals encourage silt deposition which is evidenced by large silt mounds in the initial reaches of all such canals. Almost all canals supply more than one village and some, such as Safi Kot, are supplied both by its own canal and another canal (Char Gul). In these cases, communities tend to give more attention to their own canal, thereby neglecting agreed maintenance commitments for the shared canal.

***Figure 5**. Typical layout for traditional canal intakes*

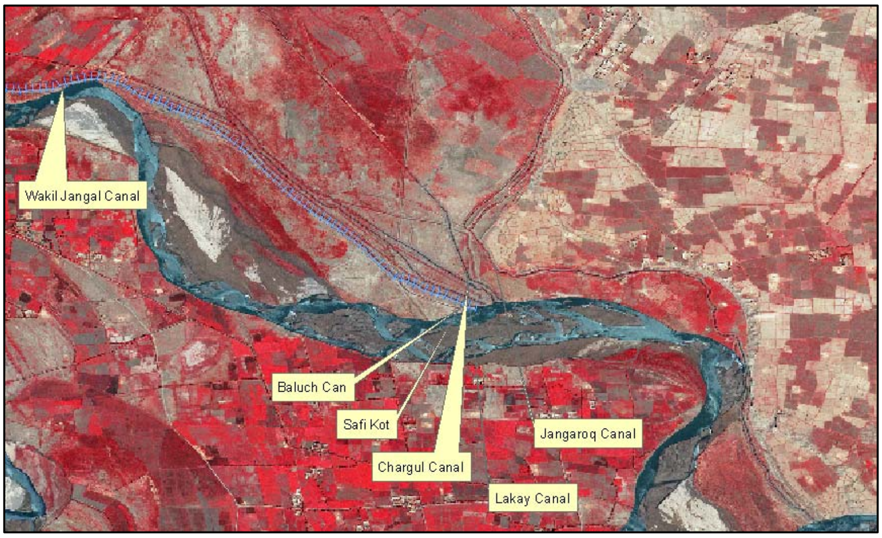
Source: KRBP, river training and control structures, first mission report (6 December 2005)

Similar intakes are used for all canals in the lower Kunduz, with river water being abstracted by means of traditional temporary diversion weirs built from soil, stones, timber and grass that extend at a flat angle into the river (figure 5). These weirs are remade every year or when they are damaged or destroyed by floods. No diversion weir supplies more than one canal, and suitable intake sites can be utilised by a number of canals with their intakes running parallel to each other. This is the

[24] Compare with Lacey's Regime Theory (G. Lacey, 1930, *Stable Channels in Alluvium*, Paper 4736, Institution of Civil Engineers, London: William Clowes and Sons Ltd., p. 259–92.)

situation for the Char Gul canal supplying the Afghan Mazar research site, as it is one of four separate canals and intakes in the same location (figures 6 and 7). In all cases the weirs are located outside the village limits with the land commanded by the canals in most cases forming the boundary of the irrigated land owned by the village. If a village has more than one canal then it is the highest canal that forms the limit of the command area.

Figure 6*. Intake site for Char Gul and other main canals*



Although flow data would indicate that sufficient water is available within the source rivers for irrigation throughout the year, water availability in the canals is affected by three main hydrological factors that reduce the amount of water that can be diverted into the canals and make excessive demands upon farmers' time (table 9 and figure 8).

Table 9*. Factors affecting ability to divert adequate water for irrigation*

	Factor	Impact
1	Low flows at start of spring irrigation season (March–April).	Although there is some rainfall, this is highly variable and much effort is needed to get water into the canals for the first supplemental irrigation of the season.
2	Short duration (up to three days) peak daily flows due to heavy rain in the catchment (April–May).	Destroy diversion weirs and when the floods have passed, river levels are too low for canal to obtain water without rebuilding of weir.
3	High flows of longer duration with diurnal variations due to snow melt (May–July). These are also exacerbated in May by high rainfall-induced runoff.	Too much water in the mid spring growing season results in frequent damage to diversion weirs and intakes at peak demand times, necessitating continual rebuilding and repairs to keep water flowing to the field at a time when farmers need to be occupied with their farming activities. At this time there will be conflicts between labour demands.
4	Low flows following snow melt season. Very little residual base flow in the flood hydrograph, giving low flows from August–April the following year.	At this time of peak crop water requirements and agricultural activities (August) there is considerable extra work for farmers to remake the diversion bund, take account of any changes in river course and land lost to river bank erosion or flood incursion and extra desilting of canals. This is not so much a lack of water, but the problem of getting it into the canal system and then conveying it large distances before it gets to the field (leads to high conveyance losses).

***Figure 7**. Main canals in Kunduz flood plain, right bank*

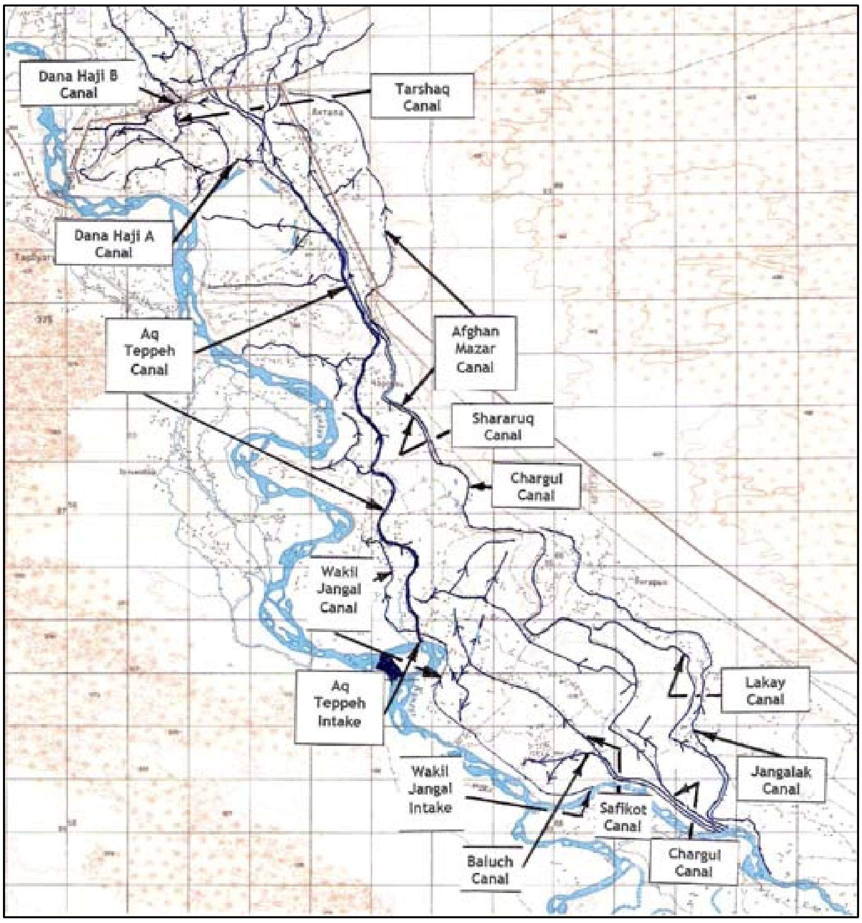
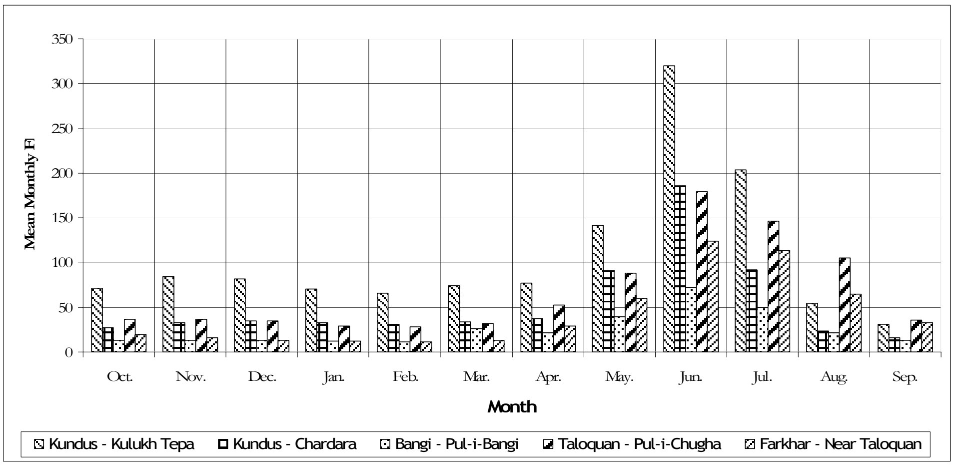
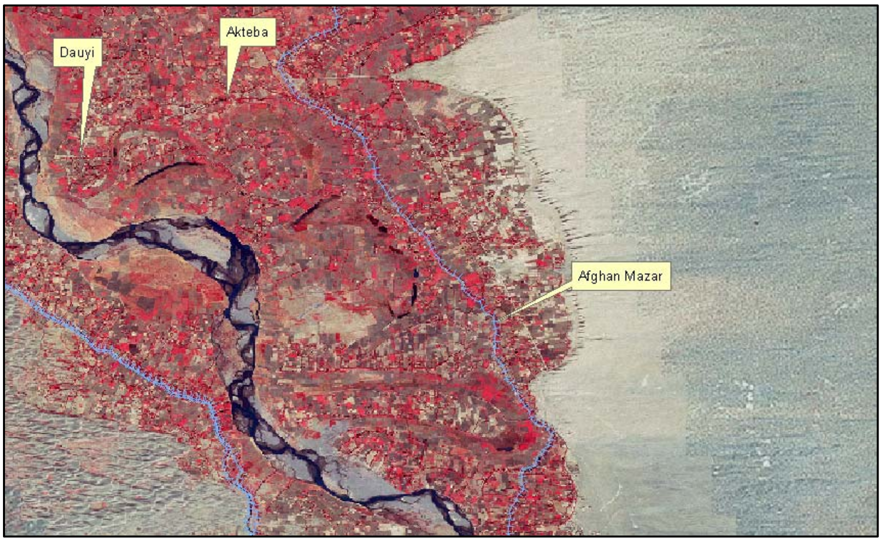


***Figure 8**. Long-term mean monthly flow data for Kunduz River (in Cumecs)*



Source: MEW/BCEOM, 2003

Figure 9. *Irrigated land, Afghan Mazar*



Command/irrigated areas

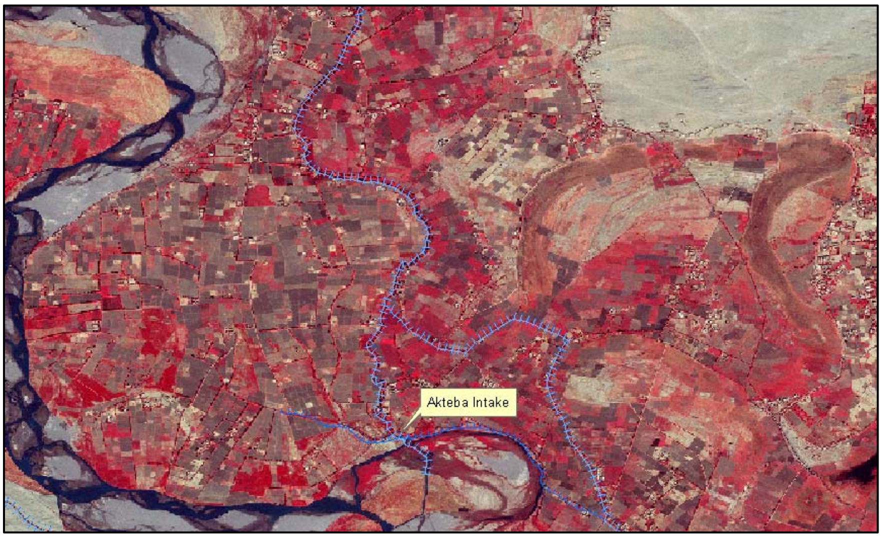
Provisional estimates indicate that the net command area of Wakil Jangal is 1,000 *jerib*, Afghan Mazar 850 *jerib* and Dana Haji 420 *jerib*. These and other details for the primary research sites will need further examination using KRBP satellite imagery together with ground truthing. The quality these data is exceptional and permits canals, drains, farm boundaries and catchments to be seen quite clearly.[25]

The village of Afghan Mazar is irrigated solely by the Char Gul main canal that also supplies the villages of Safi Kot, Baluch, Char Gul, Jangarak and Deh Afghan before it arrives at Afghan Mazar, the last village on the canal system.[26] This canal is near the intake and adopts similar alignments. Throughout its length the canal runs close to other canals and has a poor cross section (in terms of its ratio of bed width to depth). This causes high siltation and severe problems of silt removal and disposal that is both time consuming and potentially ineffective. About thirteen years ago, a head section of the canal was re-excavated, as farmers were unable to get water as far as the village. However, problems persist at low river stage. Afghan Mazar has particular problems with Safi Kot village, immediately up-canal from it, as it obtains irrigation water from both its own canal and the Char Gul canal. As such, they put less effort into cleaning and ensuring good water flow in the Char Gul canal.

