

# The Potential of Spate Irrigation in Sindh

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**Spate Irrigation  
Network**





## **Africa to Asia and Back Again: Testing Adaptation in Flood-Based Farming Systems**

The Potential of Spate Irrigation in Sindh  
A Research Study

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## Review Note by Spate Irrigation Network Foundation

This is a time that we need to care of all resources – there is no resource we can neglect. Our aspirations grow and so does our population and our economy.

An important resource but one often forgotten is the use of floodwater for beneficial use. Not always well known the use of flood water has a long history in Sindh and in Pakistan as a whole. Even today close to one million hectares of land in Pakistan is prepared for the use of short term floods, also called 'spate' or 'hill torrents'. This form of agriculture is in urgent need of being revitalized – making use of some of its strengths: very good soils, unique farm products, in some areas access to groundwater that is frequently recharged from the floods and a new sets of techniques to better buffer water from the short duration floods.

I am delighted that this study took place – setting out the potential for spate irrigation in Sindh Province and outlining the different opportunities to make it contribute to food security and rural wealth. In other parts of Pakistan the use of flood water is more prominent, but in Sindh it can create the basis for highly productive farming. It requires a departure however from standard approaches that have prevailed over the years in the smaller catchment of Sindh Province where building small dams was seen as 'the only way'. This has often done harm to the spate irrigation systems that rather having their potential used often suffered from inappropriate interventions. Rather than stocking the silt laden floods behind dams and cause the newly created reservoirs to quickly silt up, it is important to spread the floods over a larger area while carrying their sediment, feeding the soils and spreading water over a large area. Then apart from better water management there is a large range of opportunities to do well in these areas – better varieties, unusual crops, special breeds, a careful approach of distributing water over an area that is not too large, so that reliability increases. These are some examples. It is important that the understanding of what these flood-based systems can bring is increased.

I also hope that it is not just a study but that it will bring much more – an impulse to bring prosperity to the areas that are dependent on spates and floods, an engagement to work in these areas, stronger farmer networks and all this being reflected in educational programs. This is also very much the objective of the Spate Irrigation Network Foundation, that aims to support the development of the areas dependent on flood water and promotes initiatives by farmers and others for such areas. The Spate Irrigation Network is a community of persons that work on this in different countries and in different capacities. I hope that as you read it this you become part of the community, if not done so already.

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## Summary

According to the 1991 inter-provincial water accord, all provinces are generally dependent on the national pool. To address water shortages and fluctuations in the river system, alternative resources need to be developed by provinces themselves. With no possibility of receiving extra water from the national pool (Indus Water), and in the absence of quality ground water, Sindh has to look into alternatives on an emergency basis. Of the alternatives, hill torrents/spate irrigation is the most promising and economical resource, particularly in the Kohistan region. Sindh has a spate flow potential of 0.5 million acre foot annually and 1.4 million acres could easily be brought under cultivation through spate irrigation in Kohistan region, Nagarparkar and Khairpur Mirs areas where water gushes down from the mountain ranges. Spate flows also can contribute to improvement of 1.1 million ha rangelands alone in Kohistan region.

Study findings show that spate irrigation is mainly a self-managed system by local communities in Jamshoro, Thatta, Dadu, Malir, Kambar Shahdadkot, Khairpur Mirs and Tharparkar (Nangarparkar) districts and currently about 80,000 to 200,000 acres of land is annually irrigated in these areas. In Sindh Usually large *Nai* are not diverted to fields due to their heavy discharge, which is beyond the handling capabilities of local farmers. Most of the water passes downstream into major water bodies (Manchar, Hamal, Kenjhar Lakes) and Indus without contributing much directly to irrigation. If this system is managed well, it could bring about 1.4 million acres under cultivation. Though agriculture production per unit area is less in these areas, but that is organic. The climate in spate region of Jamshoro and Thatta is highly suitable for high value horticulture crops (mainly onion and tomatoes). Some sites particularly in Jamshoro and Thatta are highly potential and suitable for the development of spate system, because the spate river has a sufficient flow, most of the farms have similar farm size and the cooperation among farmers for the development of their irrigation system.

Some areas of Kohistan region are not suitable for agriculture purposes but the soil conditions and weather is appropriate for the development of rangelands while in other areas check dams and other appropriate structures and vegetation cover can significantly recharge the aquifer. The opportunities for spate irrigation to recharge the groundwater are generally available, but they depend on (1) aquifer systems and (2) groundwater quality. With respect to the latter, parts of Sindh are well-endowed, for instance the area around Thana Bula Khan in district Jamshoro. In spate irrigation system most recharge occurs through the river bed and by slowing down the hill torrents. In addition, recharge can further be enhanced through sub-surface dams. There are also suitable sites for storing flood water in the ponds to provide water for humans and livestock, lift irrigation, environment and biodiversity conservation, block plantation and various other purposes.

Though Small Dam Organization has started working on large hill torrents to construct storage dams on the lines of perennial irrigation but similar experiences in other provinces and elsewhere in the spate regions did not prove much success. The study reveals that the spate irrigation system has great potential in Sindh but it lacks institutional support and mechanisms for optimal development of the spate areas keeping in view the local water rights. There is a

need to work on small and medium hill torrents, but with a holistic approach. Spate resource has the capacity to substantially contribute in meeting water requirements in arid regions of the province where other resources are not available.

Research and Development Foundation (RDF), a nongovernmental organization with the support of Oxfam Novib has conducted study on spate irrigation to find its potential, present constraints and set of recommendations for the development of this systems in Sindh province. The study will be helpful for government institutions and other stakeholders to further plan and work on this important and under developed sector in order to deal with water stressed situations in the province and contribute to the livelihood and food security of the spate dependent communities.

Spate irrigation potential is in the poorest areas of the province where there are not much other development opportunities. Therefore, these areas deserve special attention at policy level for its sustainable development through local resources such as spate flows. Increasing population and adverse impacts of climate change compels to rely on local resources more. Spate region of Sindh is one of the such opportunities, where development work need to be started on emergency basis.



## 1. Introduction

Sindh is predominantly an arid region with an extremely hot weather during Summer and cold in winter. Temperatures frequently rise above 46 C<sup>0</sup> between the months of May and August, and the minimum average temperature of 2 C<sup>0</sup> occurs during December and January. The rainfall is erratic. Sindh has vast tracts of desert and no perennial rivers originates in the province. The extent of irrigated land is small when contrasted to its food needs, though the potential for expansion exists. Sindh mainly relies on Indus water for irrigation and its share of water is allocated through the 1991 Indus River Basin Accord. Under this accord Sindh receives 48.76 MAF annually.

During cropping season the demand for water increases tremendously throughout the country and Sindh experiences a shortfall. Underground resources are minimal in many places and generally are not fit for use for agricultural or non-agricultural purposes. It is estimated that Sindh province has a safe ground water yield of 4.4 to 8.1 MAF, but in order to utilise it substantial usage of very costly energy resources is required<sup>1</sup>.

Being participatory in nature, environment friendly and low cost, the spate irrigation is a unique system in which flash flow from ephemeral River is diverted to fields on one or both sides by constructing earthen structure, through canal(s). These fields are bounded by earthen embankments ranging from 3 to 8 feet. Upon sufficient irrigation of the fields, earthen structure is breached to let the flash flood flow downward following the same practice and so on. These rivers are dry throughout the year and discharge floods only during rainfall in catchments, mostly during monsoon season. This traditional irrigation system is prevailing since centuries and mostly without any institutional support. Community practices are applied in managing the spate flows. It is called Nai in local languages. Spate irrigation system prevails in the seven districts of Sindh – mainly in Kohistan region (Qambar Shahdadkot, Dadu, Jamshoro, Malir, Thatta), Khairpur Mirs and Nagarparkar.

This study focuses on holistic approach to hill torrent flash floods as a comprehensive and economical resource base for sustainable development in poverty stricken areas of Sindh. Spate areas in Sindh are mostly politically disadvantaged, environmentally degraded, remotely located and least developed. Spate resources have hardly received any serious attention from policy makers, technical experts or donors in the province. Spate system could significantly contribute in the poverty alleviation and economic growth of country.

## 2. Research Methodology and Working Approach

Keeping in view the scope of the study, primary data were collected through focused group discussions with farmer groups, mainly with members of the Barani Abadgar Tanzeem in Jamshoro, Thatta and Dadu. The field research involved a series of structured discussions with various local stakeholders. This was followed up by second round of interviews in field with key informants to verify some information and clarification of issues.

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<sup>1</sup> Sindh Water Resources Development and Management Investment Plan – Asian Development Bank TA No. 7180 - PAK, 2010

Meetings held with numerous Sindh Government departments such as the Irrigation Department, Agriculture Department, and Small Dams Organization. Consultations were held with senior faculty of the Mehran University of Engineering and Technology Jamshoro, Sindh Agriculture University Tandojam, officials of the Pakistan Agricultural Research Council and local NGOs.

Several spate river system sites in Sindh were visited, workshops were organized with members of the NGOs and media to obtain their opinions about the development of alternative water resources options in the province, such as spate irrigation. Intensive meetings were convened with farmer organizations.

Secondary data were extensively reviewed as some organizations have studied this sector on country level. The famous report "Master feasibility study of Hill Torrent Potential in Pakistan" conducted by NESPAK (1998), is key report among others. Pakistan Agricultural Research Council (PARC) documents (listed in reference) have been reviewed. The relevant information including maps, graphs and figures for Sindh province have been extracted, reviewed and incorporated into this report. For clarification of certain issues, the authors have been consulted too. The reports of the spate irrigation development project by Water Resources Institute of PARC in Dadu and Jamshoro districts was reviewed to get information of what PRAC has done for spate areas in Sindh and what are their findings. The studies and research reports of International spate irrigation network and UNESCO Institute of Hydraulic Education (The Netherlands) were reviewed. Information from FAO-UN have been obtained to verify the facts. The reports of Sindh Arid Zone Authority are the good source of spate irrigation in Kohistan region and information have been used.

The main features of this study are:

- Identification of spate irrigation system and their command areas;
- Legal Frameworks and Water Rights in the Spate Areas of Sindh
- Types of Structures and Infrastructure Facilities
- Cropping patterns and production;
- Specific problems in the management and utilization of spate water
- Recommendations for the further improvement of spate irrigation Sindh

Special attention was paid to determining the land and water resources which are the key elements in the development of an irrigation system in hill torrent areas. It is not possible to develop spate irrigation systems concurrently or in the same way at all sites because different scenarios could require diverse approaches of spate water management.

Spate irrigation sites in the Kohistan area provide potential locations for the installation of windmills mainly for lift irrigation and other purposes as well, such as generation of energy. Karchiyat location in Jamshoro district is one of the potential site for wind energy.

