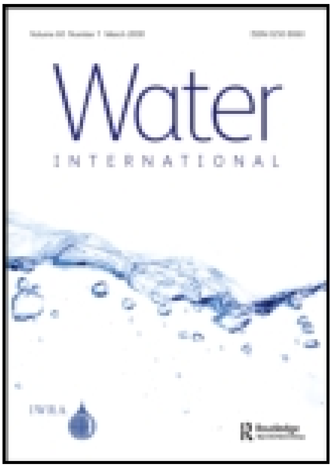

Water International
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rwin20

Water distribution systems and on-farm irrigation practices: limitations and consequences for Afghanistan's agricultural productivity

S. Alan Walters[a] & John W. Groninger[b]
[a] Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, USA
[b] Department of Forestry, Southern Illinois University, Carbondale, USA

Published online: 18 Mar 2014.

Water International, 2014
Vol. 39, No. 3, 348–359, http://dx.doi.org/10.1080/02508060.2014.895888

Water distribution systems and on-farm irrigation practices: limitations and consequences for Afghanistan's agricultural productivity

S. Alan Walters[a]* and John W. Groninger[b]

[a]*Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, USA;* [b]*Department of Forestry, Southern Illinois University, Carbondale, USA*

(*Received 1 April 2013; accepted 15 February 2014*)

The absence of a reliable water supply to farmers is the single most important impediment to food security and agricultural expansion in Afghanistan. Agricultural water supply and distribution systems are reviewed, and a pragmatic strategy is outlined to increase water capital and to better utilize available water. The development and dissemination of on-farm practices that improve water management through community-based approaches represent the best opportunity for improving farmer livelihoods, maintaining social stability and developing a sound agriculture-based economy in the immediate future, independent of the success or failure of national water policies.

Keywords: agricultural extension; food security; *mirab*; sustainable agriculture; water-use efficiency; Afghanistan

Introduction

Improved agricultural productivity is essential for achieving and maintaining social stability and sustainable economic development in Afghanistan. Agriculture provides more than half of Afghanistan's gross domestic product, although only 15% of the total land in the country is arable and less than 6% is cultivated (FAO, 2011). Estimates also indicate that between 80% and 95% of Afghans live in rural areas and are directly or indirectly involved in agriculture (Torell & Ward, 2010). Most families are engaged in subsistence farming, and many farms are insufficiently productive to achieve food security. Typically, most will farm only about 3–5 *jerib*s (0.6–1.0 ha). Many are share-croppers or squatters.

A consistently adequate supply of water to farmers is the most important factor that prevents accelerated agricultural expansion in Afghanistan (Walters, Groninger, & Myers, 2012). Massive water projects are still ongoing in Afghanistan, with large-scale infrastructure improvements anticipated, including the building of dams. This is the latest effort within the last several decades to dramatically modernize irrigation systems and improve agricultural capacity. Previous efforts have often failed to meet local expectations as projects were not completed, inadequately maintained, or crippled by flooding and other consequences of poor upper-watershed health (Groninger, 2012).

The agriculture sector has been devastated by the post–Soviet invasion hostilities. These served to isolate Afghans from accessing information on new and improved

*Corresponding author. Email: awalters@siu.edu

irrigation technologies. Warfare, rural depopulation and subsequent neglect have left water delivery systems ranging from partially functional to completely destroyed. Although a complex array of problems influence water availability, including insecurity of the water supply, most agree that the primary limiting factor to crop production in Afghanistan is the inefficient use of available water (Thomas & Ramzi, 2011; Walters et al., 2012). Increasing crop productivity per unit of land (rather than expanding into more environmentally unsuitable areas) is the most appropriate strategy to accelerate the growth of the rural Afghanistan economy. The most likely way to achieve this goal is through the improvement of irrigation technologies and field production and management practices, along with the development of human and institutional capacity. Until then, the potential for increased supply and international marketing, identified as a priority in the Afghanistan National Development Strategy of 2008 (ANDS Secretariat, 2008), will remain largely unfulfilled.

During critical use periods, agriculture practices in Afghanistan use about 95–99% of the freshwater resources available through agriculture irrigation systems (Azimi & McCauley, 2002), but much is used inefficiently, through mismanagement or poor irrigation practices. The overuse of water by upstream users often leads to drought conditions for downstream areas (Thomas & Ramzi, 2011). Chronic overgrazing and the poor condition of rangelands reduce upper-watershed buffering capacity, further contributing to growing-season water shortages in the downstream crop-production areas (Walters et al., 2012). In recent years, agricultural areas, especially those used for rainfed wheat cultivation, have expanded at the expense of rangeland (Azimi & McCauley, 2002; Saba, 2001), and the associated decline of vegetation cover resulting from land-use conversion apparently contributes to downstream water resource and flooding issues. Consequently, many producers (primarily downstream users) within impacted watersheds are not receiving the water they need to sustain family consumption, let alone produce the surplus needed to bolster exports (Torell & Ward, 2010). Given the myriad problems relating to freshwater resources and their use in Afghanistan, the objective of this article is to provide an overview of water supply, demand and irrigation required to increase agricultural productivity. Suggestions are offered to improve project success and sustainability in current and future irrigation projects, with an emphasis on improvements closest to the farm user.

