They are unknown but they cover an area of more than one million hectares, which is close to 10% of all irrigated land in Pakistan: spate irrigation systems, also called 'rod kohi', 'sailaba' or 'nai' in different parts of the country. Dependent on making the most out of short duration floods, they embody a unique and ancient culture of water sharing.

This book describes for the very first time these special systems and the societies they have given rise to.

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Spate Irrigation Network

THE DRY SIDE OF THE INDUS: Exploring Spate Irrigation in Pakistan

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We were wandering time and again
When the Lord settled us
Then the rain came
And all depressions filled
Fields could not be crossed
Only those who are genuine could traverse
The others were left behind
Listen my friend Farid only those are saved
Who have a guide to follow

Khwaja Ghulam Farid, Sufi Poet from Rajanpur District,
Pakistan (1850-1905)

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PREFACE

This book is about the lesser known side of the Indus River in Pakistan – the dry plains along the Western mountain ranges. This land is home to tamarix trees, dwarf palms, Sufi poetry and kilometres-long earthen bunds that guide flood water to irrigate fields. It is also home to the earliest civilization known to man – the millennia old settlements dotted near the places where the rivers enter the plains. These settlements have ancient cattle breeds and their water rights are centuries old. The water rights have been recorded in books dating back to 1872, 1902 and 1908, which are still cherished as local treasures. This is the land of spate irrigation, one of the world's largest forms of water harvesting – not unique to Pakistan but nowhere as extensive as here. It is called *Rod Kohi* in Khyber Pakhtunkhwa (KP) and Punjab, *Sailaba* in Balochistan and *Nai* in Sindh.

There is a development side to this as well. The acreage under spate irrigation, using erratic floods to provide water for agricultural, human consumption and livestock, is substantial. By most reliable estimates the area covered in a year (depending on rainfall and floods) varies between 340,000 hectares and 1.28 million hectares – the latter equivalent to 7% of the entire irrigated area in Pakistan. The area equipped for spate irrigation however is measured to be more – over two million hectares, with the potential being more than that – probably close to three million hectares. It covers large portions of the cultivable land in the districts of D.I. Khan, Tank, Kohat, Laki Marwat, Bannu (KP), D.G. Khan, Rajanpur, Mianwali (Punjab), Kacchi, Sibi, Jal Magsi, Qila Saifullah, Loralai, Musakhel, Barkhan, Las Bela, Kharan (Balochistan), Dadu, Larkana, Jamshoro, Karachi, Nagarparker and Thatta (Sindh) and the Federally Administered Tribal Areas (FATA). Then there is scope for new introduction of spate farming in the *barani* (rain dependent) lands of Punjab and KP and Azad Jammu and Kashmir.

This is also an area where there is widespread poverty, probably more than any other area in Pakistan. The poverty is due to the uncertainties of livelihoods that depend on floods, the absence of reliable drinking water supply and the

marginal location of the fields – often far away from the main population centres and easily forgotten. As periods of drought are part of spate irrigation, they cause hardship and even the temporary depopulation of areas. The spate areas have high infant mortality, low literacy rates and infrequent school attendance. Water resource scarcity also implies that power dynamics are strong in these areas. There are considerable tensions among upstream and downstream areas and between landlords, often absentee, and (hereditary) tenants.

In spite of the huge potential of the spate irrigated areas and the opportunities to address poverty and generate growth, this 'dry side of the Indus' is much neglected and almost invisible in the government policies and programmes. There have been few initiatives from the civil society organizations and some investment in headwork, but no all out focus on improved water management to bring out all opportunities for development in these areas. In the last thirty years there has been a slow deterioration in water management, with traditional institutions losing their vigour. This is demonstrated in the construction of unauthorized water diversions, the silting up of the flood channels and the formation of gullies distorting the hydraulics. In addition, there has been degradation of forest resources, rangelands and livestock material.

Yet on the positive side, there are also considerable opportunities to revive livelihoods and improve the productivity of spate irrigated areas. Crop yields of the main spate irrigated crops (sorghum, millet, wheat, pulses) are low compared to international figures and can be improved, whereas improved grain storage can reduce losses that now stand – based on pilot activities in D.I. Khan - at 5-20%. The spate areas are probably the most suitable areas in the country for the cultivation of oilseeds, food legumes and coarse grains. In addition there are a number of very promising crops that can do with better marketing and processing, such as guar and sesame. There are also intriguing minor crops – from area-specific vegetables and medicinal plants to truffle mushrooms.

There is also scope to improve forest production – indigenous species along river banks or in special plots in the outwash areas. Livestock is an important and stable source of income and spate areas have produced important and famous breeds, such as Bhag Nari cattle, Sindhi Red Bull and Lohani cattle,

Barbari Goat and Balochi Sheep. There are examples that suggest that improved fodder and feed (such as molasses blocks and urea treatment) as well as rangeland management can work wonders. Much more can be done to ameliorate drinking water supply by improved clay or plastic lined drinking water ponds for humans and livestock. These interventions will allow the water to stay in the ponds for much longer periods.

Water management – the lifeline of the dry areas – has been problematic in spate irrigation territory. The introduction of subsidized bulldozer services since the 1970s made it possible to quickly construct earthen bunds, even when rivers were in flood. The subsequent deterioration and withdrawal of this subsidized equipment created a setback and in the meantime also undermined local institutions. In the past the effective co-management system of the local government (under the Revenue Department) and farmers ensured the regulation and timely construction of the earthen structures (kamara).

While there is an impression that institutional support for water management in spate areas is constantly declining, traditional local management systems are still strong and deep rooted. There is rich knowledge on how to make the floods work for agriculture and domestic water supply. To set things right, moreover, often requires relatively small investments – but they should be the right thing in the right place. There are many low cost, high impact improvements, such as reinforced earthen diversion bunds, fixed canal intakes, bed sills, gully plugs, improved field intakes and overflow structures. A number of these interventions have been experimented with, showing considerable benefits and reassurance that investment in spate areas yield good results.

With this book we would like to take our readers to the fascinating ‘dry side of the Indus’, with its impressive resource management system. We hope that this book will contribute towards removing the lack of understanding for the spate irrigated areas of Pakistan and the neglect that comes with it.

The book is a joint effort of the Pakistan Spate Irrigation Network, the Pakistan Agricultural Research Council that has undertaken applied research on spate irrigation in Pakistan

(some of which is shared in this book), Intercooperation Pakistan that has provided support for the spate irrigation program in KP and MetaMeta and UNESCO-IHE, that are the convenors of the International Spate Irrigation Network. The Spate Irrigation Network aims to exchange knowledge on spate irrigation between the different countries where this unique form of resource management is practised and catalyse new initiatives for improved livelihoods in the spate irrigation areas. For more information also visit www.spate-irrigation.org. The support of the World Bank and the Royal Netherlands Embassy (under the Dutch Support Program) and IFAD (under the PTA Grant Program) is acknowledged.

The Authors and the Contributors

1 How it all began...
Introduction to Spate Irrigation in Pakistan

The land appears to be desert at first sight – coated with a dusty light brown hue it stretches flat for miles, the brown interrupted with the green and yellow of sparse vegetation, mostly shrubs and small trees. In the distance are the blue grey hills, looming up on the horizon, far away from the settlements. The people who live here in small villages and hamlets are often the poorest of the poor in Pakistan – but as descendants of fierce armies and famous tribes who once marched across this ancient land, they are dignified and hardy. It is also the land of mystics and visionaries. The culture is unique, rich and colorful: poetry and songs but also camel weight lifting competitions and dog fights and quail fights – in which land, money and even marriages are betted. The mighty Indus River serves as a lifeline for the people of Pakistan and is located nearby – but most of these lands are not provided with irrigation from the river water.

They are located on the dry side of the Indus – near the western mountain ranges, away from the large canal areas, instead dependent on the rains that come occasionally to this parched land, transforming it overnight. The rains in the vast catchment areas that spread into Afghanistan create rushing hill torrents. The water from these torrents cascades through the mountains, gathering speed and comes down flooding through the arid plains, bringing life to the land and hope to the people. In good years, when the people's prayers are answered, the floods are plentiful and manageable and there is enough water to irrigate the fields. For without flood water, this ancient form of irrigation would not exist. Spate irrigation is not unique to Pakistan, but in this country it is one of the largest systems in the world.

The spate irrigation complex in Pakistan is the second largest system after the Indus Basin irrigated agricultural system. It dates back to the Mehergarh civilization, which archaeologists say could be as old as 9000 years, and whose remains have been found in mounds located in the Balochistan province. Long before the Pharaohs or the Mesopotamians, the early settlers of Mehergarh were domesticating animals for farming and growing crops by using flood water. Remnants of large bunds (earthen dams) up to 5000 years old have been founded in the Khuzdar district in Balochistan, suggesting that a complex organization existed at that time to maintain these earthen structures. In the Khyber Pashtoonkwa (KPK) and the

Punjab, the first spate irrigation systems existed at least as early as 330 BC. Then there are the long mysterious 'gabarbands', that diverted water from the dry rivers and that can still be found in Larkana, Dadu and Las Bela districts.

Spate irrigation or hill torrent irrigation is today practiced in all the four provinces of Pakistan as well as in FATA and is called *Nai* in Sindh, *Sailaba* in Balochistan and *Rod Kohi* in KPK and Punjab, with *Rod* meaning torrent bed and *Koh* meaning mountain. In this system, water from sporadic flash floods is diverted to irrigate land and fill drinking water ponds. These flash floods have been occurring naturally for centuries, and it is said that most of Alexander the Great's retreating army was destroyed by flash floods in Balochistan. The largest areas under spate irrigation are on the plains bordering the mountain ranges, along the Koh-I-Suleiman and Kirthar Ranges as well as on the Kacchi plains.

It normally rains briefly but heavily in two periods of the year – in the summer monsoon season and during the winters. When the flood waters caused by heavy rainfall enter the plains, they are diverted and guided by earthen bunds that depend on the lay of the land. Some bunds are many kilometers long, several meters high and up to 20 meter wide at the base. Close to the mountains, the bunds tend to take part of the fast flowing flood, but lower down they block the river and divert the entire flow. Water is then guided through a system of flood channels, sometimes marked by low side bunds – all constructed by the local farmers in preparation for the flood seasons. For centuries, the making of these bunds would be a festive time, with farming communities gathering together with their oxen to build these bunds together. At night, stories would be told and music played on drums as the farmers shared a special meal called *Sobat* (roast chicken with thin slices of bread) from the same large tray. Holy men would come to bless the fields and the draught animals before the work began.

Today, with the introduction of bulldozers and tractors, the bunds can be built faster and don't require so much manual labour. The communal spirit has withered, causing many of the bunds to be neglected if the farmers can't afford to hire the bulldozer. The old festivities have now sometimes become commercialized events, less to do with making bunds and

more to do with entertainment. However, the engineering has not changed and the farmers still have to construct earthen diversion structures (called *wakra*) which raise the waters in the flood channels and lead them into the bunded fields. These bunded field (called *bundat*) are often very large – as much as 15 hectares sometimes, though they may be divided into sections. There is an entire ancient vocabulary specific to spate irrigation, which is partly captured in the glossary.

There are different spate irrigation systems located in the mountain areas. These are smaller and make use of free intakes. Spate irrigation certainly supports local farming systems, but also rangelands, trees and drinking water supply – either by filling water ponds or through the recharge of shallow aquifers in some places. However, due to its reliance on floods as the source of water it is inherently risky and uncertain. Even then in dry areas it is the most cost-effective way to retain and store water. Improvements in soil and water management, farming and governance have considerable potential to increase water productivity and enhance livelihoods in one of the most-poverty stricken areas of Pakistan. These lands can be transformed if enough attention is paid to them by scientists, policy makers and fund managers in Pakistan.

It is estimated that the land prepared for spate irrigation in Pakistan today is around 2.02 million hectares, out of which around 1.28 million hectares are commanded in a wet year but this can reduce to 340,000 hectares in a dry year. This is 2 - 7% of the entire irrigated area of Pakistan, a country that is entirely dependent on its agriculture. Spate irrigation is practiced mainly in the arid yet picturesque areas of Kohat, Dera Ismail Khan, Tank, Lucky Marwat (in KPK), Dera Ghazi Khan, Mianwali, Rajanpur (Punjab), Larkana, Dadu, Jamshoro, Thatta, Nangarparker (Sindh) and Barkhan, Las Bela, Kila Saifullah, Kharan, Loralai, Musakhel, Makran and the Kacchi plains of the province of Balochistan. In addition spate irrigation is also applied in FATA. The largest area under the spate irrigation farming system is in Balochistan followed by the KPK, Punjab and Sindh.

Subsistence crops, often sorghum, millet and wheat are planted only after irrigation has occurred. In Pakistan, there are two main cropping seasons – in summer and winter. Crops are grown from one or more irrigation using the moisture

Box 1.1

The first civilization

Mehergarh is a 9000 years old settlement located at the foot of the Bolan Pass on the Kacchi plains south-east of Quetta. It is believed to be the location of the earliest civilization, pre-dating the cultures of Egypt and Mesopotamia. Neolithic Mehergarh consists of four mounds where we have the first evidence of domestication of animals and cereal cultivation. Supported by the Pakistan Department of Archeology, French archaeologists have been carrying out extensive excavations there for some years. These excavations, studies and research have led to pushing back the date of these settlements to 7000 BC. Even in that early period there were well-developed villages with agriculture, the beginning of animal domestication and evidence of long distance trade.

stored in the deep alluvial soils formed from the layered sediments deposited from previous irrigations. Spate systems "grow" their own soils, and rely on nutrients transported with sediments from upstream catchments to maintain fertility. The soil is thick and when dry, it cracks into clay block forms – just underneath lies moist, fertile earth which is ploughed and then seeded with various crops.

Crops grown in spate irrigation systems are usually organic, and don't require inputs like fertilizers and pesticides. They are of a higher nutritional value and are less susceptible to disease. The spate areas are famous for their melons and pumpkins, which are sold all over the country. Since the flooded fields are free of pesticides and other chemicals, they become natural wetlands which attract migratory birds from as far as Siberia. Every year, the flooded fields come alive with the sound of ducks and other waterfowl as they rest and feed in the winter months, on their way south. They return again in spring, on their way back to Siberia and colder climates – the Indus flyway is an internationally recognized migratory route for birds.

This type of agriculture requires high levels of cooperation between farmers to divert and manage the distribution of flood flows. The uncertainty stems from the unpredictable numbers, timing and volumes of floods, the occasional very large floods that wash out diversion structures, and the frequent changes to the *Rod* channels from which the water is diverted. Substantial local wisdom has developed in the location and construction of diversions and in organising water distribution and

managing flood waters. In D.I. Khan, large irrigation systems have developed over centuries and there is a fair measure of equity between upstream and downstream water users.

Up to the late 19th century, there was no government organization for the management of the flood irrigation system in D.I. Khan District. The British Colonial Government saw the arid area as a buffer zone against a possible invasion from the Russian Army in the era of the Great Game. As it did not want to subsidize its operations here, it sought of a way to make the area more productive and more secure, essentially by improving the water governance of the dry belt. In 1908 the famous Bolton Report was written about the *Rod Kohi* irrigation system which is still valid today. Sir Henry Bolton, the British Deputy Commissioner appointed to the district, formulated water rights for the farmers of the area. These water rights are locally known as *Kuliyat-e-Abpashi* (set of rules for diverting flood flows) and *Riwajat-e-Abpashi* (set of culture and practices for diverting flood water). The management system is composed of basically two types of flow (a) perennial water flow from springs which is locally called *Kala Pani* (b) Flood water flow from the upstream hills, locally called *Sufaid Pani*. In English, this literally means "black water" and "white water"

Promising potential

The spate irrigation system in Pakistan has enormous potential. According to conservative estimates, a significant amount (more than 50%) of flood water is allowed to escape and flow into the Indus River each year. This flood water often brings fish from the other rivers and streams into the Indus as well which is healthy for its ecology. Of the remaining flood water, however, more than 2/3 is not properly used for irrigation. One study by NESPAK 1998 estimated that even 6,925 Million hectares could be developed under spate irrigation, the lion share of it in Balochistan. Though this seems an overestimate, there is clearly a large potential, especially if spate irrigation is modernized and ample attention is devoted on its agricultural potential. A lot can be done to improve the livelihoods of the poverty stricken communities living in spate areas.

Attention for improving the management and productivity of spate irrigation also comes the fear that in the absence of this hill torrents will create considerable damage to the irrigation and drainage structure build along the West Bank of the Indus, such as the Chasma Right Bank Canal, the Kacchi Canal and the Main Nara Valley Drain/ Right Bank Outfall Drain. Clearly a rethink of dry-land agriculture on the 'dry side of the Indus' is required.
In the highlands of Balochistan, spate irrigation systems are located in the Khurasan Mountain Range, on the eastern slopes of the Suleiman Range and the Central Brahui Range. The lowland systems are located in the vast Kacchi plains, Las Bela and Kharan Basin. The potential area for spate irrigation in the province is around 1.07 million hectares (even 4.68 million hectares in the above-quoted NESPAK study) out of which only around 0.20 to 0.30 million hectares are commanded in a low flow year. The world's largest spate irrigation system – consisting of a series of earthen diversion (called *ghanda*) along the Nari River in the immense Kacchi plains – is located in Balochistan. At present several of these earthen ghanda are being replaced by new barrages. This innovation is promising but needs to be followed carefully, particularly the impact of the centuries-old system of water distribution.

In KPK, the largest and most established area under this system of irrigation lies in D.I. Khan and Tank. D.I. Khan District is located in the shadow of the Suleiman Range and is home to hardy Pathan tribes who settled in the area a few centuries ago. The farmers live in small villages, clustered near streams originating from the mountains. These are closely knit communities where families are often related to one another and land is passed down from father to son. The tenants here have hereditary rights to the land: as their ancestors helped developed the land their title is forever, unless they give up working on the land. Few leave unless their conditions become very desperate. The farming is dependent on two types of floods – the short duration flood, whose time limit ranges from 12 hours to one week and the long duration floods, with a flow period from two to three months. The flood water flows in different torrents known as *Zams* (which are perennial) and *Rods* in D.I. Khan. The flowing seasonal streams or *Rods* (or *Nullahs*) are blocked and diverted by the farmers with temporary diversion structures

which are also called *Sods* or *Gandi* or *Ghatti* in the local language. Large tracts of land in D.I. Khan and Tank districts of KPK are available for cultivation – out of a total of 0.69 million hectares of land, only about 0.26 million hectares are irrigated under *Rod Kohi* agriculture.

The spate irrigation areas in the Punjab province lie mostly in the mountain areas of D.G. Khan and the flat land of Rajanpur. Although spate irrigation has been practiced for centuries in the Punjab by the local communities, there has been little support from the public sector. The Punjab government focuses instead on canal irrigated agriculture. Still, more than 52,854 hectares of cultivated area in D.G. Khan is irrigated by spate flows from seven major hill torrents. In recent years part of the land that was spate irrigated has been converted in perennial irrigated areas, supplied from the new Chasma Right Bank Outfall Drain. At the same in the several of the flood rivers (Sanghar, Vehova, Kaha) new diversion and river bed stabilization structures have been built. However, this work is by and large incomplete as their no downstream command area development or agricultural modernization. This constitutes a big opportunity unutilized. In Punjab extensive spate irrigated areas are also available in Rajanpur with potential similar to D.G. Khan.

In Sindh, spate irrigation is practiced mostly by tenant farmers or small landowners in remote pockets, far away from the towns and cities. They grow enough only to feed themselves. There is little understanding of the scope of spate irrigation and the largest area is under spate irrigation in the Naj river may be converted to a perennial system if the water is dammed. There are serious doubts however as to the wisdom of such activities, as the likelihood of the reservoir silting up with the heavy silt-laden flow is high.

The spate farming system in Pakistan is very important since it grows crops used in animal feed for livestock all over the country. It produces a large part of the pulses (food legumes) and oil seeds but there is scope to do much more: higher production by better water management and better inputs; developing value chains marketing the high quality staple produce and special niche products. Spate areas have also developed special local breeds of cattle and goats.
This part of Pakistan is steeped in spiritual culture and the

local people regularly visit the shrines of famous mystics and follow a more tolerant, Sufi approach to Islam. In fact, the travelling Sufi saints from Afghanistan and Central Asia helped to spread Islam in the subcontinent, converting the local populace with their message of peace and inter communal harmony. These saints are buried all across the spate territory, and their shrines still attract thousands of people who come to pray and seek divine guidance.
At the policy level, spate areas must receive a priority place since there is a huge resource for livelihoods of millions of poor people lying inadequately attended. Spate irrigation systems should be encouraged since they are often low cost, environmentally sustainable and are based on local knowledge of people who feel confident to use them. These areas serve for food security of people and serve as rich grazing ground for our livestock wealth. A rich plant biodiversity is available in these areas, including a few world famous and rare plants with high economic value. These have enormous potential cash value if marketed properly. Spate areas are also environmentally friendly and sustain various kinds of endangered wildlife. These include cranes, flamingoes, houbara bustards and the Suleiman wolf.

Spate irrigation relies mostly on indigenous knowledge and requires relatively little investment for its practice and maintenance. The most important aspect is that the people manage it themselves. Although it is practiced in all the four provinces of Pakistan, little about it is known in the country and it needs to be promoted at both a national and regional level.

2 LOOKING BACK IN TIME...
History and Extent of Spate Irrigation

Legendary beautiful the Queen of Sheba is mentioned in the Bible and the Holy Quran. She is the powerful merchant queen who brings gifts to Solomon and eventually bears him a son, Menelik, who becomes the founder of the Ethiopian imperial dynasty. One version of history locates her empire in the interior of Yemen at Ma'rib. Her empire and that the civilization of the Sabeans was based on spate irrigation, as the current ruins of Ma'rib and Sirwah testify. Spate irrigation probably started in present day Yemen, when the wet climate of the Neolithic period became more arid, and has been practised there for around five thousand years. The Ma'rib dam at one time irrigated 9,600 ha with spate flows diverted from the *Wadi* Dhana, and was constructed in the third millennium BC.

Over the centuries, large traditional spate systems irrigating areas up to 30,000 ha were developed in the arid lands of Yemen in individual *Wadis* (streams). Sophisticated water sharing arrangements were formalised amongst the farmers, with rules relating to water rights written in records dating back at least 600 years.