Wakil Jangal is supplied from its own canal with the intake about 2.5 km down-stream from the Char Gul intake. Previously, the intake was located just down-stream from the Aq Tepa intake, but about fifteen years ago this was moved about 5 km upstream to its present site. The Wakil Jangal main canal now crosses over the Aq Tepa canal, around 30 m downstream from its intake, and then divides into three secondary canals about 150 m further down the canal. The irrigated areas supplied by the canal comprise some of the better former higher terrace land. It does, however, suffer from bank erosion, and significant areas of land to the west of the village have been lost.

[25] Quickbird high resolution imagery has a minimum order size of 25 km^2 for archive data and 64 km^2 for new data. It is of similar quality to aerial photographs and can be enlarged to 1:2000. The use of these data reduces the time for the study design process by providing recent basic data on individual project areas – requiring shorter periods of field data collection and surveys.
[26] 2,340 *jerib* with rights to irrigation from canal; see Lee, *Social Water Management*.

Figure 10. *Aq Tepa intake*



The Aq Tepa canal is a large old canal that supplies many villages, most of which are located in the vicinity of Dana Haji and in the delta-type area north of Aq Tepa Bazaar. Its capacity has been estimated at about 5 m^3/sec. It takes a reasonably straight alignment towards its command area with the first land being irrigated about 3 km from the intake. A number of villages are supplied before the first Dana Haji offtake, around 11 km from the intake and where the main canal starts to divide into a series of secondary canals to supply the delta-type area to the north of the bazaar.

Water management, and system operation and maintenance

Each main canal has a *mirab bashi*, and most communities elect their own *kok bashi* to handle on-farm water distribution. Farmers and villagers are aware of their water rights. *Mirabs* are traditionally elected in late March or early April (Hamal), but in Qala-i-Zal, communities state that the election takes place in Hut (February/March). This can conflict with maintenance works, as at this time *mirabs* are usually busy with canal cleaning. On-farm water is allocated on the basis of a local measure, *paw-ab-daqiqa*, that relates seed application to land area, similar to the *juftgaw* system in Herat. The presence of this system of measurement indicates old, established irrigation systems; the details of this, along with operation of the canal systems in both normal and dry years and the coping mechanisms adopted by those furthest from the water source, will require more detailed research.

Routine cleaning is carried out annually before the start of the irrigation season in Hut (February/March) and can take up to 60 days.[27] Labour is provided by the irrigators depending on land holding, according to a local system that converts to one person per day for 30 *jerib*, one person every two days for 20 *jerib* and one person every three days for 10 *jerib*.[28] In addition to routine cleaning, farmers must provide labour for frequent interventions to offset the effects of flow from side washes due to rainfall/runoff and diversion breaches due to diurnal snow melt and high runoff flows. A number of major problems with the maintenance operations are faced by the farmer groups:

[27] Throughout the area few irrigation structures on main and secondary canals have been improved, and much time is spent cleaning canals and repairing them at wash crossing and intake sites.
[28] See Lee, *Social Water Management*.

- Relatively long distances between the villages and sites of cleaning and repair works: all intakes are far from village (1–4 hours' walk depending upon canal);
- Major problems with desilting and disposal of excavated material (especially with the Char Gul canal); high silt mounds on the banks of the canal from previous maintenance mean that excavated material has to be handled by several farmers to raise it the 3–4 metres with no step in between;
- Disputes between farmers on neighbouring canals on where to place the silt so as not to affect other irrigation canals and the command of the land;
- Conflicting demands for family labour between agricultural, operation and maintenance, and domestic activities; and
- Poor cooperation among villages (reported by villagers interviewed in Afghan Mazar).

Crops and cropping patterns

In many parts of the Kunduz valley, only one crop per year is possible because of water shortages that relate more to issues of getting water the long distances to the field rather than too little water in the river. Full water requirements are achieved from May–July, provided that the intakes survive the high flood flows. At this time of year river water levels are high enough to enable full supply to enter the canals. From August onwards, levels in the river are much lower and it is far more difficult for farmers to ensure that full supply levels are achieved in the canals.

Crops cultivated include wheat and barley, clover and some lucerne. If there is enough water for a second crop, farmers will cultivate some vegetables: carrots, turnips, cotton, mung beans, flax, sesame, maize, green maize for fodder and melons. Some farmers have fruit trees but many were lost during the drought. Some farmers cultivate poppy, but this is not a common crop at present. Farms with good water supplies grow cotton and rice but these water-demanding crops are discouraged to enable the limited summer water supplies to go further.

Severe soil salinity exists within the Kunduz–Khanabad flood plain, and it is exacerbated by limited or no drainage.[29] Although no technical details are available, this salinity is very visible – especially adjacent to and north of the Char Gul intake where tracts of land are either out of production or are becoming unproductive. It is probably prevalent in other areas but it is obscured by farmers cultivating the salt deposits back into the soil. The salinity is reported to be from a combination of the soil and water, but this has yet to be confirmed as no measurements of soil or water quality have been made. One major concern relates to the livelihood of farmers who have abandoned their land: little is know about this and it is unlikely that they have moved into livestock, as farmers need some irrigated land for this.[30]

Programmes in the areas

Most irrigation-related activity in the lower Kunduz is being undertaken with EU funding for the KRBP. This has five components and is implemented by government through contracts with private companies and NGOs:

- river basin planning;

[29] This, together with insufficient rainfall and water for leaching, will lead to a build-up of salts in the soil profile.
[30] See Fitzherbert, *Livestock Husbandry*.

- upstream catchment conservation and forest regeneration;
- social management of water;
- irrigation rehabilitation; and
- capacity building.

The KRBP, which will run for four years, was preceded by preliminary feasibility studies, with the main programme inputs starting in June 2004. Government is supported by a technical assistance team that comprises long-term and short-term international staff[31] working with locally hired engineers. It started slowly because of the time it took to hire suitable staff and find an appropriately equipped office in Kunduz, and the first contracts for improved infrastructure will be granted in 2006. A primary task of the technical assistance component is training of (mainly government) staff for the (future) RBA.

A number of activities relating to crop production/improvement and canal cleaning/ provision of structures are being undertaken by other agencies (FAO, WB-EIRP) and NGOs (GAA, Mercy Corps), and research in the primary research sites is being done in close cooperation with these. One research site is located at Mia Ali, to the south of Kunduz, and although there is no irrigation in this area, GAA have been working successfully on water harvesting there. This develops local knowledge and skills and offers potential for use elsewhere where irrigation water sources are very limited.

3.4 Herat

The research sites in Herat province are located on the right bank of the lower Hari Rod River River in Pashtun Zarghun district (Tunian and Ghorak) and in the rolling hills of Kushk, due north of Herat (Khalifa Rahmat and Sir Zar).

***Table 10**. Herat climate data*

		Temp (Celsius)		Hum-idity (%)	Wind (km/d)	Sun-shine (hrs)	Solar rad. (MJ/m2/d)	Et_o (mm/d)	Rain-fall (mm)
		Max	Min						
Herat 964 m (a.m.s.l) Latitude 34.13 N, Longitude 63.13 E	Jan	10.4	-2.9	76	199	4.3	8.7	1.4	45
	Feb	13.2	0	75	225	4.4	10.7	1.91	35
	Mar	18.6	4.2	67	276	5.2	14	3.19	48
	April	23.6	8.3	70	233	5.6	16.9	3.94	32
	May	29	13.2	53	242	9.3	23.5	6.07	8
	June	34.6	18.3	44	294	11.4	27	8.24	0
	July	36.4	21.2	39	397	11.7	27.1	9.81	0
	Aug	35.2	19.1	37	363	11.3	25.3	8.91	0
	Sept	31.4	13.2	45	251	10.4	21.7	6.13	0
	Oct	25.4	6.9	54	199	8	15.6	3.8	1
	Nov	17.4	0.6	66	164	6	10.8	2.04	9
	Dec	12.4	-2	73	164	4.4	8.2	1.39	33
	Av.	**24**	**8.3**	**58.3**	**250.6**	**7.7**	**17.5**	**4.74**	**211**

[31] Technical assistance is provided by a consortium of Landell Mill Limited and Mott MacDonalds and partners.

Sites using water from the Hari Rod

The climate in Herat Province is the harshest of all the primary research areas. Limited rainfall and high evaporative rates means that only in January does rainfall balance ET_0 (table 10). Crop water demand is high for both spring and summer crops, and frequent and regular irrigation is essential for good production.

Irrigation water and canal systems

Irrigation water for Gawashk and Tunian is derived from the Hari Rod via the Atishan canal. This canal supplies ten villages, with Gawashk being the first and Tunian about midway (table 11). It is one of many quite long canals that have intakes some distance from the villages that they supply,[32] as the 6 m high banks of the Hari Rod River mean that it is about 5.5 km before the canal can command the land. In addition to this, the highly braided river course of the lower Hari Rod near the Atishan canal intake means that the river sometimes flows close to the right bank, where the intake is located, and sometimes on the other side, close to the left bank which is more than a kilometre away.

***Table 11**. Details of villages supplied by Atishan canal*

Villages and secondary canals supplied by Atishan canal		House-holds	Families	Population	*Juftgaw*	Command area (*jerib*)
1	Gawashk	19	56	311	6	720
2	Pushtin	25	71	365	6	720
3	Bala Deh-i-Turan	51	163	990	12.25	1470
	Payan Deh-i-Toran	63	133	790	0	0
4	Aliabad				13	1,560
5	Qala-i-Namak	36	92	552	4	480
6	Tunian				20	2,400
	Mahalla-i-Masjid-Jame Tunian	52	151	906	0	0
	Mahalla-i-Gaw Khoran-i-Tunian	52	142	607	0	0
	Mahalla-i-Qala-i-Kohna-i-Tunian	44	112	601	0	0
	Mian Deh-i-Tunian	35	72	683	0	0
7	Qala-i-Khalisa	35	170	526	20	2,400
8	Qala-i-Zewar Khan	20	80	398	2	240
9	Qala-i-Sayed M. Khan	30	50	251	2.75	330
10	Aliabad	unknown	unknown	unknown	14	1,680
11	Jenda Khan	unknown	unknown	unknown	20	2,400
	TOTAL				**107**	**14,400**

Source: DACAAR, Herat; AREU farmer discussions, December 2005

In spring and early summer (late March—May), water levels in the Hari Rod are high enough that the flow spreads across much of the river course and close to the Atishan high level or spring intake. Diversion of water into the canal at this time is therefore relatively easy. Once the main flood period has passed, water levels drop significantly (figure 11) and surface flow becomes scarcer, spreading thinly across

