Paper No. 746

HILL TORRENT MANAGEMENT INITIATIVES IN SOUTHERN PART OF PUNJAB AN OVERVIEW, IMPACT ANALYSIS & WAY FORWARD

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ABSTRACT

The southern part of Province Punjab is bordered with Suleman Range on its west side which is extended in length of 360 Kms from Ramak (upper side of Taunsa) to Kashmore (start of Sindh) covering District D.G.Khan and Rajanpur, while eastern drainage body is River Indus. Rainfalls during monsoon months (July to September) in Suleman Range having catchment area over 24500 square Kms generates flash floods known as Hill Torrents (local name "*Rodh Kohie*") with high concentration of eroded material. These Hill Torrents are 200 in Nos., out of which 13 are major. These Hill Torrents after passing through piedmont area (Fan area) known as "*Pachad area*" in a width of 30 Kms to 40 Kms i.e. covering about 34500 Sq Kms (9400 Sq, Miles) crosses D.G.Khan Canal and Dajal Branch through 22 numbers cross structures creates havoc (oftenly) upto River Indus. It damages the irrigated lands, crops, houses and public / private infrastructures, (specifically more recent in years 2008, 2010, 2012 and 2013) causing losses of billion of rupees. On the other hand vast area, about 5,00,000 acres, cultivable rain fed piedmont (*Pachad*) area fails to receive valuable irrigation water. Hill Torrents generally associated with uncertain flood flows have kept D.G.Khan and Rajanpur Districts Hill Torrent fan area socio – economically very weak. Since 1929 Hill Torrent floods to date, number of studies and plans were proposed to control / manage the Hill Torrent Floods. In 1980, Federal Flood Commission of Pakistan (FFC) conducted a detailed study to address Hill Torrent problems in D.G.Khan area and proposed Hill Torrent management plans for each major Hill Torrents. Some initiatives to address the problems at Kaha, Mithawan and Vidore Hill Torrents were taken from 1992-2002. These includes water diversion arrangements and flood protection facilities. On having experience, Government of the Punjab planned to invest further for Hill Torrents management and started comprehensive development projects at Kaura, Vehova and Sanghar Hill Torrents in 2009, improved Kaha Hill Torrent in 2011 and Vidore Hill Torrent in 2012 which are at different stages of completion. These projects have shown tangible results/ benefits in terms of 50% - 60% utilization of Hill Torrents water for irrigation with increased irrigation intensity upto 50% against 8% - 10% existing. Mitigation of moderate to high floods, reduction in damages and up lift in the economy of area and poverty alleviation with positive impacts on environment. This paper covers the over all review of innovations for Hill Torrents management in D.G.Khan area with focus on further potential for sustainability of initiatives to driver full benefits of Hill Torrent water with an enhanced safety against flood hazards.

1. INTRODUCTION

Punjab occupies a pivotal role in Pakistan's economic life and accounts for 80% of Pakistan's agricultural production. Over 90% of the agricultural output in Punjab comes from irrigated land utilizing a major part of its conventional water resources and land.

The agriculture in barren area in 360 Km belt between Suleman Range and D.G.Khan Canal / Chashma Right Bank Canal locally known as "Pachad area" in Districts D.G.Khan and Rajanpur is being practiced as spate irrigation with hill torrent flows of Suleman Range. The flood water in monsoon at one side destroys the infrastructure in D.G.Khan Canal / Chashma Right Bank Canal command area due to erratic nature of flows while on the other side barren land in piedmont area (Pachad area) are deprived off water for agriculture. Mostly these

streams of torrent flows dry up after the rains and their influence is only felt for a few miles below the hills. The torrent water is used for irrigation through a network of diversion and dispersion arrangements by community since centuries.