In Pakistan, spate irrigation has also been practiced for a very long period. One can of course only speculate but the foothills where the rivers enter the plain are still dotted with historical sites. The one most explored is Mehrgarh in Balochistan but all along the foothills there are traces of the Pre-Indus civilization, some unfortunately bulldozered by farmers because of their fertile sediment. It was one of the most important agricultural production systems until the end of the 18th century, when the development of canal irrigation started under the British colonial administration.

Elsewhere in the region, spate water from about 260 *Wadis* in the north-west coastal area of Egypt was used for irrigation since the Roman era, while spate irrigation has been practised in Morocco and Tunesia over a similar period. There are large areas under spate irrigation and flood water spreading in Iran. In Eritrea, spate irrigation only started at the beginning of the 20th century by Yemeni migrants from across the Red Sea, and in Sudan by the British Government. Elsewhere in East Africa spate irrigation is increasing, especially in Ethiopia.

Box 2.1

The earliest dam, the Queen of Sheba and King Solomon

It is believed that the construction of the Ma'rib dam commenced around third millennium BC, and was completed in stages over the next 500 years. The structure had very well constructed stone abutments and irrigation off-takes on both banks, which partly survive. The dam itself was constructed from rock and soil, and breached on five or six occasions between the 4th and 7th century BC when the final catastrophic breach, which is described in the Holy Quran, occurred. In its final form the dam was about 18 m high and 700 m long, and irrigated farmland supporting a population of between 30,000 to 50,000. The farmers grew maize, millet, barley, and other crops. The dam was intended to divert water from spate floods, rather than to store water over long periods, as storage of flood waters would have resulted in fairly rapid sedimentation. It thus functioned more like a diversion barrage than a dam.

The early origins of the dam are credited to the legendary Queen of Sheba who built her empire around the frankincense trail in Yemen and commanded the rich trade. The story of the Queen of Sheba is intertwined with that of King Solomon, who managed to win her over. Earlier she had vowed not to give herself to him, unless he would find her taking anything that belonged to him. Cleverly, he placed a glass of water next to her bed. Waking up at night, she drank from it. Having taken his property, albeit only a glass of water, she could not longer resist him. Their relation bore Menelik, the first emperor of Ethiopia and founded of the Ethiopian House of Juda.

King Solomon is also said to have visited what is now Pakistan. He climbed what is the Takht-i Suleiman (Solomon's throne) or Koh-i Suleiman mountain range. From there he looked out over the land of South Asia, which was still covered in darkness. He then turned back without descending into the new territory.

The history of spate irrigation in many countries thus dates back several millennia, whereas elsewhere it is a relatively new introduction. Since spate irrigation requires intensive labour and contains certain risks, it tends to disappear as soon as farmers have access to better economic opportunities, as is the case in Saudi Arabia. That is unless the production systems are overhauled and made to fit modern day economies by making most use of conjunctive water, producing special crops and developing quality staple foods.

Spate Irrigation today

In certain regions of the world, farmers' know-how about spate irrigation has evolved through the centuries, allowing the transformation of initially rudimentary systems into farming areas growing from a few hectares to more than 30,000 hectares. Some spate schemes rank amongst the largest farmer managed irrigation systems in the world.

Today spate irrigation provides livelihoods for large numbers of economically marginal people in areas as varied as the Middle East, Far East, Africa, South Asia and Latin America, but is mostly practised outside the formal state managed irrigation sector. In some countries there are promising developments with the cultivation of middle-value crops from spate irrigation, but generally spate irrigation supports the cultivation of subsistence staple crops, with low returns.

This generates variable incomes between good and bad years, and requires high inputs of labour to maintain intakes, canals and field systems. Periods of drought have forced farmers to abandon their schemes, and local management structures have suffered in such periods.

The most comprehensive information on the current extent of spate irrigation around the world comes from data compiled by the Food and Agriculture Organisation (FAO), supplemented with case studies from other countries. These data suggest a global total of 3.1 million hectares, yet the extent of spate irrigation in practice in China or Central or Latin America is not known. The FAO data are based on government statistics

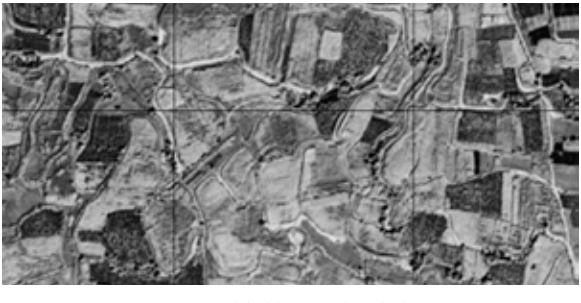
Box 2.2

Spreading the flood

In field-to-field spate irrigation systems plots are inundated for a short period. A field bund is then breached to allow water to travel to the next plot, before all the water infiltrates in the first field. Under these circumstances fields do not need to be fully levelled and only coarse land levelling is carried out by farmers.

that often ignore the smaller farmer managed informal schemes, and they can only be taken as indicating orders of magnitude. The true area of spate irrigation might be conservatively estimated to be at least twice that recorded by current FAO statistics.

Only a relatively small number of public programs to develop and improve traditional spate irrigation have been carried out in these countries. Most important is that spate irrigation requires a special approach and that the opportunities that spate irrigation systems bring are not always widely understood. It has been hard to undertake successful interventions, as spate schemes, in spite of the apparently simple technologies used, can be hydraulically and socially complex and standard perennial irrigation approaches do not work. These complexities were not always appreciated in past modernization projects, which have had mixed results. Large numbers of existing spate systems still need to be improved to reduce the excessive labor required to keep them operating and better spread the water and conserve soil moisture. There are also many improvements possible in crop agronomy and processing for instance and combining spate irrigation with groundwater use. There are also large areas in dry zones where spate irrigation could be introduced to improve crop yields in marginal rain-fed areas.



Spate irrigated fields in Wadi Zabid, Yemen

	Year	Estimated area under Spate Irrigation in ha	Source
Afghanistan	**2012**	150,000	MEW Afghanistan (2012) www.spate-irrigation.org
Algeria	**2001**	56,050	FAO Aquastat
Eritrea	**2004**	16,000	Haile (2005)
Ethiopia	**2007**	140,000	Alemehayu (2008)
Iran	**2008**	450,000-800,000	Kowsar (2008)
Morocco	**2008**	79,000	Oudra (2008)
Myanmar	**2012**	73,500	Ministry of Agriculture and Irrigation of Myanmar (2012) www.spate-irrigation.org
Pakistan	**1999**	340,000-1,280,000	Ahmed (2008)
Somalia	**1984**	150,000	FAO Aquastat
Sudan	**2007**	132,000	UNEP (2007)
Tunisia	**1991**	30,000	FAO Aquastat
Yemen Rep.	**1999**	117,000	World Bank (1999)

3 How it all works together...

Engineering in Spate Irrigation systems

Spate irrigation systems are by their nature dynamic. They have to deal with small and large floods, distribute unpredictable quantities of water over a large area, cope with changes in river beds and deal with high sediment loads. When the floods come, the water moves extremely fast and is quite forceful. Farmers in Pakistan say that they are often swept away by the sheer force of the water, although it might not be very deep.

The water carries with it sediments which can be as high as 10% of the total volume of the flood. These sediments are both a blessing and a curse. Silt carried by floods brings fertility. However, because some floods carry cracking clay or coarse sand, water users may even try to avoid such floods. Sediment also causes lands to rise and flood channels to silt up. Some of this is flushed and some of this is used to construct field bunds, but over time the land may lose command.

Spate river beds are very dynamic and spate irrigation is about managing water as much as it is about managing sediment loads. If the distance between bunds is too short, the sediment may not get into suspension and the river gets choked. If the river bed levels at the lower part of the river increase or decrease, than this sedimentation or scour will gradually move upwards and affect the upstream off-takes.

Under these circumstances the engineering has to be ingenious. Whereas in standard modern water engineering the idea is to control the water, in spate systems in Pakistan water is ‘managed and guided’ with long earthen bunds. A different hydraulics is at work here – taking the energy out of the water by guiding it along, spreading it over the command area and making sure it does not turn into erosive sheet flow. Traditional spate systems are also said to have an in-built safety valve for they break in very large floods and so prevent the damage that may come with these unusual events. Ironically, it is often small floods with no sediment load that damage earthen bunds as these ‘clean’ floods chip away at the soil structures.

Box 3.1

The art of the earthen bund

Earthen bunds – called *sad* (D.I. Khan), *ghandi* (D.G. Khan), *ghanda* (Kacchi) or *bundat* (Lasbela) are the backbone of spate irrigation systems. Their length ranges from 50 meters to several kilometres long. They divert flood water from the river bed and gently guide the water along and stop it from flowing to low-lying areas or back to the river bed. In the past the bunds were made with the help of bullocks, but nowadays tractors and bulldozers are used. In constructing the bunds the lay of the land is very important. If the bund only has one off-take the preference is to have the bund at an angle or even an arc with the flood flow to dissipate the energy and make the flood water manageable. In constructing the bund, material deposited in the river bed is used. The preference is for loams. Cracking clays, gravels or saline deposits are avoided. If necessary even the river bed is excavated to remove these. To make the bund compact, it is built up in layers of three to four feet and tractors or bulldozers are driven across them.

There are several ways to strengthen the earthen bunds. Stone pitching or pegging wooden poles in the surface of an earthen bund or simply providing brushwood will armour the surface of the bund. Providing gabions or carefully laid plastic sheeting inside the bund will reinforce the bunds. In some parts of Yemen traditional conical stone abutments are placed inside the bund (called *algamas*) to give it more strength.

Spate irrigation systems have generally been forgotten by public authorities and development agencies since they are associated with low value subsistence crops and are located far away from the seats of decision making. The contribution they can make to both the production of main and minor crops is not always understood. However, spate irrigation has an important development potential in low income arid areas.

Most spate irrigation systems have evolved and improved over time in reaction to the changes which have impacted the systems. Improvements were in most cases implemented by the spate irrigators themselves, and were developed over long periods of time.

Investments in civil headworks

In some countries there has been considerable effort to 'modernize' spate irrigation and replace traditional structures with civil headworks. A prime example of this approach is Yemen. Most of the spate rivers on the coastal plains from Aden to the Tihama are now equipped with concrete diversion structures, new flood channels and sometimes sediment excluding devices and breaching bunds. In spite of the high original investment, the track record of these structures in Yemen is not good.

Some systems (*Wadi* Zabid) are faced with high sedimentation. In others (*Wadi* Siham) the new headwork and canal only carry a fraction of the spate flow. Where the systems work reasonably well, they have in many cases upset the traditional water rights. Upstream weirs have given upstream water users control over the flow, allowing them to monopolize the spate flows at the cost of downstream communities. In the past this was difficult because earthen bunds would break and water would find its way downstream. The modern structures in Yemen often consisted of a cut-off weir anchored on the bedrock. These blocked the subsurface water flow in the river sediments and caused downstream well to dry up.

In Pakistan this approach has not been so widespread, but where it was applied it did not have much success. An evaluation of 47 such spate systems built with national funding in Balochistan between 1960 and 1990 revealed that only 16 were still operational.

The overriding factor behind the failure was the inappropriateness of the concept of controlling the flow at a single point with heavy civil engineering works rather than managing the inherently varying spate rivers. The technical designs for spate systems resembled those for perennial flows, and did not accommodate the capricious nature of the flood rivers.

Some structures were not able to withstand the force of the violent peak floods. In other cases, headworks were by-passed by the braiding river. Moreover, the provisions for sediment transport were generally insufficient and intakes silted up.

Box 3.2

Spectacular failure

One of the most spectacular failures of modern civil engineering in spate irrigation is the Mithawan Dam in the hilly areas of D.G. Khan district, Punjab. This dam was supposed to store flood water and distribute it over seven channels. However, it took one year of floods to completely fill the dam with sediment and render it utterly useless.

Avoiding these pitfalls would have required substantial investments in large headworks, silt excluding devices and long marginal guide bunds. Though, with these investments, it would have been possible to control the rivers at a single point, the low returns to spate made such high investments difficult to justify

Against this patchy track record of 'engineered' headworks, there are a few exceptions. In some rivers *pucca* flow division structures have been constructed. These have stabilized critical river sections, divided the spate flow over several command areas and thus ensured that no area would receive flood volumes that were too large to handle. Recently also low weir or bed stabilizers have been built for instance in Vehova and Sanghar in D.G. Khan. Such structures are very useful and constitute recommended practice.

Bulldozer programmes

The more substantial support to spate irrigation has come in the shape of bulldozer programs. Under a number of aid-in-kind programs, Pakistan received a large number of bulldozers and front loaders in the 1970s and 1980s. Much of this earthmoving equipment was deployed in the spate areas. Bulldozer services were made available at a heavily subsidized rate with 'bulldozer hours' allotted to or through local influential people. The political favoritism that went with the bulldozers bespoke of their popularity.

They bulldozers changed the landscape – they made it possible to quickly build and rebuild earthen bunds, even when a river was still on recession flood. They also made it possible to construct bunds in new locations and to make existing bunds

bigger. They were also deployed to plug ravines and gullies that always threaten to rut a spate irrigation command area. With the bulldozer programs farmers remained in charge of the systems, as the work was done under their guidance. An entire art developed of keeping the bulldozer operators happy and making them work seriously, particularly those bulldozer operators who had the 'skill' of making the bunds compact and strong.

There were drawbacks too. With the arrival of the bulldozers (and tractors as well) the traditional maintenance on the basis of pairs of bullocks and the organization that went with it broke down. As the bulldozers were routed through powerful individuals rather than community organizations, a system of political favors developed. Another downside was that traditional water rights were sometimes upset, because upstream farmers were able to build bigger and stronger bunds than they used to.

Not so long ago the bulldozer programs more or less unravelled. Much of the equipment had outlived its full operational life and in the words of the farmers, many bulldozers are now 'tired'. Subsidies were withdrawn and there came a general shortage of the heavy equipment, with farmers relying more on heavy tractors. In other countries local entrepreneurs came up renting out earthmoving equipment at cost, but this has not happened in rural Pakistan. Since 2010 however some Provinces have restocked their fleet of bulldozers.

Improvements to the traditional systems

Against the dismal performance of engineered headworks, improvements to the traditional systems have given better results and often very high returns against modest investment.

There is a range of relatively low cost improvements that can make a large difference. These are listed below:

Main Flood River	
Reinforced intakes	Fixes intake of flood channel and makes it easier to control, particularly in dynamic sections of river bed
Bed stabilizer	Avoids regression of river bed – but have to make sure it does not reduce subsurface flow. Can be made traditionally by
Conical stone abutment	Can be used for intake to flood channel, for anchoring and protecting bunds and spillway structures
Earthen Diversion Bund	
Stone pitching	Strengthens the bunds and reduces erosive effect of floods
Polythene plastic sheet reinforcement	Strengthens the bund and avoids effect of piping and rodent damage
Poles and brushwood protection	Strengthens the bund and reduces erosive effect of floods
Gabion reinforcements	Strengthens the bund
Permeable spillways	Allow controlled spilling of high flows without damage to the main earthen structure
Flood Channels	
Gated flow division structures	Can divide flows in accordance with water rights and split the flow in manageable quantities
Un-gated flow division structures	Can divide flow in accordance with water rights and also stabilizes channel beds
Spillways and escapes	Avoids excessive floods and can lead water to lower lying channels without gullying and rutting

Fields	
Improved intakes	Allows bunded fields to be watered and then be closed with stop logs thus avoiding backflow
Field to field *nucca's*	Allows water to spill from high field to low field whereas stilling basin avoids field erosion and field gullying
Overflow structures	Allows water to spill from field to field without damage to field bunds that makes it difficult to control water in the field

The Water Resources Research Institute in Pakistan (WRRI), which is a part of the government's National Agricultural Research Center, has been working on improving spate irrigation systems in Pakistan since 1994. They have worked on a series of high impact improvements, such as gated flow division structures, field inlets and field to field nucca's. These activities are described in more detail in the next chapter, but several of these command area structures have been able to revitalize agriculture over an area of 3,500 hectares with a structure costing USD 2,500. While cost effective improvements in flood diversion are possible, the scope for command area improvement is even more spectacular. In these cases it is very much a story of the right structure in the right place, which can only come from intensive discussion among water users themselves.

Box 3.3

Low cost high success

In the Rehanzai Bund in Balochistan, located at the confluence of the Bolan River and an off shoot of the Nari River on the Kacchi plains, farmers constructed a very large new soil bund with external financial support in order to spread flood water over more than 15,000 ha of land. The total cost of the project was USD 80,000. The advantages of such programs have been that they have kept local management intact and generally relied on simple low cost improvements to the infrastructure.

Lessons learnt

Most large spate irrigation improvement projects have been dominated by a heavy engineering approach, where traditional, independent diversion structures have been replaced by one or two permanent gated diversion weirs supplying new canals. The record of most of these projects is not positive. The operation and maintenance of the larger diversion structures and canal systems is difficult and expensive. In particular sedimentation at intakes and in canals is often not properly controlled in these 'modernized systems'. Preference should be given to easy and economical techniques to improve pre-existent structures, rather than building new structures from scratch, and abandoning the existing traditional structures. The current philosophy is to improve the river bed, for instance stabilizing it by bed bars. This will allow farmers to build their own diversion, something that is very difficult if the river bed is eroded and rutted.

From past experiences, it appears that improving farmers' systems with a more modest scope seems to obtain more encouraging results. It appears that regardless of the size of the diversions, the user farmers must be the ones who direct the design, planning and execution of the improvement works or structures to be repaired or installed. The technician's role should be limited to explaining the available options and helping the farmers in choosing the most appropriate improvements for their area (most failures in improvement projects of big areas came from a lack of participation of user farmers).

Successful interventions

Experiences with smaller farmer managed systems have often been successful and cost effective. Here small improvements have been introduced to improve the reliability of existing traditional intakes, for example through access to bulldozers at subsidised rates, or improvements to intakes constructed using masonry or gabions.

Most investments in improving, or in some cases extending spate irrigation to new areas, can only be justified as part of a wider poverty alleviation program. In these cases technical interventions, such as the construction of low cost permanent gated diversion structures, have the potential to improve spate irrigation by increasing the control over the diversion and distribution of spate water. However, they must take into account the existing irrigation practices based on traditional rights regarding the allocation and distribution of spate water.

With low crop returns even in good years and the likelihood of occasional crop failures, spate-irrigated agriculture provides a precarious living. To alleviate poverty in spate-irrigated areas it is not sufficient to focus only on the improvement of spate irrigation. Water is not the only constraint to improving the productivity of spate-irrigated agriculture, and many poor households only rely in part on spate-irrigated agriculture for their incomes. Successful alleviation of poverty in spate-irrigated areas also depends upon:

- Improvement of access to inputs, extension services and marketing for spate-irrigated crops.
- Where it is possible the development of conjunctive use of ground and spate water, including access to credit for installation of (collective) wells and pumps.
- Improvement of the productivity of livestock as well as the processing and marketing of livestock products.
- Creation of opportunities for wage labor and off-farm income, in particular for landless households.

These activities should be developed so that poor households in spate-irrigated areas have the chance to substantially increase their incomes.

4 CONSIDERABLE SCOPE FOR IMPROVEMENT... Experiences from a PARC program

In recent years spate irrigation systems in Pakistan have faced several challenges. Due to the neglect and lack of overall management, natural events like drought and extra ordinary floods, and inadequate options of alternative livelihoods, the spate systems have steadily deteriorated in the country since the 1970s. Farmers complain that because of poor governance and the politicization of the society, communities no longer cooperate with one and another to maintain these systems. Another reason is that most of the resident farmers are tenants and they do not receive an expected support from the absentee land owners for ensuring access to water. Farmers therefore are losing faith in making a fight for access to water for their lords who seem to have stakes in other things rather than only in their lands. These traditional farming communities are facing increasing poverty and hardship, caused mostly by water shortages and inaccessibility. According to one farmer based in D.I. Khan District "people no longer fear God, nor respect the law nor care for their brothers".

Box 4.1

Dr. Shahid Ahmad, who was the initiator of the first National Research and Development Project in Pakistan covering all the four provinces, recalls that:

"During 1992, I was visiting D.I. Khan. For the first time observed the spate irrigation at work in the Gomal *Zam* command area at three to four locations, such as Yarik and Hathala. The first thing came to my mind was how come we the so-called 'experts' never thought of initiating research and development in *Rod Kohi* areas. After initial study we found that D.I. Khan, D.G. Khan, Barkhan and Musa Khel and Thana Bula Khan are promising Target Areas to initiate the National Research Programme on "Development and Management of *Rod Kohi* Irrigation System in Pakistan". This was the start of an until now continuing research program, approved during 1994-95. It was the largest research project ever handled by Water Resources Research Institute. The initial guidance came from Major Rtd. Aminullah Gandapur who became our teacher in *Rod Kohi*. The selection of several talented young professionals from the area proved to be a lucky one as they are now Champions of Spate Irrigation in the respective ecologies. Later on follow up projects were initiated. Spate irrigation is going to be the future potential area for development of livelihood in these fragile ecologies and now the Ministry of Water and Power under the Water Sector Task Force recommended investment of USD 300 million in collaboration with Friends of Democratic Pakistan. The Report was published in early 2013 and is now open for circulation by the Asian Development Bank."

There has been little outside expert support to spate irrigated areas in recent years. Two organizations however have made noticeable contributions. Water Resources Research Institute (WRRI) under the Pakistan Agricultural Research Council in Islamabad launched '*Rod Kohi* System Development and Management' Project which has been working on improving spate irrigation systems in Pakistan since 1994. The first generation '*Rod Kohi* System Development and Management' Project concluded in 2004 with a total cost of USD 900,000. The WRRI has done considerable work at its field stations located at D.I. Khan (KPK), , D.G. Khan (Punjab), Thana Bula Khan (Sindh) and Barkhan (Balochistan). This then continued under the title of National Research and Development Project on "Water Management of Spate Irrigation Systems in *Rod Kohi* areas of Pakistan" up till 2010. Among international players, Swiss Agency for Development and Cooperation (SDC) launched a project called "Project for Livelihoods Improvement" in 2003 which was implemented and technically supported by Intercooperation Pakistan. This project focused in *Rod Kohi* areas of KPK (Draban and Chowdwan *Zams*) in improving water conveyance and management issues for enhancing people's livelihoods. This project was concluded in 2007 and was taken over SDC funded "Livelihoods Programme", also implemented by Intercooperation (IC). Since 2011, Inter-cooperation has up-scaled *Rod Kohi* development under a Water for Livelihoods project in both Intercooperation and Pakistan Agriculture Research Council are active collaborating partners in D.I. Khan.