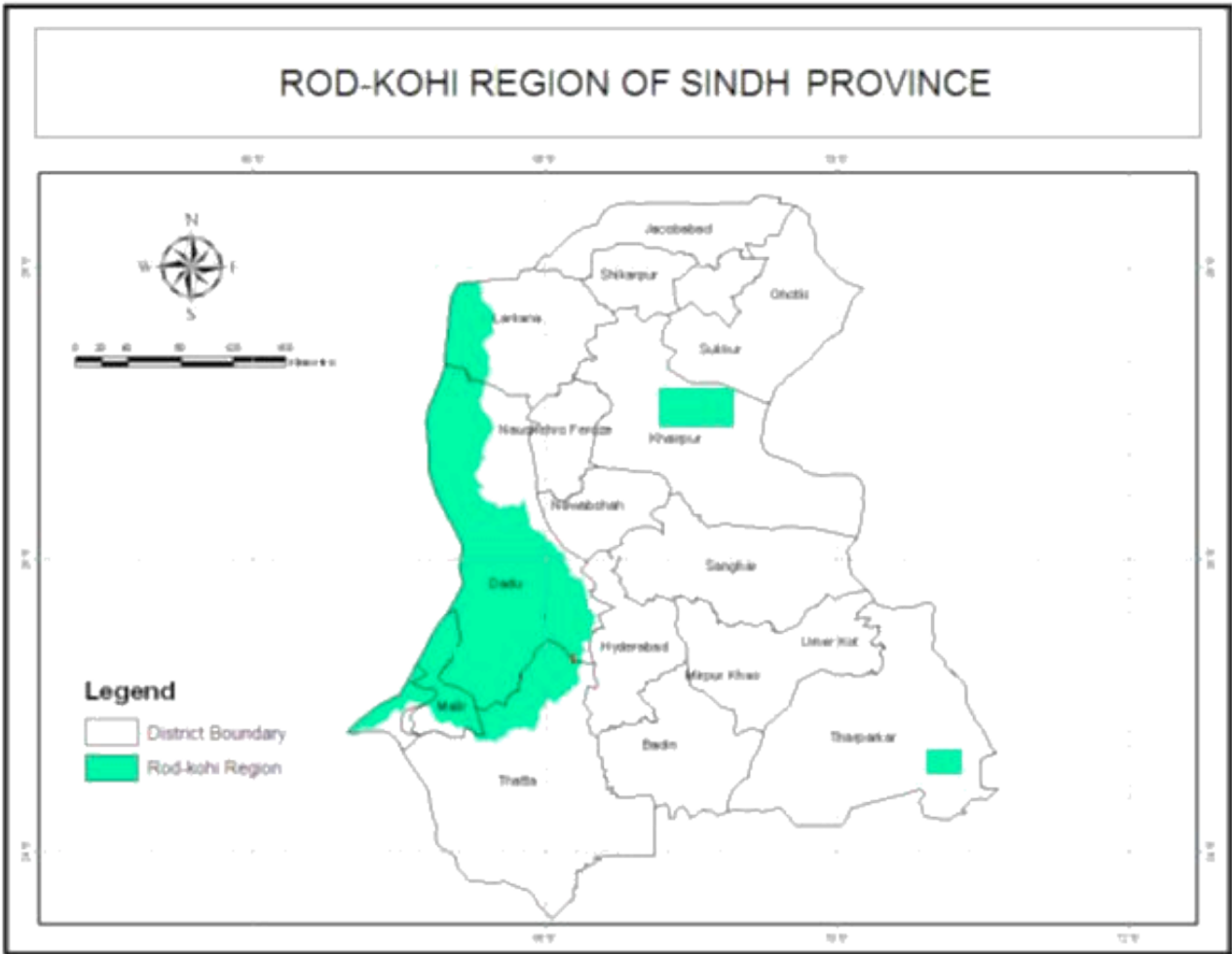
The study has some limitation due to non-availability of disaggregated data pertaining exclusively spate area. The maps and flood discharge data is also not

available for each ephemeral river. However, various sources of information have been used to fill the gaps as much as possible.

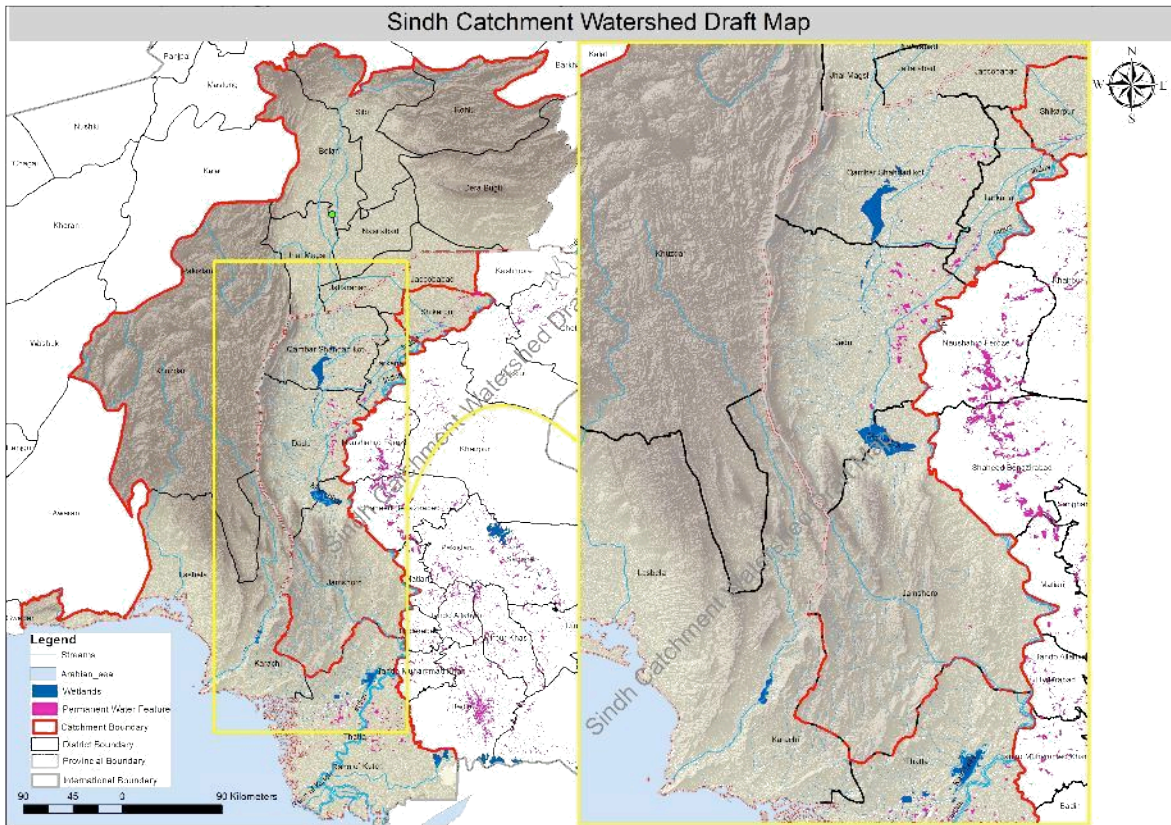
### 3. Spate Irrigation in Sindh

The Sindh main spate region, also called Kohistan, other than Khairpur Mirs and Nagarparker, lies mainly within longitudes 66° 37'–68° 24' East and latitudes 24° 42'–27° 58' North in the western part of the province. Kirthar spate belt, other than Gaj Nai zone, covers an area of 23,092 square kilometres, of which 73% has been classified as lowlands (0-300 meters above sea level), 16.4% as hilly area, and 10.3% as middle mountains. In terms of elevation 6.5% is between 1000 to 2000 meters. The bare soil, i.e. cultivable waste land, is 0.8 million acres. 1.1 million acres are classified as rangelands. Crop cover (both spate, rain-fed, wells and other sources) is 0.5 million acres when 100% of the available area comes under crops during exceptional rainfall. The forest cover is only 3% in this zone.

Khirthar Range Hill Torrents discharge heavy floods during monsoon and strike the Flood Protection (FP) Bund. Malir Nadi of Karachi Area crosses the Karachi-Hyderabad Railway Line and the National Highway. Baran Nai of Sehwan Petaro Area crosses Karachi-Hyderabad Super Highway and Railway Line, while Kalu and Choherh Nallas outfall into Keenjhar Lake after crossing Karachi Hyderabad Railway Line. Flash flows damage everything in their way – infrastructure, settlements, lands, and properties. **Map: Spate Irrigation in Sindh**



**Source:** PARC, Islamabad 2010



These hill torrents vary in length and discharge magnitude and fall into two categories. Locally the larger ephemeral rivers are called *Nain* and the smaller *Rakh*, though this terminology may change from one valley to another. Some hill torrents discharge flash flows for a short duration lasting from a few hours to a few days only but at high magnitude. The command area of larger spate irrigation systems may not necessarily receive rainfall but remote catchments might and flash flows appear all of sudden. The quality of spate water depends upon the soil characteristics of catchments.

In Sindh Usually large *Nai* are not diverted to fields due to their heavy discharge, which is beyond the handling capabilities of local farmers. Most of the water passes downstream into major water bodies (Manchar, Hamal, Kenjhar Lakes) and Indus without contributing much directly to irrigation. Some *Nai* with catchment areas ranging from 20 square kilometres to more than 7117 square kilometres could also flow perennially.

Medium and small streams have natural canals and water enters into the agricultural fields by gravity. Farmers use *Nai Baran*, *Gaj*, *Dawoo*, *Desvi* and a few others to irrigate comparatively small areas.

**Table: Water Resources of Kohistan Spate Unit in Sindh**

Annual Rainfall (mm)	Volume (BCM)	Annual Runoff (BCM)	Water use (BCM)	Balance (BCM)	Runoff Coefficient
127	2.933	0.501	0.106	0.396	0.171

**Source:** PARC, Islamabad 2010

At the moment the Karoonjhar spate system has 400 square kilometres of catchment area and with potential benefits of 10,912 acres. It is the only viable source for the agriculture, livestock and drinking requirements in the area.

