1 The Potential for the Development of Spate Irrigation Systems in Pakistan

Practical Notes Spate Irrigation

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Introduction

This note serves to highlight the potential of spate irrigation in Pakistan, the current use and the scope for expansion and increased productivity. Special attention is paid to the cost and approaches of spate irrigation development. Pakistan has utilized most of its surface water in the Indus basin canal irrigation system. The main potential for agricultural development is under spate irrigation. This is estimated by one source[1)] even at 6.93 M ha - based on an estimated flood run-off from the area west of the Indus of 23 km^3 per annum in an average year. This is very substantial and can be set against the current spate irrigated area of 0.34 to 1.28 M ha in dry and wet years and a maximum developed command area of 2.02 M ha[2)]. Though the estimate may be too high, what it establishes is that there are opportunities to develop a larger area under spate irrigation. Apart from expanding the area there is considerable scope to improve the productivity of the existing areas and the two should go together. Developing spate irrigation will both considerably improve national food security and improve livelihoods in some of the poorest and unsettled areas in the country. Even in spite of the current substantial extent (ranging from 3 to 10% of total irrigated area in the country) and the supposed even much larger potential, spate irrigation in Pakistan is a largely unknown quantity. Pakistan has the largest area of any country globally under this resource management system. Spate irrigation in Pakistan has a long history. Bunds as old as 5000 years have been found in Khuzdar district in Balochistan, suggesting that a complex organization existed at that time to operate and maintain the systems. Many of the sites of earliest habitation – Mehrgahr in Balochistan and several sites in DG Khan - are places where ephemeral rivers discharge onto plains – the same places where spate irrigation occurs at present. In Balochistan there are large and mainly unexplained ancient diversion bunds, the so-called gabar bandhs.

Figure 2 Weir structure, head regulator and canal at Shabo Headworks, Pishin district, Balochistan.

Spate irrigation in Pakistan has a large potential but is also largely unknown and not well understood. Spate irrigation occurs in the area west of the Indus in all four provinces (see Figure1). It is called nai in Sindh, sailaba in Balochistan and rod kohi in NWFP and Punjab. In the system, water from short duration flash floods is diverted to irrigate land and fill drinking water ponds, water rangelands and forest ranges. Traditionally water is diverted from free intakes (on the piedmont zones) or (further down in the plains) with the help of earthen diversion bunds build across the ephemeral rivers. These structures are usually built in such a way that they wash out in very high floods – thus preventing that potentially destructive high floods play havoc with the command area. Once diverted flood water is guided and spread over sometimes very long distances usually making sure the floods do not erode the command area. Spate irrigation is usually pre-planting and hence soil moisture conservation is very important as there is a time-lag

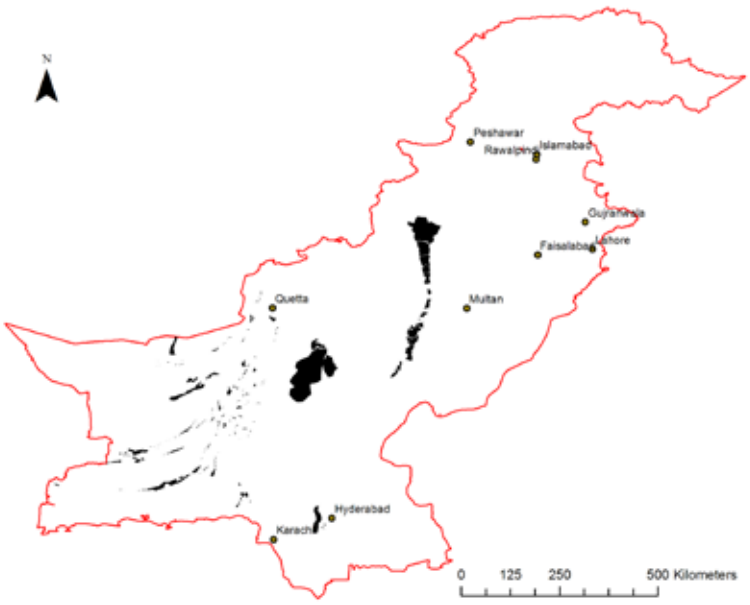

Figure 1 Areas where Spate irrigation occurs in Pakistan

1) NESPAK. 1998. Master Feasibility Studies for Management of Hill Torrents of Pakistan - Balochistan Province", National Engineering Services of Pakistan
2) Based on an estimate

between the timing of watering and seeding. Another special feature of spate irrigation is the management of sediment. As sediment loads of spate flows may be as high as 10%, spate irrigation is as much about managing water and it is about managing sedimentation.