Water resources

More than 80% of the water resources for this country originate from melting snowpack and glaciers in the Hindu Kush mountains. As is typical in arid environments, the amount of rainfall used specifically for crop production is usually very small, because of the difficulties in managing unreliable rainfall and extreme runoff events (Wheeler & Kay, 2010). Irrigation for agricultural crops and livestock depends primarily on the major river basins for fresh sources of water (Table 1).

Agriculture irrigation consumes about 2 km^3 per year. Estimates indicate that the country has 75 km^3 of potential water resources, of which 55 km^3 and 20 km^3 are surface and groundwater, respectively (Ahmad & Wasiq, 2004; Persaud, 2012; Qureshi, 2002). Total groundwater extraction amounts to about 3 km^3 on an annual basis. Considering the obvious impacts of frequent droughts and a strict dependence on limited available freshwater for survival, Afghans collectively have placed little emphasis on water conservation or protecting downstream water quality (Groninger & Lasko, 2011; Palmer-Molony, 2011). Despite all the international aid monies that have been provided to this country,

Table 1. Constituent rivers, catchment area and water discharge of the four primary river basins of Afghanistan.

Basin	Rivers included in this basin	Catchment area (km^2)	Storage capacity (billion m^3)
Northern basin	Wakhan, Kokcha, Kundz, Pamir/Panj, Marghab, Shirin Tagab, Samangan, Saripul, Balkh, Kashan, Kushk, Gulran	302,000	24
Southwestern (or Helmand) basin	Helmand, Arghandab, Ghazni, Trank, Arghastan, Musa Qala	218,600	6.5
Western basin	Khash, Farharod, Aderskan, Harierod	85,300	2.5
Kabul/Indus basin	Kabul, Kunar, Alishing, Alinegar, Logar, Panjshir, Shutol, Ghorbund, Laghman, Maidan	72,000	22
Total			55

Source: A. S. Qureshi (2002), Water Resources Management in Afghanistan: The Issues and Options. International Water Management Institute, Working Paper 49, Pakistan Country Series 49. http://ageconsearch.umn.edu/bitstream/92703/2/WOR49.pdf

relatively little emphasis has been placed on water-related issues, and most would agree that Afghanistan's water resources are still poorly developed (Center for Policy and Human Development, 2012).

Irrigation technologies

Irrigation is critical for agricultural activities in Afghanistan given the relatively meagre and variable rainfall events associated with areas with suitable soil conditions. The irrigated areas produce almost 85% of all agricultural products in the country and 70% of the wheat, Afghanistan's primary food crop. Currently, roughly 3.9 million ha of land is cultivated, with approximately 1.3 million and 2.6 million ha managed using rainfed and irrigation management practices, respectively. However, Afghanistan's potential irrigable area is about 5 million ha, almost twice the amount currently under irrigation (ADB, 2003).

Although there are significant water resources available for irrigation of crops and water for livestock, Afghanistan suffers from damaged or poorly maintained irrigation infrastructure and poor overall performance of existing irrigation systems (Torell & Ward, 2010). Despite the long history of Afghan dependence on irrigation for agriculture, knowledge lost due to war and 30 years of isolation has left a deficiency in water management technologies (Groninger & Lasko, 2011). Large parts of irrigation schemes were destroyed during the Soviet occupation in retaliation for local support for the *mujahideen*, and in many cases these lands remain unpopulated. Waterlogging and salinization of soils are also locally important constraints to irrigation agriculture, particularly in the Harirud, Farah Rud, Balkhab, Murghab and Helmand Valleys (Qureshi, 2002).

There are four basic irrigation types in Afghanistan: surface canal systems, springs, karezes, and wells. Surface canal systems include both modern and traditional types, with intakes from various rivers and streams, largely fed by snowmelt. Modern surface irrigation systems provide water to about 10% of the total amount irrigated in Afghanistan, while traditional canal irrigation systems represent approximately 75%. Karezes (underground aqueducts – see Hussain, Abu-Rizaiza, Habib, & Ashfaq, 2008), springs and wells provide another 15% of the irrigation water for the country.