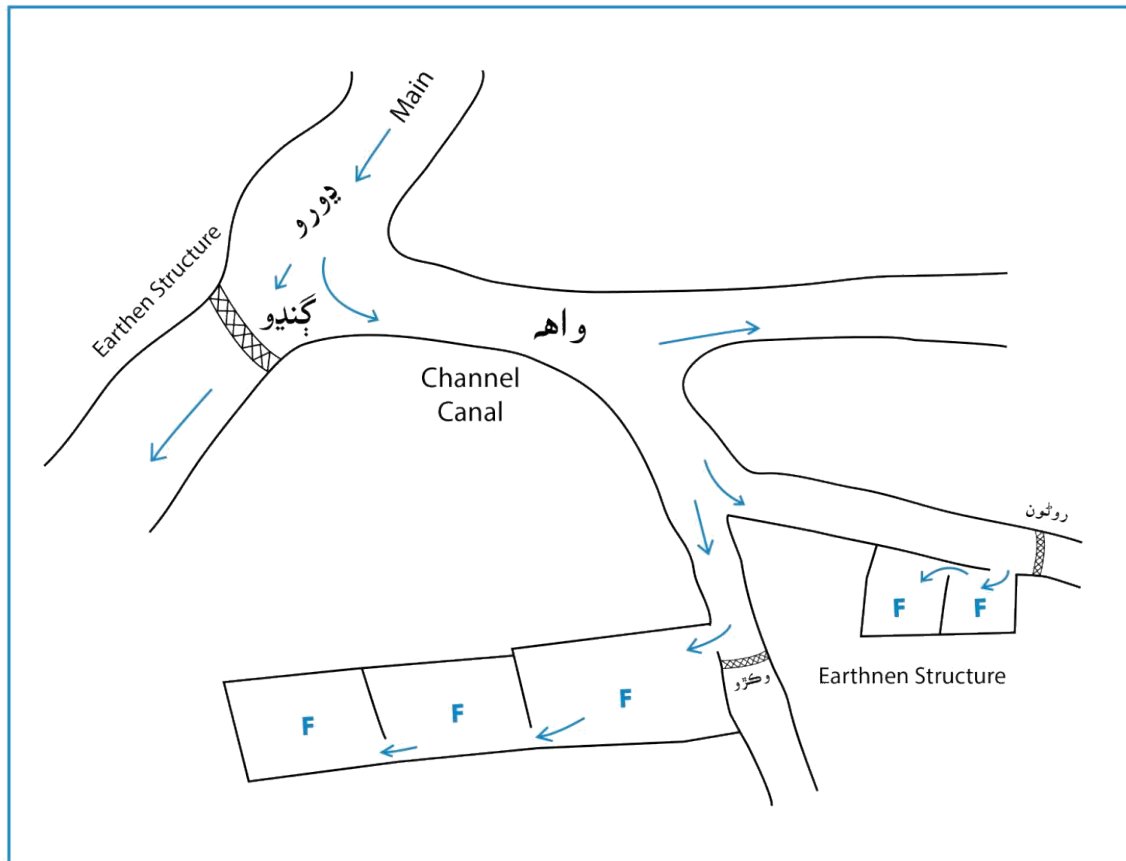
**Table: Cultivable Wasteland Water Conservation Potential of Various Hill Torrent Areas of Sindh<sup>2</sup>**

Area	Cultivable Wasteland		Average annual Conservation Potential	
	(Hectares)	(Acres)	(MAF)	(MCM)
Khirthar Range	279,300	689,871	0.296	365
Karachi	64,560	159,463	0.094	116
Sehwan & Petaro	207,000	511,290	0.330	407
Sub-Total Sindh	550,860	1,360,624	0.720	888

The hill torrents in lower Kohistan (Jamshoro district) have the largest catchments and relatively higher than the average rainfall of other areas with part of the catchment area situated in Balochistan province. According to various sources the present area under rain-fed/spate is 80,000 to 200,000 acres annually, depending upon spate discharge.

The comparative advantages of this area are escalated by their proximity to Karachi, the largest urban centre in the country, which consumes a huge quantity of fresh fruits, vegetables, green fodder and other cash crops. The commodities can be delivered in a short time and at a low cost. Experts say that development of irrigation infrastructure will transform this area into food and fodder basket – both for human and livestock sector.

<sup>2</sup> Master Feasibility Studies for Flood Management of Hill Torrents of Pakistan, NESPAK, 1998



### **A Typical Spate Irrigation Diversion System in Sindh**

The above illustration shows how the breach in the first field remains open allowing water to continuously flow to all fields downstream until water reaches the last field or the flow ceases. If there is excess water once all fields with water rights have been irrigated sufficiently, under local rules and rights the inlet/intake of first field is not closed and the water naturally flows downstream to no man land which could be rangelands or any barren lands. After irrigating a field, all outlets leading to downstream fields are closed. This requires supervision until the water recedes to prevent an intentional breach by a rival or by natural hazards.

This practice has certain pros and cons. The free flow from the last fields allows the sediments to drain away partially, otherwise the level of the field beds would be raised each year. However, if the inlet to the first remains open constantly other problems arise. For example, during 2011 the winter rains brought an unexpected spate flow which took its natural path and all fields with mature crops were submerged, resulting in heavy losses.

### **Spate in District Khairpur Mirs**

Ubhan Shah spate catchment is situated in the North-East of Nara Taluka, District Khairpur. This area is famous with the name of *Jara Takar* means the twin Mountains. This catchment is about 875-1500 square Kilometer within Badshah Sultan and Shadi Shaheed range of Mountains. It is part of the Nara Valley. There are many small and medium natural streams/Nai originating from

Ubhan Shah. In this area the Foaji and Awal Khan Nai Desoi are the largest Nais, which receives the huge quantity of water; most of the water is wasted in the catchment area due to heavy percolation rate in the valley. The rain-fed streams run off the slopes and the water is impounded within the mud levees. The drainage slope of hill torrents in the area is towards to Mehrano valley across Kot Diji mountainous area. Most of the catchments of Ubhan Shah area collect the surplus run-off through spate Foaji-I, II, Awal-I, II and other torrents during intensive rains. The heavy amount of run-off is percolates within the valley, remaining 20-30% run-off reaches within the command at Mehrano valley of Tehsil Kot Diji.

About 8000-1000 acres of scattered land is cultivated under spate irrigation in two Taluka's of District Khairpur Miras (Nara & Kot Diji). Besides some adjoining areas are also irrigated through Mir Wah.

### **Spate in Qambar Shahdadkot District**

The Qambar Shahdadkot district is rich with fertile lands, which are fed by the Rice Canal and Khirther Canal. Spate is another source of irrigation for some of the areas of district. The western Khirthar range of Qubo Saeed Khan , Ghaibi dairo and adjoining parts of other Talukas within Khirthar ranges are irrigated through numerous flash floods by spates. The spate streams/Nai in district Qambar Shahdadkot are Narani, Mardan, Khargani, Buz, Alkah, Dhadhar, Khenji, Wahandri, Trapen, Mazarani, Mazarani, Teerani, Tuni Nai, Gerelo, Buri, Dilan, Chhanhya, Kehar Ji Nai, Radh, Saghro and Tuni.

Khenji River makes a head start from 1508 m (5000 ft) a.s.l high peak Machhul and causes flash floods during rains. This point is also called as Toshangi/Tushangi in the shape of a natural pond.

### **3.1 Major Spate Streams/Nais in Sindh**

Numerous hill torrents flow through Sindh's seven districts. Shahdad Kot, Dadu, Jamshoro, Malir District of Karachi, and Thatta Districts receive spate flows from the Khirthar range. Two districts receive water from nearby hills: Khairpur Mirs (Ubhan Shah, Kot Diji, Mehrano, Shadi Shaheed) from Shadi Shaheed Range and Tharparkar (Nagarparkar) from Karoonjhar Range. Some portions of the catchments are located beyond the administrative boundaries of Sindh, especially in Baluchistan province.

**Table: Spate Rivers, Location, with Discharge and Potential Area**

S. No	District	Name of Spate	Catchment Area (Acres)	Yr Av. Rainfall and Intensity Inches	Max. Flood Discharge (CS)	Total runoff of Max flood AFT	Area for Agriculture
1	Jamshoro &	Ocha	61440	6	38,886	9722	4680



	Malir						
2	Jamshoro & Malir	SUK NAI	31040	6	14293	<u>3573</u>	2500
3	Jamshoro & Malir	KOTRI	17920	7	2894	3134	3050
4	Jamshoro & Thatta	KAND DHORO	38400	8	17583	5128	2850
5	Jamshoro & Thatta	UPPER MOI.	43200	7	29358	7339	3200
6	Jamshoro & Thatta	ULLAR	20480	7.02	16188	4047	4000
7	Jamshoro & Thatta	RHOOJA	15360	7	11957	2989	2070
8	Jamshoro & Thatta	NAI MANGO	11200	7	10510	2628	1560
9	Jamshoro & Thatta	WATTAN WARI	11200	8	7181	2095	200
10	Jamshoro & Thatta	SARI	17280	7	13,346	336	1650
11	Jamshoro & Thatta (Kenjhar)	Rodh	54400	7	40102	1002 5	4850
12	Jamshoro & Thatta (Kenjhar)	KUNI	35840	7	26379	6595	1950
13	Jamshoro & Thatta (Kenjhar)	Kalu-I	16000	7	11390	2848	2250
14	Jamshoro & Thatta (Kenjhar)	KALU-II	64000	7	40033	1000 8	2800
15	Jamshoro & Thatta	LANGHEJ I / TURI	28800	8	20416	5955	1950
16	Jamshoro	JHARAND O	32552	8	16072	4688	2750

17	Jamshoro	MUIA	21440	7	1747	3987	2720
18	Jamshoro	THANDD O-1	37120	8	34650	8662	2750
19	Jamshoro	Pukhan	46454	6	26090	6617	
20	Jamshoro	Rani Kot	32398	6	8137	8220	
21	Jamshoro & Dadu (Manchar)	Bandhani	53373	5	29759	7440	
22	Dadu (Manchar)	Angai	111938	5	59714	1492	
23	Dadu(Manchar)	Khandhani	11336	5	6228	1527	
24	Dadu(Manchar)	Haleli	1779	5	9837	2390	
25	Dadu(Manchar)	Kando Babar	117251	5	64078	1602 0	
26	Dadu(Manchar)	Bahawal Babar	48927	5	23199	5854	
27	Dadu(Manchar)	Nali	29900	5	13917	3480	
28	Dadu(Manchar)	Taki	37120	5	20149	4980	
29	Dadu(Manchar)	Makhi	24320	4	9083	2271	
30	Qambar Shahdad Kot	Salari	3280	4	13268	3492	
31	Qambar Shahdad Kot	Buri	51840	4	21932	5483	
32	Qambar Shahdad Kot	Dillan	48185	4	20416	5104	
33	Qambar Shahdad Kot	Mazrani	21745	4	10208	2552	

#### **4. Policy and Institutional Framework for the Management of Spate in Sindh**

Presently spate irrigation in Sindh province is mainly managed by the communities themselves on each ephemeral river, though on a limited scale. The diversion structures, where necessary, are made, water is diverted and applied by farmers themselves. It has found that the adequate institutional support of government departments lack in construction and application of water under spate system, thus coverage of spate flow is minimum as compared to its potential. Government interventions do care of the infrastructure and lands and settlements from floods but not utilizing floods as a resources as such.

