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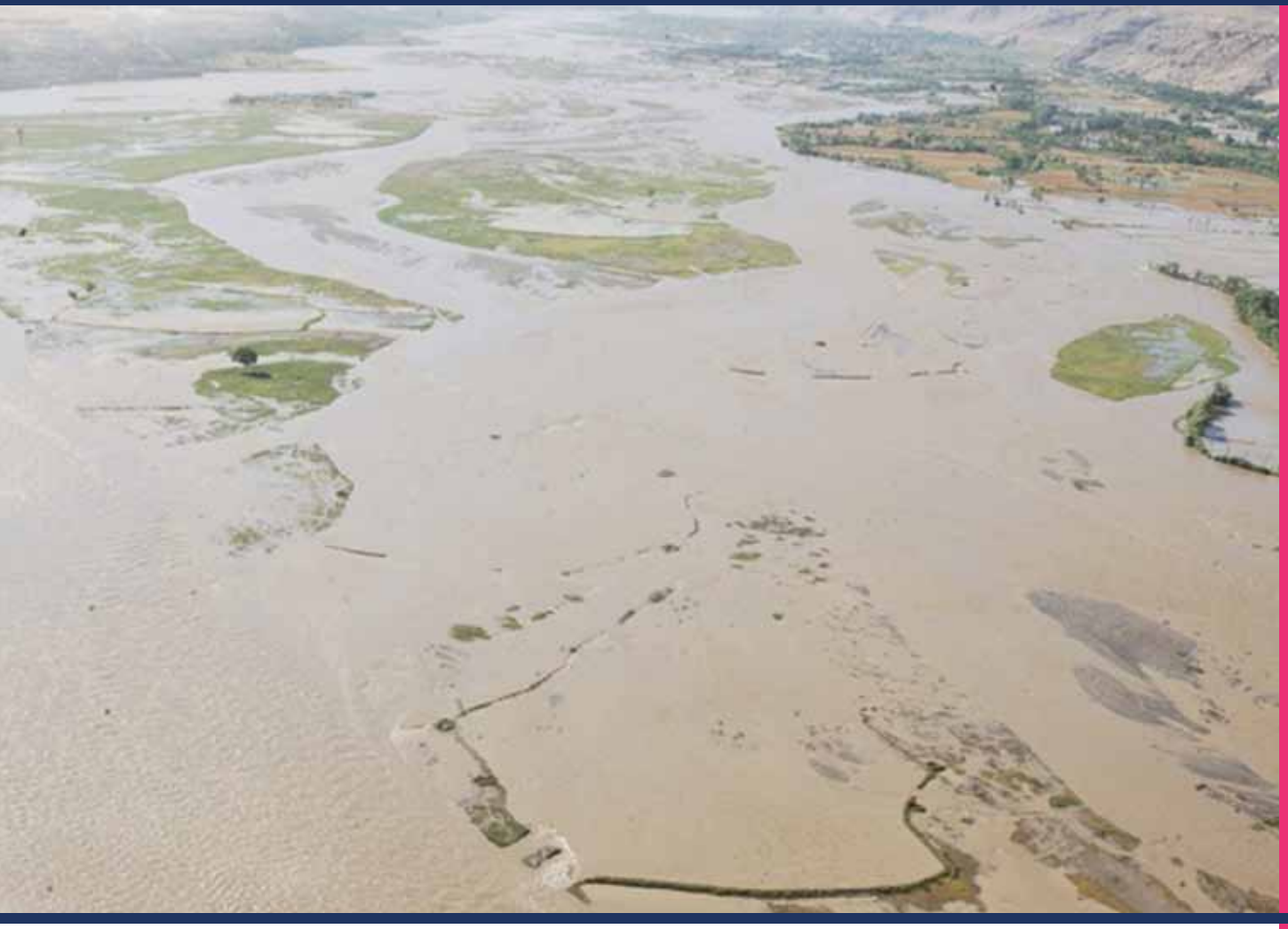
Spate Irrigation in Afghanistan



Overview Paper Spate Irrigation

Spate Irrigation Network

Introduction

This paper discusses the occurrence of spate irrigation in Afghanistan, an ancient system that harvest short duration floods and seasonal flows. These systems occur widely in Afghanistan, serving a command area of maybe close to 150,000 ha – yet they are little known or recognized across the country. The techniques in spate irrigation differ from conventional irrigation system, but spate systems in spite of their inherent uncertainty have potential for improvement as well as expansion and for making a larger contribution to agricultural development in some of the most neglected parts of the country.

Afghanistan is an arid, semi- arid to sub-humid climate country, with a high geographical, seasonal and annual variation of precipitation and snow. During the winter, the temperature drops considerably and precipitation is in the form of snow mostly in the Hindu Kush mountain areas. In the summer, the opposite occurs; the temperature rises with almost zero precipitation mostly in the south and south-west deserts and less in the east and north east. This arid to semi arid climate is not so favorable for rainfall agriculture without supplementary irrigation except in some areas in the north. Annual average precipitation in the country is about 300 mm (Grieser, Gommes et al. 2006). However, the amount of rainfall in each region usually varies from year to year e.g. 1200 mm in the higher altitudes of the northeast mainly in the Salang areas and 60 mm in the southwest deserts, with 365 mm on average according to USGS accumulated region-wise annual rainfall data for 2009-2010 (USGS 2010).

On the other hand, the majority of rivers in Afghanistan are ephemeral, largely determined by melt water from the mountains with flash floods in the spring which cannot support regular water for agricultural land. However, Afghanistan has for centuries been engaged in building small water storage and diversion structures in various forms to ensure a year-round water supply for some arable land. Therefore, building small dams for water storage in the spring season and also traditional intake and diversion structures has been common place in the country for thousands of years for irrigation purposes. However, currently in Afghanistan water storage and irrigation structures are limited to some parts of the country; most of them are at least 50 years old. Nevertheless, they provide year-round irrigation water only for 330,000 ha arable land throughout the country which is estimated 10 % of the total irrigated lands.

