Rod Kohi Irrigation System in Southern Punjab

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Organization of presentation

- Pakistan’s water situation
- Potential of Rod Kohi system
- Rod Kohi irrigation System overview
- Challenges of Rod Kohi system
- Problems of Rod Kohi System
- Mithawan hill torrent, study area
- Study area characteristics
- Farmers response survey
- Possible solutions
- Conclusions
- Recommendations

Pakistan's Water Situation

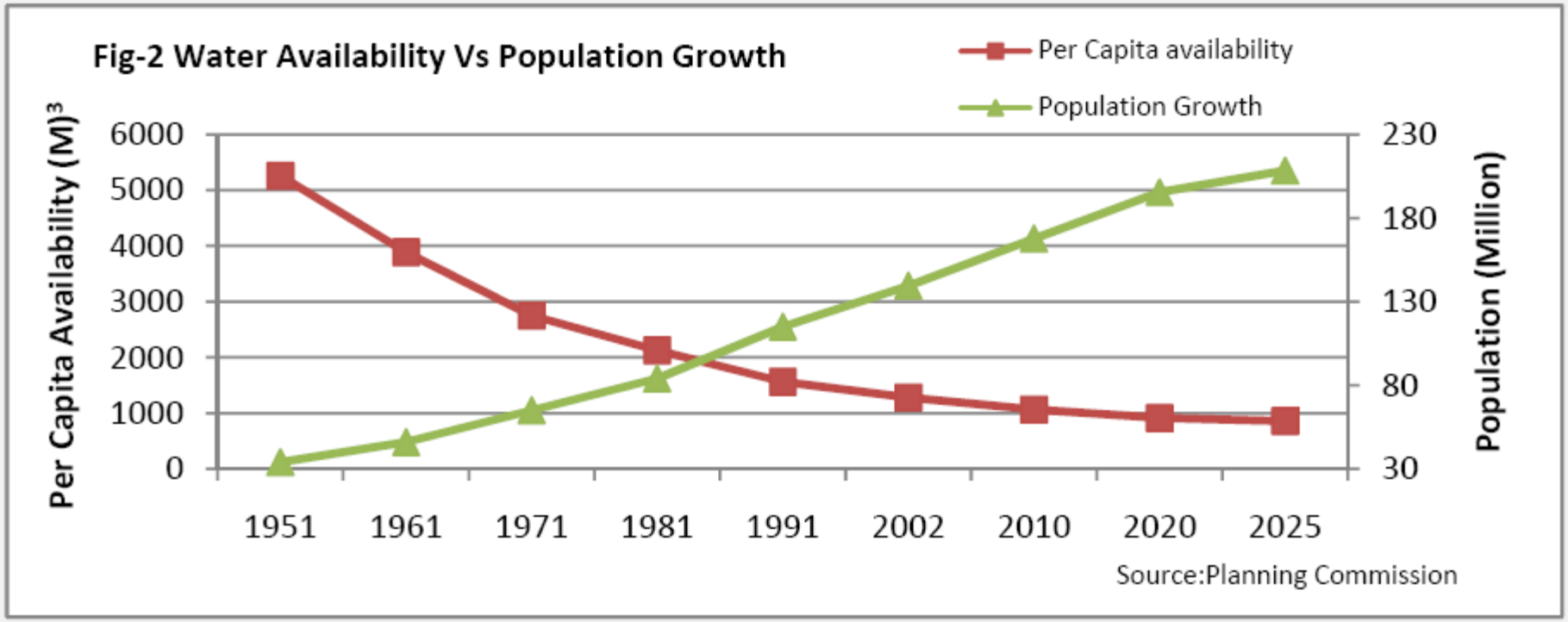


Table-3: Water Scarcity Indicators (Faulkenmark Indicator)	
>1700M^3/Capita	Water Scarcity Rare
<1700M^3/Capita	Country faces seasonal or regular water-stressed conditions
<1000M^3/Capita	Water shortages hamper the health and well being of the human beings-Economic activities are affected
<500M^3/Capita	Shortages are severe constraints to human life

Source: IRSA

Source: ESP, 2009-10

Annual Flow of Major Rivers: Climate Change Effects

River	Average Annual Flow (1922-61) MAF	Average Annual Flow (1985-95) MAF	Average Annual Flow (1996-2000) MAF	Average Annual Flow (2001-08) MAF
Indus	93	62.7	61.07	57.35
Jhelum	23	26.6	21.00	18.87
Chenab	26	27.5	26.81	22.97
Ravi	7	5.0	2.11	2.55
Kabul	26	23.4	19.42	19.10
Total	189.0	148.8	130.41	120.84