In most of these areas the farming systems are traditional and of subsistence nature and the WRRI successfully introduced low-cost interventions which have helped farmers improve their productivity. It has focused on developing several engineering techniques to distribute the flood water from channels and minor canals to the fields using water diversion and distribution structures.

Aside from constructing flood diversion and distribution structures, the project has also worked on conveyance system rehabilitation, construction of field inlet structures of different types, improvement of water reservoirs, installment of sand filter hand pumps for clean drinking water and plastic lining in diversion bunds to avoid seepage and breakage.

This chapter describes the work done under this project – as an example of the scope for considerable improvement. The various innovations in D.I. Khan have been extended with the support of Intercooperation. Particularly after the devastating floods of 2010 major rehabilitation was done – not just restoring the system but improving them and considerably strengthening their governance.

D.I. Khan in the KPK

D.I. Khan is the southern-most district of KPK, with the Suleiman Mountains lying in the west. The district takes its name from the Baloch chief who settled there towards the end of the 15th century. His descendants ruled the city he founded for 300 years. Although D.I. Khan City was swept away by a flood in 1823, it was rebuilt further back from the nearby River Indus. Although a river runs adjacent to the city, the people face shortages of fresh water since they are not able to use the river water for irrigation purposes.

The people of D.I. Khan are mostly Baloch and Pashtun tribesmen who settled in the area as spate irritation evolved many centuries ago. The city is known for its universities and colleges and the dates which are grown here in abundance. In fact, the dates are one of the city's major exports. There are numerous date palm groves in the district, although the local people now complain that these are dying due to the shortage of fresh water.

The Chashma Barrage constructed over the River Indus is located near the city and canal irrigated areas have developed on the banks of the river. Spate irrigation however continues to be important. There is low annual rainfall in the area and the major source of water for irrigation in the foothills comes from the *Rods* or hill torrents. There are a total number of the thirty *Rods* in D.I. Khan district and the total *Rod Kohi* command area is 224,592 hectares of land. The farmers plant their crops in two seasons; from mid-November to mid-February and Mid-July to Mid-September. Apart from the 30, *Rods*, there four main *Zams* Gomal, Sheikh Haider, Daraban and Chaudhvan – that carry both perennial flows and flood water.

PARC has been operating a program that pilots and implements improvements in the spate irrigation in this area. The field office is located in D.I. Khan town and one of the first problems that the PARC staff wanted to address was the shortage of freshwater for both domestic and livestock use. They noted that the farming communities had built earthen reservoirs for drinking purposes. These reservoirs are filled by either rainwater or runoff water from spate. However, since the livestock of the area was also drinking water from the same ponds, this lead to health hazards. The ponds, moreover, were shallow and they dried up early in the dry season, forcing people to travel long distances for their daily water requirements. Keeping in view the intensity of the problem, the project staff started working on cleaning and deepening the earthen reservoirs in the area for drinking purposes. A successful innovation was the use of polyethylene lining of the ponds, eliminating seepage of scarce water. These black plastic sheets had to be laid with skill, taking care to anchor them and avoid any damage, as this would encourage rats to destroy the lining. Sand filters were installed in some of the ponds to provide silt-free and insect-free water.

The WRRI also constructed water distribution structures in the target area of Hathala, located 45 km from D.I. Khan city in the Kolachi Tehsil. This area is mostly farmland irrigated by spate floods. There are large fields here, owned by landlords who have access to tractors. Their homes are located in D.I. Khan, but many have small guesthouses in the fields where they can spend the night if need be. There are lots of trees in this area as well – nearby there is a wildlife refuge where partridge and deer run free.

Box 4.2

Dying date palm groves

Chaudhvan village is a picturesque old settlement with groves of date palm trees. The water circulates throughout the village through lined water channels and is distributed at six am daily. During the British era, water was so plentiful that the local farmers were growing grapes, mangoes and apples as well. However, with the neglect of Chaudhvan *Zam* it became silted and the area started facing severe water shortages. The local people say that their date palm groves are dying. Many families have already sold their groves or cut down the date palms to grow other crops.

The WRRI has experimented with different designs and construction materials in the distribution structures in Hathala, which help to regulate flood water and distribute it to the cultivated fields. The main purpose of the structures has been the improved control and management of the flood water within the canal area. They have divided and regulated flows – making sure part of the water is diverted to higher land that is entitled to it and another and manageable part goes to the lower part, avoiding scour in these areas that would destroy the canal and cause the rutting of the land. These structures avoided damages during the high flow conditions. They also increased the stream size during low flow conditions. The cost of the masonry structures installed in Hathala ranged from USD 200-300 per structure (with farmers contributing around 50% of total cost in labour). The structures were designed with a capacity of 200-250 cusecs of flood water. These cost-effective technologies were introduced successfully and have been adapted by the local communities. This can be regarded as an innovative idea to manage spate flows under both the low and high flow regimes as the flow width is divided into three sections with wooden planks which helped to manage water under varying hydraulic regimes.

Normally farmers build an earthen bund to divert water to irrigate their fields and breach the bund after the irrigation is over so that downstream farmers can irrigate their fields. The effort was made by the project to reduce the drudgery and unreliability associated with the construction and operation of these earthen bunds to divert water to the command area. Steel gates were installed to regulate and divert flood water. These regulating structures have saved farmers considerable toil. The gated regulating structures were installed in several places in D.I. Khan district and have proven to be quite effective in regulating spate flows. However, their performance in sedimentation and scouring in the downstream area have to be evaluated over a longer period. The beauty of the earthen structure is that it provides the best hydrological equilibrium in terms of sedimentation and scouring.

To control the water flow into the fields, *pucca* inlet structures were also introduced. These structures can irrigate over three hectares of land and their cost is only USD 35 (with farmer sharing 50% of cost). Their purpose is to close the inflow and

Box 4.3

Controlling the floods

Three gated structures were installed in Garra Ramzi, Tehsil Drabingi in D.I. Khan district by the WRRI costing around USD 3,500. Before the gates were installed, only a few acres of land was under cultivation in the area. Now 4,000 hectares have come under cultivation. The gates saved the bunded fields from the erosive velocity of water, which would have otherwise broken the bunds. Thanks to the controlled floods the local farmers managed to grow bumper crops of sorghum, millet, mustard, rapeseed, chickpeas and wheat. The farmers were so heartened by the successful intervention that these structures have been replicated all over the command areas.

outflow to the land once the huge land block is filled with water. With the help of stop logs the intake is closed and this prevents that water from the filled land block flows out again.

Pre-cast water application structures called pipe-*naccas* were also installed as overflow structures. The nacca's lids are easy to operate and there is no opportunity for vandalism as is the case in using wooden planks (traditional method) and steel gates. What they do is that they regulate the orderly flow from one field to another – this prevents that the receiving downstream field is faced with a gush of water that scours the field and causes water to disappear. Pre-cast *naccas* of different diameters were used to construct appropriate structures considering the area to be irrigated and amount of water required. The cost of the structures ranged from USD 30-70 with a capacity of 10-20 cusecs depending on the numbers and sizes of pipes. The performance of these structures was found to be satisfactory and farmers are now adapting this technology which is cost effective and easy to install and maintain.

The project also helped improve water conveyance systems through the rehabilitation of the shallow water channels which convey water from the main torrents and the shaping and raising of bunds in the season prior to the floods. Stone pitches and plastic sheets were used in critical sections of the bunds to prevent seepage of water and ultimately control the breaches.

A total of 120 structures were built by the WRRI in cooperation with local farmers in the target area of Hathala. These included inlets, outlets and diversionary structures. Based on the performance and impact of the technologies, critical evaluation was undertaken for the assessment of the potential for large scale adoption by farmers. However, with the completion of the construction of Gomal *Zam* Dam and canal network, this will no longer remain a spate area therefore, in future the spate research and development program has to be shifted to some other *Zam*.

The WRRI also conducted experiments for crop enhancement of millet, wheat and chickpea crops using simple and practical interventions. These included evaluation of yield performances of farmers' un-graded and graded seeds and the introduction of an improved variety of seeds. The project also experimented with yields of melon and introduced forest plantation in the command area of arid plants like zizyphus and tamarix. Due to free grazing, natural vegetation in the district is scanty. The people in D.I. Khan still use camels for transportation purposes and own large numbers of livestock.

In the follow up projects, several other interventions were introduced covering aspects of water productivity, integrated land use, amendment of saline groundwater using EM (effective micro-organisms) bio-fermenters, drip irrigation for fruit plants and melons, biogas generators for tube well operation.

D.G. Khan in Punjab province

D.G. Khan district is similar in landscape to D.I. Khan district – the land is mostly flat and arid, and spate irrigation comes from seven major *Rods* which include Kaura, Vehova, Sanghar, Sori Lund, Vedore, Sakhi Sarwar and Mithawan. There are many minor spate systems and medium spate rivers are Bajha, Litra, Bhaati, Kahwan, Mahoi, Belob, Sori Khosa, Gazi, Satai, Khumbi, Berh, Sufaido, Joho, Kurd, Sor, Dalai, Zai, Dalana, Sabokha, Choti Bala, Nangari. In total there about 200 major, medium and small irrigation systems in foothills of Suleiman range in D.G. Khan and Rajanpur districts. A part of the D.G. Khan district includes the Suleiman Range, but the WRRI's target area was selected

in the mountainous tribal area of the Mithawan watershed. This is a picturesque but poverty stricken area, located in the Suleiman Mountains far from the main towns. These tribal areas do not come under the writ of Pakistan Government and the tribesmen govern themselves as they have for centuries. The reason for selection of this area was that the target area receives both flood water and perennial water and is a groundwater oasis courtesy a series of springs.

The nearest big settlement is Sakhi Sarwar, which sprang up centuries ago around the shrine of a mystic saint who is still revered by both Muslims and Hindus. Every year, his birth anniversary is celebrated with great fervour and thousands of pilgrims descend upon this remote corner of D.G. Khan. Rice is cooked in large urns and distributed to the pilgrims – there is a legend that these urns will never go empty as long as the shrine remains intact.

In Mithawan, irrigation is dependent on *Kala Pani* (perennial) flows from natural springs. The total area of the Mithawan watershed comprises 993 square km. The area consists mostly of mountains with a valley comprising 16 hamlets. The *Kala Pani* stream flows are provided to settlements in Dholi, Sohrbun and Khan. Flood water is available in the downstream area for irrigation. The area receives very low rainfall, most of which occurs during the monsoon season between July and August. Winter showers take place in December and January and the average annual rainfall varies from 200 to 300 mm.

The discharge of the mountain streams fluctuates with the occurrence and distribution of rainfall and the availability of stream flows. According to the participatory rural appraisal conducted by the project staff, water is one of the most limiting factors affecting the productivity of the area. Keeping in view the heavy losses occurred in the conveyance system WRRI introduced the concept of aqueducts. In total, seven aqueducts of different lengths and cross sections have been constructed in the target area. Not only is the existing area being cultivated on a regular basis now, but new expansion of irrigated area is going on due to the ensured availability of water.

To overcome the excessive loss in water in the earthen channels (more than 50% of the water carried by the earthen channels was wasted due to seepage), a watercourse of 100

Box 4.4

Water lifeline

An aqueduct of 69 m was designed and constructed by the WRRI in the Dholi area of Mithawan using a steel truss frame. The aqueduct was designed with the capacity to carry 2.5 cusecs of water. The total cost of the structure was USD 2,500 and it provided irrigation to around 25 hectares of land. The aqueduct brings water from a perennial spring called *Banz* Dee located eight km away in the Suleiman Range. Individual landholdings have increased from less than 0.4 to 2 hectares in the area. The local farmers have even started growing cash crops like cotton and sunflowers.

meter length was lined with stone masonry. This intervention brought an additional area of more than six hectares under irrigation. The problem of water conveyance across the torrent bed was handled by constructing siphons and aqueducts. Pre-cast water diversion and application structures were constructed to overcome junction losses and to control and manage diversion of water to the fields. All along the watercourse, new fields have been planted, with farmers growing guar, millet, sorghum, mung beans and vegetables. These fields are surrounded by trees and other shrubs and from a distance they look like oasis in a mountain desert.

Water storage for humans and as well as livestock was a major concern in the Dholi area. People, especially women, have to travel long distances along with their livestock to reach the water points. Most of the women in the area still store water in traditional goatskin pouches to carry to their homes. Small and medium sized earthen water reservoirs were constructed in the target area to help the local people. Farmers were motivated to participate in the construction of these reservoirs and proper sites were selected to harness rainwater. Water stored in these ponds is now providing supplemental irrigation and some farmers have also experimented with fish farming in these reservoirs. The results have been encouraging. It is also expected that seepage through these reservoirs will help create a fresh groundwater resources after some time.

In order to conserve and manage rainwater in the watershed areas, 1,200 eyebrow terraces were constructed along the contours of the hillsides in staggered fashion to harvest runoff and to detain the silt load. 40 Trenches were also excavated along the contours of the hilly area in an alternate manner to

arrest the sediment and gravels coming with the runoff. Thirty loose stone check dams of various sizes were constructed across the waterways to reduce water velocity, control gully formation and trap the silt coming with the runoff. Acacia species were grown in these pits for the promotion of vegetation and grass species were broadcast in the upstream catchment areas.

Due to the ensured supply of perennial water with the WRRI project's activities, the local farmers have started growing cash crops like cotton and sunflower as well, aside from millet, sorghum, guar and wheat. Due to the lining of watercourses and construction of aqueducts, water loss has reduced tremendously and water conveyance efficiency improved by almost 60%. The cropping intensity of the area has increased which in turn has increased the overall production of the area. At the start of the project, there was only one flour mill operating in Dholi and now there are seven small flour mills to cater the village and other neighborhoods in the area, indicating improved cereal production.

Another positive outcome of the project is that out migration of the community has halted due to the constant availability of water. Families who had migrated from the area are starting to return to cultivate their ancestral lands.

In the follow up projects, the attention shifted to Vehova, where large-scale spate irrigation system similar to D.I. Khan was selected for the introduction of various interventions. The experiences of D.I. Khan were very valuable and interventions were designed accordingly. Emphasis was placed on improving water productivity at the farm level.

Thana Bula Khan in Sindh province

The WRRI field office in Sindh is located in Hyderabad city, but their target area is situated at a distance of 16 km from Thana Bula Khan which is located near the Khirthar National Park in the Khirthar Mountain ranges. This is Pakistan's second biggest national park and provides an important habitat for a variety of endangered animals like the Sindh Ibex and Urial and birds and reptiles like pythons, which are characteristic of the arid subtropics. Nearby is the vast and

mysterious Ranikot Fort, one of the largest forts in the world, whose walls resemble the Great Wall of China. Most of its 29 km long wall is made up of natural cliffs and barricades of mountainous rocks which at places rise as high as 610 m above sea level. Only about eight km of the wall are man-made, built with yellow sandstone. No one really knows for sure why or when it was built.

Thana Bula Khan itself is an old Hindu settlement, which still has a functioning Hindu temple dedicated to various Hindu deities, including a local holy man who built a nearby water reservoir manually. Most of the Hindus living here did not migrate to India after partition and today they own most of the land in Thana Bula Khan. They live in harmony with their Muslim neighbours and this is in general a peaceful area with little crime. Both spate irrigation and dug well irrigation is practiced in the Thana Bula Khan area. However, due to a continued dry spell of six years, spate irrigation was discontinued and land was cultivated from the water taken out of the dug wells. The water level in the dug wells receded from 9 to 37 m during this period. There were heavy rains and since the farmers were not prepared for flooding, they suffered huge losses from damage to fields and bunds.

Due to the prolonged drought, the WRRI team concentrated on rehabilitating 15 dug wells in the target area to meet the water needs of the local farmers. The villages are not organized and represent just a collection of hamlets with small land holdings and it is extremely poor area. The subsistence farmers often have to walk for several km to the dug wells to fetch potable water. EM ceramics were introduced for improving combustion efficiency of diesel pump sets. Horizontal drilling was also conducted by the WRRI staff in the dug wells to increase well yields since the ground water had started becoming brackish in some wells, which is resulted in reducing productivity of crops due to soil salinization and hazardous to human health. The horizontal drilling resulted in a considerable increase in water availability and was adopted by many farmers to increase the productivity of dug wells farming.

The project also developed two water reservoirs fed through spate flow and helped to rehabilitate several others by stone pitching and constructing spillways. These reservoirs recharge ground water and provide clean water for livestock. They also

Box 4.5

Windmill for water

Around five hectares of new agricultural land was developed for cultivation in the target area by WRRI. This agricultural land is located near the bank of a torrent bed near Thana Bula Khan town. Here the groundwater was available at a depth of 24 meter from the soil surface. A pump of 75 mm suction and 62.5 mm delivery was installed on the dug well. The water column in the dug well was about six m and diameter of the well was 3.7 m. The large diameter of the dug well is because of extremely low yield of well and larger diameter directly enhances the well yield. A light-diesel locally designed flywheel type engine was installed for pumping water from the dug well. Later on it was replaced by a windmill to harness wind energy instead of using high diesel fuel. Cotton crop was grown on this land on an area of 2.4 hectares. Trickle irrigation was also introduced on an experimental basis.

serve as natural wetlands where migratory birds can rest and feed in the winter months. Tractors were also hired by the project to level land and dig furrows in selected agricultural fields where a variety of crops were grown on an experimental basis and data collected on their growth and the amount of moisture needed. The data was collected during the drought years for a study on improving water efficiency.

Cotton crop was introduced in a total area of 27 hectares near the dug wells by WRRI with promising results. The yield of cotton crop varied from 1,433 to 1,778 kg per hectare. Farmers received a gross income of about USD 600-750 per hectare. Onions are the major cash crop of the area where dug wells are used as a source of irrigation. WRRI conducted a study on the harvesting index and yield data of 25 farmers in the target area. The data indicated that the harvesting index varies from 85% to 96% with the application of fertilizers and pesticides. The yield of onion crops varies from 18,280-19,760 kg/ha. The gross income per hectares varies from USD 3,750-4,200 which is high. Onions grown in this area are supplied to the big cities of Karachi and Hyderabad and with the prices of onions increasing every year, the farmers are ensured a good income from this important crop. This area has great potential for off-season vegetable in the country due to its micro climatic conditions and improvement in spate irrigation helps to harvest water in fields and recharge groundwater considerably.

Box 4.6

Bearing fruit

To supplement incomes during the drought years, the WRRI project staff also introduced a local variety of zizyphus which produces fruit called *ber* that can be eaten and has cash value. The zizyphus variety was grafted by the project staff over a period of three -four years and then introduced to the local farmers in Thana Bula Khan who have grown it alongside their fields. The plants require little water and bear fruit in February/March. The farmers harvest the fruit and sell it in the local markets. The *ber* sells for around Rs 20-40 per kg and is sold in fruit markets of Hyderabad and Karachi.

Barkhan in Balochistan province

Barkhan district lies in the eastern part of the Balochistan province – it is a rural area and the major Baloch tribe settled in the district is called the Khetran. Barkhan is derived from Baro Khan, the founder of the Barozai family who once ruled this area. The project area is located near the villages of Jahalwani and Sirati. The Jahalwani area is irrigated by spate floods from two small *Rods* called Khanki and Garabacha. Both these *Rods* have distinct command areas where farmers manage the system on a participatory basis according to their water rights. Supplemental irrigation is applied with groundwater lifted from dug wells using electricity at the tail end of the *Rods* where mostly almonds are grown in addition to other field crops like wheat, sorghum and vegetables.

The Sirati area is largely served by small *Rods* originating from small catchments. This area is typical of the many small spate systems one finds in the mountain valleys, each system typically irrigated not more than 12 hectares. However, ground water is lifted through traditional Persian wheels located in small valleys. The local people earn their livelihood mainly from livestock rearing.

The most limiting factor for crop production in the area is the low rainfall and its skewed distribution. The annual rainfall ranges from 175-350 mm and for most of the time the torrents are dry. The flood water, which is unpredictable in terms of its magnitude and timings, spreads in vast sheets leaving behind a thick layer of silt.

Box 4.7

Sharing the flood water

32 Distribution structures were constructed in the main channels of the target area. Before the construction of these structures, there was a lack of proper distribution of water among farmers and they faced conflicts over the sharing of water. The materials used in these structures were locally available stones. Gabions were laid at the crest while the wing walls and nose were made of stone patching grouted with cement to reduce the cost. The cost of the structures varied from USD 25-75, out of which 30% was borne by the farmers in the form of unskilled labour. These structures experienced around four to seven floods every year and their hydraulic performance was satisfactory.

The uncertain availability of hill torrents causes either floods or prolonged drought. Water diversion, control, application and distribution at the field level were the major problems in Barkhan valley. There was also seepage of scarce water in ponds and conveyance systems and the inadequate availability of water for domestic and livestock uses. Control structures including diversion and distribution of water, field inlets and outlets were constructed, keeping the cost as low as possible.

In addition to the distribution structures, 161 diversion structures were also constructed. Earlier farmers used mostly loose stones or earthen bunds which were prone to damage by rushing floods. In order to efficiently utilize the flood water, 118 field inlets/disposal structures were also constructed. These engineering structures not only increased the cropped area but also improved water application to fields, reduced bund breaking and damages to the conveyance systems and labour costs. The structures were monitored for their performance and the floods passed safely with no damages incurred.

A total of 65 dug wells were also renovated and rehabilitated. To check seepage losses from earthen ponds, polythene plastic film was laid over the wetted parameters of the ponds. Watercourses were lined with reinforced concrete pipes and polythene to control conveyance losses in the watercourses. 28 heck dams were also constructed to check the velocity of flow and silt deposition outside the ponds which enhanced the storage capacity for a longer time. De-siltation of ponds was

carried out and bunds were stabilized through compaction, stone patching and providing spillways for the safe disposal of excess water. All this work was done with the whole-hearted participation of the local farmers.

The Impact of WRRI Work

The research and development activities undertaken during the period of 1995-2010 provided large scale information, knowledge and performance of interventions for management of water, enhancing productivity of crops, livestock, forestry and range in all the four provinces considering wide variation of physical, hydrological, social and economic consideration. Different types of spate irrigation systems were also studied and appropriate technologies were developed and upscaled with the help of Intercooperation in D.I. Khan. The research and development work in 15 years has provided technology, methodology and processes for up-scaling the outcome of various pilot studies and it is expected that in the forthcoming investment projects the outcome of research and development by WRRI would provide required information to successful implementation of investment projects. The spate irrigation is now part of country's water sector strategy approved by the government of Pakistan.