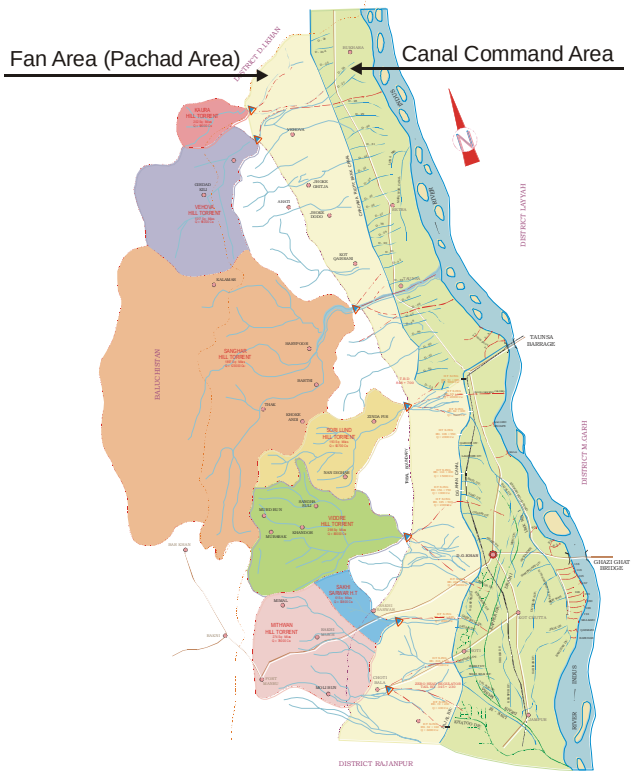
Management of hill torrents had been remained under study to manage and conserve water for irrigation and mitigate flood damages which includes structural and non structural measures. Public investment by Government of Punjab for this purpose is being made since 1992 to date, as this area (Pachad area) has potential prospects for development of agriculture by use of torrent flows, which also mitigates flood hazards.

2. DESCRIPTION OF HILL TORRENT FAN AREA.

2.1. Physiography and Climate.

D.G.Khan and Rajanpur Districts primarily consist of three distinct physiographic units. The *Suleman* Range, with hills exceeding 7,000 feet height lies in the extreme west of the area. Geographically this range lies between longitude 69^{o} 10' E to 70^{o} 49' E and serves as a divide line between Khyber Pakhtun Khaw (KPK) Balochistan and Punjab Province. Piedmont plain is sandwiched between the *Suleman* Range and abandoned flood plain in the eastern part forming an elongated strip along the Indus River. The piedmont plain has been formed by the detritus material, transported by the hill torrents and sheet flooding, emerging from *Suleman* Range and runs almost parallel to the D.G.Khan canal command area. It is a gently sloping plain forming an intermediate zone between the mountains and the flood plain of Indus River. The general gradient is five to six feet per mile towards south-west. The main features are the aggrading channels of hill torrents and gently rolling areas covered by clayey deposits.

Fig: I INDEX PLAN OF HILL TORRENTS IN DISTRICT D.G.KHAN.