Source: Flood Forecasting Division, Lahore, 2009

Climate Change Effects on Indus Flows

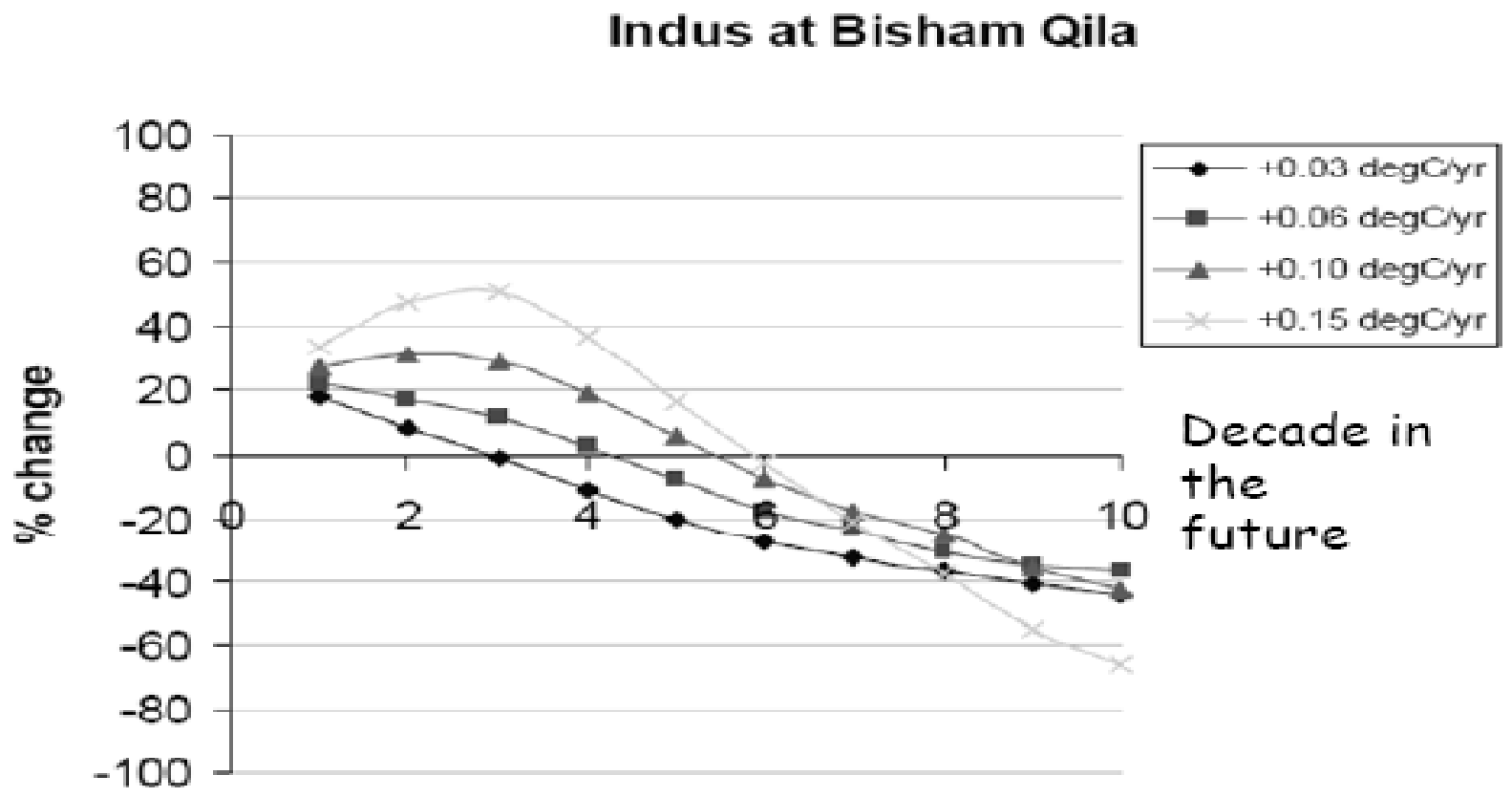


Figure S8: Predicted changes in Indus flows just above Tarbela

Source: Rees, 2005

Source: WB, 2005

Surface Water Availability

Table 2.4: Actual Surface Water Availability (Million Acre Feet)