5 THE HARD LIFE...
The Socio-Economic Setting

Most households in spate-irrigated areas are poor, with families living on less than USD 1 per person per day. These families, often as large as eight to nine persons, live in traditional houses constructed with mud walls (often collected from spate sediments) and thatched roofs. They live in small villages or hamlets and rarely travel to the large cities. They sleep early and awake at the crack of dawn to start work in their fields. Most live in dread of the drought years – these are difficult years when the rains fail and they cannot grow their crops. In many areas of Pakistan families from the spate irrigated area migrate temporarily to the Indus Basin irrigated lands with their livestock and belongings if floods are late or do not come at all. The migration takes place in the months of November and December and they stay until the wheat harvest is in, where they work as agricultural labourers, whilst their livestock feeds on the stubble and has water to drink. They also live in fear of the heavy floods, which can sweep away their newly sown crops, damage their bunds and inundate their homes.

While a few powerful land owners located at the head of some schemes generate high incomes from commercial scale farming, most spate irrigators are poor subsistence farmers. They lack basic amenities such as potable water and sanitation, electricity and health care. There is high infant mortality due to malnutrition among children and pregnant women, as well as anaemia, malaria and other health problems. These are mostly feudal areas with a conservative and patriarchal society in which women's freedom is restricted. People living in mountainous area are facing more problems with comparison to the people who live in plain of the spate irrigation area. Inside the mountain there are small patches of land which are irrigated by small catchment spate called *kacchi.* Life here is more isolated than it is on the plains.

The literacy rate in most spate areas in Pakistan is very low – an average of 10%, which includes primary, middle, high school and recitation of the Holy Quran. Many farmers earn their livelihood from a mix of activities: not only farming but also labour, daily wages, livestock sales or shop-keeping.

A large part of the land is cultivated by hereditary tenants. These tenants helped develop the land and construct the in the

past. They ensure that the fields are maintained and in some cases have partial ownership of the lands. Their landlords usually cannot take other tenants while they are resident. But if they ever leave the land, then they lose their tenancy rights over it.

In several districts under spate irrigation including Dera Ghazi Khan and Rajanpur, Dera Ismail Khan, Bannu, Kohat, Lakki Marwat, Kohat, Barkhan, Musa Khel, Loralai, Killa Saif Ullah, Kalat, Khuzdar, Noshki, Kharan, Gwadar, Turbat and Lasbela, the lands are often owned by the tribe and clans who occupy the plains and as well mountain and the hills. This has been the case since ancient times. All the irrigable lands and in some case hills and rangelands are distributed among the sub-clans of the tribes. Almost all the tribes have their own area where their tribal man lives with the land title. Such land titles are registered in the revenue records of government except in some of the high altitude tribal regions. In many instances, tribal chiefs have always occupied lands close to the water source. Apart from these lands, there are village commons called *shamilaat* which may be owned and used by the entire tribe. Everyone from tribe is allowed to make a house there, graze animals and take the fuel wood.

Every year a huge number of nomads having large flocks of sheep and goat come to the spate irrigated area and local trade take place between the local farmers/tenants and the flocks holders. This is particularly common in lowland Balochistan. Nomads come from the highlands, but also from the Federally Administered Tribal Areas and Afghanistan in the winter months to eastern part of the Indus and stay there until the end of March. Sometimes there are conflicts between the nomads and local farmers on the use of pastures and damages by livestock to trees and crops.

Role of women

Like elsewhere in rural Pakistan, women are often denied inheritance of land. Women often end up with landownership due to being widows and head of a household. They however often find it difficult or impossible to cultivate their fields themselves due to the lack of labour force and draught

animals, as well as cultural or religious constraints. In many areas females are denied to inherit the land rights so they are deprived of the family assets after their marriages.

Although women play multiple important roles in spate-irrigated agriculture and in rearing livestock, their condition in the spate areas of Pakistan is deplorable. They do not have full control over farm income, nor do they have a say in decision making. They often have no choice in the arrangement of their marriages. As spate systems are labour intensive, they are expected to give birth to several children, preferably male. In some cases this social necessity to have a larger human force may also imply that one man may have more than one wife at a time and several children with all of them. This further contributes to deteriorating the status of women in the family, their health and as such the overall state of poverty of the farming family.

The women not only look after the home and its maintenance, but also join in during the work in the fields. Females support the male farmers during harvest time and work physically with them. They are in charge of storing the grains as well. While animal grazing is mostly the male farmers' job, the females are responsible for caring for the animals and milking. They also fetch potable water and collect fuel wood, which can take up a large part of the day.

In the more conservative areas of Balochistan and KP, their mobility is restricted inside and outside their villages. They have little or no access to health facilities and educational institutions. In poorer households they are often engaged as wage labourers or are involved in producing handicrafts for sale. To meet the requirement of labour intensive irrigation and agricultural production, women are often married off within their tribes or families the moment they reach puberty. They are expected to produce children until menopause. Usually the nutritional requirement for women to survive the burden of continuous pregnancy and lactation is not fulfilled adequately.

Box 5.1

A women's burden

Women have considerable indigenous knowledge about spate irrigation and farming systems and summarised below:

Balochistan	Almost all agricultural activities are carried out by women, except the tillage of the land. Women may assist the male members of their households with the supervision of the infield irrigation and the repair of minor damage to the earthen channels close to their fields during day light. Livestock is predominantly the domain of women, who are responsible for cutting and transport of fodder, milking goats and cows, preparation of a variety of dairy products, taking care of sick and pregnant animals as well as the drying of dung for fuel. The grazing of the livestock is the responsibility of men.
Dera Ghazi Khan	Women have knowledge of the intensity and magnitude of spate floods and rainfall in their areas, and are involved in supervising irrigation, guarding infrastructure, and cultivated fields. Men usually carry out the diversion and distribution of spate waters.
Sindh	Women have knowledge about spate systems. They are in charge of seeds and storage of crops. They help their husbands during harvest time and are involved partially in the sale of harvested crops as well. There is no *purdah* (obligation to go veiled) in Sindh and the women have greater mobility than in other areas of Pakistan. They can travel freely to the markets alone and to fetch water from dug wells often located several km away.
Dera Ismail Khan	Women from tenant and self-operated owners' background are well informed about spate systems and accompany men to the water source, help protect bunds, and provide support by holding lamps at night. They also carry food to the fields. They are involved in agricultural operations such as irrigation, weeding, harvesting, cleaning and grain and seed storage. They are not involved in the ploughing and sowing. Women also spend a great amount of time looking after livestock and poultry.

Subsistence crops

Subsistence and low-value drought-resistant crops, such as sorghum, millet, wheat, pulses, oilseeds, chickpea and melon, dominate cropping patterns in spate irrigated areas, while the production of fodder to support livestock is also a priority. Although there is considerable variability if flood water is concentrated or used in conjunction with groundwater, the yields of most spate-irrigated crops are low. In bad years some parts of the command areas may not produce any crops, while the crops on other fields may only receive enough irrigation to be grown for fodder or be harvested while still not mature. Farmers mainly use and grow local varieties, which are adapted to the local agro-climatic conditions. Seed is normally retained from one year to the next which turns susceptible to crop diseases. However, there are few substitutes for the traditional seed varieties, as agricultural research tends to be concentrated on perennially irrigated crops. In general, farmers in spate irrigated areas do not use chemical and organic fertilisers; neither do they incorporate crop residues in the soil, except roots and stubbles. Most spate farmers cannot afford to use chemical fertilisers, and believe that the nutrient requirements are satisfied from the fertile sediments deposited during irrigation. Especially a lot of potash comes with flood water.

Although the use of tractors is increasing, many farmers still use bullocks to prepare their fields, including the repair of field bunds and building up canal banks and constructing diversions and closing down of gullies at field caused by the over topping and breaches. One bullock cart driven by oxen can cultivate up to six hectares of land. Many small farmers

Box 5.2

Water is everything

At a tenant farmers meeting in Vehova, D.G. Khan district, the issues facing spate farming were discussed:

"If the bunds break, we go into debt and it is very difficult for us to repay the money we owe. To control water is everything for us – we can grow anything, onions, potatoes, vegetables, as long as we have water. We have to maintain the system including building bunds and protecting them by ourselves but when the crop is ready we have to give a share to the landlord".

however are ‘too poor to farm’. In Lasbela (Balochistan) for instance it is very common for poor land owners to give land on tenancy to owners of bullocks. The ploughing of fields before irrigation and ploughing and planking of fields after pre-sowing irrigation is very much important to store and conserve soil moisture. The preservation of soil moisture is essential to secure a higher productivity.

In general, farmers try to minimise the use of hired labour, and largely rely on family labour. Additional labour may need to be hired only at times of harvesting and threshing. Areas with more reliable spate irrigation and regular cropping have often attracted a high proportion of landless families, who form the basis of a permanently resident labour force.

Surplus grain and/or cash crops are usually sold within the community, in local markets or to nomadic herders. Traders may come to a village to purchase any surplus produce, but some farmers prefer to take their produce to large urban centres in order to get a better price

Livelihood strategies

With low crop returns even in good years and the possibility of crop failures always in the background, spate-irrigated agriculture makes a precarious living. Farming households adopt a number of livelihood strategies to cope with these uncertainties. The most common is the diversification of the household economy. The co-existence of livestock keeping and spate irrigation is almost universal. Small animals in particular are an integral component of the household production system. Other strategies include:

- Saving surplus of grains from year to year.
- Investing in easily disposable property, such as livestock in general and draught animals in particular in good years when there is crop surplus, selling them off in a drought year.
- Wage labour and off-farm activities provide additional household income.
- Locally available natural resources are widely exploited e.g. selling of fuel wood trees and wood on the lands owned by a certain households.

- A failed flood season often triggers substantial migration of able-bodied male family members in search of labour, leaving most of the burden on women.
- Following a dry year, money is borrowed from other family members, or local money-lenders to purchase additional food items, or to obtain seeds for the next cropping season.
- Traditional mechanisms of solidarity and mutual assistance play an important role in the local communities.

Role of livestock

Livestock keeping is an integral component of the livelihoods strategies of most households involved in the cultivation of spate-irrigated crops. It is an asset as important as land in many cases. Oxen, and to a lesser extent camels, are traditionally used for the preparation of the fields and the maintenance of the field bunds as well as the reconstruction of the diversion structures in the riverbeds and the cleaning of the flood canals. Camels and donkeys are used for the transport of crop produce, transporting of green fodder and drinking water for livestock and people on daily basis.

Box 5.3

Cooperation

Faheem Mian Khel comes from a progressive farming family. He has established an NGO called Veer (Voice for Education and Equal Rights). This NGO is implementing development projects in the area with national and international funding from donors, trying to improve people's livelihoods.

"I started the NGO around 15 years ago. Under various projects, we are introducing different interventions like water harvesting techniques and vaccinating poultry and livestock in several partner villages in the district. The aim is to increase people's income. We are making village organizations and training activists. We are working mostly in spate areas. Because of less rainfall in the past few years, there has been a lot of out migration in the area due to poverty. But the social structures in the villages are strong. Whatever is said about D.I. Khan, this is a peaceful area and people are generally cooperative."

Cows, goats, sheep and poultry are raised as a source of food. Milk, dairy products, eggs, meat, wool and skins are the main livestock products, mainly used for home consumption but also sold to raise cash. Goats and sheep have high reproductive rates and high degree of resilience to drought conditions. They are an important form of "saving" as they can be sold in crisis situations. Oxen are also sold to bridge adverse years. Cattle, donkeys and camels provide dung, which is used as fuel by making dung cakes and as a building material by mixing it with soil and straw.

The ownership of at least one pair of oxen is a good indicator of wealth. In many households it is difficult to support a pair of oxen because the farm size is too small to produce sufficient fodder to feed them in years with normal floods. At times of drought, oxen and other large animals are at risk, and many households do not have any choice other than to sell them, or to move to areas where fodder is available.

Out migration

Migration in spate systems is quite common, especially during drought years when there are no floods and hence no irrigation and no crops. Another reason for migration is the search for

Box 5.4

Pulling power

Special breeds of cattle are found in spate irrigation and farming systems, which have evolved over hundreds of years. These are tough cattle which are known for their pulling power and are used in bullock carts throughout Pakistan. The most famous amongst these are the *Bhag Nari* breed of oxen and the *Rojhan, Dajal* and Red Sindhi breeds of cattle. They are used as draught animals. The *Lohani* cattle are smaller in size, but just as tough and are usually found in hilly areas. In recent years, the prices and rearing of these cattle have significantly increased. They are now beyond the financial capacity of most self-operated owners and tenant farmers. Amongst goats, the *Barbari* goat is well known in Balochistan's spate systems. The Balochi Sheep is another tough breed which can withstand extreme hot and cold weather conditions.

waged labour by male household members. Normally seasonal migrants return to their communities before the start of the flood or cropping season to assist in irrigation, seedbed preparation and planting of crop. Small landowners, with land that has a low probability of irrigation, migrate each year, as their landholdings cannot support their households throughout the entire year. Other landowners only have to migrate in search of labour in dry years as their landholdings produce enough crops in normal years to sustain their households. In the spate-irrigated areas of D.G. Khan and Balochistan, seasonal migration is common.

Farmers having spate-irrigated land may also decide to migrate permanently if they can find permanent employment elsewhere. In Pakistan the existing spate irrigation systems often cannot support entire communities as population growth rate is high.

Box 5.5

A hard life

Farmer Motia Khan from Dad Palari village near Thana Bula Khan in Sindh has eight hectares of land and grows vegetables, sorghum, millet, and beans. His voice hints to a hopeless, desperate feeling which many farmers in the area share. Most of the people of his village have migrated out of the area due to the long period of drought in recent years.

"This is a very hard life… survival is difficult. The whole family works in the fields. Because of the heavy rains, our fields were damaged. All the seeds were washed away during the monsoon season. We are so poor, what can we do? There is no work here in this area and no schools for our children. What we really need is a tube well so we can have a steady supply of water for our fields. Right now, we get drinking water from a nearby well, which is not enough for our needs".

The water table in many spate-irrigated areas in Sindh is falling due to the installation of an increasing number of dug wells and tube wells as a risk coping strategy. Farmers are installing these wells in order to become less dependent upon the unpredictable supply of spate water for irrigation purposes. The result is that older and shallower wells dry up, and fields are abandoned due to desertification. Ultimately, the population of entire villages may have no choice other than to migrate permanently.

Box 5.6

Examples of conflicts on water

A rich family of Gundi Umer Khan of D.I. Khan owned lands at the lower side of the Bund. The land had no legal right for irrigation from the flood water owing to its location and hence was locally called *"Gher Mutaliqa"* (lands with no rights to the steam) in the *Rod Kohi Riwajat* and *Kulyat-e-Aabpashi*. The Gundi Umer Khan family however always took advantage of the breach of the bund to water their fields. When Water for Livelihood project and Veer responded to the community's demand to build a spillway at a critical point to protect the band after the approval from EAC *Rod Kohi*, the individual owner did everything possible to stop the operation. The underlying fear was that his land will not get flood water if the bund is not breached. During one year of struggle, he used technical arguments, influence from the court and political harassment while the project tried its best to convince him in a friendly way. Eventually the case was taken to the District Commissioner by all the affected farmers since the Extra Additional Commissioner *Rod Kohi* also appeared to be in an awkward position under the land owner's influence. A joint meeting was organised with all the stakeholders where farmers took a vocal lead. The land owners had to step back and eventually the spillway was constructed. The bitterest of feuds and conflicting situations can certainly be resolved by dialogues, a little bit of tact and a heavy dose of friendliness. However the bigger lesson was that farmers' collective voice is hard to neglect.

The second example is from the head of Daraban/Chowdwan *Zam* in D.I. Khan where two *Rods* originate for both the *Zams*. At this point there is a century old dormant conflict between Miankhel and Babar tribes of the two *Zams*. This conflict eventually will jeopardize the interest of several users. A went to the site and analyzed the situation in depth in the presence of representatives of Water Users Associations from both the *Zams*. On one hand, the team learned that a distant analysis of the situation without going to the site can be completely erroneous. On ground one could clearly see that the agreed ratio of 60:40 between the two tribes was not being realized to physical changes in the ground. Another learning was that a complex conflict such as these can benefit from the involvement of a neutral third party. The leaders from the Babar tribe (Chowdwan *Zam*) did not see any problems since the situation at that moment ran in their favour with much higher quantity of water naturally coming to Chowdhwan *Zam*. For the second Mainkhel tribe, this was a conflict that must be resolved. Such conflicts must be dealt with in a multi-stakeholder dialogue, with factual evidences on table and a flexibility to accept certain give and take for all concerned. Without addressing such issues, any investment in spate areas can only bring temporary benefits since the very root of the issue is not addressed.

Depopulation is a constant threat in traditional spate irrigated areas. If the number of farmers goes below the level needed to reconstruct diversion structures and to clean canals, traditional systems cannot be sustained. Ultimately, the remaining farmers may have to abandon the entire spate irrigation system. In this situation outside support is needed to rehabilitate spate irrigation system from sources like government and donors

Water related conflicts

Scarcity or issues related to distribution of natural resources and power struggle often result in conflict. At times these conflicts are extended to generations creating social divides and deprivation. Water, being a lifeline in spate areas is capable of determining social relationships in the spate communities. . Spate experts therefore are usually keen in understanding the history of resource management systems before suggesting structural and non-structural means to improve them. Most of conflicts emerge from the claims regarding ownership of the source. Others surface from unjust distribution of water when it is most required. There are conflicts that flare from the acts of power in their zest to occupy most share of the resource for their interest.

More than water scarcity sometimes, it is these and other conflicts that are responsible for people's poverty in spate areas. This calls for the need for a more institutional approach in spate areas whereby water users (eventually farmers) may act together to deal with such conflicts in time and in a balanced manner. There is often only investment in engineering infrastructure, there is large scope in discussion water distribution and making small investment in water control structures within the command areas, as the next chapters also describe. There is limited but very encouraging experience in setting up water users group for the entire spate area with real responsibilities in water management. It may take a careful process for such institutions achieving legitimacy among larger, rather heterogeneous communities, but it does not mean that such initiatives are not taken. The government cannot take position on such conflicts all the time since it is either weak, is remotely located or is

Box 5.7

Water User Association as a partner

At the heart of Daraban *Zam*, Sad Naleen is a permanent bund as per *Rod Kohi* Kulyat & Riwajat-e-Abpashi; it not only divert flood water to agricultural fields but also divert and distribute flood water in other irrigation channels. It is the central point of *Rod Kohi* system irrigating lands of more than a 16 villages with 1,600 farming households with over 41,000 acre lands. Flood 2010 caused historical damages and destruction in entire region of Daraban and washed out many permanent and other *bando basti gatties* (other settlements). Water User Groups of concerned villages conducted series of meetings and dialogues to develop joint consensus and discuss with VEER development organization to take up with Water for Livelihoods (W4L) team. Veer and W4L conducted social feasibility with active involvement of local community and also analyzed costs and benefits of the proposed rehabilitation scheme with 1,000 cusec capacity technically being supervised by PARC and supported by Intercooperation. Issues such as improvement in conveyance efficiency of the system, equitable distribution of water as per water rights among the 16 villages in the down-stream area, safe removal of the excess water and reducing risk of damages to the main Gandi Umer Khan road were also considered in the scheme. The Water Users Association was a partner at each step. A joint consensus was built at all villages' level to properly contribute both financially and physically in the implementation process. Sad Naleen was successfully completed in 2011. Seasonal floods in 2012 served to provide irrigation in all 16 villages (8,000 hectares). In villages Gara Sheikh, Gara Watoo, Gara Mir Alam and Kikri lands were irrigated after more than one decade without any water supply.

influenced by a more dominant opinion – usually from the powerful ones. Therefore the conflict context is often better addressed by home-grown institutions. Such institutions can also become excellent partners in implementation of physical infrastructure, ensuring their joint ownership, equitable benefit sharing and future maintenance.

1.1 Spate flow Kot Kaisrani D.G. Khan Punjab

1.2 Breaking of Soil Diversion Bund

2.1 Kuliyat and Riwajat copy, D.G. Khan 1963

2.2 Repair of diversion bund D.I. Khan

3.1 Guide bund in command area

3.2 Flood in channel

4.1 Horseshow in D.G. Khan

4.2 Girl carrying sister... and water container

5.1 Shrine of Khwaja Shamsuddin

5.2 Sobat meal

6.1 Winnowing mustard chaf

6.2 Cooking at home in hamlet near Thana Bula Khan

7.1 Sorghum - main crop

7.2 Harvesting mustard

8.1 Sesame harvest

8.2 Wild teenda fruit

9.1 Managing water at field level

9.2 Ploughing and planking to conserve moisture

10.1 Plugging seepage hole in guide bund

10.2 Farmers discussion with engineer

11.1 Construction of permeable spillway in earthen diversion bund

11.2 Road serving as low weir river bed stabilizer Vehova D.G. Khan

12.1 Improved field inlet - avoiding backflow of water from bunded field

12.2 Special breed Red Sindhi bull

13.1 Rope, prayer mats and charpoys made from 'mazri' desert palm

13.2 Tamarix plants

14.1 Haji Shahar mini barrage under construction Nari River Balochistan

14.2 Damage after 2010 massive floods

15.1 Manchar Lake

15.2 Dug wells following declining water table in Sindh

16.1 Improved steel grain stores

16.2 Mainstreaming spate irrigation in education

6 CROPS GROWN AND THEIR *BARKAT*...
Agriculture in Spate Areas

Spate irrigated areas are often located in remote locations, far away from the major towns and markets. In general, spate-irrigation supports relatively low value agriculture, although there are exceptions and moreover there are many opportunities to increase yields and financial return. Low value farming being common is due to the recurrent uncertainties in the timing, number, and size of the floods that can be mastered to irrigate the land. Bunds and flood channels may be damaged both by small and large floods. Damage to earthen diversion bunds is caused by high floods, often prompted by farmers who make cuts in the bunds so as to cause it to fail and spare the command area from excessive erosion. Damage is also caused by – ironically – sometimes by low floods – especially those that are 'clean' and contain little sediment, 'eating' their way into the earthen bunds. Damage to flood channels occurs when excessive quantities of water rush through the channels, breaking the side bunds left and right. Another problem with flood channels is sedimentation – reducing the capacity of the channels to move the flood water downstream. This also creates back pressure on the earthen bunds, causing them to fail. Yet without doubt the worst years are those when, few if any significant floods occur, making cropping impossible.