Surface canal irrigation systems

Surface canal systems are by far the most commonly used method to bring irrigation water to fields and can be found in every province. These range in size from a few hectares in high mountain valleys to extensive networks on the northern plains (Lee, 2003). Canal irrigation systems occur most extensively in the larger river basins on the periphery of the country. From these large canals, water is diverted to small irrigation channels (watercourses) before reaching the fields.

The amount of water provided to each farmer varies between, and sometimes within, canal systems and may be determined according to several criteria, including the amount of land under cultivation, the crop, the irrigation scheme, the available water rights, and the amount of water present at the main source (Rout, 2008; Thomas, Mumtaz, & Azizzi, 2012). For example, in the Balkh-ab watershed, each community served by a canal has a customary property right in water, based on the *paikal* system, which is an indigenous land-water unit equal to 80 ha of irrigated land and the accompanying water needed to support the irrigation of this land area (Torell & Ward, 2010). Water rights are clearly defined and determine allocation within some of the more functional systems. However, in many other areas, these regulations are not strictly followed, and water distribution is primarily achieved based on informal agreements among farmers. In many cases, a farmer's irrigation turn is considered fulfilled whether or not water is present in the canal at the appointed time.

Modern surface irrigation systems have engineered intake structures and permanently installed gates for water control along the water distribution system. These modern surface systems are primarily concentrated along three major river valleys: the Kunduz in the north, the Kabul and its tributaries in the east, and the Helmand and its tributaries in the south. Modern systems are primarily located in five provinces that include Kunduz and Balkh in the north, Helmand and Kandahar in the south, and Nangarhar in the east. These provinces have about 90% of the area in Afghanistan that is irrigated by modern surface systems, while smaller amounts can be found in Parwan and Ghazni Provinces. However, the irrigation water volume from these canals often falls by up to 70% during years with droughts, directly influencing the productivity of agriculture during those times (Shobair & Alim, 2004).

Traditional surface systems rely on brush/log diversions, with water delivery via earthen water conveyance and control structures. These are typically built by local people, and the intake structures on these systems have traditionally been constructed with available building materials and indigenous engineering knowledge. These rarely survive spring floods and must be rebuilt annually, immediately prior to the spring irrigation season. The operation and maintenance of traditional and many of the modern systems are carried out by local water users, and are typically headed by a *mirab*, the traditional local water manager or 'water master'. Water user associations and *mirab*s are ancient local institutions commonly found all across Afghanistan. The role of the *mirab* is in transition and is being slowly integrated into water user or irrigation associations. Traditionally, *mirab*s may be compensated with a share of the crop produced by the water users they serve. *Mirab* selection differs by locality. In certain instances, the *mirab* is a farmer-elected leader who is given the authority and responsibility for distributing water within any given canal system (Torell & Ward, 2010). Although the *mirab* may be selected from within the local farming community, he is not necessarily a farmer. *Mirab*s control water distribution, perform minor maintenance, and organize community members into work details to perform major canal maintenance and repairs. Furthermore, they attempt to adjudicate differences over water use between different water users along the length of a given canal. Maintenance activities include repairing and desilting canals, and extending intake structures in the river. Canal repair and maintenance works are executed by mobilizing large groups of labourers, and farmers in the area must contribute labour, cash, or other in-kind support (Qureshi, 2002). On larger canal systems, *mirab*s delegate physical tasks of operation and maintenance to one or more assistants, called *chak bashi*s in some areas. This traditional system of water distribution is functional in many areas which lack both the support and effective authority of higher-level institutions, such as village or provincial councils or national government, to administer or allocate water (Torell & Ward, 2010). However, the absence of technical water resource and professional irrigation expertise in these instances hampers the effectiveness of irrigation practices for crop production (Walters et al., 2012).

In traditional and modern irrigation schemes, the dominant irrigation methods are basin/border irrigation for cereal crops and furrow irrigation for vegetables and grapes. Farmers generally lack knowledge of crop water requirements, and over-irrigation of crops is common, which can often lead to devastating disease problems, such as *Phytophthora* blight in various vegetable crops (Walters et al., 2012). Qureshi (2002) indicates that the overall water efficiency is only about 25–30% for both modern and traditional irrigation schemes, for the following reasons: (1) high conveyance losses in traditional schemes with earthen canals; (2) high operational losses in modern schemes with unlined conveyance canals; and (3) high on-farm distribution losses (e.g. over-irrigation and inadequately levelled land) in both traditional and modern schemes. Furthermore, there is usually a waste of irrigation water in traditional schemes during the first half of the growing season, through unregulated floodwater entering canals, and a shortage of water during the second half of the season, when river flow decreases to its annual minimum. Due to the low water-use efficiencies and lack of adequate inputs for maintenance of irrigation systems, yields of horticultural crops tend to be very low. Skills such as irrigation structure management and maintenance have apparently been lost within many Afghan communities (Groninger & Lasko, 2011).