Period	Kharif	Rabi	Total	%age incr/decr. Over the Avg.
Average system usage	67.1	36.4	103.5	-
2003-04	65.9	31.5	97.4	- 5.9
2004-05	59.1	23.1	82.2	- 20.6
2005-06	70.8	30.1	100.9	- 2.5
2006-07	63.1	31.2	94.3	- 8.9
2007-08	70.8	27.9	98.7	- 4.6
2008-09	66.9	24.9	91.8	-11.3
2009-10	67.3	26.0	93.3	-9.9

Source: IRSA

Source: ESP, 2009-10

Situation demands urgent need of water conservation, wherever possible including torrent hills "Rod Kohi"

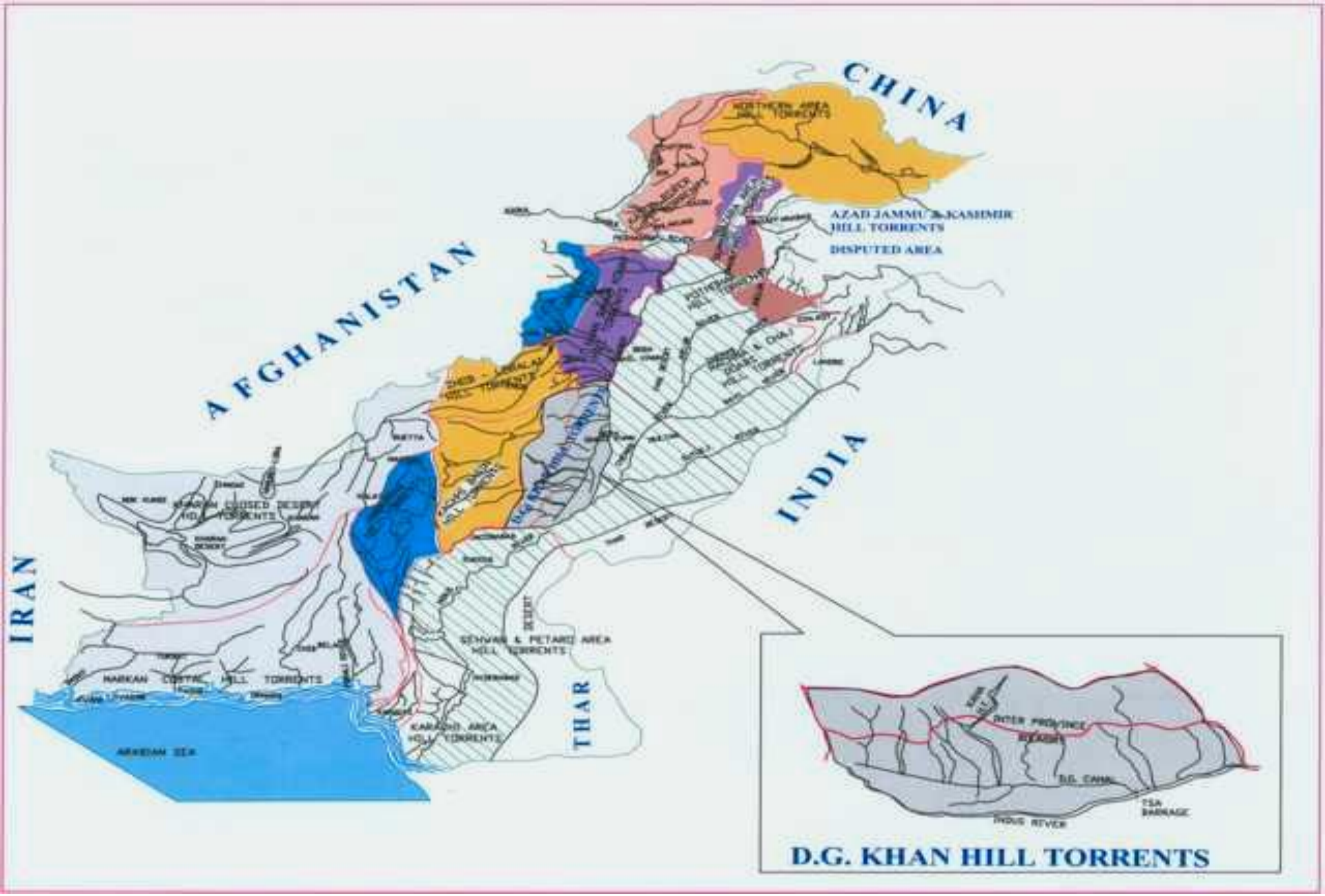
What is Rod Kohi?