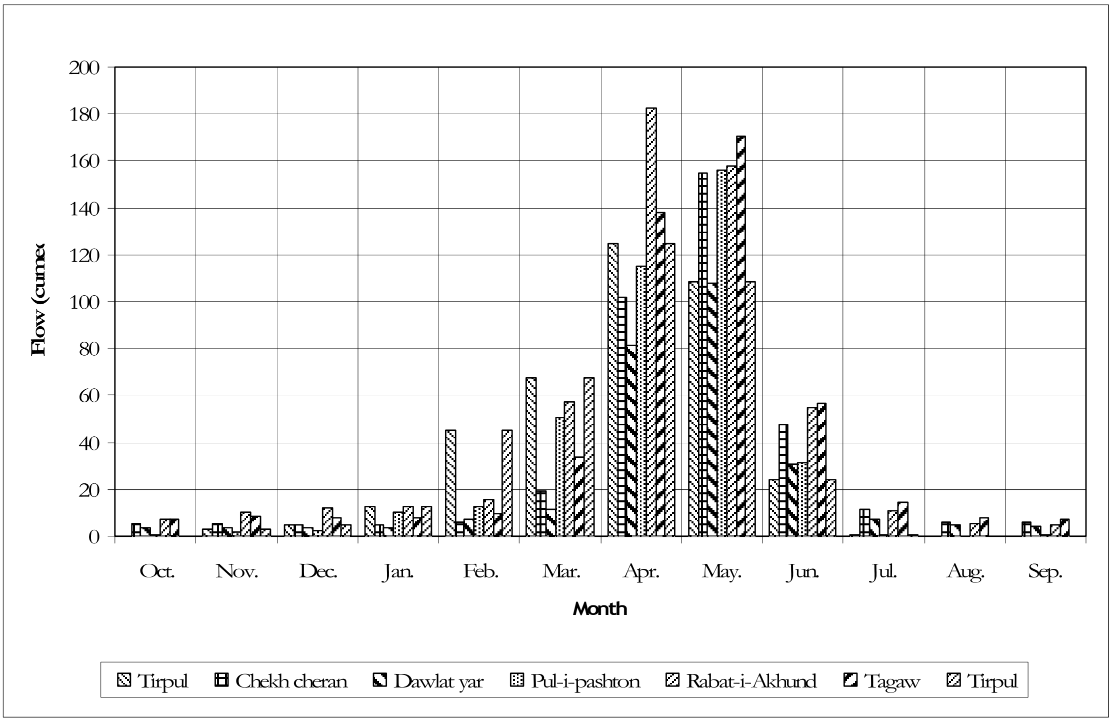
[32] EIRP is planning rehabilitation of structures on the primary canal.

the whole wash. Farmers must then use the summer low-level intake near Burya Baf village, downstream from Marwa and around 16 km upstream from Gawashk, and 10 km above the spring intake. At this time of year, water available for irrigation is a combination of surface and subsurface flows that are forced to the surface in certain places by subsurface rock strata. Farmers manage to tap these "springs" by building a series of bunds in the river course to divert flow towards the right bank intake.[33] As the flows decline further, the Atishan *wakil* will have to agree with the *wakil* of the upper canals to permit flows to pass down to their diversion.[34]

Command/irrigated areas

Data on the areas commanded by the Atishan canal vary greatly from 7,500 ha (EIRP) to 4,000 ha (DACAAR). Estimates made from available maps and satellite imagery indicate a figure of around 2,250 to 3,000ha (11,250 to 15,000 *jerib*), considering the intervening washes, wash disturbed land and land lost due to river bank erosion. This agrees with approximate conversions from the local units of measure.[35]

***Figure 11**. Mean monthly flows for the Hari Rod (m^3/sec)*



Source: Ministry of Energy and Water (MEW)/BCEOM, 2003

Conveyance of the water from intake to the irrigated areas presents major problems as the canal crosses many washes, and in its upstream reaches above Gawashk it is very close to the river course. The river banks are deep silt, around 6 m high, with

[33] In the past, these "springs" were closer to the right bank near to Burya Baf village. Over time the accumulation of transported material in the Hari Rod has covered these places, and surface water is now found further upstream and nearer the centre of the river course, making the process of diversion and abstraction much more difficult.

[34] The Atishan canal used to have a formal water-share agreement with four upstream canals: Marwa (Marabad), with the most water; Zamanabad; Burya Baf; and Shukur Khan. See Lee, *Social Water Management*, for more detailed explanation.

[35] 14,400 *jerib* or 2,880 ha. Part of the confusion arises from the conversion of the *juftgaw,* the local historical measurement of water and land. This is the amount of land that two oxen can plough in a day and reflects land type, slope and soil. It varies locally and therefore does not easily convert to a standard unit of measure.

the top layers comprising pure silt and the lower layers silt and gravel. This is very erodible material and collapses easily when undermined by the river. Farmers have attempted to move the river away from the banks by building stone spurs across the river bed near them, but each year more land, and often parts of the main canal, are lost.

Water management, and system operation and maintenance

Tunian canal[36] has one offtake from the Atishan canal, just downstream from the Surkh Rod wash, and it supplies about 2,400 *jerib*. A total of twelve tertiary canals are supplied from six rebuilt division boxes.[37] These have been sized in accordance with the agreed *juftgaw* and fitted with simple vertical lift gates. The designs were discussed closely with the farmers, but omitted considerations of disposal of excess flow.

Table 12. *Details of tertiary canals supplied by Tunian Canal*

Tertiary canal (*joy*)		Division structure no.	*Juftgaw*	Remarks
1	Sariol	1	2	~
2	Lar-i-Dawran	1	2	~
3a	Lar-i-Tarozar Bolar	2	1	~
3b	Lar-i-Tarozar Payan	2	1	~
4	Gosha	3	1	~
5	Pushtawan	3	1	~
6	Shasht	4	2	~
7	Pushtidai	4	2	~
8	Howsak	5	1	~
9	Baghar	5	1	~
10	Baiyi	6	1	Not visited
11	Mobanide	6	1	

Source: Discussions during first field visit, December 2005

As part of the process of farmer involvement, DACAAR assisted in the establishment of the Atishan Canal Water Users Association (ACWUA). Membership dues are being collected and already amount to about 50,000 Afs. The Association's charter[38] sets out some activities and responsibilities for the WUA, but it will need further improvement and elaboration as farmers currently see this as a farmers' association or cooperative rather than an organisation to assist them with canal and water management.[39] It provides a good starting point for farmer cooperation and transparency in relation to water-related issues. Although water rights are historically known by the canal users and are calculated in *shab o roz* (24-hr flow) dictated by land size, discussions during fieldwork revealed a gap between theory and practice. Allocation for Tunian is sixteen hours of flow every ten days during the dry season.

In the flatter alluvial soils that derive from silt deposited by the Hari Rod, good on-farm water management is practised. Furrow, basin, border strip and raised beds are used to irrigate a range of cereal, vegetable and fodder crops. At the start of each canal network and on the periphery of the villages where slopes are steeper and

[36] Known locally as the Joy-i-Deh.
[37] Improved by DACAAR and the community (labour by farmers; materials and guidance by DACAAR).
[38] Written by a DACAAR engineer following a study tour of India.
[39] Discussions during fieldwork revealed that farmers see it as a source of funding for animal or other purchases for members.

soils coarse, application practices are rather poor, and wild flooding is common. On the steeper alluvial fans this practice is observed throughout, except near Herat where border irrigation is used with the land divided into 1–3 m wide strips.

System operation and maintenance is carried out under the planning and supervision of the Atishan canal *wakil*, who has been in the post for 30 years and owns ten *jerib* of land in Tunian. At present he is assisted by two *mirabs* also from Tunian, but there is sufficient flexibility within the system for additional *mirabs* to be elected if required. Apart from routine desilting and cleaning works, the main problems facing the *wakil* and *mirabs* are:

- the damage caused to the canal by the numerous washes that divide the flood plain from the surrounding hills;
- loss of land and main canal due to river bank erosion by the Hari Rod; and
- getting water into the main canal at times of low water in the Hari Rod.

Crops and cropping patterns

In late autumn, about 50 percent of land is planted with wheat, the main subsistence crop, with some of the remaining land planted with Persian clover that is cut 2–3 times annually. The early cuts are used for green forage, with the last cut often kept for seed. The residue is fed to livestock along with wheat and barley straw and the residues from peas and other legumes. In spring (Hamal/Sawr), millet, some cotton, barley (for grain and straw) and a variety of legumes, pulses and vegetables (broad beans, field peas, lentils, chick peas) are planted. If there is sufficient water, some potatoes may also be planted. In addition to these, a wide variety of vegetables are cultivated for household consumption including onions, spinach, carrots, turnips, white and red radish, eggplant and tomato. About 25 percent of the land is fallowed in this cycle[40] and then planted with wheat the following November, along with a proportion of the land sown with wheat the previous year. In some places where water availability permits, perennial lucerne is cultivated and usually managed for 5–8 years before ploughing in. If there is sufficient water, 6–7 cuts a year can be obtained, but less if water is a constraint. The early cuts are fed to the livestock as green forage, the later cuts dried for hay.[41]

Although salinity is not reported as a problem, much salt was seen in the dry areas in the river bed and bank sides. This could well be in the soil, as the farmers report, but it should be examined further as it may be influencing yields. At present, no water quality or soil tests have been made, and this must be addressed.

Programmes in the areas

Tunian village has received assistance from both DACAAR and NSP using DACAAR as the implementing partner. The support has been systematically provided, and as well as small irrigation structures built at each tertiary canal turnout, culverts under the access roads have also been provided. With earlier DACAAR support, a culvert crossing beneath the Surkh Rod wash at the Tunian offtake was provided, as well as a gated structure on the Atishan canal to permit the division of flows. This now needs rehabilitation and improvement, and is expected to be included under EIRP that is planning to rehabilitate the main structures on the Atishan canal in 2006. The Kunduz PRT is also intending to support canal wash crossings in the area.

[40] Tunian village practises rotation of water and land.
[41] For details on crops and farming systems, see Fitzherbert, *Livestock Husbandry*.

Other sites within the Hari Rod valley

Ghorak village is a small community of about 35 households and a population of 350, located in the foothills to the northeast of Tunian at about 1170 m a.m.s.l. and 40 km from Herat. In the east, the village is bounded by a seasonal river with a small perennial base flow provided by a spring around 1 km upstream. To the south the now-defunct Zamanabad canal delineates the village limits. This site typifies those along the foothills where small springs occur at the break slope between the steep hills and the outwash fans that form the sides of the valley. There are no *karez* or other springs in the vicinity of the village.

The flow of Ghorak spring is about 2–4 L/s at source and by the time it reaches the village, it is following subsurface. Before DACAAR built the well and hand pump two months ago, this spring provided the village drinking water – an old and reliable source that did not dry up even during the drought. This is still used as villagers maintain that the yield of the new well is too small to meet community needs. Field observations indicate that the well discharge is insufficient to meet peak demands and that some form of storage facility would help. This would be possible considering the site topography.

From the end of January to the end of June, stronger runoff flows occur in the wash and are used for flood irrigation of about 30 *jerib* of spring crop. Under NSP, a new diversion weir and main canal were built from the wash to just above the village. Construction quality is reasonable but the design concept is poor – failing to recognise that the canal will be overtopped by flood flows. Some strategically placed simple gates would have greatly enhanced the works and reduced future maintenance requirements. Near the village, the canal slopes are very flat, producing high losses. The farmers plan to line this section, but the levels will need careful examination to ensure that the canal can command the extra back garden land in the village that they want to irrigate.

The main irrigated land on the right bank of the wash downslope from the village is steep (5–10%) with poor, stony soils. Farmers understand that the land is not very productive and adopt a lower seed rate than for flood plain alluvial soils (about 5–6 *man* per *jerib*). Wild flooding down the slope is an unsatisfactory irrigation method: it causes further reduction in soil fertility as the fines (small particles) are washed out by the fast-moving irrigation water. Twenty families are involved with this irrigation and the land used is rotated from year to year. If rains occur in January, farmers sow wheat (the main crop), barley, legumes, chick peas and fodder, finishing the crop with irrigation from the wash. Other crops cultivated include *talkhak* and *shamlit*, both very drought-resistant[42] legumes/pulses that yield higher than wheat under these conditions. Farmers mentioned that their constraint is water and not land; however, they could already cultivate 1–2 ha of summer-irrigated vegetables or fodder crops. Their apparent lack of interest in crops is probably due to livestock production, their main interest, and conflicting labour demands.