Though there are national plans for each water sector, but plans and sectoral analysis and strategies at provincial level are not clearly stated. Sindh province experiences a particular handicap due to the lack of institutional systems of dealing with the spate irrigation sector. Spate irrigation is neither reflected in annual development and special development plan in the form of human resources development and deployment, financial allocation and number of schemes to be planned and initiated nor included in departments plans. Though Sindh Small Dam organization's mandate includes construction of small dams and weirs in arid areas but spate irrigation management holistically is not much taken into consideration yet.

Incorporating spate irrigation schemes in annual development plans in water scarce Sindh could have benefited more population and the area if serious efforts were made at institutional level. As compared to KPK, Punjab and Balochistan, little attention is paid to the development of spate in Sindh. Though indigenous water rules and rights exist in Sindh and practiced by the local population but are not part of revenue department's legal framework. While these rules are practised and part of judicial system in other three provinces.

It is found that farmers/ group of farmers at local level oversee the diversion and management of the hill torrents flash flows on their own. This is a somewhat different practice from other provinces. In other provinces of Pakistan, officials are appointed to look at the hill torrents. However, in Sindh, Nai Gaj has its own subdivision within the Irrigation Department, Government of Sindh.

The development of hill torrents could significantly contribute to the achievement of guiding principles of the draft National Water Policy such as equity, efficiency, participatory decision making, sustainability and accountability. The Government of Sindh should also focus on these principles while developing water resources including the hill torrents. Outside the Indus Basin Irrigation System (IBIS), S Irrigation and Power Department is responsible, through the Small Dams Organization, for the identification and development of viable water resources for storage, diversion and ground water recharge. Small Dam Project was launched by Government of Sindh in 2007 to meet the demand of irrigation and potable water to the population of neglected and remote areas in Sindh, by constructing Small Dams, Delay action Dams, Weirs and barriers across the river passages to store and recharge the sub surface water.

The Department of Agriculture covers extension, research, engineering and On

Farm Water Management (OFWM) programs in the province. At present rules of OFWM are principally designed for canal irrigated areas. These rules need to be modified in order to facilitate water management outside the basin.

## **5. Management, Water Rules and Rights of Spate Irrigation in Sindh**

In Sindh spate irrigation region, the local water management system is very simple in nature. Locally there are two terms used in many areas, i.e. Nai Barani and Rail Barani. Nai Barani is where the spate flows are guided through proper inlets/passages to enter into embanked fields and the Rail Barani is to let the water flow freely to areas of depressions, rangelands, open fields and lands normally not having water rights. Rail Barani situation applies when spate flows can't be controlled and they end in vast patches of lands.

The flash flow passes through a naturally formed passage and is gravity-fed towards the fields. In some cases manmade earthen structure is placed across the ephemeral river to divert flow to the fields through canals/channels. In some cases, where more than one village has water rights, there is a simple division point across the main river bed at an appropriate site so that the spate flow enters the branches/canal(s) leading to the first field. Although there is not much formal regulation or management of spate, farmers know their place in the sequence of irrigation, depth, obligation to pass water from their field to next field and if a dispute arise community elders sit together are consulted and the issue are mutually resolved locally.

Irrigation rights begin in the upstream fields and pass consecutively to owners of downstream fields on turn basis. There is no rule on depth of water but once a field is three quarters full, care is taken to allow water to pass to the next field through a breach at an appropriately wide point.

The areas of fields mostly range from 5 acres to 20 acres depending upon the ownership, terrain, possibility of receiving water through gravity etc. Each field has soil embankments from 4 to 8 feet in height with suitably wide bases. Local rules govern the height to which field embankments can be erected in order to maintain equity of ponding. Fields on the periphery have embankments on three sides and the fourth side remains open to allow localised runoff other than spate flow.

In case a heavy flow has damaged the first field and overflow of this field has caused damage to the next field, everyone will help rebuild or repair the field and no penalty is imposed on the owner of the first field. If a single canal can't pass water appropriately, then two branches can be built by mutual understanding with agreed criteria. Most of the fields are composed of clay and loam with high percentage of sand, are uneven and gently slope away from the point of the water intake.

All landowners dig wells on their own land and no rules exist to determine the minimum distance to be kept between wells. Landowners in Thana Bula Khan complain that the sealed road crossing the hill torrents has blocked underground water downstream. Similarly in some areas people believe that water storage dams add salt into nearby underground resources. Both issues need to be verified by technical experts before a final conclusion can be drawn.

## **6. General Characteristics of Spate in Sindh**

### **6.1 Sedimentation Aspects of the Spate in Sindh**

Most of the catchments have been denuded of vegetation cover in the province. Therefore flash flows carry a high percentage of sediments and the steep gradient from catchments to the command area further accelerates the process of scouring and adding silt and other eroded material. The high velocity of flash flows and their large magnitude causes continual changes in the location of the channels and watercourses.

Sedimentation impacts the command area in different ways: canals, fields and storage reservoirs may silt up quickly, but the fine sediments can be beneficial because they carry nutrients which increase soil fertility.

High sedimentation loads quickly silt up modern civil engineering structures such as weirs and reservoirs. The changing nature of flash floods coupled with very high sedimentation makes it difficult to design modern structures for water storage and conveyance. As a result, in many cases, a major portion of these flash floods is wasted or causes enormous damage in the already underdeveloped regions.

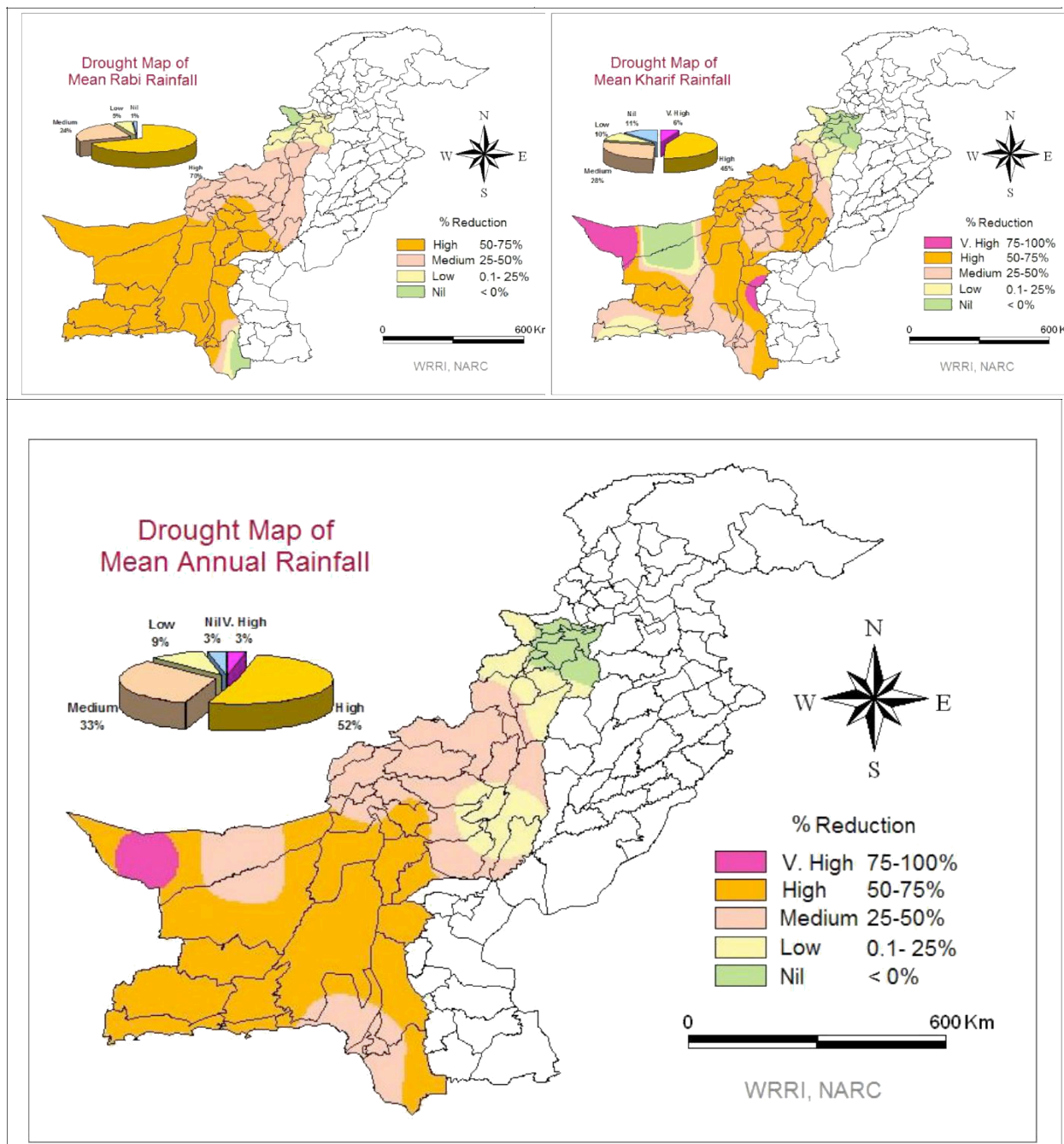
### **6.2 Climate of Spate Areas in Sindh**

The Climate of Kirthar spate irrigation zone is arid subtropical continental (sub mountain) and marine tropical continental characterized by intensely hot summers, mild winters and late summer monsoon rainfall. The late summer rainfall helps the crops and vegetation as winter is approaching and evapotranspiration decreases and is somewhat beneficial. The mean annual rainfall at Hyderabad, the nearest climate station in the region, is 173.5mm measured over the period 1957–2006. About two thirds of annual rainfall occurs during the monsoon period (Jul–Aug) and one third in the remaining part of year. The average annual temperature during 1957–2006 was 27.67°C while average monthly minimum and maximum temperatures were 17.99°C and 34.08°C. May and June are the hottest months while December and January are the coldest months. The winters are short lasting for about 3 to 4 months. The southern part is influenced by the sea breeze. As described earlier the rainfall in Karoonjhar (Tharparker) is higher, i.e. around 400 mm annually.

### **6.3 Rainfall**

Rainfall varies considerably in the province – lowest in upper Sindh (Guddu and Sukhar area), slightly higher in Kohistan region and highest in Karoonjhar hills in Nangarparker (460 mm). In many parts the average annual rainfall is between 100 and 150 mm. Low rainfall compels development of enough feasible sites for diversion, storage and recharge structures so that nothing should be wasted. Regardless of the potential of rain generated flow, spate floods are opportunity for additional water resources outside Indus valley. Spate irrigation depends upon rainfall and the extent to which it can be practiced is influenced accordingly.