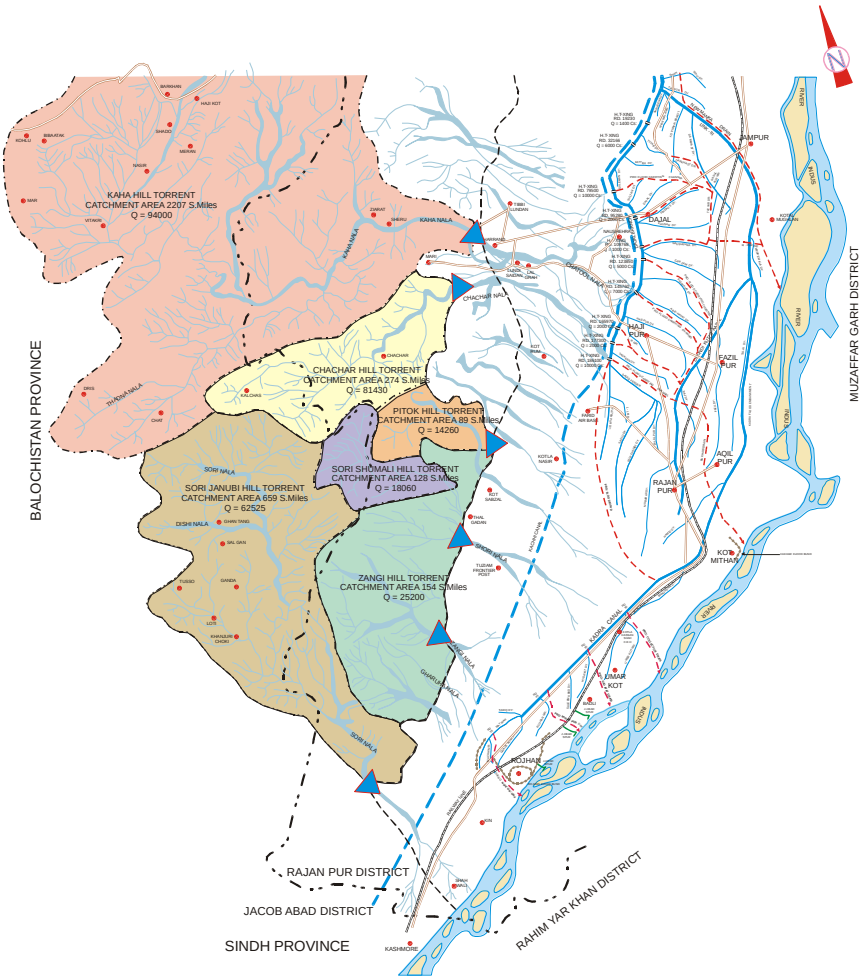


The abandoned flood plain has been formed, mainly, by the sediments deposited by Indus River during the sub-recent time and covers about 0.44 million acres. The flood plain has

a general slope of about two feet per mile towards south. The Figures I and II shows the Geographic location of area in District D.G.Khan and Rajanpur respectively.

The *Suleman* range is devoid of vegetation. Climate of the area is arid. Rainfall varies between 125 mm to 375 mm (5-15 inches). Rain fall distribution is uneven, erratic and patchy. Concentration of rain fall / precipitation is mostly in the month of July and August (Monsoon period).

Fig: II INDEX PLAN OF HILL TORRENTS IN DISTRICT RAJANPUR.



2.2. Traditional Management of Hill Torrent Water.

Spate Irrigation is traditionally used for diverting hill torrents into cultivable command areas for growing seasonal crops. The farming system is characterized by extreme events of floods and droughts. So, a unique irrigation system for hill torrent area is being practiced, known as *"Kamara Irrigation"*?

a. *Kamara* Irrigation.

The intermittent and erratic patterns of precipitation events, being the unique source of stream flow irrigation, have become the sole basis for the evolution of *Kamara Irrigation System* since centuries. This system enforces the sequential water rights and dictates the irrigation pattern from upper to lower riparian, without consideration of the duration and magnitude of the storm generated flow. Under the system sometimes, the far flung lower riparians remain

deprived of irrigation facilities during a low flow year. It usually entails the construction of an earthen diversion weir across the torrent with large channel on one or both sides of the river to convey flood water across large distances. These earthen diversion structures and water conveyance system has traditionally been constructed by the beneficiaries / communities themselves, making use of traditional technology. Farmers construct field by making embankments from 3 to 6 feet (1.8 m) high to store the water depending upon the soil type, share in water and various other factors. Upon drying up water in the field box crops are sown which thrive on the moisture stored in the soil. There is no further irrigation except rains, if any occurs.

Never-the-less, the system is hardly capable of managing the low flows, whereupon the medium and high flows destruct the farmer's earthen diversion arrangements; the flows rush down assuming the shape of floods which usually cause unprecedented damages to the local economy. The wastage of irrigable flows and the resultant loss of edible, potable and encashable agricultural production, coupled with the flood losses being inflicted since centuries together is well presented by the current socio-economic parameters and the existing standard of livelihood of the locals of the area. The gross command area, comprising all the major and minor hill torrents is about 2.5 million acres which includes the cultivable area of about 0.5 million acres. Still the cropping intensity remains 8-12 percent under the existing *Kamara* system, the actual yearly cultivated area varies hardly from 20-30 thousand acres in each major hill torrent area. This area utilizes only a fraction of the hill torrents annual runoff which approximates to about one and a half million acre-foot in *Kaura*, *Vehova* and *Sanghar* Hill Torrents when assessed against a 25-years recurrence.

Another aspect of the Spate Irrigation System of *Rod-Kohi* areas is the occurrence of the perennial water (known as *Kalapani*), which is available throughout the year in the upper reaches. It contributes significantly to sustainable farming in the area and used for high value crops like fodder, fruits and vegetables.

b. Water Rights and Water Users Groups.