Groundwater irrigation sources

The other types of irrigation systems in Afghanistan (karezes, springs and wells) utilize groundwater resources. The karez is an ancient irrigation technology. Current estimates indicate that about 6000–7000 karezes exist, scattered throughout Afghanistan, irrigating about 163,000 ha of land (Azimi & McCauley, 2002; Hussain et al., 2008). These systems access aquifers at mountain foothills and conduct water via sloping subsurface tunnels to the heads of surface irrigation systems for downslope croplands. In essence, these are underground tunnels, constructed horizontally on a slight slope from a source of groundwater, which later emerge at the surface some distance down the slope. This allows water to flow to the surface by gravity to reach the lower and flatter lands that are best suited for agricultural irrigation (Hussain et al., 2008). Vertical air shafts ('wells') are spaced periodically along the horizontal tunnel to allow access to the kareze and removal of earth during construction and cleaning. This system harvests groundwater without any need for mechanical devices and can supply relatively large areas of land with water for both domestic and irrigation purposes. However, it is generally not able to provide enough water for large-scale agriculture and often loses its importance compared to canal systems.

Karezes are concentrated almost exclusively on the eastern, southern, and western flanks of the Hindu Kush mountains, in a belt stretching from Parwan Province north of Kabul across south-eastern Afghanistan to Kandahar, and in the western provinces of Faryab, Herat, and Farah (Garner et al., 2002). Karezes are often overlooked as sources of irrigation, but they supply more than 15% of irrigation water in provinces such as Kabul and Farah. Karezes are traditionally constructed and maintained by a specialized group of artisans called *karezkan*. *Karezkan*s are generally well paid by local standards because their work is both physically demanding and dangerous. The past decades of war have limited the functionality of karezes in Afghanistan, which generally require regular maintenance to work effectively. Some have been deliberately destroyed by warfare, or sabotaged, or mined, to make rehabilitation difficult. Many foreign governments and non-governmental organizations have provided assistance to clean and restore damaged karezes through food, cash-for-work, or training and equipment provision programmes.

Springs provide water to only about 5% of the irrigated agricultural lands in Afghanistan. However, they can be important sources of irrigation and drinking water in certain locations. Springs provide more than 15% of irrigation water in Badghis, Bamyan, Ghor, Parwan, Samangan, and Uruzgan Provinces (Garner et al., 2002). In Uruzgan, springs and karezes together supply more than 50% of the irrigation water. Compared to other sources of water for irrigation, springs require few repairs and little maintenance. Canals that distribute water from springs are similar to those of smaller traditional surface systems.

Drilled wells have traditionally played only a localized role as a water source for irrigation. However, this practice has increased dramatically, both in urban and rural areas, and wells are now abundant from Kabul to Kandahar (Garner et al., 2002). In the east, south, and west, thousands of new wells have been constructed as supplemental sources of water, and wells are quickly replacing karezes in these areas as water sources for irrigation. For example, the northern part of Helmand Province does not have direct access to the Helmand River and relies on irrigation water from natural spring and groundwater sources that flow into karezes. Deep tubewells have been dug in this area to offset the decrease in kareze output, but have in turn contributed to depletion of groundwater resources. Often, wells are being drilled near karezes, since the aquifers in these areas have historically been good sources for underground water. In some areas in northern Afghanistan (e.g. Kunduz and Baghlan Provinces), dug wells have been used to a limited extent to irrigate agricultural crops, but are more important as sources of drinking water. Wells are increasingly becoming a significant source of irrigation water and are serving the critical role of helping many Afghan farmers maintain orchard and vineyard productivity. However, at the same time, many new settlers in some areas (e.g. Helmand Province) have developed new farms on land once devoid of irrigation. Here, newly drilled wells have become the only source of irrigation water – without regard for long-term sustainability.

Many traditional groundwater-resource irrigation systems have decreased or lost functionality over the past several years due to recent droughts (Slobar & Alim, 2004). Furthermore, the deep wells that have been recently dug in the vicinity of karezes and shallow wells have reduced the water discharges in these traditional groundwater irrigation systems, further threatening their sustainability. In most urban areas, shallow wells are limited for drinking use and other household activities. As water levels continue to fall, many poorer families are unable to dig their wells deeper and are forced to obtain water from communal wells or water trucks. In some cases, families, especially women and children, must walk several kilometres daily to meet domestic water demands.