Figure 3 Spate irrigation: high potential for oilseeds and pulses

Characterization

Spate irrigation in Pakistan can be characterized in three main categories:

- Spate irrigation systems based on floodwater generated from hill-torrents and diverted through natural, earthen or weir regulated structures;
- Spate irrigation systems with headworks for diversion of floodwater into a canal network and tanks for storage and regulation;
- Spate irrigation systems combining both non-perennial and perennial flows.

Non-perennial Spate Irrigation System is defined as "diversion of floodwater through natural, earthen or weir regulated structures and channelized into a water conveyance network for delivery to the command area as per agreed water rights and allocation rules". The fields are normally of large size and vary from 2 to 10 ha. The depth of water ponded in the field is a function of bund size. Farmers normally try to irrigate maximum amount of water because they are not sure when they will receive the next spate flows. A deep irrigation of 1-2 m depth is sufficient to grow winter wheat in temperate environments, if the incident rainfall is >100 mm during the later part of the growing season.

Spate Irrigation with Storage Facility is defined as "diversion of floodwater and channelised into a canal network through Headworks for delivery of water to the storage Tanks. Tanks are designed to store floodwater to provide reliable and sustainable supply of Spate water during crop growing season". The delivery of water from the storage tanks is provided to the command area as per agreed water entitlements. Some of these systems – especially Bund Kushdil Khan in Pishin - have been in use in Balochistan for more than 100 years, which were constructed in 1880s by the British rulers. This system is locally named as 'Tank Bandat' in Balochistan and different names in other provinces, but in the Agriculture Census of Pakistan it is named as 'Tank Bandat'. Around 21% area under Spate irrigation is having 'Tank Bandat'. As long as sedimentation is under control, this is a very effective system of managing floodwater and allocation of water to the water users.

Combined perennial and spate irrigation systems, Several emphemeral rivers have perennial base flows. These perennial flows maybe transported in the same channel providing non-perennial floodwater, which damage the perennial system during spate flows and farmers have to continuously manage both the flows. In DI Khan and DG Khan this system is named as "kalapani" meaning black water, whereas the non-perennial floodwater is locally named as "sufaidpani".

Another variation is river systems that are semi-perennial. Two main semi-perennial rivers are the Nari and Porali (Las Bela). Whereas in other ephemeral rivers the duration of each floods in measured in hours or at the most in days, in these semi-perennial rivers flood flows last weeks – making it possible to serve a large area and distribute water over the command area.

The area cultivated in spate irrigation estimated from the Agricultural Census was 0.34 M ha in 1999-2000. This was however a drought year

Figure 4 Spate farmer of D.I. Khan

Table 1. Potential area of Spate irrigation in Pakistan

Province	Major Torrents or River Basins	Potential Area (mha)	Actual Spate Area Cultivated in 1999-00 (mha)
Federal	-	0.271	-
NWFP	25	0.862	0.109
Punjab	17	0.571	0.048
Sindh	-	0.551	0.011
Balochistan	17	4.680	0.185
Pakistan	-	6.935	0.343

Source: NESPAK 1998; Agriculture Census of Pakistan, Census Organization of Pakistan, 2000[3)]

– and it may reflect a historically low – as can be assessed from for instance the minimal coverage for NWFP and Punjab – where there are substantial areas under spate, however (see map). The highest spate cultivated area lies in Balochistan province followed by NWFP, Punjab and Sindh. The spate cultivated area in the wet year would be almost quadruple of the reported Spate cultivated area in 1999-00 because the floodwater doubled. In one-out-of-four years, the cultivated area can be increased to 1.28 M ha, particularly if the spate flows are well distributed in the crop growing season.