The term 'water rights' refers to as the priority of using the manageable, flows of hill torrents in accordance with the prevalent *Kamara Irrigation System,* following the *'Saropa Paina'* rules. The *Saropa Paina* (head to tail) rules strictly dictate the irrigation sequence starting from upper (head) farms / fields to the lower (tail) agricultural areas. The terms are sometimes associated with the irrigation off-takes / *wahs* when these are categorized in accordance with the water rights. These are:

- Haqooq wahs
- Non-haqooq wahs

Haqooq wahs are those off-taking channels which have the priority rights to use hill torrents flows. Non-*haqooq wahs* can only draw the flood flows which are in excess of the needs / capacity of the '*haqooq wahs*'.

3. SOCIO-ECONOMICAL CONDITION OF AREA.

3.1 Economy.

Economy of the '*Pachad*' area is entirely based on agriculture and livestock. It is thus affected by the cropping pattern largely controlled by availability of water and mode of irrigation. Lack of communication, illiteracy and other infrastructure facilities are the cause of low standard of living for the greater part of population and the main constraints in the development area.

Majority of the population lives in the rural areas and depends upon agricultural production with hill torrent irrigation in *Pachad* area where rainfall generally sustains a varying cropping pattern depending upon the season and its duration.

The main products are Sorghum, wheat, pulses, oilseeds and livestock (meat and wool) of *Pachad* area.

Mode of communication and transport charges affect the economy of area. The market value of produce in the villages is about considerably 10 to 25 percent lower than the trading centers depending upon the mode of transport.

3.2 Agriculture.

Agriculture in the area is predominantly rain fed. Only 8% - 12% of the total cultivable area is presently irrigated. Agriculture in the area is below subsistence level. Major crops are millet (*jawar* / *bajra*) covering about 40% of the cropped area followed by wheat representing 23%, gram 22% and 15% other crops. Crops yields are very low, mainly due to uncertain and erratic amount of water at critical stages of crop growth, non availability of improved seed, inadequate use of fertilizers and pesticides, insufficient cultural practices lack of credit facilities for the purchase of farm inputs, lack of modern technology for land crop-water management.

At numerous places, farmers have been diverting flood flows into small channels for irrigation purposes since decades, but many have become non-functional due to physical, technical, financial and social constraints. Most of the water is wasted by run off through hill torrent streams which during floods often cause damage to land and life and end up in Indus River. Because of this the lands of area are not being utilized according to their potential. Without proper management of water resources, subsistence level of farming would perpetuate causing thereby more deterioration in the socio-economic condition of the farming community.

3.3 Livestock.

In the absence of organized and developed agriculture in *Pachad* area, livestock raising is an important supporting occupation for farm families, because this is a major source of income for the farmers and its contribution to agricultural development is substantial Livestock also contribute to security against crop failures in years of exceptionally high floods or drought. The livestock in the area include cattle, buffalo, goat and sheep.

4. SALIENT FEATURES OF MAJOR HILL TORRENTS.

There are 200 hill torrents in the area, out of which 13 are categorized as major, having discharge more than 10000 cusecs. The detail of these torrents given below:-

Sr. No.	Name of hill torrent.	District	Catchment area (Sq. Miles)	25 years return period discharge (Cusecs)	40 years return period discharge (Cusecs)	Historical maximum peak flow.		Cross Structures over canals.		
						Year	Cusecs	Canal	Location (RD)	Capacity (Cusecs)
1	Kaura	D.G.Khan	202	---	61184	2010	128500	Chashma Right Bank Canal has crossing, where flood carrying channels leads the water to River Indus.		
						2012	43628			
2	Vehova	D.G.Khan	1017	---	87200	2010	110500			
						2012	67882			
3	Sanghar	D.G.Khan	1897	---	139715	2010	229000			
						2012	99225			
4	Sori Lund	D.G.Khan	193	68370	---	2012	82786	D.G.Khan Canal	51000 69100 82400	5000 20000 5000
						2013	97710		108857	2000
5	Vidore	D.G.Khan	298	67650	---	2010	97109	D.G.Khan Canal	185500	2000
						2012	145101		242215	15000
6	Sakhi Sarwar	D.G.Khan	61	30960	---	2010	32643	D.G.Khan Canal	279320	5000
						2012	8604			
7	Mithawan	D.G.Khan	274	78000	---	2010	61905	D.G.Khan Canal	316430	2000
						2012	49500	Dajal Branch	19230 32166	1400 6000