## Maps: Showing the Rainfall Pattern During Drought of 1997 to 2003

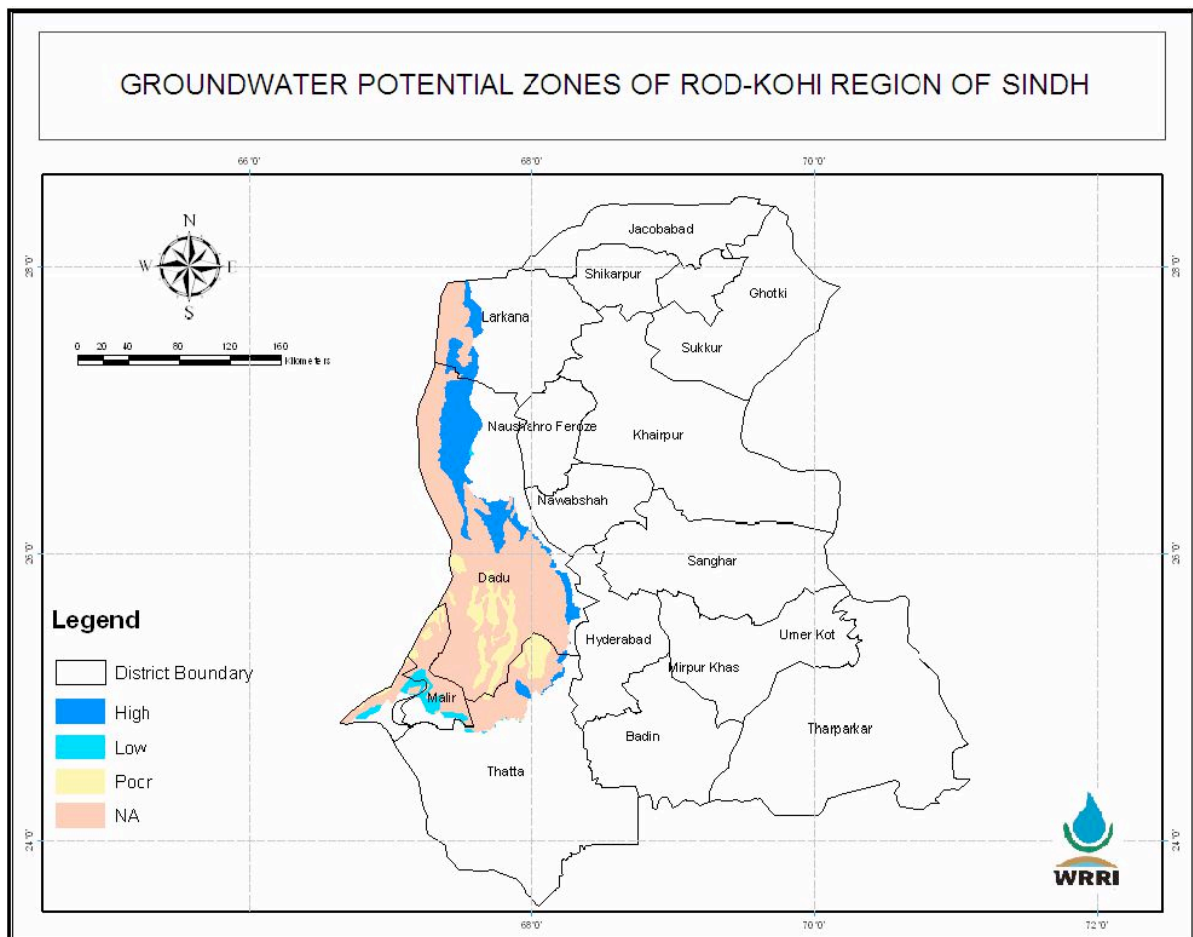


Source: PARC, Islamabad, 2009

### 6.4 Groundwater in Spate Irrigation Regions in Sindh

Ephemeral rivers contribute ground water recharging in various ways. Spate flow replenish ground water wherever soil geology and other associated factors permit. In Sindh ephemeral rivers such as Nai Gaaj, Nai Baran and all other major Nai have base flow and its discharge depends upon the spate flood occurrence and regularity. Ephemeral river beds are the main locations of aquifer recharge. The disturbance in ephemeral beds such as excavation of gravel from Malir River's bed is the best example of how activities can hamper the base flow and lead to vanishing ground water resources. Spate flow also contributes to springs throughout its passage. Moreover, direct application of

water into irrigated fields contributes towards percolation of water throughout the command area.



Source: PARC, Islamabad, 2009

All wells (dug well and tube wells) are installed near the banks of these ephemeral rivers. These are shallow wells ranging in depth from 4 to 20 meters. Shallow aquifers are readily recharged during spate flow passing in rivers. According to local farmers in Manjhand area, such a dug well yields water for 12 hours a day. Since water yield is low, farm size is roughly 5 acres per well. Water is pumped through diesel driven pumps and are costly to operate. High value agriculture especially onions and tomatoes are grown. It is important to note that horticultural slack season (November to February) for tomatoes and a few other vegetables prevails throughout the country. However, spate irrigation area of Sindh (Dadu, Jamshoro, Malir and Thatta districts) have a unique agro-climate and thus offers horticultural opportunities during this particular time period. The downstream area of Nai Baran has great potential of water recharge due to its geological characteristics.

About 378.4 million hectares area in Sindh spate region indicates the presence of high potential zone of ground water availability mainly in parts of Dadu, Japnshoro, Shahdad Kot and Thatta districts. It is important to put more focus

on the medium, low and poor regions for artificial recharging of the ground water. Every single drop is precious in this harsh environment as it is the only source of water.

The present zones of poor and areas not yet studied can be further explored to see the possibilities of artificial recharging through spate floods. This can easily be done during high floods which in many cases can't be controlled and diverted to agricultural fields and thus goes to waste. It can be enhanced by flood breakers and subsurface dams as is practised in other counties, Floods take a heavy toll of life, infrastructure, settlements and properties. Floods can't be prevented completely. However, through proper planning, means can be developed not only to minimise flood losses but also to conserve the surplus flows for ground water recharge and other useful purposes such as ponds for drinking and livestock.

**Table: Detail of Potential Groundwater Zones in Spate Region of Sindh**

Districts	High	Medium	Low	Poor	NA	Total (000 Ha)
Dadu (Jamshoro)	289.2	00	2	145.1	982.2	1418.2
Karachi East	00	00	37.9	23	127.5	188.4
Karachi West	00	00	20.8	7.9	49.9	78.7
Larkana (Shahdad Kot)	69	00	00	00	119.5	188.5
Thatta	20.3	00	4.1	60.4	165	249.7
Total	378.4	00	64.9	236.4	1443.9	2123.5

Source: PARC, Islamabad, 2009

### 6.5 Environmental Aspects of Spate

Poor status of vegetation coverage in watershed/ catchments results in heavy sedimentation through spate flows and causes issues in command area and ponds. The absence of check dams on the way down stream causes erosion and damages resulting in degradation of soil and vegetation. The speedy flow damages the river and canal banks and sometimes deepens the river bed and field inlets become elevated making it difficult or even impossible to divert water to fields. Long intervals of rainfall and drought cause adversely the rangelands and ultimately poor livestock conditions. On the other hand speedy passing of flash flow does not contribute much the aquifer replenishment. There is another side of the picture too; water discharge from a newly constructed or under construction storage dam is without sediments and will not contribute to field



fertility. Similarly the controlled flow of this clear water supplied to command area through lined canals will have a minimal effect on ground water recharge and rangelands development, which could otherwise have occurred through free flow. This scenario needs rethinking while moving to new strategies of making storage reservoirs. Instead of concrete storage dams, diversion structures, whether earthen or concrete, are considered more useful, economical, environment friendly and according to local need plus.

Long periods of drought causes land degradation through wind erosion, decreasing of vegetation cover, weakening of field embankments, evaporation of ponds, drying of shallow wells, decreasing flow of springs and base flow of ephemeral rivers. To overcome environmental problems, spate irrigation as a holistic approach needs to be strengthened through institutional support and community participation. For which the scope and need is essential now than ever before. This will be beneficial by producing livelihood opportunities on a larger scale to the poorest communities in the province, environmental improvements, recharging of aquifer, filling of ponds for domestic and livestock use, supply of fuel wood, fodder for livestock and availability of non-timber forest products. Overall, it will create micro climatic zones to facilitate the appropriate farming practices locally.

## **6.6 Poverty and Social Aspects**

According to a study (SDPI 2012) poverty is a major issue in rural Sindh where 50% of the population lives below the poverty line. Here per capita income is low, caloric intake is less than requirement, access to education, sanitation and health facilities is inadequate, unhygienic environment and insecure access to natural resources prevail. This is the widespread situation throughout rural Sindh. Generally in rural zones barrage areas within Shahdad Kot, Dadu, Jamshoro, Thatta, Khairpur are much better off than spate irrigation areas. The spate irrigation areas within these same districts illustrate the worst picture of poverty and vulnerability due to their specific agro-ecological conditions, i.e. during drought times and flooding periods. Here more than two thirds of the population can be classified as economically vulnerable and low income groups are predominant. The Tharparkar district is the least developed district in the province. Hence, these areas need special attention and development strategies and spate irrigation development has the potential to reduce poverty and enhance socio-economic conditions.

The spate irrigation particular sites and districts are among poorest areas in the province. These areas lack basic facilities such as education, health, roads, safe drinking water supply, extension services etc. Literacy rate is low especially among women. Marketing facilities are inadequate and local produce are priced less. Unemployment is higher as industrial and manufacturing services are not available and income from traditional and local resources is low and irregular. Local populations don't have adequate financial and organizational resources in order to be able to develop spate irrigation by themselves. Some small sites have the potential to develop irrigation using dug wells or tube-wells, but financial resources are insufficient to begin such activities. Likewise farmers are hindered by the availability of funds to construct permanent or improved diverting structures to bring spate flows for use. These areas are also politically weak and thus can't influence political leadership to get their help for spate irrigation improvement through government. Since spate farming is presently

considered a low income activity it does not draw any substantial investment by wealthy individuals or investment groups.