Sites in Kushk

Khalifa Rahmat Ulya

The two main villages in this valley take their name from the Khalifa Rahmat wash. Most houses of the total of 150 households and about 500 *jerib* of irrigated land are located on the right bank, and access to the village can be a problem in the rainy

[42] These require only two irrigations.

season as the wash is steep and fast when in flow. Drinking water is obtained from seven shallow wells (12–15 m deep) in the village built by DACAAR.

Irrigation water and canal systems

The main source of irrigation water for Khalifa Rahmat (1,300 m a.m.s.l) is a perennial spring source rising in the high hills near Qala-i-Uchi, around 3.5 km to the south. This spring provides reliable flows that were only partially affected by the prolonged drought, when the flow decreased by about half. Once the stream leaves the rolling foothills, much of the flow disappears into the wash, only emerging in places where the subsurface strata pushes it to the surface. Farmers have developed two intakes for the main right bank canal, the lower one using seasonal runoff from the right branch of the wash and late spring flows, and the upper one on the left branch near the village of Qala-i-Uchi at a narrow rocky site where flows are always on the surface. A smaller left bank canal that directly taps wash surface flows supplies the irrigated lands across the wash from the main village.

All the canals have poor cross sections and the main right canal follows a tortuous alignment close to the hills. This crosses many small washes and depressions before reAching the irrigated area, producing high conveyance losses. Once it has passed through Khalifa Rahmat-i-Ulya, the right bank canal continues a further 1.5 km downstream to serve the other village of Khalifa Rahmat-i-Sufla. Flows for the lower village can be expected to be small and erratic and are supplemented with runoff water harvested from the neighbouring hills.

Command/irrigated areas

Average land holdings are 1–3 *jerib* but a wide variation exists, ranging from landless households to more than 10 *jerib*.

Water management, and system operation and maintenance

The three villages in the valley share the wash flow, using a seven-day rotation system. Under this arrangement, Qala-i-Uchi, the most upstream village, receives the first day, Khalifa Rahmat-i-Ulya the next five days, and Khalifa Rahmat-i-Sufla, the lowest village, the last day. Within Khalifa Rahmat-i-Ulya, irrigation is provided on a rotation basis with one hour of flow provided per *jerib* every seven days. The village does not have a *mirab* but will nominate one when water shortages or disputes occur. Responsibility for operation and maintenance is assumed by the *arbab* who assigns cleaning and repairs in proportion to the amount of land owned. The main maintenance takes place in spring (April) before the start of irrigation. Additional cleaning to remove any restrictions in the flow is done in August and September when demand is high and flows are small. When a *mirab* is appointed, he receives a payment of 5 *kharwar* (approximately 400 kg) of wheat contributed by farmers in all three villages using the canal water.[43]

[43] See Lee, *Social Water Management* for more details.

Crops and cropping patterns

The main crop of winter wheat is planted at the end of November (Dalw) and harvested in mid August. A seed rate of about 7 *man* (4 kg) per *jerib* (*joft*) or 140 kg per hectare is used.[44] Farmers who cultivate wheat generally plant about half of the land, sowing the remainder in spring (Hamal/Sawr) with Persian clover, chick peas, onions, some barley and other similar crops. If there is sufficient water potatoes and onions are also grown. In summer, if there is water, some farmers sow a second crop of barley (in Asad/Sonbola) after the wheat harvest. This is cut as green fodder in late autumn (Qaws). Vegetables — mainly carrots, turnips and onions — are cultivated close to the houses or by farmers with small holdings. Where holdings are less than one *jerib,* only these higher-value crops are grown. Grapes were also seen in both the left and right bank areas and are farmed collectively by the group of farmers around the plot. Each family involved takes over an agreed number of vines and shares the plot irrigation water allocation.

Programmes in the areas

DACAAR has worked with the community for some time and are held in high regard. They have built culverts, a flume, village wells and river bank protection. The school has been built by a Norwegian NGO. There is no NSP in the village.

Sir Zar

Sir Zar is a small village (40 households, including 20 landless households) about 200 m higher and 4 km by road to the southeast of Khalifa Rahmat. One *karez* and three springs existed when former *kuchi* first bought the land, but aside from one small spring, these have not worked for fifteen years. Examination of the small upstream catchment indicates very limited potential for irrigation, as it comprises a lower ridge between the two neighbouring larger catchments. Drinking water is taken from the existing spring, with water accumulated in a *hawz* for one to three days to provide sufficient quantities to enable abstraction. Three wells have been built by DACAAR in the village, but these are not functioning.[45] Although the village has limited resources, there is scope for water harvesting — mainly for augmenting drinking water supplies for people and animals.

The income of the village is from livestock rearing, carpet making using bought wool, and remittances. All village land is rainfed with wheat planted and the end of November and chick peas in early April. Both crops are harvested at the end of July. During the time of the Soviet occupation, no land was cultivated in the village as residents moved higher up the valley for safety. Sharecropping takes place, but, unusually, the sharecropper gets seven eighths and the owner, who only provides the land, the balance.

[44] The term *joft* is often used in Herat instead of *jerib*. It means “a pair” (of oxen) and is a commonly used term for a unit of land in Iran. As with elsewhere in Afghanistan, land holdings are calculated by farmers according to the quantity of seed sown rather than in *jerib*. Yields are calculated in the same units, with farmers measuring success in terms of yield gained versus seed sown. For a farmer this is a more logical way of estimating return on investment.

[45] The villagers reported that a DACAAR-trained mechanic from the area used to maintain the pumps and was paid 30 kg of wheat. He has been away for two years so no maintenance has been carried out.

4. Comparison of the Different Sites

Comparative details on the irrigation systems in each primary research site have been prepared from the data presented in this report and another of the seven reports in this series, *Social Water Management* (table 13). Technical details have been compared (table 14) as well as the timing of irrigation management in relation to rainfall and river flow patterns in each area (table 15). To demonstrate the water management at each of the pilot sites, the initial data relating to water management and system operation and maintenance has also been summarised (table 16).

***Table 13**. Overview of situations at each primary research site*

Canal/area	Agricultural production	Major constraints
Nangarhar province – Achin district		
Khawaji Otarkhel	Main winter-sown crops: opium, wheat, barley (mainly for cutting green), clover (3–4 cuts), winter vegetables, with 90-day maize planted at the end of May and harvested in September. Onion, eggplant, tomato, spinach, radish, okra, chilli and cabbage grown in summer for own consumption. Amounts grown depend on where farm is located in the irrigation systems and the availability of water.	• water shortage in summer months • siltation of intakes • illicit cropping pattern
Sra Qala Maruf China	Main winter-sown crops: usually opium, some wheat and clover. Summer maize occasionally, if sufficient water.	• land holdings very small • severe water shortages • usually no summer crop
Nangarhar province – Batikot district		
Janikhel	Wheat, Persian clover, berseem, barley both for cutting green and for grain. Wide selection of winter vegetables: onions, garlic, radish, cauliflower etc. Winter potatoes, sugar cane. Summer crops: maize – both green fodder and grain, cotton, mung bean for export – both green (most) and black gram. Some rice. Summer vegetables: tomatoes, eggplant, peppers, cucumbers, okra etc. Sweet melons.	• no water management system from Nangarhar canal so users established their own effective *mirab* system • no major constraints at the moment
Ghazni province – Khwaja Umari district		
Chel Gunbad Turmai Qala-i-Naw	Main crops: wheat, fodder, potatoes, some barley and vegetables. Important cash crops: apples, plums, apricots, some pears and peaches and potatoes. Fruit trees mostly grown in the lower part of the valley.	• unplanned expansion of deep wells • long intervals between irrigation at peak
Zala Qala Pyada Rah	Main crops are winter wheat sown in Tir Mahi, and spring crops of barley, clover, lentils, *shokhal*, field pea, vetch and potato if enough water. Some apples, apricots and mulberries are grown with fodder crops also cultivated in the orchards. Clover cut green for both livestock and human greens in spring.	• limited land • need additional *karez* maintenance • winter and spring crops only due to severe summer water constraints
Kunduz Province – Qala-i-Zal District		
Dana Haji	Small land holdings with single and double cropping, pasture lands, variable soil quality – good on terrace, seasonal drainage problems in old meander. Crops cultivated: wheat and barley, clover and some lucerne. If enough water for a second crop, some vegetables, carrots, turnips, cotton, mung beans, flax, sesame, maize, green maize for fodder or melons. Some farmers have fruit trees but many were lost during the drought. Farms with good water supplies grow cotton and rice but these are discouraged to enable limited summer	• water from Aq Tepa canal used by large flocks of livestock from the Dasht-i-Abdan area • intake structure requires a lot of labour-intensive reconstruction work • problems with silting up of the canal

	water supplies to extend further.	• insufficient water in drought years
Afghan Mazar	Single-crop agriculture due to water conveyance problems, small- and medium-sized holdings and soil salinity. Crops cultivated: wheat and barley, clover and some lucerne. Some farms at the upper end will cultivate some vegetables, carrots, turnips and maize if there is enough water for a second crop.	• insufficient water in most years • poor canal cross sections • siltation and cleaning problems • no reliable intake structure • sharecropping • unregulated upstream water taking • maintenance problems/ labour shortage
Wakil Jangal	Small, medium and larger land holdings with double cropping, horticulture, good soil quality. Wide range of crops, as for Dana Haji.	• flood problems in limited areas next to the river
Kunduz province – Khanabad district		
Mia Ali	Rainfed and pasture lands.	• severe water shortages • would benefit from small-scale water harvesting
Herat province – Pashtun Zarghun district		
Tunian	Single and double crop, mostly small- to mid-size land owners, 30 percent landless tenants and workers, partly sandy soils. In late autumn, 50 percent of land is planted with wheat, the main subsistence crop, with some Persian clover cut 2–3 times (early cuts used for green forage with the last cut often kept for seed). Residue fed to livestock with wheat and barley straw and residues from peas and other legumes. In spring, millet, some cotton, barley (for grain and straw) and a variety of legumes, pulses and vegetables (broad beans, field peas, lentils, chick peas) are planted. If sufficient water, some potatoes may also be planted. Wide variety of vegetables cultivated for household consumption including onions, spinach, carrots, turnips, white and red radish, eggplant and tomato.	• water shortages due to intake and conveyance problems • loss of main canal and land due to stream bank erosion by Hari Rod
Ghorak	Seasonal irrigation in spring. If rains occur in January, farmers sow wheat (the main crop), barley, legumes, chick peas and fodder finishing the crop with irrigation from the wash. Other crops cultivated include *talkhak* and *shamlit*, both very drought-resistant legumes/pulses that yield higher than wheat under these conditions.	• poor stony soils • steep slopes • unsuitable irrigation method; • in drought years, no runoff and thus no irrigation is possible • poor design for NSP weir and canal could result in flood damage
Herat province – Kushk district		
Khalifa Rahmat-i-Ulya	Single and limited double crop areas with animal husbandry, rainfed area extension, pasture corridors, medium-sized holdings. The main crop of winter wheat planted at the end of November and harvested in mid August. Farmers who cultivate wheat generally plant about half of the land, with the remainder being sown in spring with Persian clover, chick peas, onions, some barley and other	• all the canals have poor cross sections giving high conveyance losses • main right canal follows a tortuous alignment close to the hills and crosses

	similar crops. If there is sufficient water, potatoes and onions are also grown. In summer some farmers sow a second crop of barley after the wheat harvest if there is water (cut as green fodder in late autumn). Vegetables – mainly carrots, turnips and onions – are cultivated close to houses or by farmers with small holdings. Where holdings are less than 1 *jerib*, only higher-value crops are grown. Grapes farmed collectively by groups of farmers around the plot.	many small washes and depressions before reaching the irrigated area giving high maintenance requirement • limited water in summer • flood damage from wash in winter • stream bank damage

The selection of crop types is similar in both winter and summer for all sites, but precise cropping patterns will reflect the altitude and climate (table 13) and the number of cropping seasons will reflect the availability of water (table 14). In winter, farmers will tend to plant their food and fodder crops first, and if there is excess water, they will plant potatoes and winter vegetables. Poppy for the production of opium tends to be grown in more remote areas or where winter wheat has a long growing season. In these areas, harvesting of the winter wheat comes too late in the season to plant the same land with a spring crop. Poppy, with its shorter growing period, permits both the winter crop of poppy and a spring crop on the same land. There is also a tradition of poppy cultivation in some areas such as Achin district and this also influences farmers' choices of cropping patterns. Where land holdings are small (less than 1 *jerib*), farmers will not grow food crops, but rather concentrate on growing cash crops of winter and spring vegetables and potatoes, with the higher returns enabling them to purchase their food needs. These farmers are vulnerable and see the considerably greater benefits that they could achieve from the cultivation of poppy on their limited land areas.