Drip irrigation systems

Although more precise application of water through drip irrigation systems would provide more efficient water use for certain agricultural activities, such as fruit and vegetable production, this technology is not used to a great extent. Drip irrigation is about 40% more water-efficient than the furrow systems which tend to be used to produce grapes and vegetables, and about 70% more efficient than the basin/border irrigation which is favoured for tree fruit and agronomic crops. The increased water efficiency in drip irrigation systems is generally related to reduced soil percolation and surface evaporation compared with other irrigation systems. However, high material costs, insufficient pressures to effectively operate these systems, and clogging of emitters by water sediments are problems commonly associated with attempts to deploy drip irrigation systems in Afghanistan. Additionally, farmers lack sufficient resources to sustain agricultural productivity through drip irrigation, or any other irrigation method, at times when water is not readily available. Significant efforts were made to introduce drip irrigation to communities across Afghanistan over the past decade, but this effort has largely failed. However, systems that tolerate high turbidity are now being used by some farmers in portions of Afghanistan.

Opportunities to improve irrigation system efficiency

Although the existing irrigation systems in Afghanistan suffer from multiple problems (Table 2), opportunities exist to potentially sustain these irrigation systems indefinitely. Critical issues include water loss from canals, inconsistent water discharges, lack of canal maintenance, no understanding of crop-water scheduling, improper drainage of fields, and lack of institutional support to help farmers improve cropping systems under current levels of water availability.

Water loss from canals

Afghanistan's rural watercourses and canals are generally unimproved trenches. Consequently, transmission losses occur through seepage, over-bank spillage, and evaporation. Watercourse linings reduce losses from seepage and spills, increasing the amount of water potentially reaching the irrigated areas. Although linings can be found in some watercourses, more are being built to reduce this significant source of water loss. Concrete irrigation watercourse turn-outs are also being built and utilized

Table 2. Problems and possible solutions for the current unsustainable irrigation and water resources in canal irrigation systems in Afghanistan, based on personal observations and communications with development professionals working in Afghanistan (2005 to 2011).

Problem	Possible solutions
Water loss from canals prior to reaching field	Use of watercourse linings in canals Use of concrete turnouts Training and technology transfer to increase human capacity building and understanding
Lack of consistent water flow in canals	Reduce water usage or wastage in upstream areas Large-scale water storage facilities
Deterioration of canals	Various infrastructure improvements in canals Maintenance of canals on regular schedule Strengthen local water user institutions
Crop-water scheduling	Farmer and mirab training Consider crops best suited for anticipated water availability
Field drainage	Laser levelling of fields through global positioning system technologies and use of precise tillage equipment
Lack of capacity in MAIL/DAIL	Increase knowledge of irrigation agriculture among MAIL/DAIL personnel Increase institutional capacity to demonstrate locally appropriate irrigation practices

in some areas. This technology replaces the manual method of diverting water from watercourses into farmers' fields: removing soil with a shovel to allow water to flow into the desired field. Although installation is costly, concrete turnouts prevent transmission loss and waterlogging around the farm intake, preventing loss of water as well as of potential arable land. However, canal gates become inoperable without regular maintenance, and subsequent clogging with silt or weeds may disrupt water delivery to downstream portions of the system (Wolf, English, & Haack, 1994). Training and technology transfer are also needed to build local capacity for regular canal maintenance, which could, by itself, significantly improve irrigation efficiency in some areas.

Lack of consistent water flow

Upstream crop demands, especially during times of drought, can significantly reduce water flow rates to downstream users. Rice production in particular is a concern in Afghanistan headwaters given the large amounts of water required for its production (Hoekstra & Chapagain, 2008; Thomas & Ramzi, 2011; Walters et al., 2012). Moreover, in the absence of a functioning central government, there is no means of regulating water use within these large agricultural watersheds beyond the purview of an individual *mirab* (Wegerich, 2010). The economic and social consequences of water scarcity are magnified by the insufficiency of large-scale storage facilities to hold floodwaters for later use during dry periods (Gohar, Ward, & Amer, 2013; Torell & Ward, 2010). In the absence of the government authority needed to create and maintain large reservoirs, on-farm impoundments could be a small-scale solution to moderate water supply excesses and shortages for irrigation and household needs, while occupying limited arable land (Groninger & Lasko, 2011). However, on-farm water storage capacity is also quite limited (Lee, 2003).

Irrigation system rehabilitation

Irrigation systems are in serious need of repair. In many cases, entire canal networks need major rehabilitation, after decades of civil unrest that has impeded routine maintenance and prevented the acquisition of adequate resources for repairs. The relatively high level of technological sophistication achieved in Afghan agriculture in the 1970s was degraded to an astounding degree by looting of equipment, destruction of irrigation systems and loss of human capacity during subsequent years of fighting (Groninger & Lasko, 2011); presently, few Afghans are sufficiently skilled to maintain and operate these systems to their capacity. An estimated 25% to 50% of all irrigation systems were directly affected by war neglect, or both (Qureshi, 2002). However, the direct impact of war on irrigation infrastructure was due less to actual destruction and more to migration of farmers to other regions or countries, leaving irrigation systems unattended (Qureshi, 2002). Some canals are completely silted, breached and not delivering water as in past years. However, there is little information available regarding the costs required to complete various canal infrastructure improvements (Gohar et al., 2013; Reeling, Lee, Mitchell, Halimi, Carver, 2012).