**Table: Deprivation Ranking of various Districts in Sindh Province**

<b>Districts</b>	<b>Provincial rank order 1 = least deprived 16 = most deprived</b>	<b>National rank order 1 = least deprived 100 = most deprived</b>	<b>Deprivation scale (1-100)</b>
<b>Low deprivation</b>			
Karachi	1	1	1.0
Hyderabad	2	12	56.3
<b>Medium deprivation</b>			
Sukkur	3	21	65.7
Larkana	4	27	69.7
N.Feroze	5	28	70.4
Nawabshah	6	29	74.7
Khairpur	7	38	75.8
Dadu	8	39	76.3
<b>High deprivation</b>			
Shikarpur	9	44	77.9
Sanghar	10	47	78.8
Mirpurkhas	11	52	81.0
Ghotki	12	59	84.8
Jacobabad	13	63	85.7
Badin	14	76	92.4
Thatta	15	78	94.7
Tharparkar	16	84	100.00

Source: SPDC 2001 Estimates Based on Population and Housing Census 1998

## 7. Climate Change and Spate Irrigation

Climate change is influencing rainfall and precipitation. Pakistan's water resources are the direct outcome of rainfall, snowfall and melting of glaciers. Presently these resources are under stress due to changes in climatic conditions. Spate irrigation is characterised by great variation in spate flow magnitude and timing. The year to year change in spate flows emerging from ephemeral rivers is a outcome of the influence of climate change. At the same time, spate irrigation is a typical strategy of adaptation practiced by local farmers for many centuries as a response. The different timings (early and late occurrence) of spate flows determine the use of different tillage practices and selection of crop varieties accordingly. Fortunately local cultivars are capable of absorbing to some extent such climatic shocks, whether dry spell or over irrigation. However, there is a need to further improve such research according to spate irrigation and agriculture. Local techniques of coping with such phenomena are unique and could be copied by farmers using canal irrigation.

In spate agriculture the single irrigation is pre planting and there are no further chances of irrigation. To possibly avoid the stress of aridity during crop timings, more focus is on simple soil moisture conservation techniques. Modification of cropping calendars, i.e. timings and location of crops is a key element of the adaptation strategy applied by local farmers though still there is a lot of room for improvements.

Under the present water management system, the low and medium flash flows are used by local farmers but they can't use high floods. Such climatic impacts need to be addressed by diverting these high floods to lands having no irrigation rights under normal spate farming system. This will result in spreading water to rangelands, recharging aquifer and conserving land from degradation. Anticipating spate flows for the coming season, local farmers develop lands, eradicate unwanted vegetation, strengthen field embankments, clear water ways, plough lands in advance to allow the flood flow to infiltrate and thus save lands from further degradation. If spate irrigation development is neglected at the institutional level, out migration, leaving lands barren and desertification could result.

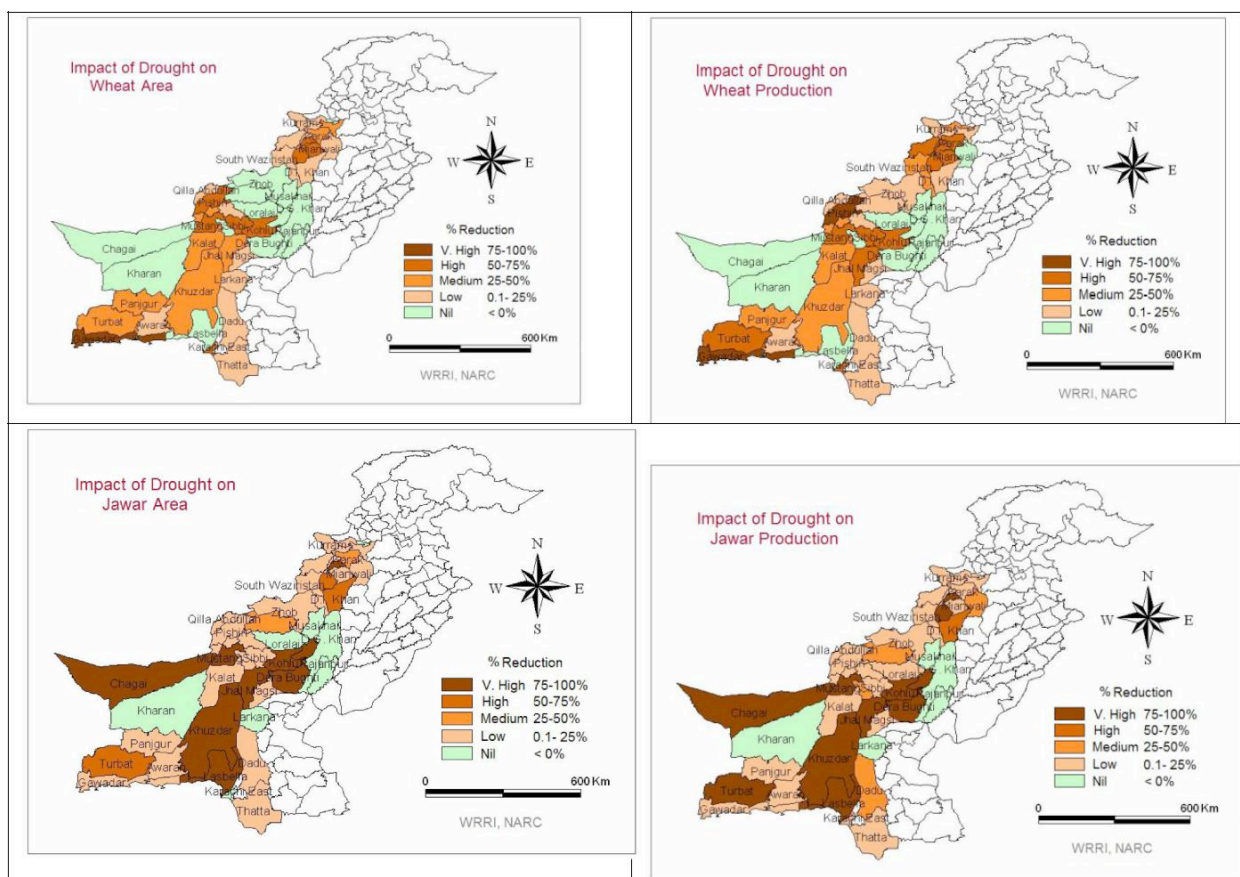
## 8. Drought Effects in Spate Areas of Sindh

During the drought (1997–2003) in spate region of Sindh, the rainfall recorded in some areas was of a medium level (25–50%). Though the volume of rainfall was reduced but it occurred in time and did not result in a reduction in crop production proportionate to the decline in rainfall. This significantly strengthens the argument that, to an extent, spate irrigation can alleviate rainfall stress.

Drought influences the whole spate irrigation system. The low rainfall brings smaller flash flows, thus irrigation coverage is less and inequitable, i.e. only the upper parts of command area can receive water and sometimes this flow is not enough for crop maturity. Spate irrigation is often thought of as being uncertain and unreliable. PARC studied the well-known drought of 1997–2003 in Rod-Kohi regions of the country. During the drought (1997–2003) in spate region of Sindh, the rainfall recorded in some areas was of a medium level (25–50%). Though the volume of rainfall was reduced but it occurred in time and did not result in a reduction in crop production proportionate to the decline in rainfall.

This significantly strengthens the argument that, to an extent, spate irrigation can alleviate rainfall stress. Similarly, when we look at two major crops of spate agriculture (sorghum and millet), there was more or less a similar pattern of drought effect on production, area and yields in all spate irrigation regions of the country. In most of the spate areas the yields of these crops indicated a reduction within 0.1 to 25 percent range. During a field survey local farmers mentioned that deep water ponds retained water during the drought. This clearly indicates that it is crucially important that ponds are designed to be deep enough in order to decrease evaporation. Kohistan region of Sindh provides ample opportunities and suitable sites where heavy spate floods can be diverted to natural depressions and pond sites to store water, which otherwise would have caused disaster. Spate irrigation in regions like Kohistan could provide the opportunity to mitigate floods and the water stored in ponds and spread to vast areas for rangelands and later the reserve could provide a resource during periods of drought.

**Maps: Showing the area and yield during drought in Sindh (1997-2003)**



It is found that there is unique characteristics of spate farming in Sindh with respect to drought coping strategies used by local population. When local farmers anticipate a yield reduction they might cut the fodder of sorghum, maize and millet before maturity. They store fodder for their domestic usage and the remainder is marketed in urban centres and fetch a reasonable income before their usual income cycle. After cutting fodder, they plough the field and plank it to conserve the moisture and seal the upper soil against voids. At the right time they sow the seed for the crop which is usually chick pea, lentils, barley and few

others. Any meagre amount of winter rainfall helps a lot to mature this crop. Such strategies help local farmers survive during drought situations. Government agencies could help them to use underground water resources to supplement irrigation and bring lands under agriculture using wells operated by solar or wind power. Use of ground water resources on a moderate scale using alternative energy, surely could be a good option to help farmers absorb the stress of drought and enable them to remain engaged in their usual livelihood activities and avoid out migration.

## 9. Crops in Spate Areas of Sindh

Spate agriculture is subsistence and unique in nature. Indeed spate agriculture provides opportunities for some crops which otherwise can't compete with other crops in canal irrigated areas. For example sorghum, millet, chick peas, lentils, coriander and oil seed crops have competition with high yielding cash crops like rice, cotton, sugar cane and wheat. Most of the canal irrigated areas covers such cash crops and only spate and rain-fed areas are left to accommodate these crops of lesser yields.

There is single pre planting irrigation and crops become mature on limited soil moisture. Any rainfall during cropping season is a bonus. It is environment friendly and low cost. The seeds are mostly indigenous, and well adapted to local environment. However, yield is less, mainly due to insufficient soil moisture under present land husbandry practices. In spate irrigated areas of Sindh, among crops, cereals have 60% share. The Rabi crops include wheat, barley and oil seeds and Kharif season covers sorghum, millet, and chickpeas. There is considerable variety of minor crops of different types such as sesame, coriander, Guar bean, *Mong* beans and other pulses besides some vegetables too. Local farmer also sow organic vegetables – both for self-consumption and market. There are also wild and semi-wild varieties (wild Tinda) of vegetables grown in spate areas. People also harness non-timber forest products from spate areas such as resin, mushroom, honey and various medicinal plants. Per acre yields for sorghum are about 298 Kgs, 204 Kgs for oil seeds and 567 Kilograms for wheat. The figures of production vary from year to year. During field survey of 2015 in Manjhand, district Jamshoro, yield for cowpeas has been recorded as 500 kg per acre referring to previous year (2014).

Main reasons behind low production include improper soil moisture conservation, low quality and incompatible seed for drought resistance and shallow depth ploughing. However, it provides substantial food requirements for local population. Sorghum no more used as major part of daily staple food but is utilised in poultry and livestock feed industry and heavily contributes in this sector at country level. Similarly pulses provide substantial share for country needs. Cluster beans are almost exported and used in various industries. Their local use is as vegetable and animal feed on a very low scale. It is worth to note that straw of guar beans, cowpeas and other pulses is most favourite animal feed at local levels and fetches higher prices than wheat straw. This directly contributes towards growth of livestock economy. Spate agriculture provides pure organic commodities – free from pesticides and chemical fertilizer. Thus its economic value should also include environmental value. This will give it edge over other agricultural commodities of non-organic nature.