- Rod: Water flowing through natural channels called “Rods”
- “Kohi” means mountains/hills
- Rod Kohi: Water coming from mountains as a result of rainfall, which is highly unreliable, short duration, high intensity causing sometimes high speed runoff water from the hills / mountains
- There are about 14 major hill torrents in Pakistan forming the second largest irrigation system after Indus Basin Irrigation system
- Hill torrents command area, forming 11 % of total cultivated area and15 million people are living there

Hill Torrent Potential

Province	Catchments Area (Mha)	Av. Annual Runoff (MAF)	Potential Agri. Land (Mha)
Balochistan	25.4737	0.5 (4.05)	0.69
NWFP	4.3597	0.4(3.24)	0.536
Sindh	3.2314	0.12(0.98)	0.18
Punjab	4.332	0.24(1.94)	0.52
FATA	2.722	0.24(1.97)	0.42
Total	40.12	1.5(12.15)	2.34

Source: NESPAK, 1995



Source: Punjab Irrigation and Power Department

Flood conditions & damages in hill torrents areas

Source: Nawaz and Han,

Unmanaged Non perennial spate irrigation

Managed Non perennial spate irrigation

Source: Nawaz and Han,

Development of hill torrent structures made by PARC

Hill torrents structure built by PARC

Source: Nawaz and Han

Rod Kohi Issues

- Hill torrents are instantaneous and not permanent source of irrigation
- Hill torrents are unreliable
- Hill torrents have high velocity and may cause severe damages if not managed properly
- Farmers build bunds, which are washed away
- Upstream farmers irrigate their fields again and again if there is less rain
- Insufficient existence of control structures

Features of Rod Kohi System

- The hill torrents drain about 55% of the total area of Pakistan (NESPAK, 1995).
- Major part of hill torrents i.e. 50% is wasted because of insufficient torrent management facilities.
- Rod Kohi commands about 2.34 Mha area having catchments area of about 40.12 Mha.
- The average runoff generated is about 1.5 Mha-m (12.15 MAF), equivalent to two large dams.
- Rod Kohi is practiced in districts of Hazara, Bannu, D.I. Khan, Karak, Kohat, D.G. Kan, Kachhi basin, Khirther range, Karachi area, Sehwan and petaro areas.
- The farmers living in the commanded areas of Rod Kohi are poor because of having lower crop yields compared with other areas mainly due to scarcity of water for drinking as well as for agriculture purposes.

Study Undertaken in Rod Kohi Commands

- The Department of Irrigation and Drainage, UAF, conducted the first survey study aimed at assessing the socio-economic conditions of the farmers in relation to Rod Kohi irrigation practices and water availability.
- The study was conducted in 2003-04 at the Mithawan Hill Torrent area in D.G. Khan.
- The study area is located in south west of Punjab under DG Khan and Rajanpur hill torrent.
- Data were collected through farmers interviews and field observations. Twenty respondents were selected and interviewed.

Study Area

- Mithawan hill torrent is one of the 14 major hill torrents of the country.
- Hill torrent emerges from Koh Suleman rage with watershed area of 741 km^2.
- Alluvial deposits with sand, clay, silt, gravel as thin layers.
- Climate is characterized as arid with average annual rainfall of 144 mm, hot summer with maximum temperature of about 48^oC, and mild cold winter.
- Area lies between foothill of Suleman range and DG Khan canal.
- Population of the study area is 0.2 million. Total cultivated area of Mithawan hill torrent is about 11010 ha with arid climate.
- Mithawan hill torrent has erratic rainfall pattern with 25-yr return period discharge of about 2210 m^3/sec (IPD, 2002).
- Groundwater potential is limited but is practiced along the irrigation canal. Rich farmers have installed deep well turbines up to 75 – 100 m depth. Natural drainage is southward along right bank of DG canal, sometimes breaches the canal and causes damages.
- Mostly people live on agriculture and livestock. Crop yields are low. Sorghum is the major crop along with Bajra, Gram and Wheat
- No fixed wara bandi system but farmers understand each other and follow traditional methods “Rewaj e Abpashi”