Within the area served by a spate river, the probability of receiving irrigation varies. Land that is higher – which cannot be reached by smaller floods or is simply by-passed – and land that is at the end of a flood channel or served from a tail end diversion structure are all more likely to be irrigated

Box 6.1

Good taste

Cereals grown under spate irrigation and rainfed agriculture are considered to have a superior taste and higher quality due to no or low application of external input. They are valued higher than products from canal areas, which are thought to have lost their original taste due to the use of chemical fertilizers. The other phenomenon associated with spate irrigation is related to the local myth of having '*barkat*' because of crops – literally meaning blessing of almighty. Farmers of these areas believe that one cannot estimate the value of the standing or even harvested crop until it is threshed. Its quantity is more than what it seems apparently and that is related to the concept of '*barkat*' from almighty.

less frequently. This could mean once in every five years. In addition there are the outwash areas (called *chall*), not entitled to floods and often not bunded, that receive water in unusual events like very large floods.

The crops grown and the agronomic practices adopted reflect these uncertainties and variations. As some have said spate irrigation is the quintessential adaptation to climate variability. Drought-resistant crops like sorghum, millets, wheat, pulses, oilseeds and cotton dominate the cropping pattern. Mustard, wild grasses and vegetables make use of the moisture left in canals but also on open areas. The production of fodder is also a priority in most spate-irrigated areas to support livestock. The animals provide traction for ploughing and field bund building and can be important sources of income. They also act as a form of saving as they can be sold to generate cash in bad years.

Coping with risks

The main source of soil moisture in spate farming is due to single pre-sowing irrigation, where farmers apply deep irrigation of 1 to 1.5 m depth. The moisture from this heavy irrigation is stored by ploughing and planking the land, when soil is in a condition to till. In some areas a second or third flood event is channelled to the same land, and when this happens it has a marked positive effect on the productivity. The global experience of spate irrigation has shown that a second or third irrigation double the yields as they take the crop out of the 'stress regime'.

In Pakistan however most spate fields receive one pre-sowing irrigation turn, if at all, and this explains the relatively low yields in spate areas as compared elsewhere in the world. Any further moisture comes in the form of rain. Also one important phenomenon is that the moisture stored in the soil during the monsoon floods tends to rise up again in the cold season, so that long duration plants receive an extra boost of moisture during the end of their cultivation season.

Farmers have developed various cropping strategies to cope with the risks inherent in spate irrigation:

- In general, they grow local varieties, which are adapted to the local agro-climatic conditions, and have a high tolerance to drought.
- They normally grow dual-purpose crops that will produce some fodder even if the floods fail and grains are not formed.
- In some locations they may practise mixed cropping (for instance sorghum, mash, mung and moth beans). When three or four different crops with different water requirements and harvesting times are planted in the same field, they can have assured harvests of grains and dry fodders. The other purpose of mixed cropping is to have food legumes (mash, mung and moth beans, which are some of the most lintil varieties) provide biologically fixed nitrogen and hence boost the productivity of the other crops. The residual stalk and straw is used for livestock and balances their feed due to high protein contents.
- At other locations crop choice is determined by the timing and volume of the first irrigation and where there are possible subsequent irrigations. In Pakistan sorghum is grown in fields with early irrigations, oilseeds and pulses in the fields that were irrigated later and the last summer floods are reserved for the cultivation of wheat during the winter months. In some cases the selection of crops is left until the soil moisture status of the fields following irrigation is known.

Grains, pulses and oilseeds are the main crops, but then there are many important minor crops. There is a variety of local vegetables, such as *teenda*, *teetak*, *chunga* and *tori* flower. Some farmers successfully try their hand at modern vegetables, such as pumpkin and ladyfingers. There are grasses and medicinal plants of higher value, many of them not catalogued and hardly known outside the spate irrigated areas. Many of the vegetables, grasses and medicinal plants are wild – like the *moola* plant, that for a short while carpets fields with its lilac flower and is used to feed goats and cows and lends its delicate fragrance to their milk.

Another fascinating product is the high value truffle mushroom that grows shortly after the floods, in crevices and underground. Many of these minor crops have huge potential and could do with more research and better marketing and

Box 6.2

Brown gold

Desert truffle mushrooms are highly valued globally, with high prices being paid for this delicacy, as it is used to add a fine flavour to food. Desert truffle mushrooms are found in most of the spate irrigated areas in Pakistan and often grow underground. The farmers know where to look for them and sell them to the local markets. However, there is considerable potential if they are marketed properly and sold abroad, or even a step further if they are grown commercially by inoculating the root material on which they grow.

processing. Besides truffles there are various varieties of naturally grown edible mushroom in all spate irrigation fields throughout the country. For local population it is great source of nutrition value coming free from nature. They also sell these mushrooms in local markets.

Crop yields

Overall, the crop yields in Pakistan are low in comparison to other countries: sorghum yield in Eritrea is easily six times more than in Pakistan and spate irrigated cotton in Yemen yields more than twice of what is common in Pakistan. A comparison between the different spate yields in these countries is given below:

Kg/ha	Pakistan	Yemen	Eritrea
Sorghum grain	400-550	400-2,500	800-5,000
Cotton	360-620	350-3,500	200-1,000
Sesame	150-350	200-500	200-800

There is a need to learn best agricultural practices from each region to be further adapted under local conditions elsewhere accordingly. There is a large scope to exchange seeds between different areas. Soil moisture conservation is the key to a good yield in spate irrigation. Soil moisture conservation is as important as the diversion of water to the land. As discussed before, timely ploughing and planking after the summer crops is hence important for a better productivity. In Pakistan, about 60% of the rainfall occurs in the summer (*Kharif*) season while 40% of the rainfall occurs in the winter (*Rabi*) season. Planting in many areas is postponed till the *Rabi* period.

Box 6.3

Eritrea's secret

In Eritrea sorghum yields are spectacularly high. Whereas elsewhere in the world it is unusual to have sorghum yields that are more than oneton/hectare, in the Eastern Lowlands in Eritrea they reach three to four tonnes/hectare and even more. The secret of Eritrea's high yield is in moisture conservation. Fields are ploughed prior to the harvest to allow the water to infiltrate. This followed by the flood season. Fields are ploughed and planked after every flood. The strategy is to give at least two floods to each plot. This makes sense as the return from the second flood is usually higher than from the first flood, because the crop is no longer stressed. Even in Eritrea sorghum fields that are only irrigated once will give 700-800 kg per hectare, whereas the second irrigation lifts this to 2,500-3,000 kg per hectare. The strategy has been to not over expand the command area, but to ensure good yields from a compact area. The higher reliability of floods in a smaller area also encourages pre-flood land preparation and makes cooperation between farmers easier as more or less everyone can expect 'something'.

Many of the spate crops sown in *Rabi*, in fact, thrive on a very remarkable phenomenon. When the seasons change from hot to cold in this period, soil moisture rises to the surface again – triggered by capillary action – and provides the right conditions for the crop to develop.

In some areas crops are planted at wide spacing to provide each plant with a large volume of soil moisture. A very dense plant population creates high competition amongst the plants for moisture, nutrients and light. As a result of this competition, plants, especially sorghum, grow very thin and tall and the yield is low. Young crop stands of high plant density are more affected by drought than equal stands of lower density.

Post harvest grain losses can be substantial – around 10% on average, but for some farmers up to 20% of the precious staple. Losses occur because grains are stored before they are completely dry, because the storage place (often used for other purposes) is humid or because of pests – or a combination of all of this. There are traditional methods to reduce grain losses: storing the grain bags in wheat chaff (makes everything dry) or using the sweet smelling but poisonous *brumba* (wild melon) as a pest repellent. Under the Project for Livelihood Improvement (PLI), VEER introduced improved grain storage

Box 6.4

Tasty melons

Sweet melons are found in most spate areas, but the ones from Kolachi in D.I. Khan district, are famous for their taste and shelf life. They are well adapted to spate irrigated areas and in fact, evolved in these areas. Project for Horticulture Promotion (PHP) worked on melon seed purification with farmers. This contributed to increased quality production of melon. There is a growing market for them in Pakistan and they fetch good prices every year. Further research into this valuable fruit, that is indigenous to Pakistan, will be useful. The two remarkable characters of the ecology which provide sweetness to these melons are hot days and cold nights coupled with the use of naturally occurring soil nutrients.

methods in collaboration with the KP Agricultural University, that largely eliminated losses. They consist of cleaning the grains before storage and storing them either in a *bindi* (large PVC bag that can store up to 2,000 kg of grain) or using large clay storage, in either case properly closed and sealed. The clay storage containers of 1.6 cubic meter volume and are made locally at a small cost. They are raised from the floor and detached from the wall, and have a special opening to take the grains out when required.

Traditional vs. improved varieties of crops

Local cultivars are well adapted to their environment, having developed over hundreds of seasons; selection has been both natural i.e. climatic, and man-made. Where water supply is limited, a local cultivar can produce some grain and fodder – and if additional rainfall or flood water becomes available, the productivity increases. These are part of local diet and food habits and people are fond of the more natural taste.

Improved varieties are rarely used. The first reason that farmers in the spate areas do not use improved varieties is because they are unavailable or difficult to obtain. The second reason is that such improved varieties often have no advantage over local cultivars. The high-yielding varieties require more water due to their higher water requirement and their rooting pattern does not extract water from deeper depths.

It is widely recognised that research into improved varieties for spate irrigation is needed. In the Arid Zone Research Institute in D.I. Khan in Pakistan some important developments have been made:

- Early maturing sorghum varieties have been made available to farmers and these give higher yields than local varieties.
- Higher-yielding varieties of millets have been developed which are not damaged by birds, and grow better in hot and dry conditions.
- A gram variety which is blight tolerant has been developed.
- Intercropping of sorghum with mung bean pulses increased income significantly.
- Several improvements in wheat production practices were developed. Late planting of wheat from October 15th to November 15th increased the yield by 50% over early planting in October. Use of deep tillage using mouldboard/disc plough improved weed control and water conservation. It increased the yield of wheat 53% over the traditional cultivator. Drill sowing of wheat increased the yield 50% over broadcasting.
- Similarly breakthroughs in the cultivation of chickpea were made. Chickpea seed treated with inoculum increased the yield by 28% over untreated seed. In general, the use of quality seed of chickpea increased the yield (60%) over poor/inferior quality seed. Higher seeding rates of chickpea (80 kg/ha) increased the yield by 60% over using 40 kg/ha. Also different application rates of methamedophos (insecticide) revealed that the

Box 6.5

Smart harvesting

In D.G. Khan sorghum panicles are harvested one by one from the standing sorghum plants. Farmers collected the panicles in a bag carried on their back (*jholli*). This type of harvesting is superior to the wholesale cutting of the sorghum stand and then removal of the panicles. The reason is that as long as the sorghum remains standing on the field it retains it sugar content and hence nutrient value for livestock.

use of one liter/ha significantly controlled the short horn grass hopper and increased the seed yield up to 45%.

- Zizyphus varieties have been grafted to produce better fruit.

Even though the focus on research farms is often on improving crop yield per unit area, other factors are equally important: the availability and sustainability of a variety are also crucial. Local cultivars still do well in terms of drought resistance, fodder value, labour inputs, taste, food value and storage, and these factors are rarely given sufficient consideration.
In most spate irrigated areas, there is minimal use of fertilisers. If at all, farmyard manure is used in areas of perennial '*kala pani*' spate farming systems where soils are either of sandy texture and relatively sediment free water is used for irrigation. In addition to this the farm yard manure is used in fields which are near to villages/hamlets due to easy access to the farm yard manure. This is a common practice in *barani* lands and these soils are called '*lapara soils*'. The productivity of certain local varieties of crops, however can in theory, be increased by adding fertiliser. However, improved varieties that respond to a higher level of inputs can only reach their potential if irrigation is adequate. Local cultivars are more adapted to water shortages than improved varieties. Most spate irrigators believe that their soils are naturally fertilised by the fine sediments that are deposited during flood irrigation. The silt is usually rich in plant nutrients.

Seed is normally retained from one year to the next. The practice of using self-produced seed can lead to various problems, such as diseases. However, there are very few substitutes for the used varieties as agricultural research in Pakistan has been concentrated on improving the yields of perennially irrigated crops.

Use of groundwater

Where spate irrigation can be combined with groundwater use, high value farming systems are the result. This is the case in the coastal Tihama plains in Yemen, where bananas and mangoes dominate the cropping pattern. Groundwater is recharged directly from the spate floods – with recharge primarily occurring through the gravely river bed – and from the subsurface flows.

Box 6.6

High protein

Mung, mash and moth beans are important source of protein for subsistence farmers. The vegetables grow easily in spate areas and are of short duration. They can also easily be intercropped with sorghum and millets. Beans are usually cooked and eaten as a main meal by spate farmers. These leguminous crops also help to increase soil fertility through biological fixation of nitrogen.

In Pakistan such combined systems are unusual because aquifers are often very deep or they contain saline water. There are some exceptions though – for instance in Kaha (D.G. Khan) and Thana Bulah Khan (Sindh) or close to the Rehanzai Bund in Ghandawa (Balochistan). In Thana Bula Khan, farmers have installed large number of dug wells and tube wells in the commands of spate irrigation systems, often close to the spate river. This enables them to produce high value cash crops such as onions by irrigating their fields with groundwater. Close to the Rehanzai Dam the water is used primarily for drinking water.

In other areas such as D.G. Khan deep well turbine pumps have been installed in spate irrigation commands in last 15 years and this trend is on increase but shortage of electricity has halted new installation and many farmers have already abandoned tube well irrigation. Where groundwater is used, the spate flow is not directly applied to irrigated fields and crops. However, new and fallow fields are irrigated through spate flows in order to capture by the fertile sediments coming through flash floods. For this reason old water courses and natural passages of spate flow are kept intact for smooth flow. Farmers believe that fields irrigated by spate flows are rich in nutrients and soil fertility is maintained even if continuously farming without any addition of chemical fertilizers.

Due to the installation of an increasing number of tube wells the aquifers in many spate-irrigated areas risk being over-exploited. Households in these areas have diminishing access to potable water as the level of the water table is decreasing, and water in a number of shallow wells in the villages is either brackish or the wells no longer supply water throughout the year. In addition, the quality of drinking water is further adversely affected, as it is affected by saline intrusion and

Box 6.7

Dug well farming

Sanyl is a young farmer whose family owns four hectares of land in the Desvi area near the town of Thana Bula Khan in Sindh. The family has installed a dug well on their farm and is now growing onions.

"The spate area is just beyond our fields. Due to good rains this year we are cultivating our spate fields as well (around 20 hectares) by growing guar, mung beans, sorghum and sesame. The dug well on our farm is 12 meter deep. We put on the motor for around 25 minutes, four times a day and use water to irrigate onion crop on four hectares of land. This year, thanks to the spate a flood water level has gone up in the well, otherwise it was on the decline for many years. Also due to the construction of the road nearby, which blocks the spate flow, we have less water in the well. The dug wells on the other side of the road have more water."

becomes more salty. There is strong link between spate flow occurrence, magnitude timings and ground recharge especially in and around river beds and fields having suitable soil geology to retain water. Similarly springs originating within the spate river are continuously recharged through the spate flows.

Fodders

In addition to the cultivation of fodders such as guar, green sorghum, and the use of leaves and grass found in the commands of spate irrigation system, natural pastures are another important source of fodders. In the Kacchi plains in Balochistan, livestock owners have to migrate with their animals to the pastures in the highlands for several months each year due to the shortage of fodders in the vicinity of their villages. In spate farming areas presence of nomadic tribes along with their livestock is highly beneficial as they consume fodders and residuals. Fodders and residuals fetch good prices due to organic nature. This is sold to nomads and even is marketed in far flung areas. Large patches of natural vegetation, mainly *gum* plant (a type of panicum) are irrigated by overflow in spate irrigation areas and are reserved for grazing in Kacchi plains since centuries.

Box 6.8

A crop for all seasons

Guar is a leguminous crop found in spate areas and its pods are cooked and eaten locally as a vegetable. Guar is highly drought tolerant and it is grown in the marginal lands. It makes good fodder for animals, having a reputation for boosting milk production. The gum extracted from the guar beans has several industrial applications – it is used in textiles, printing and the pharmaceutical industry. It is also used as a no calory binding agent in ice-cream and soups and as a drilling fluid in oil fields. Guar seeds are used to make gunpowder as well. The world market for guar gum is growing and is served by USA, India and Pakistan. In spite of this, some of the guar mills in Pakistan are in decline and there is much potential in boosting the production and processing of guar. This crop provides good financial return to the farmers and its hay is liked by livestock.

Trees and bushes also play an important role in spate irrigated areas. In most systems trees and brushwood are used to construct and protect the earthen diversion structures and to close the field inlets after irrigation. Spate areas are richly endowed with horticultural wealth. With little certainty of water, spate areas can do wonders in the field of fruit production and farmers' livelihood can take a new turn. D.I. Khan is one such example, richly blessed with some of the most famous tropical varieties of dates, melon and other fruits. Examples have shown that a serious investment in horticulture can result in large benefits for the farmers.

Box 6.9

Horticultural promotion

The Project for Horticulture Promotion (PHP) pioneered the establishment of Germ Plasm Unit (GPU) in Rakhzandani D.I. Khan in 1999 to produce disease free, pre basic and basic plant material. In GPU for tropical fruits most of the germplasm (Dates, Mango, Guava, Zizyphus and Falsa) was collected from the other two provinces of Pakistan, Balochistan and Sindh. In case of date palm alone, 16 varieties were secured in the GPU. Leading commercial varieties of dates from all over Pakistan were included in this programme. PHP also contributed in seed purification of famous Bukhara variety in melon. The project closed in 2004. In this short intense period PHP contributed to further variety screening and a varietal improvement programme for high-yielding, true-to type and certified germplasm for further multiplication by farmers for enhancing returns from their fields.

Multi-purpose trees are common, such as the wild Olive for producing better quality fruit, Tamarix for making wooden tools, charcoal and for protection of bunds and channels, zizyphus for producing high quality honey and Salvadora is used for fodders, for its fruit and for medicinal purposes, especially dental care.

The 'Queen of the Desert' is the Zizyphus (*ber*), producing the so-called 'poor man's apple'. Particularly when grafted, fruit yields can be high. *Ber* honey is considered the most exquisite of all honeys and one finds Pakistani honey exported to the Middle East.

Box 6.10

Extending the Olive Branch

Wild Olive, known as *Olea ferruginea* (zaitoon), grows in several spate areas in KP and Balochistan. This small tree produces fruit of low quality berries, growing between 500 and 2000 meters elevation withstanding a wide rainfall and temperature ranges of 250-1000 mm/yr and -10-40°C respectively. The extensive wild olive tree stands provide an additional option of top-working on the trees, especially for low income families to produce olive of better quality. Intercooperation's Farm Forestry Support Project explored top-working of wild olive in District Karak and Kurram Agency of FATA and received a high percentage of success. Budders were produced from among the farmers. Over a period of five years, top-work of over 35,000 trees was conducted by 250 trained farmers. Abundant fruiting resulted from trees grafted four to five years earlier. One successful example is in Shahbaz Ghundai (Karak). This success needs to be taken forward by complementing the grafting of the wild trees with local processing infrastructure and ensure that the benefits are diversified and cashed by poor farmers.

Bee hives in fact are common in spate areas, with bees feeding on the trees as well as on the rape seed. The honey found here is much sweeter than other honey and is sold for high prices in the local markets. In Sindh, the indigenous variety of honey sells locally for as much as Rs 2,500-3,000 per kg and many farmers are taking up bee keeping as an alternative form of income. Honey produced in Karak has even crossed the market share of honey produced in Kashmir. It is capturing national and international markets due to its sweetness, quality and purity from the *Zizyphus mauritiana* nectar. Around 400-600 tons of *ber* honey is produced in Karak district which is over 40% of the provincial production.

In several spate irrigated areas *Gum arabica* is also common – its resin having a market in the international confectionery industry. Often these trees grow wild, but recently several farmers have started to try their hand at spate irrigated forestry, protecting their land from browsing animals and creating small mini-catchments in their fields. This required new ownership arrangements, as in some areas tree ownership traditionally rests with the land owner. With the encouragement of the Project for Livelihood Improvement, (PLI) new co-sharing arrangements were made, giving the tenants an equal share in the tree production and a strong incentive to look after the tree crops.

Spate irrigation, although it has to live with a degree of uncertainty, has enormous potential to reconcile food security with natural resource management. There is scope to improve the productivity of the major crops and make more out of a wide variety of minor crops. Where spate irrigation can be combined with groundwater recharge – as in some parts of Pakistan – systems with high livelihood security are possible. With efficient use of water, effective grain storage and diversification of farm and off farm sources of income more *barkat* is possible. This can result in improved food security of people and livelihoods of thousands of farmers.

7 How the flood water is used...

Water Rights and Distribution Rules

The way rights are defined in spate systems is very different from perennial systems. In essence water rights in spate systems react to situations that may occur. They describe the commonly agreed acceptable practices in a given situation, rather than quantifiable entitlements to a resource, as in perennial systems.

In case of spate irrigation (*Rod Kohi*) areas, when the floods come, the water is distributed to the farmers according to an established system of water rights and rules of distribution. These have evolved over the centuries and are often recorded so that every farmer knows his rights and obligations. These water related institutions are among the oldest institutions in the area. Water distribution rules impose a pattern, and reduce the risk of conflict, by regulating relations between land users that have access to flood waters. Water distribution rules make it easier to predict which land will be irrigated. As such they encourage pre-flooding land preparation, which is important for adequate water storage and moisture conservation as well prepared lands will be able to absorb the water from the floods. Water rights and water distribution rules also define the likelihood of irrigation for different areas and hence serve as the key to the collective maintenance and rebuilding of diversion infrastructure. Agreement on how water is distributed is a precondition for cooperation.