Diversion dam development has a long history in this arid region and has a significant role for agricultural and economic development. According to the MEW/EIRP, this region has a history going back thousands of years. In the early 19th century the presence of small and also large irrigation canals was a curious feature e.g. the Sultani or Imperial canal on the right bank of Helmand river was an indication of cultivation antiquity (Tate and McMahon 1909). Therefore, this area was known from ancient times as the bread-basket of central Asia. Similarly, in the north-west close to Herat, there are elongated fields that are fed from ephemeral streams and are known as the granary of central Asia (Arthur 1885). Hence, the spate irrigation system in Afghanistan has an ancient history and enormous potential mainly in the east, south-east, north, north-east and west. However, according to conservative estimates, a significant amount (more than 75 %) of flood water mainly in the spring season is allowed to escape and flow into neighboring countries each year. In addition, more than two-thirds of the remaining flood water is wasted due to the poor infrastructure system and is not properly used for irrigation. There is an essential need to improve the livelihoods of the poverty-stricken communities living in spate areas where harvested water can be used for the crop production cycle.

Hence, spate irrigation is an emerging interest. The government of Afghanistan has also expressed its intention to improve spate irrigation but insufficient technical knowledge, unrest and poor hydrological data seem to form a tremendous challenge. However, intuitively spate irrigation is already there but it is unknown and it comes primarily as a semi-perennial and flashflood type of spate irrigation. On the other hand, spate irrigation is quite different from conventional irrigation systems and therefore, requires a special approach and skills. Also, at the policy level, spate irrigation should be encouraged since it is low cost, environmentally sustainable and people friendly. It gives sustenance to the poorest of the poor and can improve grazing for livestock. However, spate irrigation is a new term in Afghanistan and requires orientation through meetings, seminars, research reports and small round tables at the local and national levels in order to make a specific contribution to spate water harnessing.

Water resources management in Afghanistan

Afghanistan has the position of an upstream country to all the riparian states in the region. Poor governance due to several years of war and inaccessibility because of geographical complexity has caused the loss of a 3rd of its surface water and just 30 % is being exploited in the country. In addition, there is rapid snowmelt and seasonal flow which causes flooding in the spring and water shortage and scarcity are common for the remaining seasons. Furthermore, social and economic development requires sufficient water for agriculture and hydropower generation. Therefore, in 2008 the GoA decided to develop the Afghanistan National Development Strategy (ANDS) with a generous contribution by national and international organizations. The Water Sector Strategy (WSS) is part of the ANDS which was developed for integrated and holistic water resources management and development with specific focus on dam and reservoir construction (GoA 2008).

Since the 1920s the Afghan government has undertaken the construction of a number of large integrated irrigation schemes and water storage projects. For example, the Helamand - Arghandab Valley Authority (HAVA) and Nangarhar Valley Development Authority (NVDA) were among the largest water resources infrastructures and irrigation schemes. The further development of these kinds of projects was halted due to internal and external factors caused by war and unrest in the country. Therefore, 90 % of irrigation systems are still being used in the traditional manner.

Snow above the 2,000 m elevation provides about 80 % of Afghanistan's water which is very important to the country as there is a natural water storage (GoA 2008). Moreover, there is more expectation for heavy rainfall in the spring and moderate rainfall in winter with very low precipitation in summer. During the last cycle of drought, the glaciers and snow melting decreased in size and volume. This trend is likely to continue with the expected warming tendency in the 21st century altering the spatial and temporal dimensions of surface flow (Joel 2007). This reduction poses additional long-term threats to the water sector of the country which requires storage because the vast majority of the agricultural land has seasonal water and mainly uses floodwater in the spring season.

The total mean annual precipitation in terms of rainfall corresponds to165 billion m^3 in the country. Of this volume, 34.5 % provides a total of 57 billion m^3 annual surface water which drains into 5 river basins, and 18 billion m^3 feeds the groundwater through surface infiltration, see Table 1. The average annual surface water per capita is estimated at about 2,300 - 2,500 m^3/year[1] (King and Sturtewagen 2010) which is close to for example Italy's mean availability of 2,700 m^3/capita year (Massarutto, de Carli et al. 2003). This quantity of water would be sufficient to irrigate approximately 7.7 million ha of land if there were no problems of seasonal scale or spatial distribution but Afghanistan's water flow pattern is seasonal mostly in spring and then the stream flow is reduced or dries up during the rest of the seasons (GoA 2008).

Extent of spate irrigation in Afghanistan

Afghanistan is an agrarian country which is heavily reliant on irrigation mainly during the summer, when there is virtually no precipitation and seasonal snowmelt from the high mountains cannot provide a year-round surface flow.

The country is characterized by the frequent occurrence of drought and floods, and 75 % of its territory is covered by mountains, 17 % by river valleys and about 12 % is arable land. The rivers are characterized by ephemeral flow regime; most of the rivers and streams in Afghanistan are seasonal and flow during three months a year, peaking in spring and early summer and remaining dry during the rest of the year. The history of irrigated agriculture in Afghanistan goes back more than 4,500 years ago (an

Table 1: Estimated Surface and Groundwater Resources (Qureshi, 2002)

Type of water resources	Annual potential[1] (billion m^3)	Present situation (billion m^3)		Potential situation (billion m^3)	
		Current used	Unused	Future use[2]	Unused
Surface water	57	17	40	30	27
Groundwater	18	3	15	5	13
Total	**75**	**20**	**55**	**35**	**40**

1) *Master plan (GoA, 1968)*
2) *When all existing and planned irrigation schemes are rehabilitated and managed efficiently*

ancient settlement near Kandahar). Except in some areas in the north where rain-fed[3] agriculture can be practiced otherwise, agricultural production in most areas of the country is not possible without irrigation as the rainfall is either meager or unreliable. The allocation of water and land is closely related to the customs and traditions of the sedentary population, and maintenance works of irrigation schemes have always been a well-defined activity in the farmers' seasonal calendar.