Education Level of Respondents

Educational Level	*No. of Respondents*	*Percent*
Illiterate	16	72.9
Primary	5	22.6
Secondary	1	4.5

Percent Distribution of Farming Experience of the Respondents

Farming Experience (Years)	*No. of Respondents*	*Percent*
10 to 20	4	18.2
21 to 40	12	54.5
41 and Above	6	27.3

Frequency Distribution of Land Holding Under Rod Kohi System

Range of Farm Size (ha)	*Percent of Total Area*	*Mean Farm Size (ha)*
0.01-5	36.4	2.53
5.01-12.5	27.3	8.26
12.51-25	9.1	15.68
25.01-50	9.1	35.41
50.01-100	4.5	60.70
100.01and above	13.6	134.90

Source: Ahmad and Choudhry, 2005

Frequency Distribution of Land Holding Under Irrigated System in the Punjab

Range of Farm size (ha)	*Percent*
0.01-5	73.66
5.01-10	17.00
10.01-20	7.00
20.01-60	2.00
> 60	0.34

Source: GoP (2003).

Frequency of Hill Torrent Occurrence per Year

Annual Occurrence	*N**	*Percent*
Once	2	9.1
Twice	7	31.8
Thrice	5	22.7
Four times	3	13.6
More than four times	5	22.8

Note: *Number of Respondents.

Source: Ahmad and Choudhry, 2005

Frequency Distribution of Duration of Hill Torrent

Duration (Hours)	*N**	*Percent*
0 to 5	5	22.8
5.1 to 10	12	54.4
10 and above	5	22.8

Note: *Number of Respondents.

Average Yield of Crops (kg/ha) Under Rod Kohi and Irrigated Systems

Crop	*Rod Kohi System*	*Irrigated System*
Sorghum	564.4	615
Gram	575.6	606
Bajra	519.5	604
Oilseed	561.6	835
Wheat	1229.9	2384

Source: Ahmad and Choudhry, 2005

Specification of the Embankments constructed for Rod Kohi Irrigation

Embankment Specification	*N**	*Range*	*Mean*
Height of Embankment (m)	22	0.91 - 2.29	1.66
No. of bunds constructed	22	1 - 15	3.86
Length of bund repaired mechanically every year (m/hr)	22	6.1 - 60.98	34.38
Length of New bund constructed mechanically, (m/hr)	22	1.52 - 18.29	4.07
Cost of bund construction, (Rs/hr)	22	200 - 250	222.95
Change in the height of bund due to silt every year (m)	22	0.04 - 0.46	0.11

*Number of Respondents Surveyed.

Water Productivity Under Rod Kohi Irrigation System

Crop	*Number of Farms*	*Range of Water Productivity (kg/m^3)*	*Mean Water Productivity (kg/m^3)*
Sorghum	5	0.043 - 0.086	0.067
Gram	5	0.056 - 0.094	0.070
Bajra	5	0.049 - 0.086	0.063
Oilseed	5	0.049 - 0.104	0.075
Wheat	5	0.142 - 0.190	0.161

Source: Ahmad and Choudhry, 2005

Assessment of Moisture Deficiency and Depth of Water for Irrigation Application

Field No.	*Soil type*	*Field capacity* (% by vol.)*	*Moisture before irrigation (% by vol.)*	*Moisture deficiency (% by vol.)*	*Depth of water required cm*
1	*Sandy loam*	22	7.58	14.42	19.5
2	Silt loam	32	10.74	21.26	28.7
3	Loam	26	10.99	15.01	20.3
4	*Sandy loam*	22	7.65	14.35	19.4
5	Silt loam	32	10.65	21.35	28.8

Depth of Water Applied by the Farmers as Observed in the Field

Field No.	*Time of App. of Water (Sec)*	*Field Size (ha)*	*Discharge of Channel (m^3/s)*	*Total Volume of Water Applied (m^3)*	*Vol. of Water Applied (m^3 /ha)*	*Depth of Water Applied (cm)*
1	780	2.43	24.04	18751.2	7716.5	77
2	2220	4.25	16.42	36452.4	8577.0	86
3	840	6.07	61.17	51382.8	8465.0	85
4	1680	2.02	12.00	20160.0	9980.2	100
5	780	2.43	24.56	19156.8	7883.5	79

Source: Ahmad and Choudhry, 2005

Irrigation Application Efficiency Achieved Under Rod Kohi Irrigation System

Field No.	*Depth Required (cm)*	*Depth Applied (cm)*	*E_a (percent)*
1	19.5	77	25.3
2	28.7	86	33.4
3	20.3	85	23.9
4	19.4	100	19.4
5	28.8	79	36.5
Average	*23.3*	*85.4*	*27.7*

On the average, hill torrents occur twice a year and 54% interviewees claimed that hill torrents last about 5 to 10 hrs depending on the rainfall patterns.