Water distribution rules also have to be placed in the context of medium and long term changes in flood irrigation systems. Increase in land levels and changes in torrent courses and flood canals are almost unavoidable in spate systems. Water distribution rules reduce the risk of such dramatic long-term changes, as well as help coping with them when they become inevitable. In the end water distribution rules tend to be packages describing the distribution of flood water, the way maintenance is organized, the practices in avoiding breaches and changes to the command areas, and the arrangements and penalties associated with operating the rules.

Recorded rules

Rules on spate rights in the larger systems in the Suleiman Range in Pakistan (D.I. Khan and D.G. Khan) have been documented in registers called the *Kulyat Rodwar. These* were prepared by the Revenue Administration during the British colonial period, which came to an end in 1947 after the emergence of two independent states of Pakistan and India. These dusty old registers are still consulted and contain the lists of all the villages responsible for the labour on each bund. During the British era, a special functionary was responsible for the enforcement of these rules, exhorting farmers to plug gullies and rebuild their bunds in that era. The spate irrigated areas were an important grain basket at the time and also an important source of tax, hence the interest by the Revenue Administration

The command areas were divided into various settlements and water diversion as per share was framed in these detailed documents.

The recording of the water distribution rules also provided the opportunity to resolve a number of long-standing disputes. The irrigation rights and distribution rules were called *Riwajat* and *Kuliyat*. These rules and rights were in most cases last updated in the 1960s. Water rights have been established for each *Rod* as well as for each village on the *Rod*. Generally, people owning land on both sides of the *Zams* or *Rods* (hill torrents) and its branches have the right of irrigation based on the general principle of *Saroopa Paina* (head to tail), which means irrigation turn by turn starting from the head to the tail. This is not always the case: in some rivers during the dry

Box 7.1

Historical landmark

It was originally Captain Crosswaithe's intention to have written the 'Irrigation Report of D I. Khan in 1907-08', known today as the Bolton Report, but his untimely death occurred before he was able to carry it out. Captain Crosswaithe was the British Settlement Officer and Deputy Commissioner who started several spate schemes in the district by constructing new channels. His bungalow is still preserved. His colleague Horatius Bolton completed the settlement report based on his notes.

Box 7.2

Customs and rules: *Rod Kohi Riwajat/Kuliyat*

- ***Gandi* (earthen structure constructed in the main *Rod* to divert or control water to be used in different fields for irrigation) cannot be constructed by concrete in the main *Rod.***
- **The field or the *Gandi* receives water according to the head and tail.**
- **Once the *Gandi* is constructed on the head and the fields are not totally irrigated, the tail cannot break the *Gandi.***
- **If the head is completely irrigated, the tail will have to write an application to the *Rod Kohi* department for the breaking of the *Gandi.***
- **A new *Gandi* cannot be constructed, it can only be constructed with the permission of the *Rod Kohi* department if it does not affect the water received in the tail.**
- **When the field is being irrigated, the owner of the field is responsible. If the embankments are broken and there is damage to the fields at the tail, the farmer of the tail may charge the head farmer according to the *Rod Kohi* laws.**
- **The *Saroba* (upstream) farmer is responsible for providing the water to the *Paina* (downstream) without any damage. He cannot give or sell the water to anyone else.**
- **If the field is already filled in one season, and the owner tries to refill it, he will be fined by the *Rod Kohi* department.**

season priority is given first to the lower parts of the system or depending on the flood level on the higher lands first.
The *Riwajat* and *Kuliyat* are followed in the streams and in the command areas in main *Zams*. Most but not all of the farmers appreciate the water rights. In a survey in D.I. Khan, 63-88% respondents said that the water laws are followed. In general the downstream farmers were relatively less satisfied with the flood water distribution system as compared to the upstream ones. Around 90% of the farmers mentioned that the water distribution system needs improvement.

Box 7.3

History of Daraban *Zam*

The flood and perennial water of Daraban *Zam* is used for irrigation as well as for drinking purpose. *Zam* water is classified into two categories, *Buga pani* (flood water/*abe sufid*) and *kala pani* (perennial water/*abe seyah*). The flood water comes from Koh-e-Aspana (mountain) situated 45 km away. The perennial water comes from many springs in the mountain on the eastern side. The *kala pani* irrigates approximately 2,000 hectares of land (10% of total) and is also used for drinking purpose in villages through small water channels. The flood water irrigates more than 36,000 hectares of land of more than 60 villages through Gud and Lorha streams. Part of the Chodwan *Zam* flood water (60%) is falling into Rud Gudh. The distribution is based on the natural terrain but there is long running tension on the fairness of the division, The flood water of Daraban *Zam* is next distributed in three branches. The Gudh stream also receives share of flood water from Chaudhwan *Zam*. In Draban *Zam*, a few locations are very important. If the channel and bunds are breached at these points, the water will escape from the system into the river. Similarly, in Daraban *Zam*, an other principle point of danger is *Sad Waruki* located down stream. This saves the Gud water from running to waste in *Khad Nahara*. Because there is no bund on *Khad Nahara*, the water would go straight to the River Indus.

A set of rules

The *sub-tehsil* (local government) office in Vehova in D.G. Khan district is a crumbling colonial bungalow which houses the revenue records for all the different *Rods*. The water rights for the *Rods* are marked on a large piece of cloth which is taken out whenever disputes arise. There are many hill torrents in the district, and every *Rod* has its own water rules and revenue record. Most of these documents were documented in 1872 and again updated in 1918 and there is an urgent need to computerize them since the lives of thousands of farmers in the district depend on these fragile records. The records also need to be updated and renewed since some of the channels have changed course and the ownership of land has also changed. With the construction of the Chashma Right Bank canal in recent years, almost 80% of the land in the area has also come under canal irrigation. Hence new areas need to come under spate, but these will require new rights.

Below by way of example are a set of water management rules for the Kanwanh spate river (*Rod-e-Kanwanh*) in D.G. Khan district. These rules were recorded during a land settlement of 1918/1919, and are still used.

Water distribution	Command area protection
Water distribution starts from the head and goes to the tail	Even if field(s) remain barren for long periods, the right to irrigation remains valid.
If after a first irrigation the upstream fields are watered, but the downstream fields are not irrigated sufficiently, then the upstream field can still take precedence in using the second flow.	The location of a diversion structure, channel intake or division structure can be changed with the mutual consent of land owners.
There is no limit on depth of irrigation of an upstream field.	If after filling his own field a land owner delays breaching his diversion structure and a nearby field is destroyed, then the losses will be met from the person who did not breach the diversion structure in time.
No body can sell or donate his share of water. In land transactions, water is transferred as well.	No person has a right to construct new branch/flood canals that deviate from the prevailing situation. However, when the channel has changed naturally, then a new flood canal can be constructed, provided the earlier flood canal is completely damaged.
A field cannot be supplied by more than one diversion structure.	When a person intentionally destroys the water then common loss is recovered both for the loss of water and the destruction of the field.
If a bund in a flood channel irrigates two fields, water will first be applied to the higher land.	On reappearance of eroded land (through siltation), the rights are vested with the original owner.
When a diversion structure has been washed away during irrigation, it is allowed to construct a new diversion even if water is already reaching other fields.	

Maintenance	Others
Common maintenance work is performed on the basis of area of land.	Ownership of the flood channel – including trees inside, is based on ownership of the adjacent fields.
To maintain the flood embankments close to a main bund is the responsibility of all users of the *ganda* (diversion bund)	A diversion structure can be constructed on one's own land as well as other's land, wherever it is most suitable in the river.
Strengthening the banks of flood canals is the responsibility of the owner of the land facing the bank.	No body can expand his land by encroaching upon the river bed.
Landowners whose fields are irrigated through overflow and not through bunds and embankments do not take part in the common maintenance work.	When one shareholder does not contribute in the common labour during the specific period, he will not get the right of water in the current year. In case he wants to contribute in future, then first he will have to compensate the previous year costs of common labour and also by a fine of eight days labour.

Types of rules

There are several types of rules that regulate the distribution of the varying quantities of flood water. Not all rules apply in every system, but it is usual to find that several rules are used simultaneously. The main water distribution rules include:

- Demarcation of land entitled to irrigation.
- Rules on breaking diversion bunds.
- Proportion of the flow going to different flood channels and fields.
- Sequence in which the different fields along a flood channel are watered.
- The depth of irrigation that each field is to receive.
- Practices regarding second and third water turns.
- Rules on small and big floods.

In addition there are rules that regulate changes in the command area and overall shape and morphology of the spate system:

- Rules on maintenance of bunds and boundaries.
- Rules on adjusting the location of intakes and other structures.
- Rules on manipulating *Rod* bed and flood canal scour and siltation processes.
- Compensation for lost land.

Demarcation rules

Demarcation rules define the area entitled to irrigation. As such, these rules precede all other water distribution rules. They define the command area, and with this the land users with access to the spate flows: the so-called *haqooq* land. Demarcation rules often protect the prior rights of downstream landowners, by prohibiting new land development upstream which could result in the diversion of flood water to new lands, formation of a new group of stakeholders, and the loss of farming systems and other established water uses downstream.

The demarcation of the outer boundaries also ensures that overspill from breaches in flood channels does not develop into an established practice. The corollary of such demarcation rules are the penalties for negligence in the maintenance of bunds and channels. In the spate systems of the Suleiman Range in Pakistan explicit agreements exist, obliging landowners to plug gullies that developed after severe floods. This is to prevent new drainage patterns from developing in these soft alluvial plains.

Rules on the breaking of bunds

The rules on breaking bunds are usually in place in areas where the entire river bed is blocked by earthen bunds, as in the lowland systems in Pakistan. The earthen bunds are generally made in such a way that they scour out in high

Box 7.4

To break or not to break

Rules on Nari System prepared in 1917 on revision of older rules and still observed:

- **From 10 May to 15 August the landowners of the Upper Nari are allowed to make *gandas* (earthen bunds) in the Nari River.**
- **When the land served by one *ganda* in Upper Nari is fully irrigated, the landowners in that *ganda* must allow landowners of the next *ganda* to break it.**
- **After 15 August the landowners of Lower Nari are allowed to make *gandas* in the Nari River.**
- **Landowners in Upper Nari are not allowed to irrigate their land during this period or let the water go to waste.**
- **Water is not allowed to go to waste to the low lying areas east and west of the Nari River. Guide bunds will prevent water flowing to these areas – all landowners will contribute towards these bunds with farmers in Lower Nari paying twice the amount per hectare in case bunds on the Upper Nari are broken.**
- **If any dispute arises, judges appointed by Kalat State will inspect the area and are authorised to decide whether a downstream party should be allowed to break the *ganda* at an appropriate time or whether a guide bund should be repaired within 5-10 days. If repairs to guide bunds are not made, the main bund of the area concerned may be broken.**
- **In case a landowner refuses to contribute *gham* (the contribution for maintenance) his land may be confiscated.**

floods. This works as a safety valve. It avoids substantial damage to the canal network, as very large floods flow down the river rather than playing havoc with the flood canals and fields. In several systems there are also rules on when farmers can break bunds, e.g. once the designated area served by an upstream bund is irrigated, or when a certain time-slot of the flood season has lapsed.

An example of such time-slots are the rules for breaking *gandas* (earthen bunds) in the Nari Spate River System in the Kacchi plains of Balochistan. The rules were formalised in 1917 and are still observed, although there is considerable tension on the actual breaking of bunds (see box). At present

a system of flood barrages is introduced on the Nari river and water distribution rules may have to be adjusted. Another river where time slots are in use is the semi-perennial Porali River in Lasbela (Balochistan).
The reluctance of upstream land users to have their bund broken is not only because it allows more water to be diverted to the upstream area, but also because it saves the effort of rebuilding the bund in a subsequent year.

Rules on flow division

This category of rules arranges the distribution of water between the different flood channels. Where an area is served by several flood channels, there may be an agreement on the proportion of flood water going into the different channels. In practice, this is usually achieved by using rather crude hydraulic structures, e.g. the head sections of flood canals may be different widths, and obstructions may be placed in front of some of the channels to achieve the required division. Flow division may also be practised along a flood channel, with the width of the field intakes determining the proportion of flow that each field receives.

Many flow divisions occur automatically when the flows are not too large. When the quantity of water is small it is diverted to one part of the command area only, and the other flood canals are blocked, usually with a small earthen bund. When flood flows are large, however, water will break the small bunds and flow to several channels simultaneously

Rules on second turns

Another important water distribution rule concerns the right to a second water turn. Several crops give significantly higher yields when the fields are irrigated more than once and sufficient moisture is stored in the soil profile. Sorghum, wheat, castor and cotton are examples.

The rules on second turns are particularly important in systems that receive a series of spates in a normal year. This poses a dilemma: can the second flood be applied to land

that has already had an irrigation or is priority given to those cultivators whose land is still dry? Both situations occur – in some cases upstream landowners being at liberty to take a second turn, as well as to restart irrigation where it stopped previously, and in others downstream lands are irrigated before upstream owners can use the water again.
The degree in which it is possible to honour these rules depends on the timing and size of the floods. If floods are very small, they may not reach tail-end areas and it may only be possible to apply them on land that was already watered. A variation on the 'second turn' rules is that the right to a second irrigation is only allowed for special crops, such as the most important subsistence crops. This used to be the practice in the past in *Rod Kanwanh* for wheat.

Rules on large and small floods

Finally, the water distribution may differ according to the size of the floods. One example given is the automatic flow division when floods are large, and able to break the bunds in the various flood channels. In other systems there are explicit rules on how to accommodate small and larger floods. Small floods tend to be diverted to the upper sections of the command area, if only because small floods are not likely to travel that far.

Enforcement of rules

The extent to which water distribution rules are enforced varies. There is a strong link with the overall governance and the social structure in an area. Spate systems need a far larger degree of discipline than other resource management systems, yet the returns are sometimes small. The enforcement of water distribution rules is related to three factors: local water user organization, relation between water distribution and maintenance arrangements and codification of water distribution rules.

There is a very strong link between the rules on distributing spate water and the organisation of maintenance. In principle the link works two-ways. In many systems the right to

irrigation by spate flows is tantamount to one's contribution to repairs to the headworks or flood channels. If one abstains from public duty one is simply not allowed to open the intake to one's field (particularly if the network of fields is supplied by individual intakes).

A second issue is the critical mass required in undertaking repairs. This is particularly relevant when repair is dependent on human labour and draught animals (as was the case in most systems in the past), and a large force is required to rebuild structures and make repairs. When tail-enders are systematically deprived of flood water supplies, they may no longer want to contribute to the maintenance. The critical mass factor hence works as a check on too large an inequity in water distribution. However, the importance of critical mass may be expected to diminish, when maintenance is mechanized or undertaken by government organizations instead.

Codification of rules

There is large value in codifying water distribution rules – because it clarifies and completes local water management arrangements and introduces a neutral factor in any dispute. Testimony of the importance of codifying water distribution rules is the continued use made of water registers, prepared as long ago as 1872 in D.G. Khan district, as mentioned. It is important to note that these all rules and regulation pertaining to spate irrigation in this area were formulated by local communities since unknown times. English colonial officers studied these practices, accepted, documented, endorsed and made them part of local judicial system. Original record and documents are in extremely poor condition and need further work to preserve such precious heritage.

Over the years, the authority with which these rules were enforced has declined. It is particularly remarkable – as one could also expect the opposite – that enforcement has declined as water became scarcer. There are a variety of reasons for this:

- Decline in both traditional and modern government as the rule enforcing mechanisms.

Box 7.5

Bulldozing changes

Farmers in D.I. Khan district complain that there is a critical link between increased violation of water rights and the mechanization of irrigation practices. Earlier it was very difficult to retain water at the upstream and the *Rod* water used to irrigate even the farms at the tail end. With the introduction of bulldozers, this scenario changed and the large farmers established power of control over water through the construction of strong bunds on the main *Rods* with bulldozers. The *Rod Kohi* department continues to implement the *Riwajat*, though it does not have any provisions for the distribution of development funds and use of bulldozers for earth work. A review and modification of the *Riwajat* and *Kuliyat* is thus important to ensure the just distribution of public sector services, especially to the small land owners and tenants.

- Decline in spate systems, with increased use of groundwater in the spate command areas.
- Confusion of responsibilities related to system management after public investment in the system.
- Change of opportunities with the introduction of mechanised power.

Changing water rules

Water rights in spate system are not static. They change under the influence of factors such as population increase and the pressure for new land development, changing cropping patterns and new marketing opportunities; the introduction of more robust diversion structures; shifts in power relations; and changing levels of enforcement. The link between enforcement and overall governance is very strong. The skewed local power distribution, the weak nature of local government and the absence of effective countervailing power create the setting for the 'capture' of spate water rights by strong players – literally bulldozing their way through.

Water distribution rules have also changed – often unwittingly – as a result of external investments in spate irrigation, from the construction of civil head works or making bulldozer time available. The construction of new, permanent and more robust head works has often resulted in better upstream control,

Effect of engineering head works	
Larger upstream control	Puts upstream land users in a position to control flows that would have destroyed their intakes in the past. Decreases downstream access to flood flows and larger flood recession flows
Combining independent intakes	Creates dependency and new tail enders – water being distributed sequentially, whereas earlier each area diverted part of the floods
Controlled flows	Controlled flows reduce risk of scour and gullying, but the attenuated flows may no longer reach the extreme ends of the command area
Changed maintenance burden	Generally reduces the dependence of upstream land users on the labour of downstream land users

integration of previously independent systems and more controlled flow and changes in the maintenance requirements. The impact of these changes is summarized below. They all result in larger control by upstream water users.

There is further need to make new rules upon completion of mega irrigation projects that convert the command area of spate systems into perennial systems, in particular the Chasma Right Bank Canal and the Kacchi Canal. This has 'freed' the spate irrigation water to be used elsewhere, but this requires a process of determining the new areas and settling the water rights for them. On several of the big spate rivers in D.G. Khan new headworks have been constructed, such as on the Sanghar River. These lie largely idle: no work has started in preparing and rehabilitating the areas that could serve as command areas. These potential areas run in the 10,000's hectares but remain unutilized. Water rights need also to be formulated in mega projects such as the Gomal *Zam* Bund with a huge impact on the spate system that was supplied earlier from this system. To formulate such rights is not something to be taken for granted but require a substantial investment in time and consultation. As described in chapter 1, there is a large potential to expand the area under spate irrigation – from the current 2.02 m hectares that are bunded to probably three m hectares. Yet what is required is a serious investment in setting up the water rights and water distribution

rules for these new areas, as well as for areas that can be served by the flood water 'freed up' from land converted to canal command land. The settling of this new water distribution systems is tedious, time-consuming but important. It will need to involve local revenue officers and engage a large number of stakeholders. This important component is now often overlooked, unfortunately: settling water rights and water distrubution is as important as improvement in engineering or agronomy for instance.

8 GETTING THE FARMERS TOGETHER…
Water management in Spate systems

Farmers have been managing spate systems for centuries. In fact, some of the world's largest farmer managed irrigation systems are spate schemes. The construction of diversion structures across spate rivers, and the operation and maintenance of a network of flood canals requires strong and effective organisations if they are to be successful. The viability of spate systems are often determined by the strength of the organizations involved in their construction, operation and maintenance.

Large, integrated systems can require relatively elaborate organizations, whereas small run-off-the-river diversions can be operated almost on automatic pilot. The larger the system, the more difficult it becomes to organize common maintenance activities, not in the least because some areas will always have a larger likelihood of receiving the otherwise unpredictable flood supplies.

Another important organizational issue is ensuring that the critical mass needed to sustain the system is retained. The collective work in many spate systems requires a considerable effort that is at risk when people move out, for instance after a prolonged drought or mega flood, or lose interest in spate irrigation, for instance because they move into groundwater irrigation, or have only marginal access to flood water.

While farmer management exists at some level in all spate systems, there are essentially two types of management in Pakistan:

- Predominantly farmer based management (less than 1,000 ha, usually found in upland Balochistan, Sindh)
- Combination of management by local government and farmer management (more than 1000 ha, *Rod Kohi* systems D.I. Khan and D.G. Khan, Kacchi and Lasbela)

Farmer based management

Farmer based management is common in all spate irrigation systems, but the level at which farmers manage the systems varies. It may range from the management of an entire large system to management of secondary flood canals and

Box 8.1

Sharing is caring

In the past, flood season was often a festive period, with farming communities co-operating with one another to carry out the labour intensive work of managing their fields and bunds. At the time of the first sowing, farmers would give sweets to their oxen to celebrate the new cropping season. Farmers would often spend days and nights on the fields, and stories would be told after dark and poetry recited. Often festivals would take place nearby where there would be sports like wrestling and dancing. The evening meal would often be shared by the farmers in the fields and would typically consist of a dish cooked with paper thin *rotis* (bread) in curried broth, with several roasted chickens placed in the middle. The dish called *Sobat* would be served in a large metal platter and farmers would seat themselves on the ground and eat from the same platter.

on farm water management only. Maintenance in spate systems can be extensive: the reconstruction of soil bunds or brushwood diversion structures in volatile torrent beds, or the repeated restoration of field bunds and canal banks. The local organizations operating these labour intensive and unpredictable systems are often intricate and impressive.

Although farmer based management has sustained complex spate systems in several areas, care is needed not to overrate local management. Many rules may be informal, and also not entirely clear or comprehensive. Leadership may be 'coincidental' and based on who takes the initiative at the time. Leadership may be contested. Powerful landowners may be able to divert water upstream and create new de facto water entitlements for themselves. Organization at the lowest level may be weak and it may be difficult to mobilize contributions. Existing arrangements may become unstuck when faced with a new situation – such as the introduction of heavy machinery or new infrastructure, changes in the river course, or the introduction of groundwater based agriculture. However, from time to time the old institution of spate water user association comes out of dormancy and start influencing and reshaping innovative decisions under new challenges.