In all research sites except in Ghazni, water is a serious constraint for summer cropping (table 14) and this is reflected by the presence of permanent *mirabs* in these areas (table 16). This constraint is irrespective of water source, but is considerably ameliorated if there is water storage upstream of the site, such as in the case of Ghazni (table 14). Although the breaching of the intake bunds (diversion structures that channel water into the canal intake) and the ability of farmers to get water into the low level summer intakes is common throughout (table 14), this should not be the primary area of attention for improvement works. The current systems allow flexibility and adaptation to river movement (both lateral and vertical) and this is precluded in most cases once permanent intakes are built. More attention must be given to the improvement of conveyance of water from the intakes to the fields through the construction of better canal sections and the provision of more suitable control structures.

The sharing of this scare water supply and the associated additional maintenance tasks needed to convey water to the fields in most cases requires the full-time attention of the *mirabs*. In Kunduz, the presence of salinity in the soils and some water sources is exacerbated by the lack of summer water, thereby preventing of the leAching of the salts from the soils.[46]

The main irrigation maintenance works for traditional irrigation systems are carried out prior to the first irrigations of the year after the Afghan New Year (table 16). The precise timing will depend upon the climate of the area and the amount of work

[46] A lack of drainage will also be a major factor, but some drainage channels have been built in the Kunduz command areas and cannot be fully used due the lack of leaching water.

to be carried out. In Kunduz, the main canal systems are in most cases very long, and the amount of silt removal and repair is large. More time is needed for this work and it therefore tends to start just before the Afghan New Year (table 15). Systems that receive water from rivers where there is high variation in flood and low flows, such as Herat (Hari Rod) and Kunduz, need to carry out a second cleaning once the floods have passed and in order to get sufficient water into the canals to meet crop water demands.

Table 14. Irrigation systems at each primary research site

Village	Elevation (metres amsl)	Annual ET0 (mm)	Average Annual Rainfall (mm)	Approx command area (Jeribs)	No of Crop seasons	Sources of Water: Name	River: Perennial	River: Seasonal	River: Mainly Sub-surface	Spring	Karez (No): Long	Karez (No): Short	Karez (No): Tile (Chow or Jarr)	Well	Tube-wells	Abstraction Method, River Diversion: Number	River Diversion: Traditional	River Diversion: Improved	Canals structures: Improved/Modern	Canals structures: Traditional	Canals structures: Outlet gates	Diversion/conveyance Problems: Breaking in high/ low flows	Conveyance Loxsses	Low flow arrangements	not able to get FSL into	Siltation	Other u/s users	Cross section	Steep Banks	no berms	Other Problems/ Constraints: Cropping pattern	Water Shortages	Irrigation method	Drainage	Water Management	Agencies/ Projects Assisting
Hari Rud River Basin - Herat Province - Pashtun Zarghun District																																				
Tunyan	1030	4740	211	2400	2	Hari Rud	✔									2	✔					✔	✔	✔	✔	✔			✔	✔		✔			✔	DACAAR; AREU; EIRP
Ghorak	1165			30	1	Ghorak Wash		✔		✔						1		✔				✔										✔	✔		✔	DACAAR and AREU
Khalifa Rahmat Ol	1305			550	1-2	Khalifa Rahmat	✔	✔		✔						3	✔					✔	✔					✔				✔			✔	
Helmand River Basin - Ghazni Province - Khawaga-Omri District																																				
Chehel Gombad	2360	3910	292		2	Jagatoo River	✔					✔				1		✔					✔													DACAAR and AREU
Turmai	2300			850	2	Jagatoo River	✔									2		✔	✔		✔															
Qala-i-Naw	2255			1150	2	Jagatoo River	✔					X		✔	✔	3		✔	✔		✔															
Zala Qala	2560			500	1-2	13 Karez					2	11							✔		✔											✔				
Paiyda Rah	2490			100	1-2	6 Karez					1	4	1	✔					✔	✔												✔				
North eastern River Basin - Kunduz Province - Qala-e-Zal District																																				
Dana Haji	335	3810	349	420	1-2	Kunduz River	✔									2	✔			✔		✔	✔	✔	✔	✔					✔	✔		✔		GAA and AREU
Afghan Mazar	340			850	1-2	Khanabad River	✔									1	✔			✔		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔		
Wakil Jangal	345			1000	2	Khanabad River	✔									1	✔			✔		✔	✔	✔	✔	✔								✔		
Kabul River Basin - Nangarhar Province - Achin District																																				
Khawagi	1700	3750	171	50	2	Pirkha Wash	✔									3	✔	✔		✔		✔	✔								✔					GAA; AREU; NSP; GAA; AREU;
Khotar Khel	1470			2500	2		✔									4	✔	✔		✔		✔	✔			✔					✔					
Sra Qala	950			550	1			✔					✔			2	✔			✔		✔	✔			✔	✔				✔	✔				
Marouf China	690			150	1	Wash		✔					✔		✔					✔		✔	✔			✔	✔				✔	✔				
Kabul River Basin - Nangarhar Province - Batikot District																																				
Jani Khel	550			2000		Kabul river via Nangarhar Canal	✔											✔	✔	✔											✔			✔		GAA; AREU;

Table 15. Irrigation maintenance scheduling at each primary research site

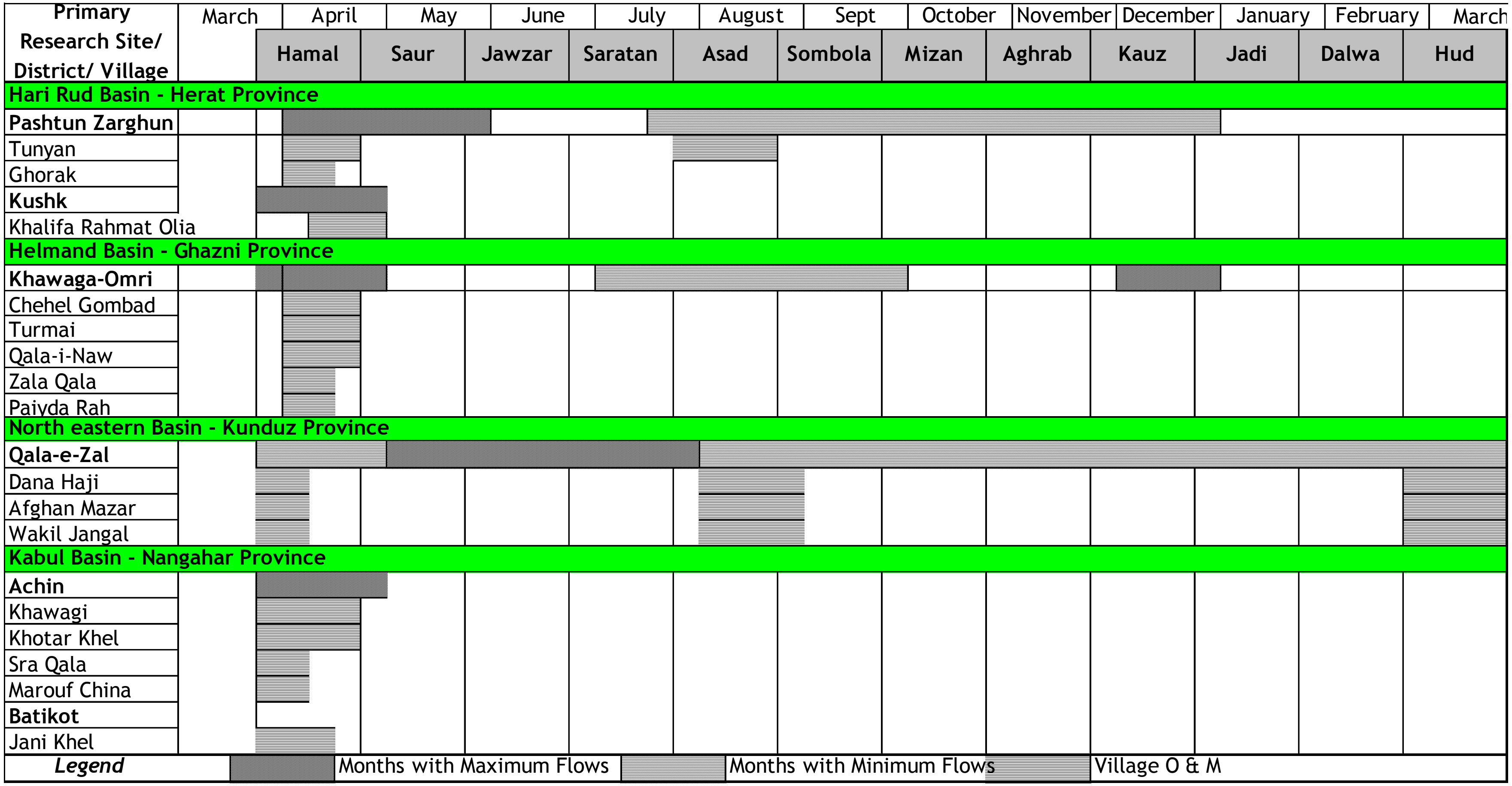

Primary Research Site/ District/ Village
March
April
May
June
July
August
Sept
October
November
December
January
February
March
Hamal
Saur
Jawzar
Saratan
Asad
Sombola
Mizan
Aghrab
Kauz
Jadi
Dalwa
Hud
Hari Rud Basin - Herat Province
Pashtun Zarghun
Tunyan
Ghorak
Kushk
Khalifa Rahmat Olia
Helmand Basin - Ghazni Province
Khawaga-Omri
Chehel Gombad
Turmai
Qala-i-Naw
Zala Qala
Paiyda Rah
North eastern Basin - Kunduz Province
Qala-e-Zal
Dana Haji
Afghan Mazar
Wakil Jangal
Kabul Basin - Nangahar Province
Achin
Khawagi
Khotar Khel
Sra Qala
Marouf China
Batikot
Jani Khel
Legend
Months with Maximum Flows
Months with Minimum Flows
Village O & M

Table 16. Water management arrangements at each primary research site

	Nangarhar	Ghazni	Kunduz	Herat
1.	***Water management***			
	Mirab per group of canals plus support from *shora*. Only use a *mirab* when water shortages occur and disputes likely (some areas for summer crop; others for spring crop where water is scarce).	No *mirabs* except in lower Ghazni valley where water shortages occur. Where no *mirab*, *shora* of elders.	Each main canal has a *mirab bashi*, with most communities electing their own *kok bashi* to handle on-farm or within-village water distribution.	*Wakil* for 30 years and two *mirabs* (Atishan canal). No *mirab* for Ghorak (too small) and only at times of shortage for Kushk. *Arbab* assumes responsibility.
2.	***Canal maintenance – routine***			
	The general cleaning done once at beginning of the New Year (Hamal/March/April) and before first irrigation of the season, to rectify damage and siltation resulting from the winter rains. Maintenance planned by *mirab*, but supervised by appointed person from each village. All farms that benefit from the irrigation water required to contribute one labourer per holding or water right, depending on size and duration of flow.	Annual cleaning starts at beginning of New Year. Organised by *shora* representative. Labour supplied by landlords, share-croppers or tenants in proportion to number of night/days of water.	Routine cleaning carried out annually before the start of irrigation season in Hut (February/March) and can take up to 60 days. Labour provided by irrigators depending on land holding according to local system that converts to one person/day for 30 *jerib*, one person/two days for 20 *jerib* and one person/three days for 10 *jerib*.	System operation and maintenance carried out under planning and supervision of the Atishan Canal *wakil*, assisted by two *mirabs*. Routine cleaning and repairs carried out annually before the start of irrigation season. Second session required in summer irrigation July–August to improve water delivery.
3.	***Canal maintenance – emergency***			
	Emergency repairs whether within the irrigation system or at the diversion structure on the wash on same basis as routine maintenance.	When a canal breach or emergency repairs are needed, land owners, sharecroppers or tenants are called on the same basis as routine maintenance to handle the problem.	Similar to routine maintenance. Farmers must provide labour for frequent interventions to offset the effects of flow from side washes due to rainfall/runoff and frequent diversion breaches, etc.	Same as routine maintenance.
4.	***Water distribution***			
	Night–day 24-hr turn (*shab o roz*). Water management done between *khels* (sub-clans). Upstream areas rotate every 4–5 days at peak. Downstream 1–2 times per month at peak and only in spring as water is a constraint. Allocation traditional and known by all population.	Night–day (*shab o roz*) system both between canals and within canals/farms. Water in canals can be sold to downstream users on a loan (*qarz*) basis. Water also sold from pumped wells for 200–300 Afs/hr.	On-farm water is allocated on the basis of local measure *paw-ab-daqiqa* that relates seed application to land area, similar to *juftgaw* system in Herat.	Water rights known historically by canal users. Calculated in *shab o roz* (24-hr flow) dictated by land size – *juftgaw*.