Sr. No.	Name of hill torrent.	District	Catchment area (Sq. Miles)	25 years return period discharge (Cusecs)	40 years return period discharge (Cusecs)	Historical maximum peak flow.		Cross Structures over canals.		
						Year	Cusecs	Canal	Location (RD)	Capacity (Cusecs)
8	Kaha	Rajanpur	2207	94000	---	2012	81500	Dajal Branch	79500 95280 109768 123850 145760	10000 2000 1000 5000 7000
						2013	96000			
9	Chachar	Rajanpur	974	81430	---	2012	49500	Dajal Branch	165970 177300 186100	2000 2000 10000
						2013	65000			
10	Pitok	Rajanpur	89	14260	---	2010	5000			
						2012	3550			
11	Sori Shumali	Rajanpur	128	18060	---	2010	7150			
						2012	4000			
12	Zangi	Rajanpur	154	25200	---	2010	3310			
						2012	3200			
13	Sori Jaubi	Rajanpur	659	62525	---	2010	3205			
						2012	4300			

5. FLOOD PROBLEMS.

The floods in hill torrent area are unpredictable and of erratic nature which usually occurs in Monsoon period.

The peak discharges of important hill torrents are shown in Figures No. III – X. The Figures XI and XIII shows the hydrographs of major hill torrents which causes flood hazards during 2012 and 2013, reflects the duration of flood and quantum of water.

Fig: - III – PEAK DISCHARGES OF KAURA HILL TORRENT
(U/s Taunsa Barrage, Tehsil Taunsa Sharif

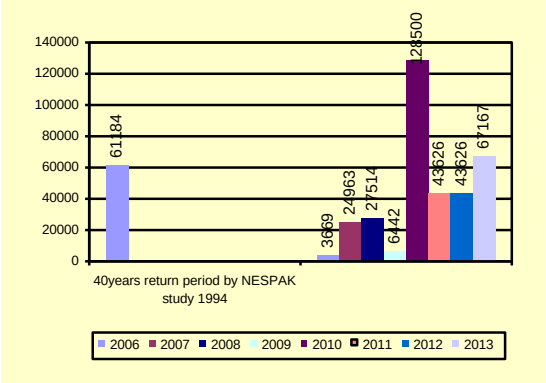


Fig: - IV – PEAK DISCHARGES OF VEHOVA HILL TORRENT
(U/s Taunsa Barrage, Tehsil Taunsa Sharif

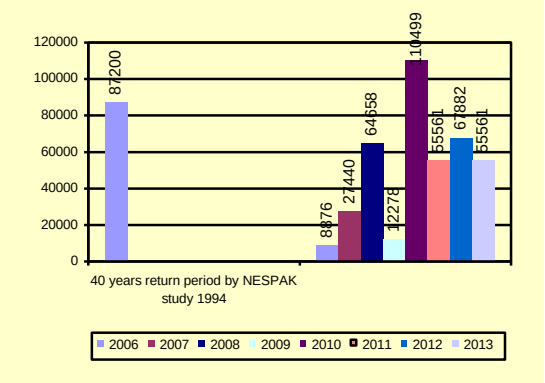


Fig: - V – PEAK DISCHARGES OF SANGHAR HILL TORRENT
(U/s Taunsa Barrage, Tehsil Taunsa Sharif