Since long ago water resources in Afghanistan have been managed through formal and informal institutional approaches which were mainly used for irrigation. Large irrigation schemes and main canals including water storage dams are managed by governmental entities at an official and formal national and provincial level. Local irrigation systems, below the formal schemes and main canals are managed by a traditional Mirab system. A Mirab is an experienced farmer who is locally elected by the farmers and landowners along an irrigation channel to control the water and take care of the maintenance and operation of the irrigation system at a local level. In general, Afghanistan has four main categories of arable lands depending on the type of water resources, which is stated in Table 2:

1. Formal and perennial irrigation schemes with water storage capacities which supply year-round water for certain types of agricultural land.
2. Informal (local) irrigation using/diverting water from the intermittent rivers, or springs and karizes.
3. The spate irrigation system using/diverting flashflood water from the ephemeral streams and dray watercourse in the traditional manner.
4. Rain-fed[4] agricultural land which particularly in some areas of the north region has a very low yield.

The second and third categories are entirely traditional systems using local materials and simple structures to convey water into an irrigation channel. The line ministries have undertaken several efforts to provide farmers with an improved, reliable and equitable distribution of irrigation water to increase agricultural productivity. For instance, the Ministry of Agriculture, Irrigation and Livestock (MAIL) has recently started on-farm water management, focusing on the institutional aspect of irrigation systems and improvement of irrigation infrastructure including training facilities for farmers on water saving techniques. On the other hand, the Ministry of Energy and Water with the technical support of FAO, has been implementing the Irrigation Rehabilitation Development Project (IRDP), funded by the World Bank to help restore irrigated agriculture production in post-conflict rural areas through an improved and reliable water supply to rehabilitated traditional primary and secondary irrigation schemes. Similarly, there are many other projects like P-ARBP funded by EU, Western Basin and WRDIP projects funded by ADB with multi-million dollars budget projects supporting irrigation systems in Afghanistan.

However, the majority of agricultural land is irrigated from the ephemeral rivers, and the term spate irrigation is not embedded in the scope of any of those projects in Afghanistan. This is not to say that spate irrigation - making use of short term floods from ephemeral streams- is uncommon in the country (Mehari, Van Steenbergen et al. 2010).

Table 2: Arable land in Afghanistan under engineered and traditional systems (MEW, 2012)

Category of arable land	Area (ha)	Date of survey
Total arable lands in the country	7,900,000	2009
Total cultivated lands (irrigated and rain-fed)	3,800,000	1978
Total irrigated lands	2,800,000	1978
Land under traditional irrigation (perennial and spate)	2,470,000	1978
Lands under engineerd irrigation systems (perennial)	330,000	2002
Land under irrigation	1,500,000	2002
Land under irrigation	1,850,000	2012

3) *In 1978 there were roughly 3.9 million ha of cultivated land of which 1.3 million ha was rain-fed and 2.6 million ha irrigated. On the other hand, the recent succession of dry years has reduced the annually cultivated area to less than 0.5 million ha (Qureshi, 2002)*

4) *Based on the Ministry of Energy and Water report, 0.15 million ha is spate irrigated land and 1 million ha is rain-fed land (Mahmoodi, 2012)*

The total territory of Afghanistan is 65 million ha, and of that 7.9 million ha is arable land. During the mid 1970s, 3.3 million ha of land was cultivated. However, presently just 1.85 million ha of land is under irrigation (Wegerich 2009), of which 150,000 ha is a spate irrigated area (Table 3). In addition, there is more spate irrigated available land from the total arable land but still not prepared for cultivation. Spate irrigated land exists all around the country particularly in the east, south, south-east, west and north regions. However, the term spate irrigation is new in Afghanistan whereas, it is a country characterized by ephemeral river regimes, largely determined by melt-water from the mountains with flash floods mainly in the spring season (Sadat 2012). Spate irrigation is a water resource management system whereby short-duration floods in ephemeral rivers are diverted from the dry watercourse for crop irrigation, groundwater recharge, local forestry improvement and even for drinking purposes in Afghanistan.

The most important cropping pattern

Agriculture activities are the most important source of income and significant livelihood strategy for the people of Afghanistan. Almost one half (55 %) of households are engaged in one or more forms of livestock (NRVA 2008), followed by non-farm labor (33 %), trade (27 %) and livestock (23 %) (GoA 2008). However, poppy cultivation is reported by 6 % of all households and it is the main crop of 12 % of households using irrigated land in summer mainly using ephemeral flow (NRVA 2008). Because of the sensitivity of capturing precise information on opium cultivation, this may be under reported but efforts are being undertaken to encourage farmers to grow alternative crops. Anyhow, the most important crops (as a %) on irrigated land in summer and winter seasons are shown in Table 4, which are irrigated through perennial and spate irrigation systems. Among all the crops, mostly watermelon and barley are sown in spate irrigated and rain-fed areas. In addition, poppy plants also do not need more water; farmers practice its cultivation more in seasonal or spate irrigated areas and mainly need water in the spring during the seasonal flow while it approaches harvesting.

Institutional arrangements for irrigation

Since ancient time water resources in Afghanistan have been managed through formal and informal institutional systems which are mainly used for irrigation. In particular, the peculiarity of the Helmand river basin valley stated the presence of very ancient cultivators' associations on an authentic basis called "Pago", see Box 1 (Tate and McMahon 1909). However, the tradition of isolated and autonomous agriculture communities dominates the country. The poor economy and unrest is a serious weakness to improving the irrigation system but during recent decades, the government has paid little attention to its improvement, despite that fact that, almost 90% of irrigation in Afghanistan is carried out

Table 3: Irrigated land in Afghanistan in terms of irrigation category (MEW, 2012)

Type of irrigation	Land under formal irrigation systems (ha)	Land under traditional/ informal irrigation system (ha)	Total irrigable lands (ha)
Perennial	330,000	2,320,000	2,650,000
Spate (flood irrigation)	0	150,000	150,000
Total irrigated land	**330,000**	**2,470,000**	**2,800,000**