5.	***Payment for services***			
	Fixed-weight wheat or barley.	Not given.	4 Kabuli *ser* (28 kg) per local unit of measure. Payment made in kind at harvest time.	9,600 kg wheat: 50% to *wakil*, 50% between all *mirabs*.

5. Policy Implications

The detailed examination of irrigation systems and water management in the villages at the primary research sites showed a wide range of approaches and problems. It is very clear that despite much information to the contrary, the basic traditional water management systems persist. They have been affected and influenced negatively in some areas by political leaders and commanders who have not respected the traditional rights and rules — with the result that the irrigation systems have not been properly operated and maintained, or have even fallen into disuse. However, with appropriate help, it will be possible to make them more democratic and equitable in line with future river basin management. Rehabilitation projects present an opportunity to revitalise the process, and technical interventions must be made carefully with this in mind. *Mirabs* will have a very important role in formalised water user organisations, and ultimately in the river basin approach, but they must also be more accountable to all water users.

There are a large number of country-wide project interventions aimed at assisting communities. From the sites visited in this study, it is evident that inadequate attention has been paid to the technical and social aspects of the designs, and this may call into question the sustainability of these interventions. Rural villages in Afghanistan have established institutional arrangements that may or may not be fair and equitable, but they are based on existing social structures. Before any attempts are made to build or superimpose new organisational WUA-type arrangements, the existence if these must be fully understood and then built upon. Creating organisations is the easy part; building institutions is much more difficult, and rules for the new organisations that challenge existing arrangements will not be accepted easily.

A number of donors are discussing "Irrigation Management Transfer" for the improvement of Afghanistan's irrigation systems. This assumes that some "authority" is in charge of the systems and that this authority needs to transfer its activities to the farmers. In practice, most irrigation systems in Afghanistan are rather old and have been developed in spite of government. This is not fully appreciated by some donors and it is critical that any guidelines for WUAs comprehend existing arrangements for traditional irrigation systems and do not try to extend a site-specific "snapshot view" to all parts of the country.[47]

Inter-village water distribution presents problems in many areas, but these could be solved with greater involvement of the communities in basin or sub-basin water management and allocation. Many areas had older systems in place that were effective before the start of the war (such as the lower Hari Rod). The mechanisms of these systems must be examined and utilised when further developing integrated water management approaches. Farmers in older traditional communities are aware of the earlier mechanisms, and they need to be assured that future proposals will be an improvement on them. Implementers must be extremely careful to ensure that their interventions do not inadvertently play into, or reinforce, existing village or community inequalities. Altering cropping patterns may encourage additional irrigation and have downstream effects that have not been considered, possibly exacerbating conflict. Equally, building permanent irrigation structures at village level and ignoring the wider dimensions of water distribution may entrench inequalities.

[47] For example, the provisional documents prepared by DAI/RAMP for the Injil canal in Herat and the Helmand valley concentrate on their experiences in these areas, and do not therefore have direct application to other systems in Afghanistan.

During the extended drought period at the turn of the century, some farmers (for example in Maruf China, Nangarhar, and Turmai, Ghazni) began using more groundwater to supplement or replace surface water supplies. The number of traditionally used shallow wells increased and several deep tube wells (60–80 m) were introduced. Although these have been banned in Khwaja Umari district for the moment,[48] new drilling was reported to be continuing in the middle and lower valley north of Ghazni. This could have a serious effect on groundwater depth in the valley, and impact on both river recharge and the tree crops that depend on the shallow table in the summer months.

Many of the problems of water management and inequalities of water distribution between villages stem from inefficient abstraction and significant conveyance losses at times of peak demand and relatively low flows. There is clear evidence of flexibility at the local level, with farmers sharing water on an as-needs basis with their neighbours, whether on the same canal or on other systems. The introduction of some modern technologies into the irrigation systems will go some way towards addressing these issues, but other interventions (such as water storage, river training and bank protection or single main canals replacing many traditional canals) will take time, comprehensive designs and considerable funds to realise. Many interventions, however, are currently being undertaken without a full understanding of all existing users within a catchment and their demands. The theory is that the interventions will only abstract the same amount of water as existing abstractions, however most of the structures observed, and those in development, do permit unscrupulous farmers to take far more water than is possible using traditional techniques. In this respect the RBA approach is essential, but sufficient funds must be delivered with matching technical expertise to compile and utilise the relevant data as early as possible.[49] It is clear that current staffing and resources for PIDs of MEW are totally inadequate for their planned future role as RBAs. There are insufficient and conflicting data on lands irrigated by each canal and diversion weir; part of this results from the emphasis on modern units of measure, while farmers deal in their own units of *juftgaw* and *man/ser* (these depend on local measures of seed rates and do not convert directly into *jerib*, but reflect farmers' perceptions of soil productivity and hence returns to seed used).

In some of the primary research sites it was noted that there are existing or potential conflicts over water and pasture between villages. As large tracts of former cultivated land are brought back into production this has increased, and with many of the interventions aimed at increasing cultivation there is the likelihood that conflicts will increase. These are not issues to be ignored or sidestepped in programming – as they relate clearly to issues of vulnerability of populations exposed to this threat. Proposed projects for areas such as Kunduz (where salinity is affecting crop land) and Herat (where the rehabilitation of old canals will cut off villagers' access to grazing areas) must be carefully examined and discussed with the communities before they are realised.

Cropping patterns in all areas are similar, and reflect altitude, aspect, soil types, water availability/reliability and returns. It is usually assumed that farmers grow opium for the money alone, but with the increase in the WFP's food for work pro-

[48] This is according to the head of the PID in Ghazni.

[49] The FAO Programme for the Rehabilitation of Afghanistan (1989–96) used this approach, which is set out in the appropriate design manual (I.M. Anderson, 1993, *Rehabilitation of Informal Irrigation Systems in Afghanistan* (design manual), UK: Agrisystems.

grammes,[50] the wheat that used to be a valuable crop is no longer as lucrative, fetching relatively low prices. Furthermore, wheat is a winter crop that is in the ground for many months in higher and colder areas. By planting it, farmers preclude other higher-value spring crops that opium, with its shorter growing period, permits. If opium is to be taken off the farmers' agenda, and many would agree to do this if real alternatives were available to them, it will have to be replaced by a crop that is readily marketable, has a shorter growing season, does not require high inputs of chemical fertiliser, is not labour intensive and can be sold to provide food for the family. Support for opium eradication is similar to watershed protection works: those who must sacrifice the most receive the least direct benefit. Afghan communities are good economists, and they are risk-averse: off-farm labour is a very important part of their social safety net system.

Returns to labour are important to most subsistence-level farmers who are using the traditional irrigation schemes. Many family members are away from their villages for extended periods; the farmer may know that many of his practices are unsuitable or could be improved, but such improvements may require more time and effort from them. Most take casual off-farm work, particularly in the summer months when water for irrigation is scarcer and casual work (such as road building) is more available. Interventions that result in reducing the time available for casual off-farm work must consider the opportunity cost of the farmer's time.

Conveyance of water from diversion weirs/intakes to farmers' fields is one of the potential major areas for improvement. In all primary research sites, large losses are experienced — whether from washing out by the transverse washes and streams, or through inefficient cross/long sections and siltation. The time taken for water to reach irrigated areas is long in relation to the allocated irrigation time, and this impacts on farmers' production if disruptions occur during the farmer's irrigation time. Interventions must not only examine the diversion weir and intake, but more importantly they must examine the time that communities spend annually on the repair and cleaning of structures and canals. By ranking these in terms of community expenditure (mainly time), community priorities will become apparent.

Many communities are unable to cultivate a summer crop due to scare or unreliable supplies of irrigation water. More efficient conveyance systems and better water delivery and use on farms will extend the areas that can be irrigated in this period. This may go some way towards reducing the reliance on illicit crops by increasing annual returns per hectare, as opium is not grown in the summer months. In addition to this, by working with communities to shorten the irrigation intervals and relating supply to crops grown, additional areas will be able to cultivate higher-value horticulture crops precluded by the current long irrigation intervals.

Although it has not been possible within the scope of this study so far to examine the actual deliveries (flow rates, time of irrigating, application rates, duration of intervals, water deficits), this will be done for some areas through detailed fieldwork in subsequent phases of the research project. Water availability and reliability (L/sec) is always greater at the top of the systems, allowing upstream users a greater chance to grow first-choice and often higher-value crops[51] and to harvest more than one crop. Traditionally, these farmers are the more influential and better off, and in many cases they are the descendants of those who originally developed the system.

[50] See http://www.wfp.org/food_aid/food_for_work/index.asp?section=12&sub_section=5.

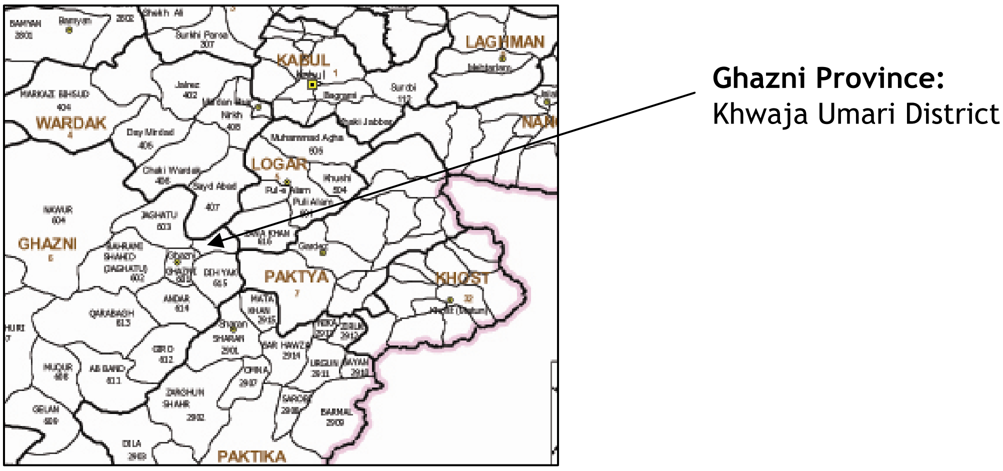
[51] This is illustrated by farmers trading water in some areas (such as Ghazni) to shorten the irrigation interval and increase water availability for crop production in between turns.