Irrigated areas of the respondents ranged from 0.2 to 141.6 ha with and average size was19.2 ha/farm. About 41% of the total farmers interviewed had culture able wasteland of about 20.6 ha/farm.

The average yields (kg/ha);

Sorghum – 564.3; gram – 575.6; bajra – 519.5;

oilseed – 561.6; wheat - 1230

Water productivity (kg/m^3)

Sorghum – 0.067; gram – 0.070; bajra – 0.063;

oilseed – 0.075; wheat – 0.161

Source: Ahmad and Choudhry, 2005

Spate Irrigation in DG Khan View

Earthen controlling structure – situation before the spate flood
Source: Karim Nawaz

Spate Irrigation in DG Khan View

Earthen control structure has been purposely breached after feeding the side fields – Jhok Bodo, DG Khan District, Pakistan.

Source: Karim Nawaz

Spate Irrigation in DG Khan View

Typical spate Agriculture fields with mixed crops sown at various stages – DG Khan District, Pakistan
Source: Karim Nawaz

Spate Irrigation in DG Khan View

A wetland and common land flooded through spate flow for common pasture – Pakistan

Source: Karim Nawaz

Spate Irrigation in DG Khan View

Vehova Spate River, DG Khan District, Pakistan.
Source: Karim Nawaz

Spate Irrigation in DG Khan View

Damage caused to infrastructure due to heavy spate flood – Vehova Spate River, DG Khan District, Pakistan.

Source: Karim Nawaz

Climate Change Impacts on Rod Kohi

- This unique system is extremely prone to devastating effects of climate change because it entirely depends on the rainfall.
- Climate change has already decreased rainfall by10-15% in the arid area over the last 4 to 5 decades.
- Climate change induces extreme events of floods / drought conditions.
- An integrated management of Rod Kohi irrigation system is imperative to mitigate the climate change effects by identifying **climate adaptation measures** to minimize adverse effects on land use and water management practices.

Mitigating Climate Change Effects

- Analyze temporal relationship between important climatic variables and water flows “Rod Kohi”.
- Identify change in land use as a result of change in water flows “ Rod Kohi”.
- Assess the degree of vulnerability of agriculture, livestock, and livelihood due to change in climate
- Conduct geophysical survey to select possible site for surface as well as for subsurface storage - ASR Technology
- Prepare Integrated plan to mitigate climate change effects action ensuring reliable water availability for large time
- 1º C increase in temperature increases crop water requirement by 10 % (Bhatti et al., 2009)
- Climate change: CWR↑ ; CY↓

Conclusions

- Rod Kohi irrigation system needs to be promoted because it is not only low cost, environment friendly and people oriented but also conserves land and water.
- Despite its enormous potential, the system has been the most neglected (27%, E_a) and under developed irrigation system because of low investment, poor farmers, lack of improved water management practices, unpredictable, short duration high intensity rainfall and runoff, non existence of control structures, lack of integrated scientific study to improve the system.
- An integrated participatory watershed management, water harvesting on the surface as well as subsurface storages along with improved water diversion control, conveyance and water application techniques need to be investigated based on site specific conditions.

Recommendations

- Water is the prime input to agricultural production for ensuring food security, alleviating poverty and curbing terrorism in the area.
- Remote sensing, GPS, GIS and resistivity survey technologies may be used to identify the potential sites for water conservation and efficient usage.
- All possible integrated measures need to be adapted to ensure reliable water availability to the poor resource farmers by adapting site specific water harvesting, storage, conveyance and application techniques.
- ASR technology also provides an option to store water in the aquifer for longer duration and with minimum water losses base on its site suitability.
- Participatory approach is needed for water conservation from watershed to the field level to practice more crop per drop.

Thanks!