Maintaining spate systems

Since the area of irrigated land fluctuates widely from year to year, it is difficult to relate maintenance contribution one-to-one to actual irrigation, as is the case in perennial irrigation. In the maintenance of spate irrigation systems there is often an inevitable degree of unfairness. There are several types of arrangements that relate maintenance contribution to water allocation:

- **Contribution according to shares.** A typical example of this is the *jorra* system, practiced in many spate irrigation systems in Pakistan. A *jorra* stands for a pair of bullocks – the unit of work in the repair programs. Agricultural fields are also measured in terms of *jorra*; the amount of land that can be cultivated with one pair of oxen. The shareholder has to participate with his oxen, in accordance to his land share irrespective of whether it was irrigated or not.
- **Graded contributions.** This is particularly common in the larger spate systems of the Kacchi plains of Balochistan. Different villages had to contribute different maintenance levies – with areas in less privileged places contributing proportionally less to the collective effort.
- **Contribution according to capacity.** This is a variation on the two systems above. In accordance with their land shares farmers are expected to bring bullocks to the common maintenance work. Farmers that do not own draught animals, however, are expected to only bring their own labour. As ownership of draught animals is a fair reflection of the returns from spate irrigation in the previous years, this system harbours a large degree of fairness.
- **Contribution according to benefit.** A part of the harvest is set aside to pay for the maintenance. This arrangement works well in systems where the benefits are guaranteed, but would be ineffective in systems where there is a genuine risk that a number of years go by without agriculture.
- **Contribution by contract.** In this arrangement only those who want to be entitled to water contribute. This is system practiced in the *Toi* War system in Balochistan.

Only those who want to receive water contribute to maintenance. All others are expected to close their field inlets. This system is only practical in a relatively small system, where it is easy to check on earlier contribution. The system cannot be used in field-to-field systems, where opting out is not an option.

An important requirement of the maintenance arrangements in place is their robustness, i.e. the degree to which they will ensure the constant rebuilding of the common works. This is particularly challenging when the work that needs to be done is substantial and there is a large chance that there will be years without irrigation for a large part of the command area. In these circumstances (graded) contributions on the basis of land shares have a larger resilience than contribution on the basis of benefit, capacity or contract. To avoid losing the contributions of the tail-enders, the likelihood of mitigating rules will be larger in such systems.

Box 8.2

Traditional organisations

In the past the flood water was managed by a system called the *Pati Dari/ Tuman Dari/ Numberdari* System in the command area of some of the *Zams* in D.I. Khan. Here the big landowners used to hire a person called the *Pati Dar* in Daraban *Zam* or *Tuman Dar* in Sheikh Haider *Zam* for the equitable distribution of perennial water flows (not the flood water) for irrigation. In most areas, the Government used to appoint the biggest landowner as *Numberdar* of the village, who would collect land revenue for the Government and also manage flood water with active community participation. He was assisted by a *chowkidar* for calling meetings of the community, collection of land revenue and informing the villagers about the flood water. The *Numberdar* used to get commission from the Government out of revenue collected and *chowkidar* used to be paid by other landowners out of their harvest. Through this system, no dispute over water rights was reported. The *Rod Kohi* system was also very well maintained. The Government abolished the *Numberdari* system in the early 70s.

Internal organization

In most farmers'-managed spate irrigation systems overhead and transaction costs are kept at a bare minimum. It is common to have a committee of experienced farmers supervising the works on an honorary basis. The committee may meet regularly and invite all farmers, depending on the strength of the local organization. Other committees come together less frequently and invite office-holders only.

Box 8.3

Reviving the past

In many *Zams* in D.I. Khan the *Pati Dari* system was the main mechanism for maintenance. The work on the earthen bunds, the trail dikes and the flood channels was coordinated by one representative from each village (the *Pati Dar*). Over the years with bulldozers replacing maintenance by farmer bullocks the *Pati Dari* system eroded.

In Chowdhwan and Daraban *Zams* (located in D.I. Khan) the system was revived and robust Water User Associations formed up, mid and down stream with the help of SPO with a local chapter in the district and VEER, a local NGO with strong roots in the area. Village Organisations seconded three representatives each to the Water Users Association and 25 members to its General Body. Water Users Associations were formed in the head reach, middle section and downstream part. These Water User Associations then federated.

The Water Users Association Federation was instrumental in reviving spate irrigation and resolving some longstanding conflicts on water distribution. After the devastating floods of 2010 the Federation identified the rehabilitation works to be done and made sure that 'things were built back better'. A series of improved distribution structures were identified making it possible to better spread water over the year. The Federation was to oversee the construction of new local earthen bunds and their timely breaking to allow water to pass on downstream in line with old rights and practices. The results have been impressive. First an additional area of 8000 hectares could be irrigated that had not been provided with water for twenty years. Secondly, no conflicts were reported and that Federation took charge. For investments things were reversed: whereas in the past farmers asked permission of the farmers, now the Government was seeking no objection certificates from the Water Users. Finally the Federation has also started a 'war fund' for maintenance to immediately respond to the need for emergency repairs.

Maintenance is usually organized as common labour. It is usual for a series of days to be planned, during which all farmers take their earthmoving equipment and draught animals and provide free labour for the execution of the maintenance works. This simplifies work arrangements and makes it easy for all to see who is present to make his contribution and who is not. In many spate systems increasing use is made of bulldozers and front loaders, available at subsidized rates in some areas. In some of the larger spate irrigation systems in the Kacchi plains in Pakistan, a water tax (called *gham)* is still collected through a network of local leaders that is used for main maintenance.

Box 8.4

Kingdom of Kalat

In Balochistan the native princely ruler, the Khan of Kalat, was one of the main enforcers of the water distribution on the main spate river, the Nari. His land was located at the tail of the system, so he had all the interest to ensure water was distributed in a fair way. The princely state of Kalat, together with its vassal states of Kharan, Makran and Lasbela, entered the modern era by the way of contacts with the British. The political connection with the British began with the outbreak of the First Afghan War in 1839, when this area was traversed by a British army from Sindh. During the British attack on Kalat in 1840, Mir Mehrak Khan, the ruler, was killed. His son, Mir Naseer Khan II later regained possession of Kalat. In 1842, consequent upon the British withdrawal from Afghanistan, the occupied districts were returned to the Khan of Kalat. The British negotiated with the Kalat State in 1854 and according to the terms of the treaty, British political agents were deputed to Kalat during the next twenty years. In 1883, the Quetta Niabat (presently Quetta Tehsil) and the Bolan Pass were permanently taken on lease by the British from Kalat State. In 1948, Kalat State formally (but not entirely voluntarily) acceded to Pakistan and became part of the Balochistan States Union. A trick was played by Lord Mountbatten: he provided the Khan of Kalat with two options. The first option was not to accept the new Pakistani State in which case the lease contracts would remain with the British but since they were no longer there de facto this meant that tenure of the land became unclear. The second option was to accept and join the State of Pakistan in which cases the land lease contracts were transferred from the British Government to the new Government of Pakistan and the Khan of Kalat would retain his ownership. The Khan – against the wishes of the senior tribal leaders – chose the latter.

The number of paid functionaries is usually small and seasonal. Remuneration is in most cases in kind (dispensation from maintenance labour, share in the crop). This is in contrast to the government staff working on spate systems, who are usually paid in cash and are retained all the time.

In larger farmers'-managed systems functionaries are appointed. In the Kacchi plains and *Rod Kohi* areas of D.I. Khan and D.G. Khan, 'engineers' (*raakha*) are appointed for the supervision of the construction of the large earthen bunds and to check the safety of the bunds during the flood season. In a few spate irrigation systems in the Lasbela region in Balochistan, '*sepoys*' are engaged. Their main role is to mobilise, if necessary by force, farmers to contribute to the reconstruction of the diversion structures. This position was established at a time when the rulers of Kalat state in Balochistan organised the construction of the diversion structures with forced labour. After the dissolution of the princely state and the formation of the State of Pakistan, farmers continued with the employment of the '*sepoys*' as they valued their role.

The most common function however is that of water master – called *rais* or *arbab*, in various areas in Pakistan. The water master coordinates the water supply to the flood channel and sees to it that water is adequately distributed along the channel or sections, assesses the repair works and mobilizes the contributions for maintenance. An overview of typical farmer-employed functionaries and their scope of work are described below:

- supervise the layout and position of earthen bund, when it is constructed.
- before the rainy season inspect the structure and point out weaker sections.
- vigilance during the spate season and communication with individual field owners, water user associations, down stream farmers and with revenue department.
- witness breaching of the *sadd/gandi.*
- co-ordination with downstream *raakhas.*

Most of horizontal communication (among field owners/ tenants, village heads, area guards) is through traditional method of *hal-ahwal* where people are bound and found of exchange of information, even of minute nature, on periodic basis and when necessary.

Other functions

The main task of local farmer organizations in spate irrigation systems has been the organization of maintenance and the enforcement of water distribution rules. Some organizations have also been active in agriculture, in particular in pest management. There are organizations at village level that have been organized by various projects but also several interest groups, such as parent-teachers associations, marketing associations, certified seed producers, village disaster preparedness committees and others introduced by the Livelihoods Programme in some of the spate areas such as Karak and D.I. Khan, FR D.I. Khan, Bajaur and Mohmand. It is useful to consider these local organizations as 'social capital', that may also be engaged in other purposes.

One such area is groundwater management. Experience of several areas has shown that the only successful examples of groundwater management were based on self regulation. In several spate systems – particularly in Sindh – irrigation is increasingly 'conjunctive', using both spate flows and groundwater. This has resulted in severe declines in water tables. It has also jeopardized the use of groundwater for domestic and drinking water purposes.

Farmers and local government

Where systems become larger, the role of local government in management – be it local administration or traditional local leadership – becomes more important and complements that of local farmer organizations. Particularly because of the 'reactive' nature of water rights in spate irrigation and farming systems, strong legitimised authority is crucial in the management of large spate systems.

Traditionally, local water user associations took care of the maintenance, providing labour, traction animals and material. The role of the colonial administration was to 'organize' these activities during peak periods and emergencies. Farmers who did not take part in the kamara (collective maintenance activities) were fined. In addition labour was also at times brought in from neighbouring areas. This engagement had a number of positive political side-effects. Grain production increased in the remote border region of British Indian Empire – bringing stability and creating goodwill among the non-controlled tribal population. New areas were brought under cultivation, resulting in settlement and an increase in land revenues.

Within the revenue department of the local administration, *Rod Kohi* departments were established which continued to exist after independence. They come under the Deputy District Officer, who until recently had the powers of magistrate and could fine, penalize and have defaulters or violators arrested. The *Rod Kohi* departments are made up of mainly regulatory staff, engaged in conflict resolution and safeguarding the application of flood water rights. The local engineering is left to farmers.

Given the magnitude of the area under spate irrigation, the staffing levels are very modest. The explanation is that a strategy of enabling governance is in force. Contrary to perennial canal systems, the policy has been to follow local decisions in case of disputes occurring in spate related issues. Local elders and community members are expected to reach consensus on sensitive issues. The administration facilitates the process and intervenes only when necessary. One of the most important points was to not prolong spate irrigation related cases in courts of law, but instead give the final authority to arbitrate or adjudicate to the deputy commissioner at the district level.

These arrangements changed with the devolution of power to local government that took place in Pakistan in 2001. Before 2001 the District Government had the authority to check on illegal action of farmers under the Minor Canals Act. The *Naib Tehsildar* could punish and fine accordingly in cases of violation of the indigenous rules agreed upon by all members of water user associations/share holders/farmers. It was very common for *Naib Teshildars* to issues non bailable warrants

to farmers failing to contribute to the collective labour. After the devolution of administration in Pakistan, these powers and authorities have been withdrawn from the revenue department, and direct involvement of the officials is in theory not possible. Under the new system the politically elected person called the District *Nazim* was head of the administration. The devolution and local government system from 2001 was slowly abolished in recent years and as no elections were held, an enormous institutional gap has emerged.. A new enactment of local government system has been done by the government in 2012. The main architecture of the system is not yet on ground, however it seems that a degree of control will be retained at the central level and a complete devolution will not take place at the district or lower levels.

Multi actor spate management

Where specialized agencies have taken responsibility for the management of spate systems, it has usually been the outcome of public investment in spate irrigation. Not all government investments have had this outcome. The role of the Irrigation and Power Department in the management of the government-constructed spate irrigation systems in Balochistan has been limited to the appointment of operation and management staff and guards and the execution of repair works on an ad hoc

Box 8.5

Weakened system

Riaz Mohammed Baloch is the current Deputy District Officer, Revenue/*Rod Kohi*, in D.I. Khan.

"There is a problem now with the spate irrigation systems. The British developed a good system and the district commissioner in those days would not tolerate anyone stealing water. But for the past four or five years, the system has weakened due to the devolution of power that has been carried out by the present government. The district commissioner no longer has the police under him. If people come to us with complaints about water rights being violated, we cannot help them. They will have to go to the civil courts, which take a long time in hearing a case. By the time the matter is settled, the flood season has passed. The small landowners are really suffering now since they have no influence or political clout".

basis. The Irrigation and Power Departments did not have a routine maintenance programme and the already inadequate budgets for maintenance were further curtailed during the 1990s. Also in other areas – D.G. Khan, D.I. Khan – public investments in spate irrigation and farming systems have not resulted in agency-management, though in some cases government has assumed responsibility for larger repairs. Federal institutions like PARC's role is limited to introducing technologies that must be taken over by district governments for multiplication and maintenance. Such initiatives are not aimed at introducing improved governance of the system (see chapter 4).

In response to the limited and uncoordinated role of the state actors, and the inadequate number of active canal masters, farmers have increasingly taken the initiative to organise the operation and management of their irrigation systems themselves without waiting for assistance from outside. This may be an opportunity in disguise to ensure that the farmers themselves learn to perform their function as duty bearers without causing exclusions in the area.

9 How the rivers are affected…

Spate Irrigation, Basin Management and Climate Change

Spate areas are picturesque landscapes with mountains in the distance and flat plains interspersed by dry channels and river beds which can turn into gushing torrents when it rains. The ecosystems found in these arid and semi-arid river basins are fragile. They can change on severe impact – the rutting and gullying of the land can turn productive land in desolate wasteland. Spate irrigation systems are also very much part of these natural resource systems, and are themselves affected by changes in the land and water resources in the river basins and are impacted themselves by climate change.

Biodiversity

Ephemeral rivers are often unexpectedly rich depositories of flora and fauna. Spates collect seeds from a large part of catchments and deposit them in the riverbed and flood irrigated fields. The moist and often organic-rich layers of silt forming spate irrigated fields provide a favourable environment for wild plants and mushrooms to germinate and develop. Logs and branches, often carried over considerable distance by spate flows, may add to this process by lodging against trees growing in or along the river channel, creating small blockages, trapping organic material, and further supporting vegetative growth.

Spate irrigated areas have ecosystems which support a great biodiversity of plants and animals. These include endangered species like the Suleiman Markhor and bearded vulture. The fox, hare, wolf and jackal are all found in spate areas, as are partridges, doves and eagles. In Pakistan, spate flows have contributed to the development of wetlands, which are an excellent refuge for migratory birds from as far as Siberia. A wetland is a valuable natural resource on which people, domestic livestock and wildlife, including migratory species, depend upon their livelihood and survival. Spate fields are favorable refugee and abode for birds especially migratory birds. These birds like spate agriculture fields as these are less disturbed by farmers as weeding, spraying and irrigation activities don't take place once seed is sown. Moreover, chemical and fertilizer free agriculture does not pose any harm to these birds and their favorite feed is seed, leaves and roots of these plants. Spate agriculture timings do suit very well to

Box 9.1

Heaven for birds?

The wetlands created by spate flows each year, especially in the winter months, are ideal havens for migratory birds like the Eurasian Cranes and Demoiselle Cranes. Some species like the Siberian Crane (called *Safaid Coonge* in Pakistan) are on the verge of extinction. Flocks of the Siberian Crane have not been spotted since 2002. Crane hunting in Pakistan is a popular sport for those living in the spate areas. For centuries, capture techniques were restricted to the old method of tossing a rope with weighted ends into low-flying flocks at night. This was called *Bolara*. Only a limited number of cranes were taken by this method. However, in recent years, the number of firearms used by local people in Pakistan and neighboring Afghanistan has risen, and more cranes have been shot. Although laws preventing the hunting of cranes now being enforced more and more, hunting continues unabated in the more far-away areas.

these migratory birds during their stay of winter camps. The natural seed's taste and size is most favorite for ornamental birds and their chicks kept by people throughout the country. These seeds are labelled specifically during marketing and sale.

Natural species of vegetation occurring in spate areas are often of considerable value. Grasses and shrubs for instance sustain livestock. *Kalora* grass, which sprouts up after the floods, is common in all spate areas and is used for fodder. *Drubb* grass, which also grows naturally and is difficult to eradicate from the fields, is also used for fodder. In the spate irrigated areas of Pakistan, the harvesting of various types of mushrooms is a lucrative side activity, with truffles fetching particularly good prices. The spates also carry wild vegetables and cucurbits to the fields. During years when the crop's harvest is poor, natural vegetation can help families to survive in these adverse periods.

The trees found in spate areas are often used for a variety of purposes. Tamarix Ghaz (*Tamarix aphylla*) and Phulai (*Acacia modesta*) and Kikar (*Acacia nilotica*) trees are used for timber and fuel wood. The Karita is used for camel fodder, fuel wood and construction. Zizyphus is a typical multi-purpose tree as it provides fodder, fuel wood, timber and fruits. Trees with large spines, such as the Acacia and Zizyphus (*Zizyphus nummularia* and *mauritiana*) are also used for the construction

Box 9.2

Gum tree

The Gugar (*Gum arabica*) tree grows in the wild in the highland spate areas of Sindh and Balochistan and is a very valuable tree. The gum that flows freely from its branches is sold for high prices to dealers who export it abroad to be used in the manufacture of chocolates and confectionery. In the local markets, half a pound of the gum extracted from this tree sells for Rs 200. The trees are found all over the Kirthar Range in Sindh and the local people generate extra income from selling the gum. Its main market these days is India where it is used in pharmaceutical industry.

of fences around fields to protect standing crops from roaming animals and to construct corals where livestock is collected and protected for the night.

The Peelu (*Salvadora oleoides*) tree is important to spate areas – it is used for shade, fuel wood and a refuge for wild animals. It is also used as a fodder for camels and at times goats. Its fruit can be eaten and it has medicinal value – its branches have been traditionally used to clean teeth.

The *mesquite* (*prosopis juliflora*) is a common plant in spate areas and landless families produce charcoal from it. It grows freely along spate streams. *Mesquite* is a mixed blessing. This shrub was introduced in desertification control projects, but tends to 'overstay its welcome'. Particularly in areas where there is livestock grazing *mesquite* spreads rapidly: the seedpods cling to the animals and are distributed widely. *Mesquite* germinates easily and once it has settled in an area it is difficult to get rid off it. It takes over the natural vegetation, does not allow undergrowth and hence greatly reduces the grazing value. It also tends to creep into waterways – including the riverbeds – choking them in the process and causing flood rivers to run wild. The *mesquite* thorns are poisonous and can even cause blindness.

In the Anambar Plains in Loralai (Balochistan) *mesquite* has completely taken over the landscape. *Mesquite* is not only a scourge, it also has some benefits to its credit. Particularly when the plants are not too craggy (as happens in the more arid areas) the wood can be used for charcoal or even timber and brings an economic return where previously there was none. The pods attract bees and have high sugar contents – they can serve as animal feed or be processed even into a

Box 9.3

Natural soap

The Lana (*Suaeda fruiticosa*) is a special plant that grows naturally in spate systems in Balochistan, D.I. Khan and D.G. Khan. For centuries it has been used as a soap and detergent by the local farmers. The branches are burnt in a specially dug hole and the secretion is mixed with the stems and fibre. The semi-cooked mixture is then cooled. It hardens, turning into a rock like substance which is used to wash clothes. Today, due to the cheap availability of soap in the area, the practice is disappearing. Only in very remote areas do people still make this soap.

sweetener. *Mesquite* can be used to improve the worst – saline or alkaline – soils. Particularly, when some of its charcoal is added as bio-char, degraded soils get a boost.

The dwarf palm locally called *Mazri* (*Nannorrhops ritchiana*) is used by local women for making different items such as mats, ropes and sandals. There are also several kinds of medicinal plants that are found in the wild in spate areas which are used by the local people to treat various illnesses. In Sindh these plants are used by the local people to treat skin diseases and jaundice. Some of these plants like Harmal, (*peganum harmala*) Panir, Isapghol (*Plantago ovata*) are sold in the local markets. There are also certain kinds of vegetables

Box 9.4

Marketing Kana and *Mazri* Or *Pesh* products

The *Mazri/Pesh* is a dwarf palm tree and grows all over the arid terrain of Pakistan's tribal areas in Balochistan and the KP. For centuries, the *Mazri/Pesh* leaves have been dried and then used to make a number of household products. Traditionally, rope or *baan* is made from the *Mazri/Pesh* leaves and this is used in *charpoys* (Bed), stools, mats, sandals and baskets. leaves and this is used in *charpoys* (Bed), stools, mats, sandals and baskets. A number of projects have made an effort to build women's skills in introducing high quality crafts from *Mazri.* Kana has been extremely useful economical in arid areas. Its cultivation has been encouraged by Intercooperation in Thal and Chauntra of district Karak while several kinds of handicrafts are prepared with kana sticks which are sold all over the country. The most famous product of kana is the window blinds which are mostly prepared by women and are appreciated in urban and rural home decor. The local women, many of whom are restricted to their homes in this deeply conservative and poverty stricken region, can benefit immensely by making these handicrafts at home. They can then sell them in the markets for additional income.

Some of the common trees and grasses in the spate areas:

Scientific Name	Local name
Salvadora oleoides	Jall/Peelu
Tamarix aphylla	Farash/Ghaz
Acacia jacqumantii	Kikar
Acacia nilotica	Kikar
Acacia modesta	Phulai
Prosopis cineraria	Jund
Plantago ovata	Ispaghol
Prosopis juliflora	Mesquite
Peganum harmala	Harmal
Caparis deciduas	Karir
Zizyphus mauritiana	Ber
Zizyphus munmularia	Wild ber
Nannorrhops ritchiaana	Mazri
Suaeda fruiticosa	Kali Lani
Salsola bariosma	Lana
Calligonum polygonoides	Phog
Calotropis procera	Ak (small)
Desmostychia bipinnata	Drub
Saccharum Munja	Sarkanda/kana
Eleusine Flagellifera	Chhimber
Cynodon dactylon	Khabbal

Sources: AZRI, http://www.efloras.org and http://www.tropicos.org/Project/Pakistan

which have medicinal properties like the *Brumba* or bitter melon. These often found growing after heavy floods. The construction of brushwood spurs and weirs requires substantial numbers of trees and branches. The intensive cutting of trees for use in spate, construction of homes and as fuel wood has led to their dwindling in spate areas. There are many other factors that cause deforestation and land degradation in the upper catchment areas from where spates flows are mostly generated. These include expanding agriculture and overgrazing driven by rising populations and soil erosion. This phenomenon by the way is not new. Research into pollen near the pre-Indus site of Nauwshero on the Kacchi plains, suggested that in 2600 BC a dramatic shift in vegetation had already taken place. One theory is that this was caused by the development of spate irrigation and the larger population pressure on local natural resources. Spate floods become flashier, and more silt laden in degrading catchments.