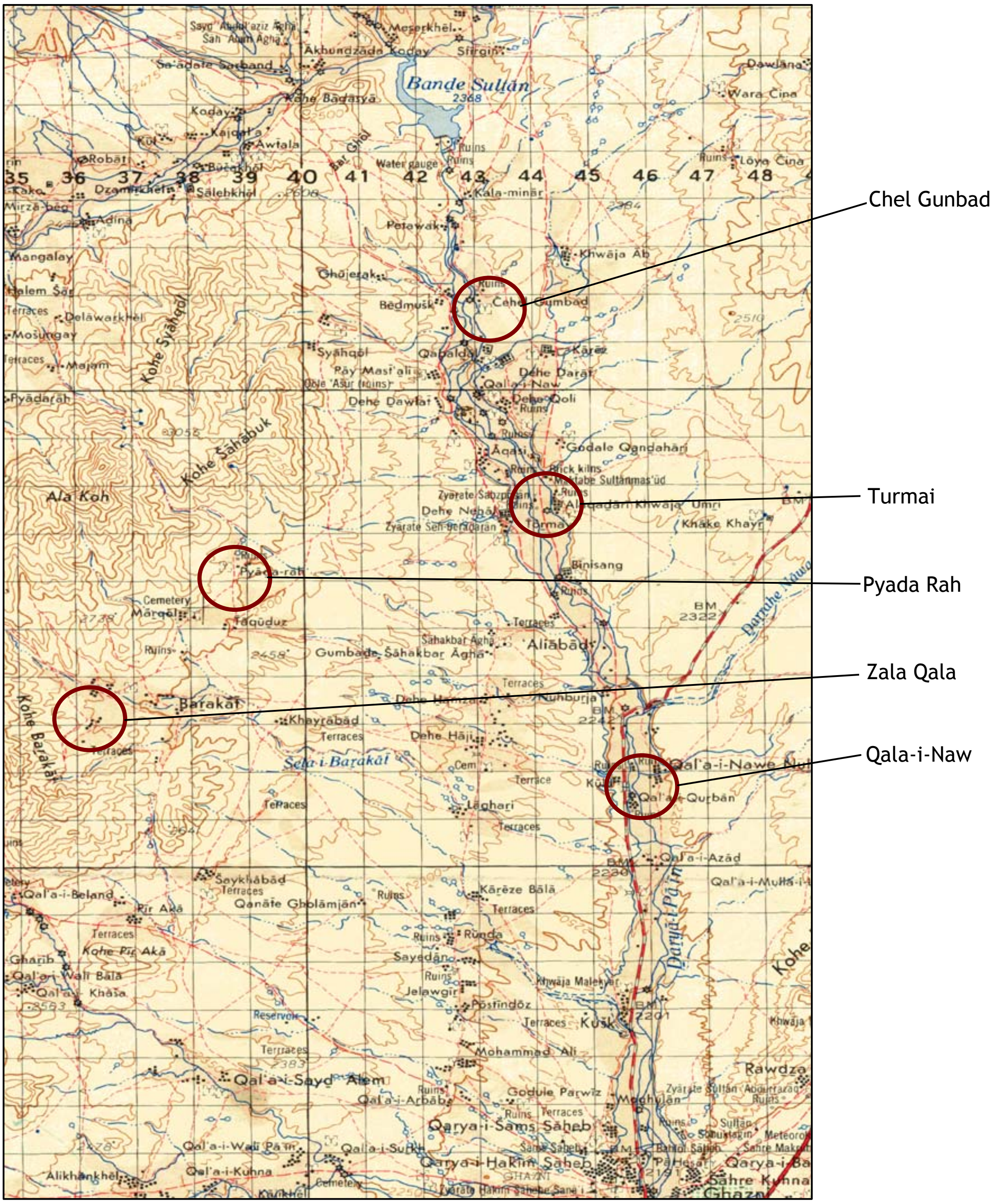
They also have a greater opportunity for abusing the accepted systems of water allocations. For the long canal systems with inherent losses, flow duration, interval and rates often necessitate high application rates. These in turn result in poor water distribution, runoff (as application rates exceed infiltration rates) and soil loss with the runoff flow. Any interventions that involve capital investments in the villages must be coupled with examination of the associated water allocation and distribution systems. Failure to do this will result in limited impact, as community *shora* and *mirabs* tend to be inherently conservative, and will concentrate on those parts of the older systems that already have the best water supply conditions.[52]

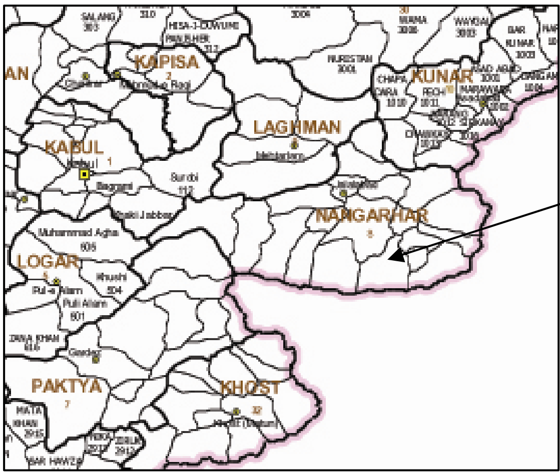
Routine operation and maintenance of traditional irrigation systems is well handled by all groups within their village or canal community resources, however periods of extreme high or low flows present the *mirabs* and *shora* with major problems. The new Water Law invests much responsibility about this in PIDs, but to date it has been shown that they have neither the resources nor sufficient experienced technical support. All programmes for the improvement of irrigation infrastructure and water management rely on PIDs for supervision of construction and follow up, but donors appear to pay little attention to the weaknesses of quality control and the operation and maintenance arrangements for the structures they fund. Some structures designed and constructed under NSP do not seem to have been built with future operation and maintenance in mind at all: instead of reducing the time commitment of farmers, they may actually increase it.

[52] Although the KRBP planned to do social water management assessments prior to investing in irrigation infrastructure, delays and the need to maintain investment schedules resulted in decisions being made primarily on technical rather than a combined social–technical basis.

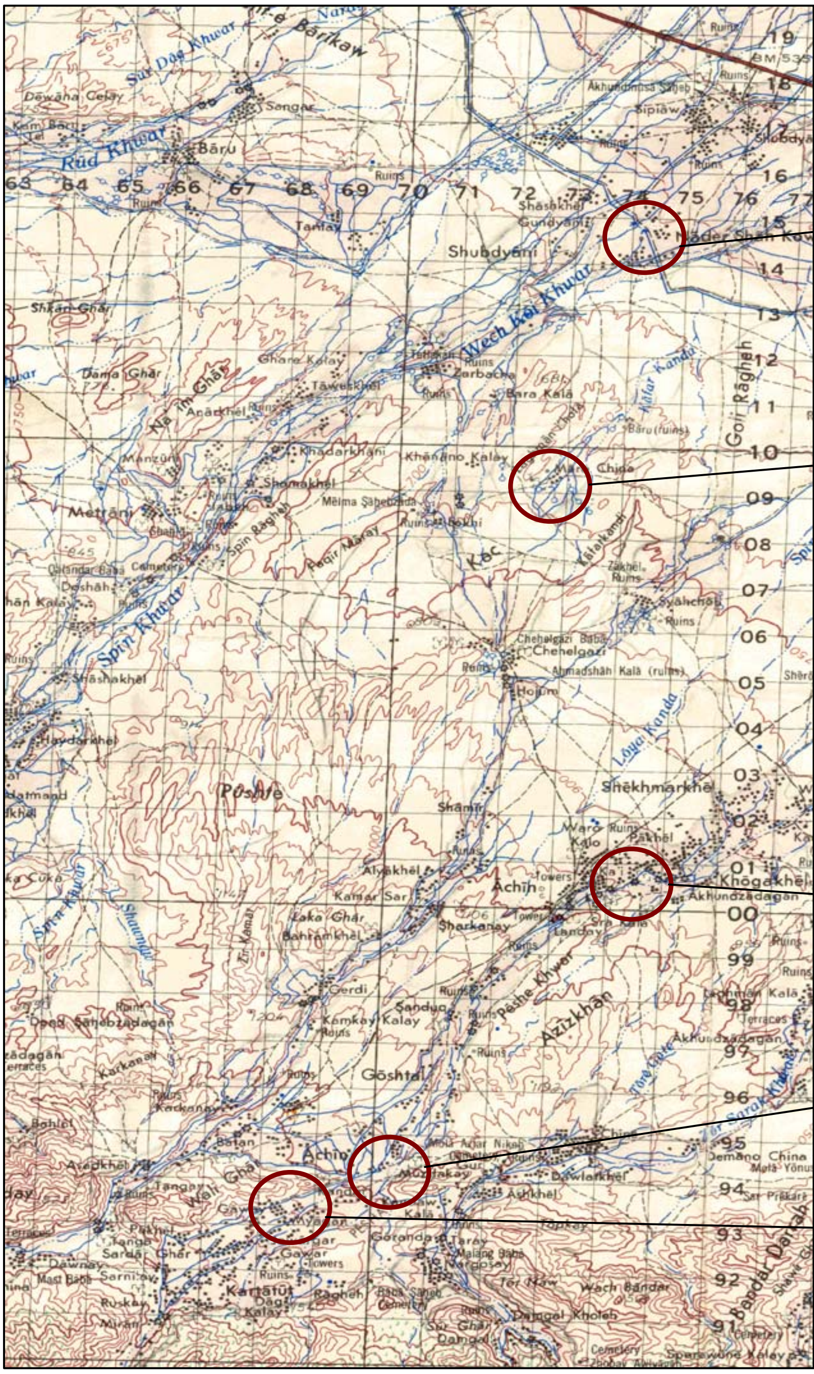
Appendix 1: Maps of the Primary Research Sites