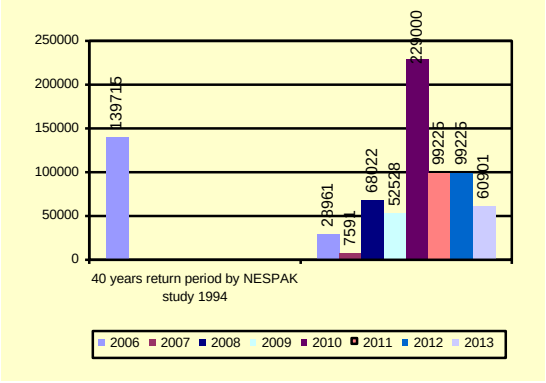
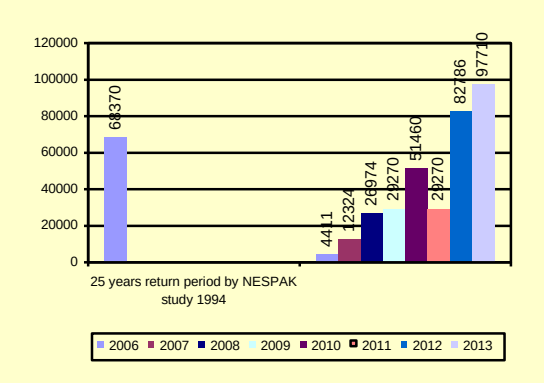


Fig: - VI – PEAK DISCHARGES OF SORI LUND HILL TORRENT.



The damages inflicted by hill torrents flooding in the hill torrent areas and canal command areas can generally be categorized as:

- Erosion of land
- Devastation of public and private property
- Environmental hazards
- Limited crop area
- Low crop yield
- Poor cropping pattern
- Damages to infrastructure
- Breaches of canals and suspension in canal supplies
- Damages to standing crops in canal command area

Fig: - VII – PEAK DISCHARGES OF VIDORE HILL TORRENT

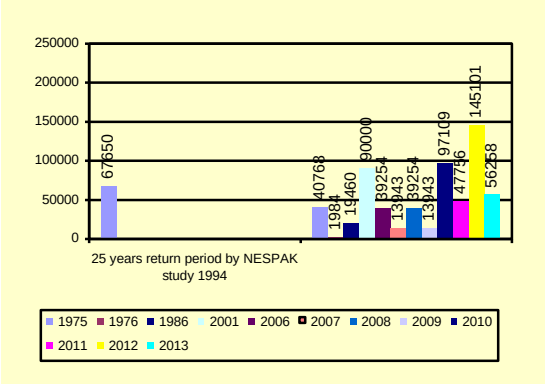


Fig: - VII – PEAK DISCHARGES OF MITHAWAN HILL TORRENT

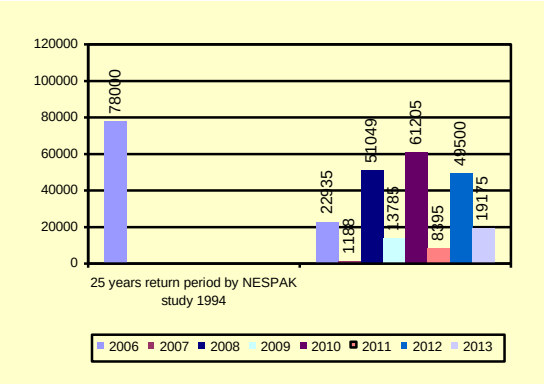


Fig: - IX – PEAK DISCHARGES OF KAHA HILL TORRENT

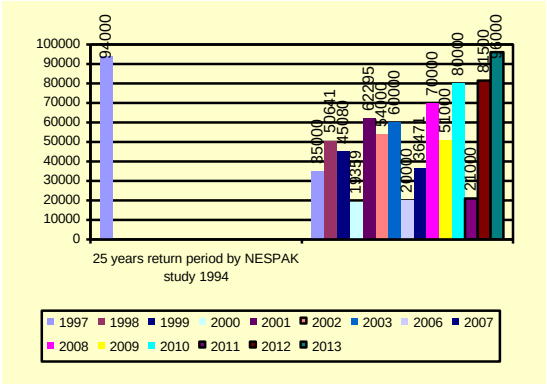
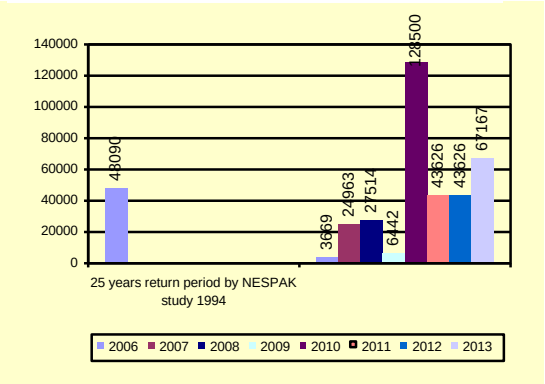