River morphology

Spate irrigation occurs either in mountain valleys or on the plains close to the mountains often at the end of a gravel fan. Particularly in the latter areas torrents tend to be unstable. Spate irrigators attempt to stabilize these sections as the sustainability of spate irrigation depends on the river not changing course dramatically, or bed levels silting up or degrading. Even then spate systems are subject to disturbance when large floods occur. Changes in the river morphology may have their origin in the lack of protection of local vegetation – the cutting of riverain forest or of river bank vegetation. They are also triggered by historic floods that result in a general lowering of river bed levels.

There is usually a gradual transition in the vegetation along spate rivers. The upper reaches experience more frequent floods, and the physical disturbance that comes with them removes the vegetation. In the lower reaches of ephemeral rivers, discharge decreases as a result of upstream abstractions and infiltration to the torrent beds. Infrequent floods result in harsh environments where only hardy drought-resistant plants can survive. Vegetation can be used as an indicator to assess the pattern and reliability of flooding.

Box 9.5

Slowing the flow

Vegetation also sometimes helps in raising the river beds. When trees such as Tamarix colonise the bed of spate rivers, flows are slowed down, sediment settles, and bed levels rise. Tamarix is also an important source of timber for construction and use in bunds and livestock can forage its leaves. However, in many rivers prone to degradation, a ban on cutting vegetation along the torrent beds has been put in place by the spate irrigation farmers.

The vegetation that develops in the river beds also plays an important role in their stabilisation. This is particularly true in spate rivers in alluvial plains, which do not have beds armoured with gravel and cobbles. While the degradation of the riverbed is often a natural phenomenon, its speed and intensity can be increased by human action, such as the cutting of trees and bushes in and along the riverbed as well as the degradation of torrent catchments.

The construction of flood canals at unsuitable sites may also increase the degradation process, as the river may change its course during a large flood.

Degradation of a riverbed may advance to such an extent that canal intakes are left so far above the torrent bed that diversion becomes impossible, and the intake and canal is abandoned. The cutting of vegetation and free cattle grazing contributed to these effects, which rendered many existing intakes unserviceable.

The use of vegetation for flood protection has the important advantage that it not only withstands normal floods, but regeneration is possible by re-growth, when damage occurs during exceptional floods. Vegetation reduces the speed of flow, allowing sediment to deposit in front, over and behind the vegetative barrier.

Flood management

In Pakistan the development of spate irrigation systems has been advocated on the grounds that it would help reduce damage to the large perennial canals on the western extreme

Box 9.6

Asia's second largest lake

The excess flood water from 17 spate streams in Sindh and Balochistan ends up in Manchar Lake, Asia's second largest freshwater lake located in a vast natural depression. 75% of the water in Manchar Lake comes from spate water. The most significant hill torrent, which causes major flooding of the Manchar Lake, is Gaj. In the unprecedented heavy rainfall in the catchments of the Gaj in 1995, a maximum flow of over 300,000 cusecs was recorded, which surpassed previous maximum flash flood discharge of 170,000 cusecs, which lasts, may be, for a few hours. However, the inflow from this source is erratic and unpredictable and has the frequency of once in three years. In addition to Gaj, there are also some other small torrents such as Angai Nai, Nari Nai, Naing Nai contributing towards Manchar. At the same time an increasing portion of the water in Manchar Lake is from the MNV Drain and the Right Bank Outfall Drain, carrying agrochemicals and salts. Evaporation has transformed the lake from a fresh water source to a highly saline and heavily polluted stretch of water

of the Indus irrigation system. The hill torrents rising in the Suleiman Mountains, and to a lesser extent in the Kirthar Range, have at times caused considerable damage to the large scale perennial irrigation systems.

Damage to the Flood Protection Bund in Sindh from flash floods from the hill torrents in 1995 was estimated at USD six million for instance. Studies commissioned by the Federal Flood Commission in Pakistan explicitly envisage the dual objective of (spate irrigated) agricultural development in the piedmont plains and the protection of infrastructure on the perimeter, such as the Chashma Right Bank Canal, the D.G. Khan Canal, the Flood Protection Bund Complex, the MNV Drain, Kacchi Canal and the Pat Feeder Canal.

There is a limit, however, to the contribution that spate irrigation development can make to flood mitigation. Very large floods – that cause the most damage – are not retained in spate irrigation systems as spate irrigation makes use only of low and medium floods. Major floods in Pakistan occurred in 1973, 1976 and 1993 and 2010. Widespread development of spate irrigation in the catchments and tributaries or the larger torrent systems can reduce the chance of large floods building up. Spate irrigation systems also tend to stabilize ephemeral

streams, which avoids unexpected downstream breaches. In general there is little experience in managing spate irrigation systems for flood retention, either for flood mitigation or for artificial recharge, although potential is there and scope does exist.

Groundwater recharge

Unlike other parts of the world groundwater in several spate irrigated areas is saline because there is hardly any recharge in layered soils. In general in areas with high salinity, irrigation from groundwater is not an option. However small prisms of fresh water stored in the bed of the spate rivers can be an important source of drinking water supply in areas with generally saline groundwater. Many spate rivers generate perennial flow throughout the year just lower region of catchments, however, it changes according to intensity and occurrence of spate flows. In Khyber Pakhtunkhwa, Pakistan's spate rivers having perennial flows are termed as *Zam*. In highlands of Balochistan and parts of Sindh shallow wells are common for agriculture and their recharge and discharge depends upon spate flow occurrence. High valued crops such as orchard and vegetables are main features of this irrigation system. In case of less ground water in river beds, these wells are only used for drinking purposes. The spate flow contribution to ground water is indirect in command area. Here ground water is saved when fields are irrigated by spate system thus underground reserves kept intact for time being.

Box 9.7

Prism of water

Subsistence farmers in Sindh near Thana Bula Khan often have to travel long distances to water ponds and reservoirs to fetch water for domestic uses. During spate seasons, they often are found digging in the torrent beds looking for shallow aquifers in which fresh water is stored. Here a farmer has found a prism of fresh water just a few feet below the surface of the torrent bed by digging a shallow well. There is enough water there for his family to fill their plastic containers and take the water home with them. There are good chances to harvest the shallow groundwater of fresh quality due to recharge by flood water. This principle can be used in other areas also.

Two types of aquifers are important in spate irrigated area. In valley bottoms one finds strip aquifers. The alluvial sediment deposits consist of generally unsorted, but coarse and uncemented material with high permeability. The deposits are found in a strip along the river bed that may vary in width from a few meters to a few hundred meters. Strip aquifers have very favourable recharge conditions and are recharged from infiltration of spate flows and from springs and seepage zones along the torrent bed. Because of their small volume and high permeability the strip aquifer are quickly depleted.

Another type of aquifer is found in the lowland systems at the alluvial fans and on the plains. They are actively recharged by the torrents, but may several thousand feet thick. They may not be homogeneous and instead consist of a number of independent groundwater flow domains, with their own recharge and discharge zones and with varying water quality. Typical examples of this category are in the form of shallow well dug around water ponds. Local population knows about geology where even in plain areas ground water is stored as result of seepage from nearby pond. Such wells are common in many areas of Kacchi plains in Balochistan, Afghanistan, and parts of foothills in D.G. Khan and D.I. Khan. These wells usually supply water for six to eight weeks depending on soil geological characteristics.

Water storage in dams

The reliability of spate irrigation would be greatly increased if water from flood peaks could be stored and then released when needed for irrigation. Construction of small dams is a currently fashionable activity on many semi arid regions. However the benefits in terms of irrigation and recharge to local upstream communities need to be balanced by the adverse impacts on downstream spate irrigators. The upstream developments change the run off pattern, with low flows and the earlier parts of the flood wave being intercepted by the dams, while downstream systems receive the flood water that cannot be retained and are spilled by dams. This can have an impact on diversion efficiencies in the downstream spate systems as most of the water resource in spate rivers flows in the low to medium discharge ranges.

Dams are not an option in many spate irrigated areas due to the rapid siltation rates that occur when dams are supplied from spate rivers carrying very high sediment loads. Very expensive dams with a very large initial capacity are needed to provide enough dead storage for sediment deposits to achieve a reasonable economic life. An example of a controversial upstream development is the Gomal *Zam* Dam in D.I. Khan, which will come at the detriment of spate irrigated agriculture in a substantial area. The longevity of the dam – due to heavy sedimentation – has been seriously questioned in a series of feasibility studies. The adequate dead storage may provide a longer life. The issue is that in many semi-arid areas there is pressure from politicians and funding agencies to respond to the water crisis by building dams, even in situations where there are more viable alternatives, such as improving spate irrigation.

It can be argued that storage of water in the soil profile in spate irrigated areas and small on-farm reservoirs or community owned reservoirs to store excess flood water in a cascade system is a cheaper option than building dams. The drainage water from Spate fields can be stored in small reservoirs. Similarly cascades of small reservoirs in the main tributary are another option. A comparison of water resource development through spate irrigation and perennial dam based irrigation is given below:

Spate irrigation	**Perennial irrigation (dam based)**
Insecure supplies, unless combined with groundwater irrigation	Secure supplies, provided dam has reasonable catchment, and a reasonable useful life before it fills with sediments
Water storage in soil profile – very low evaporative losses	Water storage in reservoirs, high evaporative losses in shallow dams
Investment cost per m^3 water stored low	Investment cost per m^3 water stored high
Sedimentation contributes to soil fertility	Sedimentation causes reservoir siltation
Cannot utilize peak flows	Can store peak flows

There are many opportunities to get 'the best of both worlds', requiring more imagination than now is usually applied. There is much scope to better combine the use of spate irrigation with storage – either in a reservoir or as groundwater. The Shabo Headworks in Pishin in Balochistan is a good example that deserves much more following. Here the topflow of the spate flows are skimmed off and stored in four off-stream reservoirs. This avoids that the reservoir fills rapidly with sediment. Testimony of this is that more than 125 years after it was constructed Shabo Headworks is still in use. The designed command area was 6,500 acres in 1,888, out of which currently 2,100 acres are still now under cultivation. It could be more if it was not for deferred maintenance on the tanks.

Another example is that the construction of series of rock check dams in the dry river bed and providing bank protection, all from local material. This is a method used in Yemen and it serves to divert part of the nutrient rich flow to the land and at the same time to replenish groundwater, because the check dams slow down the velocity of the flood flows.

Thirdly the use of sub surface dams or sand dams in the arid areas of Pakistan is still not widespread. A subsurface dam is constructed below the surface in a dry riverbed. It creates a barrier for the subsurface flow flowing in the gravels of the riverbed. By doing so, it raises the groundwater table and makes the wells surrounding the river bed much more dependable.

Climate change and spate irrigation

Spate irrigation is the quintessential adaptation to climate variability. There are many mechanisms in place to cope with the uncertain and heavily peaked supply of water as well as periods of droughts. These mechanism are both in water management and in the organization of society and economy.

Climate change is likely to affect spate irrigation systems in Pakistan as well. Most of the spate areas are subject to a dual dilemma of either too little or too much water. In both ways, the situations need to be managed since they risk local

livelihoods. A study was conducted by Intercooperation and Pakistan Meteorological Department based on the decadal temperature scenarios for D.I. Khan District for four seasons. There is a slight increase in the average temperatures during the day time. The seasonal patterns for temperature change indicate that winters will become cooler falling by about 0.3°C on average per decade. Springs will become hotter by about 0.7 °C per decade that may also imply early summers. The summer and fall temperatures trend show insignificant change with only a slight increase in maximum temperatures (day temperature) but a declining trend for minimum temperatures (night temperature). These changes are not insignificant since D.I Khan is situated in a heat surplus zone. It is also important to take into account the changes that take place at higher altitudes where waters originate. The study shows that temperatures increase will be higher in magnitude in higher altitude areas. This will directly influence hydro-meteorological balance of the *Rod Kohi* area.

The Intergovernmental Panel on Climate Change in the Fourth Assessment Report has made a number of general predictions for Pakistan. First is the higher frequency of flood events, the occurrence of larger floods, a rise in temperature, and the higher chance of pests and diseases. These changes will put stress on the adaptive capacity of the spate irrigation communities. The extreme variability in any year however cannot be managed by traditional irrigation system and needs measures for preparing the area against risks.

In the table below an overview is given of the possible impact, what it means and what it takes to respond to the changes. Not all climate change comes in the shape of threats: some present an opportunity as well.

Another study in D.I. Khan compiled community perception regarding changes in weather patterns. Over the last 30 to 40 years, the intensity of heat has increased, with a longer summer and shorter winter seasons. Rainfall has gradually decreased, or has become very intensive, leading to more frequent droughts or flash floods. It is getting hotter with every passing year. Some 30 years ago, rains were consistent. Crop sowing is often delayed due to late arrival of rains, but then temperature rises too fast. Hailstorms have increased

Possible climate change	Likely impact	Likely adjustment or effect
More frequent floods	The effects depends very much on the nature of the catchment and the rainfall pattern – more medium sized floods are beneficial; more very large floods not	Possibly increased production
More larger floods	Damage to diversion structures and risk of gullying and damage to command area	May need to intensify use of outwash areas for rangeland or agroforestry Strengthen diversion structures Better village flood protection
Temperature rise in summer More difference in day and night time temperature	Higher soil evaporation Crop sensitivity to temperature	Adjustment in cropping patterns and crop varieties More emphasis on moisture conservation through mulching and other techniques
Higher risk of pests and diseases	Uncertain about direction of this impact	Better vigilance and back up systems in pest control

over the years. In past, heavy floods came at regular intervals, approximately every ten years. Now such floods are very unpredictable. The villagers remember that in 2006, the village of Kohawar was destroyed by flash floods, third time within a decade.

Similar evidence came from Karak where people witness scorching summers and the monsoon arrive even in June, though unpredictable and very intensive. Rains used to be more regular and hence natural springs were abundant. Drought has become a regular feature of the area.

The villagers have their own knowledge of early signs of opportunities and disasters. E.g. in case of D.I. Khan, a cold breeze blows from the north-east forming clouds named

Box 9.8

Living on a prayer

Due to the uncertainty of water availability in Pakistan, the local farmers often turn to their religious faith in bad years when the rains fail. Around five km from Hathala village in D.I. Khan is the shrine of Pir Atal Sharif, where the local farmers often go to pray for good rains. The shrine, located in a settlement in the middle of spate irrigated fields, is over 200 years old. The settlement was founded by the Sufi saint buried in the shrine, called Khwaja Shamsuddin. He was a Syed (direct descendant of the Prophet) known from the Gilani family of Baghdad. Sufism emerged around 300 years after the death of the Prophet Muhammad PBUH and was basically a renewing and corrective movement to safeguard the essence and spirit of Islam. Sufi networks highlighted the need for personal purification, constant awareness and self-knowledge in order to attain knowledge of God. There are shrines of Sufi saints located all over the spate regions of Pakistan. Farmers say that whenever they offer special prayers for the rains to come, their prayers are heard by the saints.

"*Bakarwal*" which brings rain in monsoon. When cold breeze blows from north-west and forms a cloud called "*Chunda*", rains arrive in summer. Sometimes clouds from south-east also bring rain. In winter, the clouds from east and west bring rain but the intensity and frequency has decreased overtime. At sunset and dawn, a coloured sky (*Palewij*) and warm winds from the south indicates a dry year. When the clouds "*Bakarwal*" or "*Chunda*" emerge with silver-lined dark clouds it is a warning for heavy rains and winds. Some expert farmers go by superstitious methods. Some put their ears to the ground, watch animal movement, insects and lizards running out of the holes, and observe number of migratory birds visiting the areas. Dust twisters on the western side in summer also suggest less rainfall. This knowledge is precious. When combined with scientific knowledge on climate scenario, it may become easier to predict risks and opportunities and plan accordingly.

A most common method to protect villages from flood is to establish protection spurs (bunds, *shehr panah*) to divert water from the villages. In other areas several other protection measures may be required to safeguard communities from hydro-meteorological risks. It is however important to

Box 9.9

Flood protection - village Kohawar

The village is located at six km away from the main D.I. Khan city at Daraban road at the extreme downstream of Daraban *Zam*. The village constitutes 350 households. The village was completely destroyed in 2006 and this was not the first time. The location of the village is rather tricky at the juncture of three streams. Though the village communities depend on flood water, they are always scared to lose their belongings when the floods arrive. 50% of their annual saving went into making preparedness for flood protection. However the quality of water received at the village demanded a larger level of investment. In 2008, Intercooperation' Livelihoods Programme built a protection wall after understanding the views of the villagers who were highly experienced in sharing the flood routes and magnitudes. The village successfully survived the year 2009 without any damages. Minor repairs were made to the bund by community. In 2010 however, a colossal flood hit the district causing major destruction in Damaan area and was rated at the second most damaged district after Swat by World Food Programme. It was obvious that the conventionally hit village Kohawar may have been eliminated from the ground since the village was even affected by floods of half the intensity. However it was a great moment to see that the village was safe and the bund successfully withstood the flood. Not only that, due to reduced velocity of water, the flood bed close to bund received sedimentation hence its level was slightly risen, pushing water away by at least six km. The villagers jubilated and made a collection of Rs. 400,000 to repair bund and increase its height. This, according to them was only one third of the saving that would have been required to rebuild the houses if flood would have hit the village, excluding the cost of humanitarian help after the displacement of families.

highlight that spate areas are most vulnerable to disaster risks, either triggered by climate change or other factors, and need consistent well planned measures to reduce potential losses. Since most of communities are already poor in these areas, they run a high risk of losing little what they have.

10 WHAT HAPPENS NEXT?

The story of Spate Irrigation Continues…

As mentioned the spate irrigation territory in Pakistan is considerable – much more than the entire agricultural area of many medium-sized countries. There is wide-spread poverty here but there are also many opportunities to move things in a better direction. As population, economy and living standards improve in Pakistan the use of water will become more and more important – especially in the *Rod Kohi*, *Sailaba* and *Nai* areas. A holistic approach is required to develop these spate irrigation areas. There is considerable scope to improve livelihoods on many fronts: improved water management, increased and diversified crop production, improved drinking water supply, improved livestock production and spate irrigated forestry. Then there is the larger agenda of better education, road access and health services.

A recent report of the Ministry of Water and Irrigation and the Water Sector Task Force of the Friends of Democratic Pakistan has also highlighted the high potential of improving the productivity in the current spate irrigation systems and even expanding the area now served by spate irrigation. The report makes the argument for a substantial revival in the spate irrigated system with investment in social management systems, better farming and marketing and in infrastructure.

Spate irrigation should be given its due prominence in policies and practices and not be omitted, as is sometimes inexplicably the case. Key decision makers, such as Chief Ministers, Governors, Heads of P&D Departments, donor representatives and in fact everyone should visit these spate irrigated areas and not just browse through this book, even though many of these areas are remote.

Several activities are required to energize the spate irrigation areas and to end the years of neglect. Here is a possible 'to do' list:

- Allocation of funds and earth moving equipment to rehabilitate and maintain the earthen bunds. This should be done through water users associations and community organizations rather than through powerful individuals.
- Appropriate investments in water management infrastructure. Often it is not so much about the money, but about subtle improvements. Working on the basis of traditional techniques and improving them is far superior

than 'importing' *pucca* civil engineering designs that have shown to have high failure rates. Minor investments in flow division structures, reinforced earthen bunds, field inlets and outlets – if made at the right location – can have very major positive impacts. All of this requires intensive involvement of spate irrigation farmers, who by any measure are the best experts.

- Improve drinking water supply for humans as well as livestock by making improved water ponds, especially when there is no other source.
- Identify existing good local practices and undertake research on dry land techniques, and very actively disseminate the findings to the main stakeholders – farmers and others.
- Since livestock is very much the domain of women, there is a need for more intensive programmes of livestock development, training and involving local women animal health workers. Farmer Field School has been a proven technique for disseminating knowledge. The use of molasses blocks, urea treated fodder can also make big improvement on the productivity of livestock keeping.
- Support the marketing of crops, especially minor crops – such a guar, medicinal plants, mushrooms, sesame and local vegetable varieties, but also main crops such as chickpea, wheat or sorghum – making use of the 'natural' way of their cultivation.
- Conduct research on organic qualification of spate crops, and identify measures to reach the acceptable standards for low external/organic certification. Make more commercial sense of the particular qualities of spate agricultural products.
- Introduce improved grain storage on a large scale. Special focus on women in this regard since usually they take this responsibility in a farm household.
- Promote spate irrigated forestry – of promising indigenous crops, such as *Gum arabica* while simultaneously introducing ownership sharing arrangements between landlords and tenants.
- Enhance emphasis on improved crop agronomy in spate areas – through better seeds and breeds – by better sharing good varieties within the countries and linking up to spate irrigated areas outside the country. Also give a

new and practical applied impetus to agricultural research activities in the spate irrigation systems.

- Strengthen the local management of spate irrigation by developing and empowering local organizations and water users associations at all levels in the system, thus reviving regulation of water flows and improving local capacity to maintain, resolve conflicts and improve the systems.
- Consider the development of *Rod Kohi* Authorities in the different provinces, that will work in partnership with local farmers and other stakeholders.
- Better networking of all those that work in spate irrigation in Pakistan – to share knowledge between public and private parties, link up with like-minded organizations and networks in other countries and to establish a forum of promoting and advocating the comprehensive development of spate irrigation-dependent areas. Also provide trainings in the different provinces and districts where spate irrigation is prevalent.
- Incorporate spate irrigation in the relevant college and university curricula to broaden the now limited pool of experts.
- Make a plan and start the preparation for the expansion of the area under spate irrigation – especially after conversion of former spate command area under CRBC and Kacchi Canal, but also elsewhere, putting adequate emphasis on the development of the command areas and the water rights and allocations.
- Using new and considered approaches for the development of the water resources in the different valleys in Pakistan – combining the harvesting of the flood water with better storage – either in groundwater or off-stream reservoirs, following successful examples outside and inside Pakistan
- Overall, familiarize government organizations, donors and NGOs on the development needs of spate irrigation areas and encourage them to work on this important area of livelihood improvement.

There is no shortage of things to do. We hope there are many ‘nexts’…!