Nangarhar Province:
Achin and Batikot Districts



Janikhel

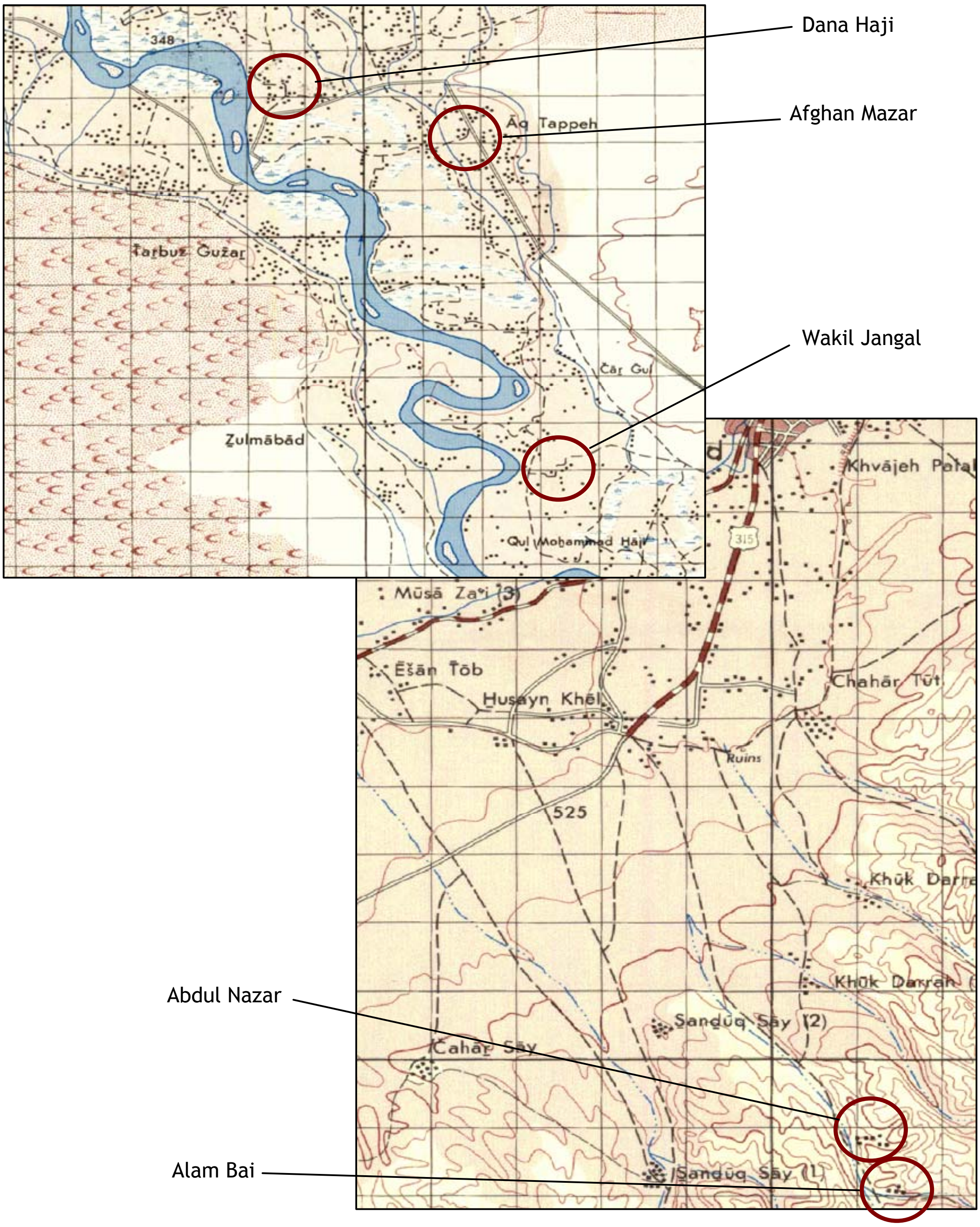
Maruf China

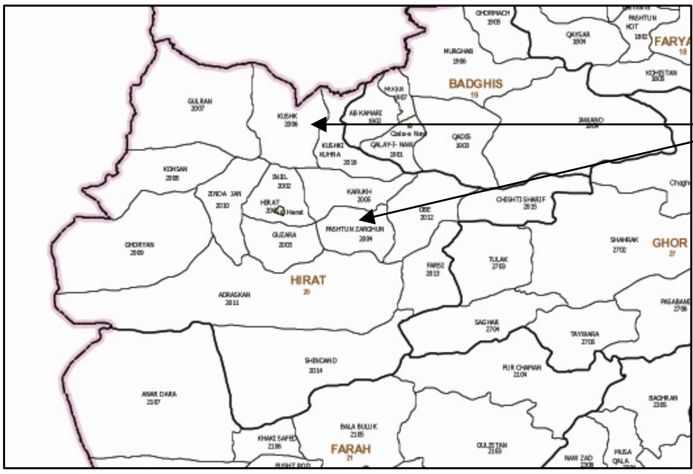
Sra Qala

Otarkhel

Khawaji

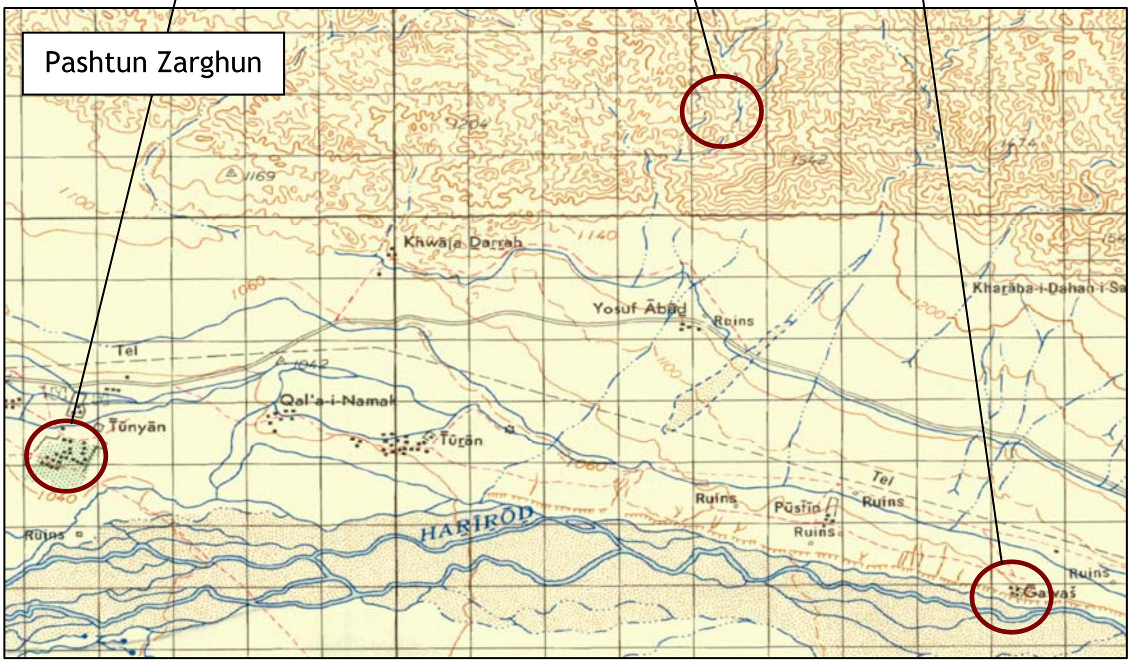
Kunduz Province:
Qala-i-Zal and Khanabad Districts



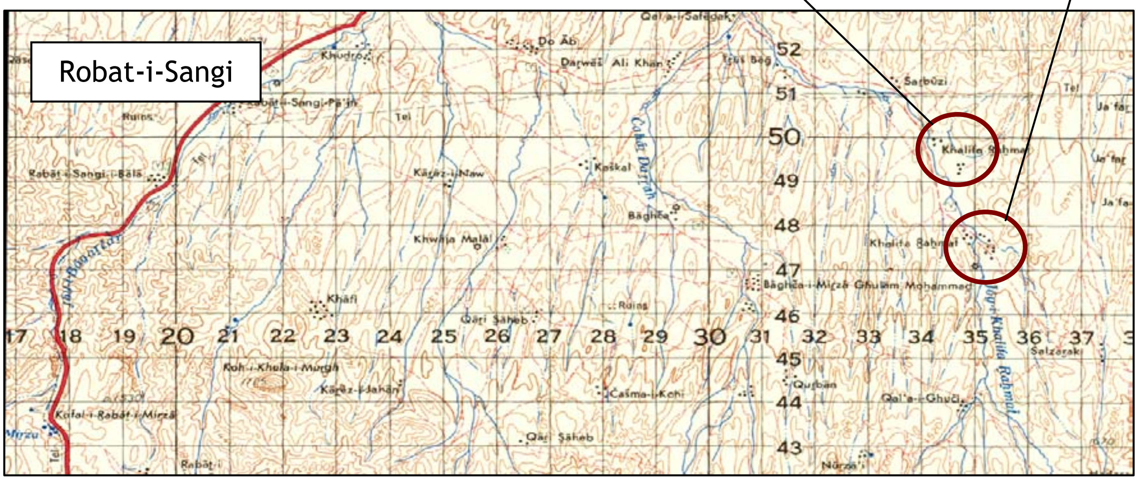


Herat Province:
Robat-i-Sangi and
Pashtun Zarghun Districts

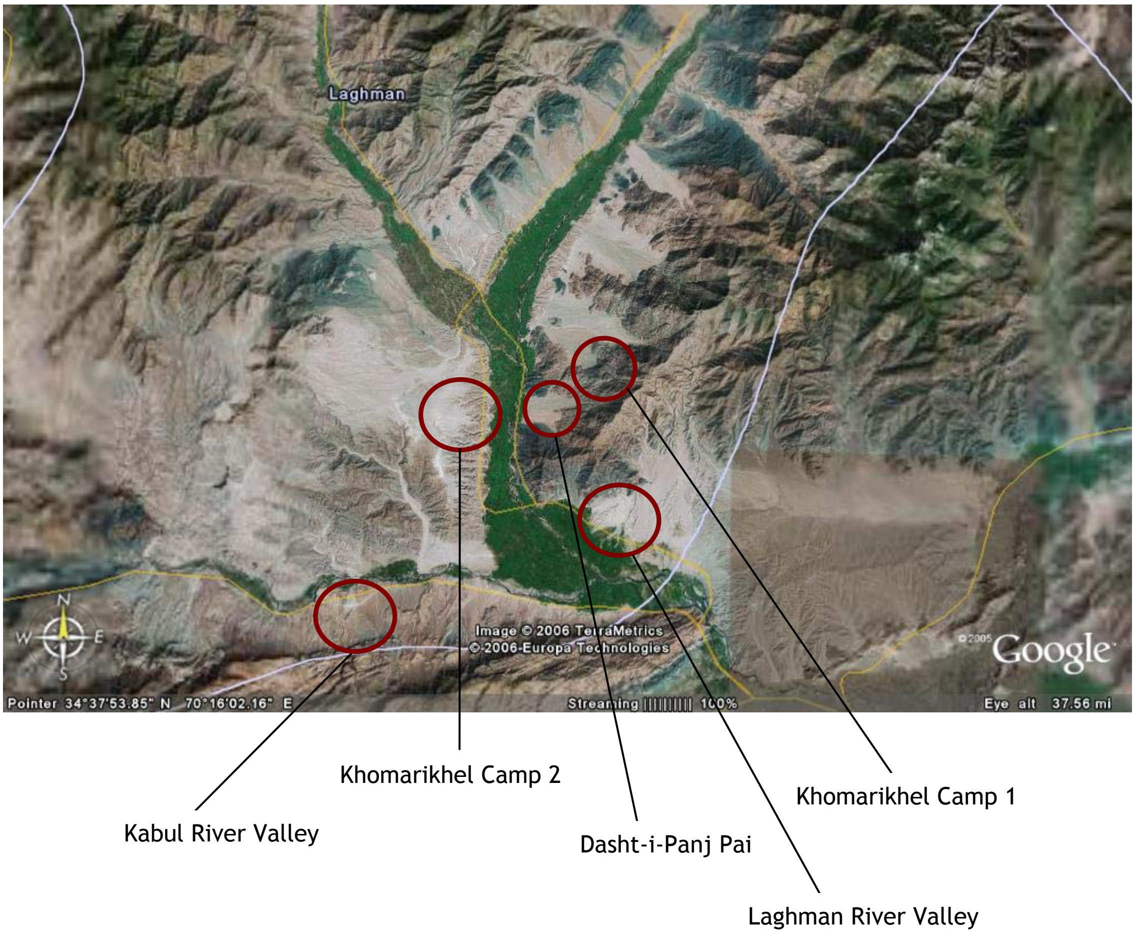
Tunian Ghorak Gawashk



Khalifa Rahmat Sir Zar



Laghman Province



Appendix 2: Afghan Solar (*shamsi*) Calendar

The Afghan solar (*shamsi*) year has the same number of days as a Common Era (CE) or AD year: 365. The Afghan solar year starts on 1 Hamal (New Year, or Naw Roz), which falls on 21 March, and it dates from the year of the *Hijri* (migration) of Muhammad in 621 AD, not from 1 AD. To find an AD/CE date from an Afghan solar year, add 621 to the Afghan year (for example, 1384 *shamsi* = 2004/2005 CE/AD).

When there is a CE leap year, 1 Hamal falls on 20 March and the additional day in the Afghan solar year is added to the last month of the equivalent Afghan solar year (Hut), that is, in mid March of the following CE year.

The Afghan solar calendar is divided into four seasons of three months each: spring (*bahar*), summer (*tabistan*), autumn (*khazan*, or *tirmah* in Herat) and winter (*zimistan*).

Season	**Afghan solar (*shamsi*) month**	**CE/AD equivalents (non-leap year)**
Spring (*bahar*)	Hamal	21 March to 20 April
	Sawr	21 April to 20 May
	Jawza	22 May to 21 June
Summer (*tabistan*)	Saratan	22 June to 22 July
	Asad	23 July to 22 August
	Sonbola	23 August to 22 September
Autumn (*khazan/tirmah*)	Mizan	23 September to 22 October
	Aqrab	23 October to 21 November
	Qaws	22 November to 21 December
Winter (*zimistan*)	Jaddi	22 December to 20 January
	Dalw	21 January to 19 February
	Hut	20 February to 20 March

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