The only estimate of the potential area under spate irrigation was made by NESPAK (1998). The total area – based on flood run-off was estimated as large as 6.94 M ha (Table 1). Out of this, 4.68 M ha are in Balochistan - followed by NWFP, Punjab and Sindh and the Federally Administered Northern and Tribal Areas. There are some important proviso's to this figure, however. First is that the estimate is not linked to an assessment of land suitability; second is that since wet and dry years alternate the area that would be sustainably available is lower: thirdly the potential estimated area includes areas that would be irrigated from small perennial streams in this area. As a result the total potential area under spate irrigation is probably considerably less – but still very substantial. Another figure that is important to assess the scope of spate irrigation is the area that is currently developed under spate irrigation: based on a detailed assessment of Google Earth this is estimated to be in the vicinity of 2.02 M Ha.

Figure 5 Spate irrigation command area, Punjab (Google Earth)

3) The Agriculture Census is normally conducted after every 10 years. The data of 2000 is the latest available in the country. The Agricultural Statistics which is being published annually does not differentiate the Spate and Rainfed systems as both are lumped under non-irrigated areas.

4) Van Steenbergen, Lawrence, Mehari and Maher (forthcoming), Spate Irrigation Guidelines. Rome: FAO.

5) Gomal Zam Dam Multi-Purpose Project. Brief of Latest Status of Implementation. Water and Power Development Authority, Pakistan, August 2007.

Box 1: Recent investment in 'modernized' spate irrigation

Gomal Zam is the largest ephemeral stream in D. I. Khan. The perennial water of the stream, at Kot Azam is distributed in a 2:1 ratio into 'Nulla Looni' and 'Nulla Kot Azam'. The flood water of Gomal Zam however was going waste and caused land erosion and ravine formations. The Gomal Zam project was a long time in the making among others because of concerns on sedimentation. First conceived in 1850 it was inaugurated in 2001 at a cost of Rs. 12.829 billions (USD 214 M). Out of this 37% is meant for irrigation development - perennial and spate. The command area is 66,000 ha - 12,500 ha under perennial irrigation and 53,500 ha under non-perennial irrigation. The unit cost per ha for the whole of the project is USD 3240/ha, but the cost of development of the spate irrigation facilities come down to USD 1200/ha[5]. The gross storage capacity of the Gomal reservoir is 1.4 billion m^3 with live storage capacity of 1.1 billion m^3.

In **NWFP**, 76 small schemes of non-perennial and perennial irrigation were completed with a total cost of Rs. 12.027 billions (USD 200 million) – consisting largely of weir-regulated simple headworks. These schemes provided new command area of 27,474 ha and provide improved facilities to 162,834 ha. The total command area benefited was 190,308 ha. The cost of development of perennial and spate irrigation systems comes to USD 1051/ha.

In **Balochistan** province, schemes under the Governors funds were developed at a cost of Rs. 173.3 millions (USD 2.89 M). The command area was around 1215 ha. The cost of development of perennial and spate irrigation systems comes to USD 2379/ha. Earlier the Marufzai and Barag spate irrigation systems were constructed as part of the Balochistan Community Irrigation and Agricultural Development Project at a cost of USD 1346 and 1478/ha.

In **Punjab the Sanghar**, Vehova and Kaura are implemented. The first two are the largest can discharge more than 100,000 cusecs of water during monsoon or any other extraordinary event. The schemes aim to divert a large part of the current unused flood water potential. The estimated cost of these projects, according to 2007 prices, is USD 26.8 million. In a typical modernization mode permanent weirs with off-takes on both sides are constructed.

Table 2. Crops yields in spate irrigation (selected crops)[7]

Crop	Eritrea yield kg/ha	Yemen yield kg/ha	Iran yield kg/ha	Pakistan yield kg/ha
Sorghum	800-3800	600-3500	2000-6500	350-700
Sesame	100-800			150-350
Mungbean			800-1100	270-550
Cotton	200-1000	350-8500		360-620

Investing in spate irrigation

Over the years there have been several programs investing spate irrigation system – often in 'modernized' headworks. The costs of the recent investments have ranged from USD 1051 to USD 2350 per ha (see box 1). This is within the range of comparable international figures for projects constructing permanent headworks in spate rivers (USD 1300-2400/ha)[4]. Projects that construct headwork on smaller rivers are usually cheaper (USD 200-450/ha). In large systems, a diversion structure has to span a wide wadi, and stand up to very large design floods. "Permanent" structures cannot be allowed to fail in large floods as in traditional systems.