Table 4: The most important crops in Afghanistan including spate irrigated areas (NRVA, 2008)

Frequency[5]	Irrigated land in winter	Irrigated land in summer	Rain-fed land	Garden plots
+++	Wheat (77)	Maize (53)	Wheat (20)	Fruit/nut (39)
++	Opium (12)	Rice (15)	Cotton (1)	Grapes (33)
+	Potatoes (3)	Other (10)	Barley (1)	Other (15)

5) *The top three frequencies within the first, second and third most important crops ((NRVA 2008). Opium cultivation in the east region is practiced more in spate irrigated areas but the improvement of the spate irrigation system ensures that water is used more efficiently and encourages famers to choose legal crops*

Box 1: Ancient cultivator association system in the Helmand river valley (Tate and McMahon 1909)

There is a peculiar system in force with regard to the cultivation of the land held by each village along the Helmand basin valley in the Afghan and Iran portions of Seistan. The inhabitants form among themselves associations called "Pago" each of which is composed of six men. There can be no doubt that this system is of very great antiquity. It would see highly probable that the name "Pago" is from the primeval root which occurs in the Latin "Pagani" and the early English "Pagi" which means the sub-division of a hundred. These associations are regulated by the heads of each township/village, and vary in number each year according to the land that is to be placed under cultivation. The partners in each "Pago" share equally in the outlay necessary for taking up land. They also divide any profit which may result from their labors. In the Afghan portion of Seistan the partners in each association set apart one man to be on the spot in the village to discharge the 'corvees' to which they are subject. This man takes no share in the work of the fields (irrigation and cultivation), and is called the "dead man". The other partners are able to devote themselves uninterruptedly to agriculture. The great drawback to the prosperous working of the system is the very short tenure on which the "Pagos" take up land. The latter being the property of the state, no one has any right to it. Each Pago has to pay a fee, before it receives a grant of lands for a single year and the Pago has no idea where the land will be situated. Also, members of an association are absolutely at the mercy of the head-man and do not know beforehand whether they will have to cultivate their lands. Other conditions are also discouraging to enterprise. The revenue tax alone amounts to practically half the yield from the lands taken up by each group of partners.

through more than 28,000 informal schemes (CFC 2012) and managed by a traditional Mirab system. Only, a few large irrigation schemes and main canals including water storage dams are managed by governmental entities on an official and formal national and provincial level.

At the national level, the two major entities are the Ministry of Energy and Water (MEW) and the Ministry of Agriculture, Irrigation and Livestock (MAIL) which are working for irrigation management and development. Particularly, MEW is responsible for the primary and secondary irrigation canals and MAIL focuses on tertiary canals based on the Water Law 2009. In addition, there are two local volunteer associations, Water User Associations (WUAs) supported by MEW and Irrigation Association (IAs) supported by MAIL with the specific responsibilities, stated in the Water Law and water bylaws.

Over the last few decades water resources management in Afghanistan has been characterized by a fragmentary evolution but in recent years it has opted to apply an integrated and holistic approach. In 2002, the initiation of IWRM was prioritized in Kabul at the first international conference attended by national and international participants. This initiation was a window towards the decentralized institutional development of the water sector in Afghanistan and then later on, in 2004, water policy recommended an integrated approach. Therefore, the establishment of WUAs and IAs was started and is an ongoing trend in the irrigation system improvement. The WUAs and IAs build on local traditions and strengthening of the traditional Mirab approach which is still applicable at the local level of formal and informal irrigation systems.

Source of spate irrigation water

As described above, much of the surface water originates from melting snow mainly above the 2000 m altitude, leading to seasonal or ephemeral, intermittent and perennial flow of the rivers. Semi-perennial flows are most common; most of the country's rivers flow for only three to four months per year, peaking in spring and early summer while remaining dry for the rest of the year. The impressive height and chain of mountains cause heavy snowfall as a natural resource that descends in a series of riverine valleys from the mountain to the rivers and streams. Mostly in the spring and summer season's intensive rainfall causes flash floods which mainly occur between April to June in the west, south-west, north and in the east which is slightly influenced by monsoon rainfall. These flashfloods are a good source of water for spate irrigated areas and provides a good source of water for

Figure 1: Repairing of a Bund Sultan in Ghazni province to collect spring water. Source (MEW 2006)

seasonal arable fields. According to FAO (1996) the average annual water use for irrigation inclusive spate irrigated areas was estimated at 20 billion m^3, of which 17 were from surface water and 3 from groundwater (Qureshi 2002).

Flood effects on agriculture irrigated areas

The Ministry of Energy and Water with the technical support of FAO/IRDP conducted a stratified random sampling survey for 56 irrigation schemes in the five basins across the country. These surveyed schemes exist on the various intermittent and ephemeral rivers areas. Seasonal floods not only provide irrigation water but in many cases can damage agriculture areas due to the high magnitude of flood frequency. On average 18.8 % of cultivated irrigated areas were damaged; the three major causes identified by farmers respectively were: 21.5 % crop diseases, 39.4 % inadequate irrigation water supply and 28.8 % flood in the stratified surveyed schemes, see Table 5 (IRDP, 2011). Traditional irrigation communities suffer from flood and afterwards the consequences which are mainly damaged crops, canal cleaning and sometimes other social disputes due to inadequate irrigation water and loss of crops. Generally, water related disputes undermine the sense of community and social cohesion, integrity and collaborative spirit. Another major problem is bank erosion mainly in the Amu basin, because flood and high discharge of the Amu River in the spring cause severe destruction and bank erosion.