Fig: - X – PEAK DISCHARGES OF CHACHAR HILL TORRENT



The damages to public and private property during hill torrent floods September 2012 in District D.G. Khan & Rajanpur in canal command areas is given below:-

Damages to cropped area

D.G.Khan District.	=	41367 Acres
Rajanpur District.	=	143272 Acres

Damages to Houses	=	45809 No.
Damages to School Building	=	103 No. (Collapsed)
	=	106 No. (Partially damages)

Other Infrastructures

Road Bridges.	=	12 No.
Veterinary Hospital.	=	2 No.
Union Council Offices.	=	32 Nos.

Fig: - XI – HYDROGRAHP OF KAHA, CHACHAR & KALA KHOSRA HILL TORRENTS IN DISTRICT RAJANPUR

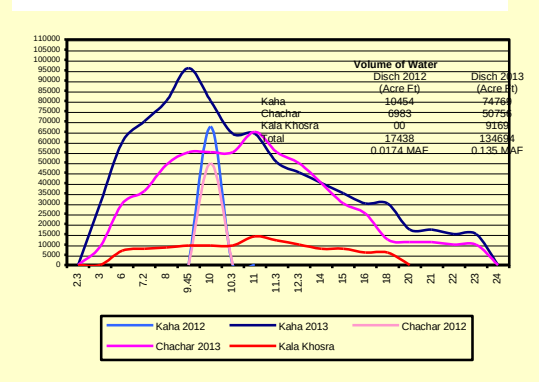
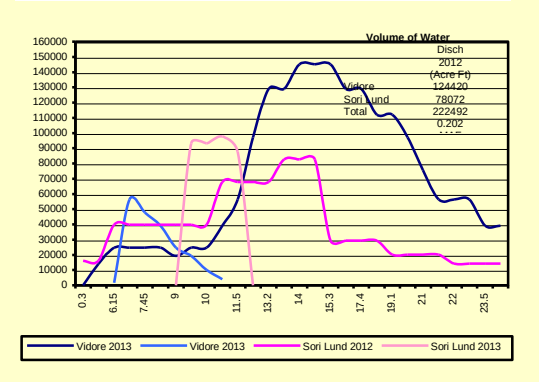


Fig: - XII – HYDROGRAPH OF VIDORE & SORI LUND HILL TORRENT AT DARRAY SITE (Tehsil D.G.Khan)



5.1 Statistics of Damages to Canal System by Torrential flows.

Year of torrential flow.	Major damages to canal.
1967 (Mithawan H.T)	D.G.Khan Canal breached in between RD. 318 – 325
1975 (Mithawan H.T)	Dajal Branch breached in between RDs 14 – 19 & 29 – 31.
1976 (Mithawan H.T)	D.G.Khan Canal breached at RDs 284 right bank, 302 left bank, 309 left bank and 322 both left and right banks while Dajal Branch beached at RDs 12 left and right, 15 right, 19 left and right and 33 left and right.
1984 (Mithawan H.T)	D.G.Khan Canal breached at RDs 322 both left and right banks and 323 both left and right banks.
1986 (Mithawan H.T)	D.G.Khan Canal breached at RDs 285 right bank, 301 left bank, 322 right bank and 323 both left and right banks while Dajal Branch beached at RDs 11 left and right and 12 left and right.
1994 (Mithawan H.T)	D.G.Khan Canal breached at RDs 286 right bank, 316 both right and left banks while Dajal Branch breached at RDs 10 right bank, 11 and 12 both right and left banks.
2001 (Sori Lund, Vidore, Sakhi Sarwar & Mithawan H.T)	Right bank of D.G.Khan Canal from RD. 130 to RD. 132 in 2000 ft length smashed and Tail regulator (Dajal Branch & Link III) were totally damaged and overturned which were reconstructed.
2010 (Vidore, Kaha & Chachar H.T)	Dajal Branch breached in between RDs. 95-96, 185-186.
2012 (Sori Lund, Vidore, Kaha & Chachar H.T)	D.G.Khan Canal breached in between RDs. 69 – 243 at 34 places & Dajal Branch breached in between RDs. 95-190 at 28 places with damages to distributary system.
2013 (Sori Lund, Kaha & Chachar H.T)	Dajal Branch breached in between RD. 54 – 190 at 79 places.