Crop-water scheduling

Although there are exceptions, farmers and *mirabs* in most communities lack an understanding of effective crop-water scheduling, which is the application of the optimal amount of irrigation water at each crop growth stage to maximize productivity. Besides adequate irrigation design and good irrigation management practices, crop scheduling has long been recognized as a key to increasing crop production on a sustainable basis. Scheduling irrigation according to crop water needs minimizes the chances of either under- or over-watering. The amount of irrigation water required to supplement crop needs depends on the water requirements of a particular crop at a given stage of growth, as well as local climate (e.g. precipitation and evaporation rates) and soil conditions. For many vegetable and fruit crops, the frequency can vary from once or twice a week early in the growing season to daily during times of peak water demand.

Field drainage systems

Irrigation water is often improperly drained from fields, which can lead to reduced crop stands and yields. Inadequate drainage impacts agricultural production by causing soil compaction, soil erosion, salt accumulation, and even crop failure. Uneven or rough field topography causes uneven water distribution to crops and impeded drainage, and may be evidenced as large pools of standing water in fields. Laser levelling, using laser emitters, global positioning systems and tillage equipment to precisely contour the topography of agricultural fields, facilitates surface-water runoff and eliminates pooling for several years following treatment. Recent research has shown that wheat yields in Balkh Province increased by more than 50% when grown in laser-levelled irrigated fields, compared to the provincial average, and chilli-pepper yields increased by almost 20% (to 23.5 tonnes/ha) compared to non-levelled furrow-irrigated fields (AWATT, 2010). While this system is not practical across all of Afghanistan, it is already commercialized in some areas.

Agricultural support services

Lastly, the Ministry of Agriculture Irrigation and Livestock (MAIL) and its provincial directorates (DAIL) lack the capacity to deliver agricultural support services. This limits opportunities to improve existing irrigation infrastructure or to address water management problems. Afghan farmers need some type of support system to improve and develop self-sustaining water management systems. This issue is currently being addressed, at least in part, by many world governments, as well as non-governmental organizations, who are trying to build local capacity to address irrigation and water management issues. Training *mirab*s to assume a water management teaching role also serves to increase local knowledge capacity (AWATT, 2010).

Future prospects for agricultural water management

Weak and inadequate institutional capacity limits implementation of proven irrigation and agricultural production technologies at both the national and provincial levels (Torell & Ward, 2010). There is little active water resource management occurring in the country. Although there are several ministries that are directly involved in the management of water resources, including the MAIL, the Ministry of Energy and Water and the Ministry of Rural Rehabilitation and Development, they often lack the coordination needed to effectively resolve water resource management issues. The lack of water-use regulation and control is evident in the falling water tables due to over-use of groundwater for irrigation purposes, inadequate discharges of irrigation water often observed for downstream users, reduced access to safe drinking water due to contamination issues, drying estuaries, and damaged aquatic ecosystems.

Watershed degradation through poor grazing practices and unregulated fuel-wood collection contributes to the water supply problem, which is further aggravated by unregulated water use by agriculture and industrial sectors, as well as household use. Although the supply of water is currently not enough to maximize the productivity of agriculture, sustain population increases and expand other industries, the problem becomes even more critical during periods of drought. The increasing demand for water has put enormous pressure on groundwater resources, and the over-exploitation of this resource has resulted in shrinking drinking-water supplies for both urban and rural populations. To preserve this important water resource, the Afghan government must develop and enforce appropriate policies to effectively manage groundwater use. Although there is little involvement or coordination of irrigation activity at the national level, the new water law that was passed in 2009 and the US government's Inter-Agency Water Strategy for Afghanistan[1] articulate a path to increase the role of central government, specifically the MAIL, in implementing a coherent agricultural water policy (Groninger & Lasko, 2011; Reeling et al., 2012). Imposing actual water authority, already hampered by unenforced laws and potentially conflicting ministry roles, is further complicated by the locally recognized informal institutions and forces that have filled the void.

Although the importance of water in the economic development of Afghanistan is frequently stated by Afghan and international development personnel alike, opportunities to achieve meaningful improvement are often overlooked. Foreign observers typically link the highly inequitable distribution of water among potential users to regional loss of livelihoods and population displacement (Palmer-Moloney, 2011). However, most Afghans outside Kabul do not expect water-rights enforcement from the central government; their requests for assistance are focused directly or indirectly on water to improve irrigation for agricultural activities (Palmer-Moloney, 2011). The authors' experience suggests that foreign advisors to the Afghan government, with encouragement from their counterparts in Kabul, are overemphasizing mostly unrealistic policies to make water distribution more equitable, while providing less support to facilitating the implementation of more plausible on-farm solutions.