However, although Table 5 shows some damage, flood also has a positive effect on increasing the yield due to fertilizing of agricultural land, nutrients to estuaries and groundwater recharge. Moreover, improving spate irrigation will avoid desertification. This is very important because, in the arid parts of Afghanistan blowing shifting sands and their accumulation is another major

Table 5: Flood frequency & affected agriculture area in the 56 irrigation schemes (IRDP 2011)

Regions	3 year average of flood incidents causing agricultural damage (2008, 2009, and 2010)			Cultivated area affected		
	Total number of floods	Number of flood damaged crops	% of floods causing damage	Actual irrigated cultivated in ha	Cultivated area affected in ha	% of affected irrigated area in ha
Bamyan	4	3	82	1,720	252	15
Herat	35	21	58	7,260	776	11
Jalalabad	76	65	86	1,020	108	11
Kabul	11	8	74	2,520	185	7
Kandahar	7	5	75	9,260	757	8
Kunduz	45	18	40	2,490	285	11
Mazar	97	38	39	11,628	962	8
Total	**275**	**158**	**58**	**35,898**	**3,326**	**71**

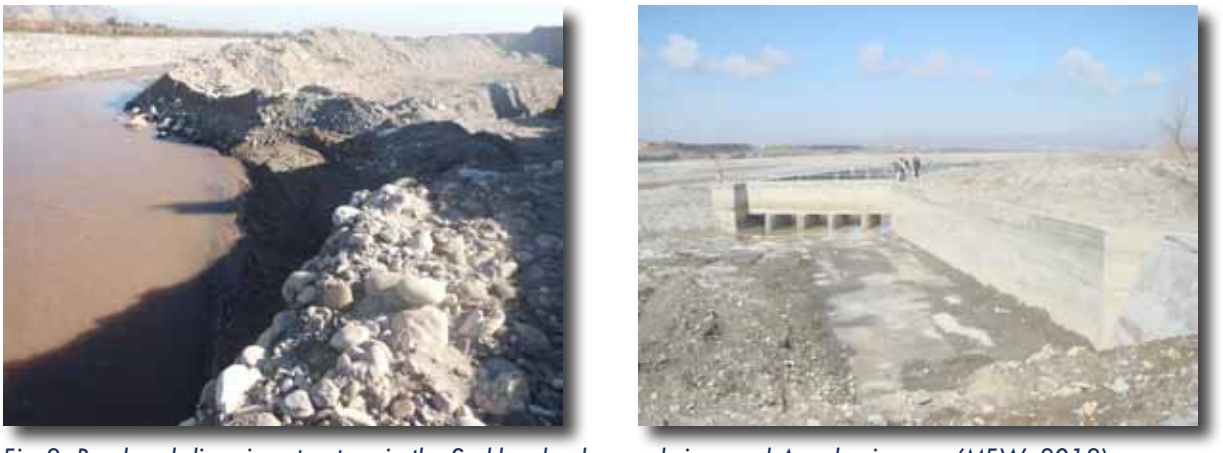


Fig 2: Bund and diversion structure in the Surkhrod ephemeral river and Amu basin area (MEW, 2012) Left: Traditional bund; Right: Modern diversion structure.

problem for farmers. The sand dunes that blow from June to September every year particularly in the south-west of the Helmand basin block the spate and perennial canals and cause a considerable extra need for manpower.

Spate irrigation structures and systems

Spate irrigation is a water resource management system in which flash floodwater is diverted from a temporarily flowing (usually dry) watercourse to irrigated fields. Farmers use different types of diversion structures either engineered type or traditional brush weirs and bunds. In general, the irrigation system, which is mainly 90 % of the traditional diversion systems, is still dominant in Afghanistan. The local techniques used by farmers comprise of temporary bund and diversion, using boulder stones, tree branches, bushes, dry grass and earthen materials. In addition, farmers also use small local intake structures in the dry streams or ephemeral rivers without support of any outside official agencies. However, some national and international agencies are working to improve the irrigation system in general but are not specifically focusing on spate water management.

However, Afghanistan has ancient and ample experience with development of small storage structures for seasonal and flood water storing. For instance, Bund -e- Sultan is a water storage reservoir which was initially constructed 1,000 years ago from local materials; stone, gypsum and lime in the ephemeral rivers of Sarab and Barikab. The Bund was modified in 1901 and turned from a traditional structure to an engineered system and provides irrigation water to 6,000 ha of land (Figure 1). Such irrigation structures are limited to some parts of the country and also most of those existing schemes are at least 50 years old. Also, in some area even along the perennial rivers due to poor irrigation infrastructures the surrounding plateau remains thirsty except in the spring season while the water level raises or flood occurs.

The three decades of war and the civil conflict that followed the 1979 invasion not only led to a standstill in irrigation improvement, but also degraded much of the existing water resources infrastructures and fragmented national, provincial and local institutions of water management. Even the lack of irrigation structures on ephemeral streams causes a loss of water and creates conflict between the upstream and downstream communities. In the last half decade line ministries have undertaken several efforts to improve irrigation systems in different provinces. For example, the recent construction of Lashkari intake has provided water for 15,000 ha of land and many other primary and secondary canals.

In comparison, spate irrigation is still largely neglected by donors and government, though informal traditional structures such as bunds, intakes and weirs on the ephemeral rivers divert a certain volume of flood and seasonal water into irrigated fields. Figure 2 shows traditional and engineered diversion structures in the Kabul and Amu basins areas. In general, almost 90 % of irrigation is done through more than 28,000 mixture informal systems (.e.g. Karez, spring, wells and river) inclusive spate water, Table 6 (Rout 2008; CFC 2012). Karezs and springs mostly depend on surface flow with discharge varying in the different season.

Table 6: Informal irrigation systems and sources of irrigation water in Afghanistan (Rout 2008)

Irrigation systems	Area (%)	Number	Irrigated area (ha)
Surface water (using various type of canal) inclusive spate water	86	7,822	2,348,000
Springs	7	5,558	187,000
Karizes[6]	6	6,741	168,000
Wells	< 1	8,595	12,000
Total	**100**	**28,716**	**2,715,000**

Cost of irrigation structure development

The cost of irrigation structures development per hectare varies from system to system. In the case of a traditional gravity system and diversion structures from the streams, there are different costs from the under groundwater or pumping system. The economics of crop production with different irrigation sources were worked out to compare the economic feasibility of irrigation investment with existing and improved technologies. However, the availability of data specifically on spate irrigation structures remains unusual in Afghanistan; the line ministries construct lateral weirs, side intakes, gabion diversions, weir intakes, etc for perennial and floodwater diversion in various costs. Investment cost per ha for the primary and secondary irrigation systems generally ranges from 450 to 1,000 US$/ha, see Table 7.