Pakistan Agricultural Research Council has developed some crop varieties suitable for spate agriculture. The optimal level of production is possible when irrigation structures to divert spate water to field are in place and functional, soil moisture conservation techniques are applied and other necessary measures are taken during cropping period. Besides this, supplementary irrigation provision in the form of wells and chances of second spate irrigation will ensure optimal production, and also will be helpful at critical stage of crop. High value crops can be grown easily and their marketing needs to be promoted as organic food commodities.

Spate agriculture only depends upon occurrence of flash flows and conditioned with functional diverting structures. Presently traditional irrigation structures are not fully appropriate and need scientific modification and required external support. The spate agriculture can easily be promoted through supporting construction of irrigation structures, new seeds suitable for such ecological conditions and better extension services.

## **10. Spate Structures & Facilities in Sindh**



### **10.1 Structures and Facilities**

Traditionally spate flows are diverted, instead controlled or stored, through earthen structures built by local farmers jointly across the ephemeral river at appropriate sites. These structures are made of soil, boulders and sometimes brush wood too. Spate flow is then guided through channels/canal to command area. In some cases natural passages are there to guide flow from Main River to fields. Upon irrigating field on one and/or both sides then this structured is breached and water is gain diverted through another diversion structure and so on. Such structures are common at small and medium ephemeral rivers. These structure require seasonal repair and maintenance. They are not strong enough to withstand extra water force and upon breaching heavy souring and erosion take place. Farmers have to spend lot of efforts to construct and reconstruct them on regular basis.

Pakistan Agricultural research council have constructed appropriate civil structure (cement, stone, and reinforcement concrete) and other measures to improve the spate flow diversion and application at field level. These are small and medium level structure, simple in design, low in cost and easily can be replicated by local expertise.

In case of modern spate irrigation schemes, focus is on concrete storage dam and then is discharged towards command area through canals. These schemes are made on lines of perennial schemes and by pass the traditional spate irrigation features where water rights are more important. These schemes are made by government departments. The Small Dam Organization intends to work on such projects.

The newly built Darawat dam has resulted to block spate flows to downstream areas and farmers have now installed lift pump from the main reservoir in order to irrigate their lands which are not in newly designed command area.

	
Darawat Dam	Pump installed in Main reservoir by downstream farmers who are deprived of their water rights

The approach of storage dams on Spate Rivers blocks the access of water to downstream users. The approach to address hill torrent flash floods is conventional civil engineering where storage dam seems best option to engineers. Storing spate flows have been failed in many locations in the country as spate flows carry heavy sediments load. Storage dams also restricts the command area and downstream farmers in certain cases are deprived permanently. Since there is no department within province deals solely or partially spate irrigation as a sector and thus lacks the institutional knowledge on this sector. Under participatory approaches of irrigation management it is vital to include community aspects particularly involvement of farmers, so as to counter the tendency for decisions to be made on narrow engineering grounds.

In the Kohistan region various organizations have worked on water resources development, though on a limited scale. Some time ago SAZDA installed tube-wells to provide drinking water.

The Pakistan Agricultural Research Council has completed two projects in Rod-Kohi areas of Pakistan: i.e. Rod-Kohi System Development and Management and the National Rural Development Program (NRDP). Drawat Dam on Baran Nai, a large spate river, has been completed by WAPDA but is still not functional, whereas Gaj Dam is under construction on Gaj Nai in Dadu District.

## 10.2. Basic Design Principle - At Field Level

Basically, a spate irrigation system consists of:

- Water, after diverted from the Ephemeral River must be distributed on the field. There are four methods (two groups) to do that:
  - *field-to-field distribution* or *individual field distribution*
  - Water is diverted to a group of bunded fields.

As soon as enough water is applied, the operator cuts the downstream field bund. This is repeated until all fields are irrigated. Individual inlets from secondary or tertiary canals have higher control on irrigation and single fields

can be watered as desired but more construction and land use for canal is necessary.

- *extensive distribution or intensive distribution*

Extensive: one single irrigation is common over the whole surface

- Intensive: fields may be irrigated twice or three times before cultivation when floods are concentrated on a small area

Both types can exist in the same system and are dependent on the moisture holding capacity of the soil and crop.

If it is watered intensive, crop must be well adjusted to moisture stress.

### 10.3. Features of Perennial (dam) and traditional Spate irrigation Structures

<b>Perennial Irrigation Modern storage Dam</b>	<b>Traditional Diversion Structure</b>
Secure supplies – provided dam has reasonable catchment and manageable sedimentation	Insecure supplies unless combined with groundwater irrigation
In shallow dams high evaporative losses, in deep reservoirs not too much	Water storage in soil profile/ shallow aquifer – low evaporation losses
Investment costs per m <sup>3</sup> stored is high	Investment cost per m <sup>3</sup> stored is low
Sedimentation may cause siltation (and prevents recharge)	Sedimentation contributes to fertility
Can store peak flows	Cannot utilize all peak flows, but shallow reservoirs may be added within command area
Modernisation often enlarges diversion volume, this leads to upstream/ downstream conflicts. Social settings and water rights should be considered (regional and local regulations).	Equity issues are dealt and water rights are secured



#### 10.4. Spate Flow and Diversion structures in Sindh



A traditional Free Intake from river to field made of soil – Jamshoro District



Photo: Low cost permanent structure to pass spate flows into fields can easily be controlled by putting wooden planks across it.

A low cost masonry stone work to divide spate flows – Designed and made by PARC in Dadu district.



Photo: Low Cost Permanent Structure – filed to field irrigation are found extremely useful and economical for spate irrigation.





### 10.5 Options for Engineering Structures in Spate Irrigation

Category	Structure	Notes
Diversion	Weirs	Create additional head and stabilizes the river bed - but siltation in front of the weir is almost inevitable - and small earthen/ gravel/ brushwood structures are often required in the end  Cut off weirs should be provided with weepholes as they may interfere with the subsurface flows
	Flow dividers	Useful to keep flows in manageable proportions - need enough protection to avoid damage
	Deflection spurs	Common higher up the river/ gravel fans Catches parts of the flood - and in case of high flood can be overtopped and exclude the large flood
	Gravel dykes/bunds	Suitable to divert flows towards intakes and can be alternative for permanent weirs (but need rebuilding) Reinforcement with gabions or abutments Often at angle
	Soil dykes/bunds	Suitable in lowland alluvial spate systems: low cost Location and choice of material is important (silty-loamy, non-saline) Reinforcement by gabions, plastic sheets, brushwood or pegs Often build at angle
	Conical abutments	Can protect intakes or heads of spurs and stabilize soil bunds
	Breaching bunds	Will act as 'fuse plugs' and break and allow large floods to pass and save main infrastructure and command area Avoid having breaching bund high up the gravel fan as they may break too fast - proper location is in plain areas
Intakes	Multiple	Preferred so as to minimize conflicts and

	intakes (and short canals)	management problems
	Open intakes	Large dimension - so as to pass large volume of flood water in short time Curved wing-walls preferred
	Orifice intakes	Will make it possible to exclude unwanted large floods
	Gated intakes	Can allow closure of area if it Mechanical operation may be difficult and mechanical operation is expensive
	Rejection spillways	Allows rejection of destructive floods
	Scour sluices (preferably with curved skimming weir)	Can work but are often closed by farmers as they do not want to loose water
	Sedimentation ponds	In most these do not work - as cleaning and flushing is cumbersome and farmers do not want to 'spend' water on this
	Trash racks	Put at angle so trash is guided to main river Need provision to clean as large trash catches smaller trash
River bed stabilization	Bed stabilizer	Make sure weepholes are provided to allow subsurface flows to pass Masonry: steep river slopes Gabions: flat river slopes
	Gabion spurs	Location and shape is important to avoid loss of area or undercutting over river bank Stepped nose to avoid scour around nose
	Revetments (several materials)	Important to have strong undertoe
	Vegetative bank protection	Can be natural or planted - needs protection against cutting/grazing
Canals and command area structures	Steep channels	Preferred in upstream areas with heavy sediment load to carry fine sediment all the way to fields (for slope look at natural drains)
	Shallow wide channels	Preferred in downstream areas with soft alluvial soils to prevent uncontrolled scour
	Stepped drop structures	Effective in dissipating energy In general try to avoid drop structures - can sometimes be avoided by using a different channel route
	Gabion flow division/diversion	Ensure that downstream apron of gabion structure is long enough to avoid back cutting Can stabilize the bed of the flood channel

	structures	
	Flow spreaders	Will spread flow at end of lined channel to avoid scour and ensure water is distributed over large section
Field structures	Improved field intakes	Allows closure of field after it is filled with water
	Overflow structures	Useful if there is level difference between to prevent uncontrolled gully in downstream field
Groundwater management	Low recharge weirs	Will reduce velocity of flows and induce recharge

## 11. Issues and Gaps in the Spate Irrigation System in Sindh

### **Water Availability and Its Use**

- Sindh has a huge potential of spate flows, i.e. 0.5 million acre foot annually even in medium rainy year, but this water is not used optimally and as a result are causing scouring, erosion and damage to costly infrastructures, settlements, lands and other properties.
- Where wells are installed in spate areas it has been observed that the water table is going down, a situation which worsens during drought and times of decreasing rainfall. No comprehensive studies have been undertaken to investigate the potential to conserve and recharge underground water by controlling the peak of flood through diverting and spreading spate flows.
- No diversion structures (*Ghandho*) for irrigation exist on main torrents and water just flows downstream into major water bodies causing damage instead of providing benefits. There is an absence of additional techniques and infrastructure, in particular flood breakers, subsurface dams and sand dams. Local made diversion structures are easily washed away and repair/maintenance cost is not affordable by farmers.
- The single intake (*Rakh*) from main river/canal to field and then to another field is generally inappropriate in the case of larger spate flows. Present field to field level irrigation by breaching the embankment is highly inefficient, time consuming and risky.
- No rules exist at either government level or among community members to maintain and observe a suitable distance between wells in order to minimise the draw down.

### **Land Use**

- Just looking at the Khirthar region where 1.1 million acres is under rangeland, because of current precipitation rates the land's carrying capacity is decreased<sup>3</sup>.

<sup>3</sup> (Pakistan Agriculture Research Council, Islamabad 2010)

- Modern scientific soil moisture conservation techniques are not practiced adequately and crops experience intense stress and therefore their yield is low.
- Simple methods of deep ploughing through appropriate tillage can increase the soil moisture retention period.
- Uneven fields result in uneven moisture levels in different parts of a field and increase the time it takes to pond the field. Since the spate flows last for a few hours to a few days only they need to be utilized quickly, otherwise they are wasted.
- Sediments cause the field beds to be raised year by year and it is necessary that this problem is managed simply and economically.
- Provision of earth moving machinery to construct earthen structures and field embankments at peak timings is a serious issue and needs government intervention and support.
- Seed from the previous year's crop is kept without grading it, or treatment and proper packing and storage and usually is not even enough for new season. Having no option of using indigenous varieties, farmers are compelled to use exotic varieties (from canal irrigated agriculture) which are not compatible to spate agriculture and their yield is poor.