Efforts to improve agricultural water use through community-based approaches should be the focus for achieving and maintaining food security, social stability and sustainable development objectives in Afghanistan. Watershed conservation practices and more efficient on-farm use of water must be the foundation for a fully productive agricultural sector. Increasing water capital through water harvesting and irrigation management needs careful consideration and implementation to avoid conflict by depriving the downstream communities that are equally dependent on freshwater resources (Torell & Ward, 2010).

Although Afghanistan faces a complex array of problems, most would agree that the primary limiting factor to crop production is inefficient use of an already limited water resource. With the exception of those living in pockets of Afghanistan little impacted by the conflicts of the past 35 years, Afghan farmers generally have a poor understanding of crop water requirements. Irrigation practices are still largely based on the maximum amount of water they can capture on their farm during irrigation turns, both to their own detriment and that of downstream users. Afghan farmers should be encouraged to use water-harvesting procedures (both small and large storage structures) and introduced and trained in modern water-saving technologies and crop varieties, which have proven successful in arid environments similar to Afghanistan (Molden et al., 2010). These could be addressed through community-level capacity building, including training efforts and on-farm efficiency improvements, whether or not national water policies addressing supply issues are implemented.

Although effective water resource management practices are critical for maintaining food security in Afghanistan, until a more broadly functional means of distributing water becomes available and underlying watershed management issues are addressed, on-farm practices that improve water management represent the best opportunity to strengthen farmer livelihoods and develop a sound agriculture-based economy. Rather than linking them to large infrastructure projects that cannot be built under present circumstances, putting these practices in place now will produce immediate benefits as well as multiply the positive impacts of any future project.

Acknowledgements

The authors gratefully acknowledge the support provided by the Afghanistan Water Agriculture and Technology Transfer Project, funded by the US Agency for International Development, and the Agriculture Development for Afghanistan Pre-Deployment Training programme, funded by the US Department of Agriculture Foreign Agriculture Service and Southern Illinois University. The opinions stated in this article are strictly those of the authors and are not intended to represent those of any government or organization.

Note

1. The strategy was never published beyond a draft but was referenced in other documents such as United States Government Accountability Office (2010).

References

Afghanistan Water, Agriculture and Technology Transfer (AWATT) Program. (2010). *Annual Report: Oct 1, 2009 to Sept. 30, 2010*. Washington, D.C: US Agency for International Development.

Ahmad, M., & Wasiq, M. (2004). *Water resource development in northern Afghanistan and its implication for Amu Darya basin*. World Bank Group, World Bank Working Paper No. 36, Washington, DC.

ANDS Secretariat. (2008). *Afghanistan national development strategy 2008-2013*. Kabul: Government of the Islamic Republic of Afghanistan.

Asian Development Bank (ADB). (2003). *Rebuilding Afghanistan's agriculture sector*. Manila, Philippines: Asian Development Bank. Retrieved from http://www2.adb.org/documents/Reports/Afghanistan/Agriculture/Rebuilding_Agriculture_Sector_AFG.pdf (Accessed 25 January, 2013).

Azimi, A., & McCauley, D. (2002). *Afghanistan's environment in transition* (p. 40). Manila, Philippines: Asian Development Bank.

Center for Policy and Human Development. (2012). *Afghanistan human development Report 2011*. Kabul University, Afghanistan. Retrieved from http://www.cphd.af/nhdr/nhdr2010/Complete%20NHDR%202011%20final.pdf (Accessed 26 February, 2013).

Garner, D. A., Svendsen, M., Assifi, T., Mickelwait, D. R., Viala, E., Aini, A., Omar, M., & Waiss, H. A. (2002). Assessment of the irrigation sector in Afghanistan and strategy for rehabilitation. Development Alternatives Inc. report for US Agency for International Development/Afghanistan.

Gohar, A. A., Ward, F. A., & Amer, S. A. (2013). Economic performance of water storage capacity expansion for food security. *Journal of Hydrology*, *484*, 16–25. doi:10.1016/j.jhydrol.2013.01.005

Groninger, J. W., & Lasko, R. J. (2011). Water for agriculture: Challenges and opportunities in a war zone. *Water International, 36*(6), 693–707. doi:10.1080/02508060.2011.613220

Groninger, J. W. (2012). Reforestation strategies amid social instability: Lessons from Afghanistan. *Environmental Management, 49*, 833–845. doi:10.1007/s00267-012-9817-6