Soil moisture conservation

Farmers use different techniques and have a traditional affinity for soil moisture conservation and cropping cultivation. The techniques involve e.g. digging a checkerboard network of shallow recessed squares a few meters in length and less than 30 cm deep with an overall bund on the three lower sides in a U-shape along moderately sloped plains. Also, small areas of land build with almost 30 - 50 cm high embankments create a barrier surrounding the cell to store water. Each cell fills with water and excess flows to the next interconnected cell and so on in a cascade manner. These kinds of techniques may conserve soil moisture until the next flood occurs. However, in many cases spate irrigated crops due to their reliance on floods as the source of water are inherently risky and uncertain, even in dry areas they are the most cost-effective way to retain and store water. Improvements in soil and water management, agronomy and governance have considerable potential to increase water productivity and enhance livelihoods in one of the most poverty-stricken areas of Afghanistan. These lands can be transformed if enough attention is paid by scientists and policy makers in Afghanistan in order to focus on flood and rain water harvesting and soil moisture. Soils in Afghanistan are generally very weak with very low composition of organic matter and therefore, farmers use fertilizers and also try flood water siltation that enriches soils and increases the moisture conservation rate. While flood water seeps down into the soil, various types of shrubs, bushes, grasses, medicinal plants, mushrooms and wild vegetables sprout in the irrigated areas. The

Table 7: Incurred costs by structure, (MEW/IRDP and WRDIP 2012)

Types of irrigation structures	System	Cost (US$/ha)
Permanent diversion structure	Primary and secondary canal	500 - 1,000
Permanent small structure	Tertiary or on-farm canal	200 - 300
Temporary structure/bund	Local diversion on-farm level	70 - 110
Operation and Maintenance	Primary, secondary, tertiary	2 - 5 % of structure cost/year

6) *Karize is an underground water gallery similar to the qanats of Iran. The tunnel can be extended up to several kilometers before they surface in the command area*

main farming method under spate irrigation is represented by a combination of plants, farmers let the land lie fallow for seasonal and floodwater to scatter cereals seeds mainly wheat, maize and barley but in the east sub-basin they also cultivate poppies which do not need frequently water.

Rules and rights of water distribution

In Afghanistan there are several types of traditional and authentic rules that regulate distribution of varying quantities of floodwater with consideration of change per time step. In most community areas farmers use the hereditary rules and regulations from the past based on the irrigable areas of each household. Each irrigation canal has a Mirab who manages and regulates water for the surrounding agriculture area. Possibly sometimes some local argument also occurs between farmers and land-owners particularly in those arable areas which get water from the ephemeral rivers or during very short flashfloods. Similarly, the diversion of more water than its specific certain rights by the upstream community along the stream will cause conflict with the downstream villages. Anyhow, villagers use traditional common customs and rules to distribute water among them, and the most common applied rules and rights are as follows:

- Identification and ascertainment of irrigated land area for each household.
- Appointment of a Mirab which is a time-tested customary irrigation management system used for each irrigation scheme.
- Diversion of water to each channel based on the appropriate amount allotted by a traditional manner in a time step and breaching or opening of bunds to allow water to flow to downstream communities.
- There are also sophisticated ways of accounting for the loss of water relating the size of land for labor demand and corresponding water rights to the position in the system (the further in the system the less water you get so the less labor obligation per unit of land).

There are many other rules that apply on a customary basis, such as the canal cleaning activity announced by the Mirab or the elders, which is mostly after flooding and settling of intensive sediment. The Mirab or head of the community allocates a specific length of canal for cleaning to farmers based on their irrigated land area. Also, the Mirab calls farmers by household and amount of irrigated land for rebuilding of the bund or hiring machinery for embankment on communal basis.

Socio-economic aspect

Afghanistan is predominantly an agrarian society with 74 % of its population living in rural areas, and 55 % of households are engaged in farming and 68 % have some type of livestock for their livelihood (NRVA 2008). Lack of a sufficient irrigation system is the main reason that farmers leave the land lie fallow rain-fed land 37 %, and irrigated land 68 % at the country level. In general, the national poverty rate is 36 % in the country with regional variations (NRVA 2008; ADB 2012).

Irrigation is crucial in improving livelihoods and achieving financial security for rural households. However, although spate irrigation typology has been totally neglected the irrigation development projects and donors' grants have made a significant contribution to Afghanistan's agriculture and socio-economic development. For example, there have been the Emergency Irrigation Rehabilitation and On-farm projects funded by the World Bank with a budget of approximately $81 million, as well as the Western Basin, Water Resources Investment and Community-based Irrigation Development Projects funded by ADB with budget of around $391 million; these are multi-million dollar projects focusing on irrigation system improvement. Similarly, there is EU support for the Amu basin (more than €120 million) and spate irrigation such as in the middles areas of the Kunduz sub-basin (Burka flood canal). Also, in the lower Panj sub-basin (ephemeral stream of Rustaq) as well as in the upper catchment there are numerous soil water conservation techniques such eyebrow bunds, staggered pits, snow pits earthen bunds and mulching (KRBP and P-ARBP 2012). An example of those projects, after three decades of strife, is the rehabilitation of the Laskhari irrigation system with a total $6.28 million budget, of which 80 % is allocated for desilting of 4.3 million m^3 of soil deposited in the entire main supply canal. The irrigable lands have increased from 1,200 ha to 15,000 ha which has provided a source of income for 17,400 households. One of the householders, Wali plainly stated that he earned $8,100 in one season from selling water-melons, melons and lady fingers. Similarly, Abdul Rahman also added that resumption of the Lashkari irrigation scheme is a new chapter in his life because, he left his 40 ha of land for many years due to the unavailability of irrigation water, see Table 8. However, the Lashkari system could be semi -perennial due to water level fluctuation in the river but the canal may have sufficient water during flood time mainly in the spring season. Flood irrigated land is usually organic and does not need supplementary

Table 8: The most common crops and expected yields/ha under the Lashkari System (MEW 2009)

Crop types	Yield (kg/ha)
Wheat	9,500
Barley	7,850
Onions	2,500
Sweet potatoes	5,000
Cumin	1,400
Lentils	8,500
Melons	15,000
Water melons	2,000
Sesame	350

input such as fertilizers and pesticides and this has a direct effect on the incremental yield and subsistence production. Hence, spate irrigated land has a reasonable yield compared with the perennial irrigated system if diversion structures and spate irrigation system are improved for efficient water use.