More important than the costs of investing in spate irrigation is the appropriateness of the investment. The examples above concerns investment in modernization – replacing the traditional diversion with permanent headworks. This has had mixed results – including some spectacular failures, such as Mithawan and Chandia. An assessment of modernization system undertaken in 1990 showed a failure rate of nearly 70%. Though design concepts have improved failure risk remain high in modernization projects, if

6) Several of these opportunities will be discussed in separate Practical Notes in this series.

7) Source: van Steenbergen and Haile (2008). Unlocking the potential: status ans scope for spate irrigation. Paper at Expert Meeting on Spate Irrigation, FAO/ SpN, Cairo April 2008.

Figure 6 Bulldozer programme at work in Danghar Wali

only because of the challenges of managing sedimentation, dealing with occasional high floods and capturing shifting low flow canals.

International experience is that modernization only works in certain cases and that in other cases improving traditional systems is more effective and economical both in investment and O&M cost. The cost of such improved traditional systems typically is in the range of USD 20-180/ha and concerns a range of interventions: using bed stabilizers, flow dividers and reinforcement of traditional earthen structures for instance. In Pakistan in most provinces a bulldozer programme has been in operation – providing earthmoving services at subsidized rates. This program has been very popular and successful as long as it lasted. It created the facilities for farmers to operate fast, create diversion bunds and guide bunds and plug ravines. Although the bulldozer programme eroded the traditional kamara system of shared labor it has become an essential feature in the management and development of spate irrigation systems in the country. As the bulldozers have not been replaced the programmes are now in decline. Reviving the bulldozer programme, with more engagement of local private sector and better skilled bulldozer operators, should be part of spate irrigation development as well.

Figure 7 Multi crop Spate irrigation field with moong beans and sorghum

Improving productivity of spate irrigation

Not only is it possible to increase the area under spate irrigation, there are several opportunities to make significant improvements to the productivity of spate irrigation . Sorghum yields in Pakistan for instance are below 1 ton/ ha, whereas in spate irrigation system elsewhere they are in excess of 2.5 ton/ha. Below is a list of option to make spate irrigation more productive:

- Make use of the comparative advantages in producing oilseeds, pulses and feeds for livestock. Spate irrigated areas are often eminently suitable these crops.
- Make more work of promoting promising minor crops in spate irrigation: wild vegetables, truffle mushrooms, tree crops. Several of these crops now appear spontaneously and sporadically yet have a potential high market value
- Improve grain storage. Introducing low cost household grain storage in DI Khan for instance has brought production losses down with 7%.
- Invest in command area structures. Given the importance of moisture management small investments in water control structures within the command area – as for instance developed by WRRI pay very high dividends
- Revisit the water distribution systems. In spate irrigation systems in Pakistan crops often get one water turn only – which keeps crops still in the stressed zone and keeps yields low
- Explore the scope for combining spate irrigation and groundwater use. Where possible spate irrigation scheme development must be linked with the objective of groundwater recharge by either replenishing the depleted aquifer or to generate new aquifers.

Conclusion

Spate irrigation can address some of the major food security countries that Pakistan is facing and help regenerate livelihoods in areas where the poor-of-the-poorest are living. What is required is a concerted strategy and investment plan, making use of the different opportunities described above for extensification and intensification. Such a strategy should put farmer initiative and management centre stage, building on a long history of spate irrigation management by farmers and local government. As spate irrigation develops new and reinvigorated institutional arrangements are required and a protection of the rights of all riparians – building on existing and well-established traditions.

Figure 8 Improving productivity. Spate irrigated onion fields

References

Gomal Zam Dam Multi-Purpose Project. Brief of Latest Status of Implementation. Water and Power Development Authority, Pakistan, August 2007.

NESPAK. 1998. Master Feasibility Studies for Management of Hill Torrents of Pakistan - Balochistan Province", National Engineering Services of Pakistan

Van Steenbergen, Lawrence, Mehari and Maher (forthcoming), Spate Irrigation Guidelines. Rome: FAO.

Van Steenbergen and Haile (2008). Unlocking the potential: status ans scope for spate irrigation. Paper at Expert Meeting on Spate Irrigation, FAO/ SpN, Cairo April 2008.

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The Pakistan 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. For more information: www.spate-irrigation.org.