Hoekstra, A. Y., & Chapagain, A. K. (2008). *Globalization of water: Sharing the planet's freshwater resources*. Oxford, UK: Blackwell Publishing Ltd.
Hussain, I., Abu-Rizaiza, O. S., Habib, M. A. A., & Ashfaq, M. (2008). Revitalizing a traditional dryland water supply system: The karezes in Afghanistan, Iran, Pakistan and the Kingdom of Saudi Arabia. *Water International, 33*(3), 333–349. doi:10.1080/02508060802255890
Lee, J. L. (2003). *Water resource management on the Balkh Ab River and Hazhda Nahr Canal Network: From crisis to collapse*. Tashkent: Central Asia Free Exchange.
Molden, D., Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., & Kijne, J. (2010). Improving agricultural water productivity: Between optimism and caution. *Agricultural Water Management, 97*, 528–535. doi:10.1016/j.agwat.2009.03.023
Palmer-Moloney, L. J. (2011). Water's role in measuring security and stability in Helmand Province, Afghanistan. *Water International, 36*(2), 207–221. doi:10.1080/02508060.2011.560748
Persaud, S. (2012). *Long-term growth prospects for wheat production in Afghanistan*.WHS-11L-01USDA. Washington, D.C: Economic Research Service. Retrieved from http://www.ers.usda.gov/publications/WHS/2011/WHS11L01/whs11L01.pdf (Accessed 25 January, 2013).
Qureshi, A. S. (2002). *Water Resources Management in Afghanistan: The Issues and Options*. *International Water Management Institute*. Working Paper 49, Pakistan Country Series 49. Retrieved from; http://ageconsearch.umn.edu/bitstream/92703/2/WOR49.pdf (Accessed 25 January, 2013).
Reeling, C. J., Lee, J., Mitchell, P., Halimi, G. H., & Carver, A. (2012). Policy options to enhance agricultural irrigation in Afghanistan: A canal systems approach. *Agricultural Systems, 109*, 90–100. doi:10.1016/j.agsy.2012.03.005
Rout, B. (2008). *How the water flows: A typology of irrigation systems in Afghanistan* (p. 58). Kabul: Afghanistan Research and Evaluation Unit Issue Paper Series. June 2008.
Saba, D. S. (2001). Afghanistan: Environmental degradation in a fragile ecological setting. *International Journal of Sustainable Development and World Ecology, 8*, 279–289. doi:10.1080/13504500109470086
Shobair, S. S., & Alim, A. K. (2004). *The effects of calamities on water resources and consumption in Afghanistan*. Rome: Food and Agriculture Organization of the United Nations (FAO). Retrieved from http://www.nourin.tsukuba.ac.jp/~tasae/2004/Afghanistan.pdf (Accessed 25 January, 2013).
Thomas, V., & Ramzi, A. M. (2011). SRI contributions to rice production dealing with water management constraints in northeastern Afghanistan. *Paddy Water and Environment, 9*(1), 101–109. doi:10.1007/s10333-010-0228-0
Thomas, V., Mumtaz, W., & Azizzi, M. A. (2012). *Mind the gap? Local practices and institutional reforms for water allocation in Afghanistan's Panj-Amu river basin* (p. 135). Kabul: Afghanistan Research and Evaluation Unit Case Study Series. June 2012.
Torell, G. L., & Ward, F. A. (2010). Improved water institutions for food security and rural livelihoods in Afghanistan's Balkh river basin. *International Journal of Water Resources Development, 26*(4), 613–637. doi:10.1080/07900627.2010.519492
United Nations Food and Agriculture Organization (FAO). (2011). *FAOSTAT database*. Retrieved from http://faostat.fao.org/CountryProfiles/Country_Profile/Direct.aspx?lang=en&area=2 Rome, Italy: FAO. (Accessed January 28, 2013).
United States Government Accountability Office. (2010). *Afghanistan development: U.S. efforts to support Afghan water sector increasing but improvements needed in planning and coordination*. GAO-11-138, Washington DC: GAO.
Walters, S. A., Groninger, J. W., & Myers Jr, O. (2012). Rebuilding Afghanistan's agricultural economy: Vegetable production in Balkh province. *Outlook on Agriculture, 41*(1), 7–13. doi:10.5367/oa.2012.0073
Wegerich, K. (2010). The Afghan water law: "A legal solution foreign to reality"? *Water International, 35*(3), 298–312. doi:10.1080/02508060.2010.486524
Wheeler, T., & Kay, M. (2010). Food crop production, water and climate change in the developing world. *Outlook on Agriculture, 39*(4), 239–243. doi:10.5367/oa.2010.0017
Wolf, J., English, R., & Haack, B. (1994). Rehabilitation assessment of the Helmand-Arghandab valley irrigation scheme in Afghanistan. *Water International, 19*(3), 121–128. doi:10.1080/02508069408686215