Recent development in flood water harvesting

The present water use efficiency in Afghanistan is as low as 30 %, mainly due to a big loss of runoff and floodwater. This is because of the uneven geographical situation, as well as poor and inappropriate irrigation systems and lay outs for the main and inter-crops. However, water loss is crucial for agricultural plants and orchards based on the MAIL/HLP mandate. A lot of pistachio trees are affected in the north region due to improper land leveling and meager and unreliable rainfall. Therefore, the Horticulture and Livestock Program (HLP) has decided to use the following five local techniques to increase water use efficiency for rain and flood water. It is a pilot project in Northern provinces such as Samanagn, Jowzjan, and Sari pul. Improvement of spate irrigation is one of the main concepts for orchard irrigation on a small scale under the HLP project. This is because; flood water harvesting (spate irrigation) is a cost-effective way to provide supplementary irrigation at the basin or sub-basin scales. On the other hand, the flood water harvesting program hinders by overlapping the mandates of line ministries and the lack of coordination in their large scale water resources projects. The Ministry of Agriculture and Irrigation could not intervene to encourage spate irrigation or floodwater harvesting at the large system level because, the Ministry of Energy and Water is responsible for management of primary and secondary schemes. There are five different local methodologies that would be implemented by the HLP for small systems:

- Flood water harvesting and spate irrigation improvement at on-farm level
- Diverting water in gently sloping valleys by installing rock-fill dams or brush wood dams
- Negarim[7] and infiltration pits for orchards and fruit trees
- Semi-circular shaped earthen bunds with tips on contour in a series with bunds in staggered formation.
- Earthen bunds on contour spaced 5-10m apart with furrow upslope.

Based on the HLP report, spate irrigation is more feasible in the country especially in Samangan, Jowzjan and Sari Pul provinces. This is because, rain usually occurs heavily twice a year mainly in the spring and winter seasons. The flood water is diverted and guided by earthen bunds to the plains which depend on the layout of the land. This project will be expanded throughout the country if there is fund availability and a ministry decision takes place. In addition, EU funded projects (KRBP and P-ARBP) also support harnessing of spate water in Kunduz and Panj sub-basins.

7) *Negarim: is a closed grid of diamond shapes or open-ended "V" formed by small earth ridges, with infiltration pits, which is appropriate for tree planting in situations where land is uneven. It is not easily mechanized and therefore; Negarim is limited to a small scale (MAIL/HLP, 2012).*

Conclusion and Recommendations

Integrated Water Resources Management is required

Afghanistan's surface water resource is mainly snow and rainfall and its geographical situation provides appropriate opportunities for its exploitation but still the lack of an integrated and holistic approach is a major challenge. Water Sector Strategy (WSS) states that Afghanistan takes a mixed approach to water management. However, more efforts have been undertaken by the government and donors for a modern management approach (IWRM) as well as expansion and rehabilitation of the irrigated area, this still needs more focus for improvement. In the meanwhile, lack of integrated watershed management can hinder further expansion of irrigated areas and also may have negative consequences for neighboring countries as well as for equity within local communities, while diversion or storing of water is taking place. The current trend of storage structures and irrigation system development for storing of seasonal and flood water needs to be in the light of IWRM principles and with a synchronized & coordinated approach between the line ministries. The holistic watershed approach with a controlled manner will encourage international donors' further financial support. Also, it will allow efficient usage of spate water which will increase the expansion of irrigated fields to a larger proportion of the total arable land (7.9 million ha) area. The ultimate outcomes of integrated watershed management and improvement of spate irrigation will encourage socio-economic development in the country.

Improving hydrological systems and obtaining accurate data

Since the 1980s, due to the unrest in Afghanistan the hydrological and metrological gauging stations have been disrupted and the data recording process has ceased. In addition, in 1996, the Taliban regime sacked the metrological office because weather forecasting had been banned as it was considered to be sorcery. Metrological equipment was ruined and over 100 years worth of weather records and data were partially destroyed. Afghanistan still does not have an advanced systematic hydrological gauging network to precisely update the hydrological data. Nevertheless, MEW has recently installed 105 hydrological stations, 69 more stations are going to be installed, and 23 weather stations and 30 snow gauges are under construction but with very slow progress. Therefore, improvement of spate irrigation systems with lack of accurate hydrological, rainfall frequency and intensity data combined with the effect of melting snow and saturated soils are big concerns are those trying to design a better system. However, local communities based on their traditional experience are trying their best to use flood water but poor irrigation system many times causes a huge risk to farmers. Improving hydrological services in Afghanistan is essential for the integrated water management and stable social and economic development. Though it may take a long time, special consideration to this would bring a positive change in this area.

Development of flood and natural disaster warning systems

Afghanistan is a vulnerable country in terms of weather/water-related events such as flood, drought, hail, frosts, deadly avalanches and storms. Specially, a flood early warning system not only mitigates risk and hazard but has also positive effects on the improvement of irrigation systems and diversion structure management for better use of flood water and expansion of irrigated areas. Hence, improving the hydro-metrological monitoring system and also using remote sensing satellite images will provide timely warning of extreme disasters and flood events, to manage water resources and provide support to agriculture & other sectors. In a country like Afghanistan using satellite sensors is very useful to provide an appropriate platform for monitoring any environmental variability at high spatial and temporal resolutions. Institutional strengthening and professional upgrading will further contribute to the development of a flood-warning system.