### ***Institutional Aspects***

- There is no disaggregated data prepared and maintained specifically about spate irrigation resources, water rules, rights and related aspects as is available in the other three provinces through provincial revenue departments. Spate agriculture lands are not mentioned as a separate category in cadastral records and land categories. The Revenue Department does not have spate river maps indicating in detail the irrigation rights boundaries as is done in the other three provinces. This makes it difficult to classify the exact area under spate agriculture or rain-fed. The existing local water rules and rights have not even been codified and included in the revenue record and are not part of the judicial system.
- Under present practices, government annual development programs do not have specific provision to include the development of spate irrigation, agriculture, rangelands and similar development activities. There is no specific development program for research on indigenous seed improvement and local cultivars suitable for spate agriculture.
- There is no indigenous seed bank where farmers can obtain certified seed suitable to drought and moisture stress conditions. Research on soil moisture conservation, spate agriculture related husbandry practices is lacking by the government and the private sector. Additionally, extension services in agriculture and livestock are very weak in spate areas.
- Spate irrigation development requires heavy earth moving machinery for the construction of controlling/diverting structures, de-silting of canals, developing and repairing of field embankments and similar earthen works. Unfortunately government departments are not equipped with such earth moving machinery to support local farmers in time and through subsidies.
- Marketing aspects specifically pertaining to the organic nature of produce from spate agriculture do not prevail as such. Government authentication and certification of organic produce are non-existent on. Local farmers do not know that organic produce as a speciality commands higher prices and

they are compelled to sell their organic produce at ordinary rates and lose what could be a substantial income.

- Rangelands development integrating the livestock sector is a missing link by institutions to address and cater to the needs of spate farming communities and the province as a whole. Integrated approaches are not used for routine development activities to be incorporated into the annual development plan.

## **12. Problems faced in Spate Irrigation by framers**

Following problems are being faced by the farmers of the spate agriculture areas of Sindh:

1. Floods timing and volume are not predictable as early information system lacks at the community level through which information of flash floods can be provided to remote communities.
2. Sometimes prolong drought adversely effects the spate irrigation system – diversion structures, conveyance canals, intakes and fields remain unattended (not possible to maintain), and people migrate to other areas.
3. Locally made diversion structure are not strong enough and washed away easily. It cost a lot to reconstruct. There is no provision of government support in the form of earth moving machinery.
4. Water from large ephemeral rivers cannot be optimally diverted by locally made earthen structures and at the same time no permanent diversion structure is made by government
5. Some rivers bed and conveyance channels/canal have gone steep due to scouring and erosion and it becomes difficult to divert water.
6. Present practice of field to field irrigation through cutting embankment is inefficient and its reconstruction is costly (intake structures).
7. No scientific knowledge available for soil moisture conservation in the fields and crops comes under water stress.
8. Local seed of crop is of poor quality. Drought tolerant seed varieties are not available in local market. Farmers also lack knowledge about improved varieties of crops, vegetables, fruit trees, fodder suitable under arid conditions
9. Farmers are not aware of new water efficiency technologies and methods
10. Rangelands are in poor condition as spate flows are not diverted there.
11. Absence of vegetation coverage increases erosion, creates sediments and canal are choked sometimes.
12. Drinking water for human and livestock is not enough, poor quality and accessibility is difficult.
13. Investment to install tube well and alternative energy unit for using ground water is not affordable by majority of farmers.
14. Organic produce of spate agriculture is not recognized for additional value/prices in markets and among consumers.

### 13. Conclusion and Recommendations

The development of alternate water resources is key for self-sufficiency in the province to meet growing needs of the food security and other uses. Spate areas in Sindh are mostly least developed. The unique nature of the flash floods produced by hill torrents and development of its potential depends upon many factors including hydrology, catchment area characteristics, terrain and land potential, recharging aquifer prospects, water rights and uses, development potential and indigenous practices. Indigenous knowledge and practices are vital aspects of this sector and we need to understand them before planning and addressing the hill torrent and spate irrigation sector. These areas have large piedmont plains with fertile alluvial soils where sustained irrigation systems can be developed. There is enough potential of developing new lands around current irrigated fields, once spate irrigation structures are established.

The establishment of new structures should easily cater for these new lands without compromising the irrigation rights of existing lands. Perennial flows of some of the major hill torrents are presently being used for irrigating the lands. Under this category, there is already a well-developed system of irrigation with specific water rights for use of perennial flows. It is anticipated that improve management of spate system will increase the base flow of river and recharge springs. On a limited scale local farmers have installed tube-wells, dug wells, developed embanked fields, ponds, diversion embankments, and other related work on their own initiative. However, there is a large scope for further extension and development. Farmers cultivate their lands using various water sources. Wells are considered a reliable source but are costly to operate especially as a falling water table is witnessed during prolonged drought. The spate flows can very economically contribute to recharging ground aquifer.

- To start any spate irrigation development program a separate detail study is needed according to a particular spate river characteristics, water rights, land tenure and poverty aspects.
- Spate irrigation project must have integrated approach to cover water, soil, livestock, human resources development, gender and off far activities.
- Under an integrated development approach both upstream (watershed/catchment) and command area need to be developed at the same time in order to foster sustainable development.
- While planning for modern spate irrigation scheme (structures like dams and weirs etc.) care must be taken for downstream water rights and equity issues under local practices.
- Revenue department needs to codify the water right and local rules pertaining to spate irrigation system in the province. Area and crop irrigated through spate should be separately categorized in revenue department and its annual reports. For effective management and utilization of spate water, revenue department should have responsibilities like it prevails in other three provinces.
- The low cost solutions like simply diverting water, guiding and spreading it on wider areas for agriculture, rangeland development, storing for livestock and human consumption and recharging aquifers are preferred over costly solutions like making dams and reservoirs.



- The spate irrigation system generally works well during low flows, but it fails in the event of high flood peaks. The system needs to be improved to cater for flood peaks or at least can be bypassed elsewhere without damaging the area. Guiding and diverting spate flows through low cost but improved designed structures in these areas would not only help in the development of sustained irrigation system there, but would also save costly infrastructure from frequent flood damages and the same will help recharging aquifer.
- Flood flow distributors/dispersion structures can be constructed over most of ephemeral rivers/streams in all these areas to distribute/divert flows to the channels finally bringing additional area under cultivation.
- Care must be taken to establish and strengthen local water user association/farmer organizations to supervise and manage these spate flows according to local rights.
- Government support is required for farmers in preparing seasonal structures (diversion, distribution pints, intake, outlet, point etc.).
- The newly developed Darawat dam has accumulated water but not yet been irrigating the command area. There is high need to design and implement a command area development project by any appropriate department, i.e. Agriculture department to cater the extension and research services to farmers. This area will be key site to provide dairy, meat, fodder and fresh vegetables and fruits to biggest market (Karachi)
- Small Dam Organization and professionals of ONFW should be given orientation, training, exposure of spate irrigation projects in other provinces so that similar work can be initiated in Sindh. Professionals should be trained in this field in the province.
- Early information system of spate flow occurrence need to be developed and implemented for area farmers.
- Small and simple meteorological setup are needed in upper catchment for weather information recording in order to have authenticated information.
- Alternative livelihood opportunities needs to be planned such as wind/solar energy to use ground water during non-occurrence of spate flows in order to stop out migration.
- Spate agriculture areas don't have round the year cropping and training program for population are required for off farm income generating activities to supplement the income.
- Spate development program are needed by government, donors and NGOs to demonstrate the improved diversion structures, inlets, dividing structures and other civil work.
- Earth moving machinery should be available by government departments under subsidies rates (there is a subsidies program already but spate farmers need priority for it).
- Rangelands needs to be developed through use of spate water. It will also decrease the erosion and sedimentation.

- Spate irrigation should be used for aquifer recharging, wherever possible, through low cost measures instead of letting it pass to any major river body (ocean/lake).
- Local capacities need to be developed/upgraded for construction of improved structures, soil moisture conservation and other land husbandry skills.
- Farmers groups need to be strengthen to work as farmer organizations to look after spate irrigation system.
- Research needs to include improved varieties suitable for arid conditions.
- Farmer field school approach from should can be applied for spate irrigation/ agriculture.
- Demonstration activities/trials for different crops, soil moisture conservation, and introduction of improved varieties are required to increase productivity.
- Farmers need to be sent for study/exposure tour to other spate regions within country to see, share and learn new things.
- Women need to be involved in skill development for income generation activities based on spate framing system.
- Skills need to be imparted for quality seed preparation by farmers themselves.
- Government (federal, provincial and local) annual development plans need to incorporate spate irrigation projects/schemes in the province.

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## **Annex Terms of Reference**

### **Research Study The Potential of Spate Irrigation in Sindh**

#### **Background**

Compared to other parts of Pakistan, spate irrigation in Sindh is not well-known nor well developed. It has less of the long history that spate irrigation has in Balochistan or the western part of the Indus areas in KP and Punjab. Spate irrigation in Sindh occurs in Thatta, Jamshoro and Dadu and some other isolated pockets. It is in some areas combined with groundwater use, but in other areas it is based on the hill torrent water only. In some areas spate irrigation is threatened by the construction of dams on the mountain streams without taking into account the existence and potential of spate irrigation systems.

#### **Assignment**

In the assignment the potential of spate irrigation in Sindh will be researched on documented. This will be done through:

- Group interviews with farmers
- Discussion with NGOs and community organization operating in the area
- Interviewing relevant government staff
- Review of grey literature, reports and data records

The research is to cover the main research themes of the Asia to Africa and back Program, i.e. efficient irrigation, moisture conservation and water conflicts. The topics in the research study in particular are:

- Prepare comprehensive assessment
- Main stream and flood patterns, incl link to groundwater
- Main infrastructure
- Current use
- Current governance
- Poverty and inclusiveness dimension
- Climate change
- Option and recommendations

Apart from undertaking the study and preparing a easy-accessible document on it, in the assignment the following is to be achieved:

- Introduce the work of the Spate Irrigation Network and the '*Africa to Asia and Back Again: Testing Adaptation in Flood-Based Farming Systems among stakeholders in Sindh*'
- In close co-operation with the Pakistan Chapter of the Spate Irrigation Network, Identify partners among NGO community and Universities in Sindh that are willing and able to promote spate irrigation