Institutional strengthening of the irrigation entities

Three decades of war and adversity have seriously fragmented Afghanistan's water sector governance and institutions. Therefore, there has been a requirement for a strong push for institutional strengthening of the public and private organizations, and especially in the irrigation sector. This is essential in order to distinguish the different categories and play complementary roles. Spate irrigation is a new term in Afghanistan, and needs a public orientation and strengthening of the national and local authorities to support WUAs and IAs. A dedicated training/capacity building program

should also be expanded by (EU, USAID, WB, ABD, PRT) funding projects to better harness the information and lessons learned, for infrastructure improvement in particular about spate irrigation. This is because; Afghanistan is by nature a spate irrigated country due to its arid climate and ephemeral river regime. While spate irrigation is relatively crucial in absolute terms, it represents a valid development option for rural populations in many arid countries.

Synchronization of irrigation activities between related entities

Irrigation plays a fundamental role in increasing agricultural production and diversification, rural employment, and food security in Afghanistan. However, public and private entities have undertaken several efforts aimed at irrigation system improvement, but coordination among them seems very weak. At the strategic level synchronization and integration of programs and fund allocation based on the basin, sub-basin and local scales will be quite effective in order to improve irrigation systems for the different categories. Coordination of irrigation activities, information and donors' funds is essential in water resources management which is an integral part of poverty reduction and increasing of agriculture productivity. Blending of the new modern approach (WUAs and IAs) with the traditional Mirab system could also decrease the explanation of the long distance between paper and practice.

Rehabilitation and development of the spate irrigation system

Afghanistan is by its nature a country with high potential for spate irrigation and the economy of the country is predominantly based on agriculture and livestock. Given that about 55% of the population are engaged in farming and 68 % in livestock therefore, an improvement in spate irrigation will induce agricultural expansion. By harnessing floods from the dry watercourse, it allows farmers to secure crop production and therefore contributes to food security and poverty alleviation. However, successful intervention in the spate system has been difficult because, (i) spate irrigation is so intricate in terms of social and hydrological aspects and (ii) investment in low value farming may hinder donor support especially in the current situation of Afghanistan. Nevertheless, to increase water capital and make better use of spate water and traditional irrigation systems, the overall strategy may include the following steps:

- For the formulation of strategy and development of irrigation systems, a comprehensive database and information systems should be established between the line ministries. This is important and could support the assessment and development of systems needed to be undertaken in the spatial and temporal scales.
- All irrigation systems within the basin or sub-basin should be systematically identified for spate irrigated areas and assessed before priority areas are given. It is important that functional traditional water rights and allocations are preserved and it is also necessary to smooth overlapping mandates of the government agencies to ensure effective use and management of water resources at all levels.
- The Afghan government (line ministries) needs to take the lead in putting in place a coordination mechanism, providing effective oversight and budget allocation, in order to improve spate irrigation specifically or embed it in parallel with the perennial irrigation development programmes/projects.
- Improvement of traditional systems for regulating seasonal water flows would decrease the occurrence of multi-province flooding due to erratic snow melt that the country frequently suffers from.
- Farmers should be encouraged to use flood and rain water harvesting and watershed management including small and large water diversion and storage structures. Farmers should be trained in the use of optimized spate water diversion and management techniques and crop patterns, which has produced successful results in other arid countries similar to Afghanistan such as Pakistan, Sudan Yemen, etc. For instance, techniques that have served these countries well should be explored and deployed be it soil guide bunds constructed with the help of bulldozers, bed stabilizers to make it easier for farmers to construct diversions or different techniques to have better field level water management such as field-to-field overflow structures or cascade drop structures (Van Steenbergen et al 2010).

Supporting participatory irrigation management (PIM)

Participatory irrigation management offers one way of improving water use efficiency. The participatory approach refers to the involvement of the irrigation users e.g. farmers including WUAs, IAs and irrigation management at all

levels. The active participation of farmers in irrigation management helps to ensure sustainability of the spate irrigation system through predictable water deliveries and allocations. Often it has been there since the beginning the roots of several systems are in the farmer initiatives dating back many decades for instance “Pago” which was a very ancient and authentic cultivation system in the Helmand basin. Systematic famer engagement can improve design and construction; reduce conflicts over water, improve operation and maintenance, and increase agriculture productivity. However, although the Afghanistan government through MAIL intends to transfer irrigation management to IAs in coordination with WUAs while blending of this approach with the Mirab traditional system is also inherently significant. Nevertheless, it still remains as a major stumbling block how the traditional Mirab system will fold into the WUAs and IAs and how to smooth overlapping mandates of the government agencies (MEW and MAIL). Particularly, spate irrigation requires the customary water allocation approach between farmers in order to avoid local conflict over water rights and also better leadership and a participatory approach may create a consensus about the irrigation system for the appropriate crop pattern based on water availability mainly in flood irrigated areas.

Maintenance of spate irrigation schemes

In general, operation and maintenance work is almost being neglected in all development programs and existing irrigation schemes particularly maintenance of irrigations infrastructures after development. However, traditional intakes and bunds are frequently re-built by farmers after each intensive flood, which is very cost-effective for local communities, using machines (bulldozer, tractor), bushes, tree-branches, boulders, etc. Therefore, it is necessary for the relevant agencies in the government and donors to embed maintenance work simultaneously after development of irrigation schemes through WUAs and IAs with a systematic manner mainly for diversion structure and bunds on ephemeral and spate flowing streams. This will help farmers with sufficient water diversion and also avoid damage to crops and land from the flooding and also assist them with a sustainable irrigation system particularly in spate irrigated areas.

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The Spate Irrigation Network supports and promotes appropriate programmes and policies in spate irrigation, exchanges information on the improvement of livelihoods through a range of interventions, assists in educational development and supports in the implementation and start-up of projects in spate irrigation.

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