6. PREVIOUS STUDIES / PLANS.

The flows of the hill torrents of "*Pachad* Area" have been used for irrigation of local agriculture areas since times immemorial, as far as possible by the farmer's own diversion arrangements. Various schemes have also been proposed by different government officials and agencies from time to time but could not be implemented due to one reason or the other, which are briefly described:

Year 1929 The first serious attempt to control the hill torrents of *Pachad* area was made after the 1929 flood. Mr. P. Claxton (Executive Engineer), studied and submit plan for flood control of hill torrents in D.G.Khan Division area. He proposed two dams at *Haran Bore* and *Gulki* on *Sanghar* Hill Torrent, one dam at *Pishi* on *Vidore* and a dam at *Harrand* on *Kaha* Hill Torrent. These proposals were not approved by the Government, being unfeasible and uneconomical.

Year 1944 – 45. Engr. Kanwar Sain, Superintending Engineer presented proposals for flood control of different hill torrents which included a distributor at *Darrah* on *Sanghar* hill torrent. These proposals could not be implemented for lack of economic justification and because of turmoil at the time of independence.

Year 1951. Mr. M. I. Ahmad, Geologist of Pakistan, after carrying out investigations of *Sanghar* hill torrent reported that as it brings large amount of silt every year, storage reservoir is liable to be silted up very soon.

Year 1952. Malik Ramiz Ahmad, the then Executive Engineer, proposed bifurcations and trifurcations at the head of off-takes of various *nullahs* for better spreading of flood flows in the fields.

Year 1958. Mr. G. E. Meads, an FAO expert visited the area and suggested storage dams, check dams and retarding dams on various hill torrents, but these proposals were not executed due to poor geological conditions and likely low financial returns.

Year 1970 – 71. A pick up weir was constructed during 1970-71 on *Vehova* hill torrent by Small Dams Organization. It has been damaged many times and restored since its construction, but could not sustained.

Year 1976 Engr. Muhammad Ismail Shaheed, (Superintending Engineer) suggested that hill torrents flows after their dispersion over *Pachad* area by means of distributors and improved irrigation channels (*wah*), be allowed to enter the canal command areas by providing additional crossings at existing canal systems and then led into the Indus River through a network of drains comprising hundreds of miles long main drain and sub-drains throughout the canal irrigated area with numerous crossings on channels, roads and railway.

Year 1977 Engr. M. A. Hameed Rehmani (Superintending Engineer), suggested the following schemes to the Specialist Committee appointed by Government of Punjab after 1976 floods.

a) Distributors with under sluices-cum-weir alongwith their training works tied to the high banks of Darrah, should be constructed for proper feeding of the irrigation channels (*Wahs*).

b) Ultimately the residual flow, if any should be retained along the D.G.Khan canal by converting their right bank into a proper high flood embankment.

c) In order to break the fury of flood, ogee type speed-breakers and check dams be considered.

Year 1980. The Federal Flood Commission (FFC) engaged NESPAK to carry out the hill torrents studies and propose a multipurpose plan for the management of flood flows of hill torrents of *Pachad* Area. Accordingly, NESPAK carried out a comprehensive study of 13 major hill torrents of the area and presented a complete management plan for each major torrent separately. The plan mainly comprised of diversion arrangements and flood protection facilities at the cost of public investment on a technically sound and economically feasible basis. The report was widely hailed and accepted.

Year 1984. NESPAK prepared Pre Feasibility report for Management of torrent flows.

Year 1995. DG Khan Integrated Drainage and Irrigation Project by WAPDA.

Year 1998. Master Feasibility Studies for Flood Management of Hill Torrents of Pakistan by NESPAK.

Year 2004. Performance Evaluation of *Kaha* Hill Torrent by Joint Venture of NESPAK, ACE and NDC.

Updating feasibility study on Hill Torrent Management Plan in *Chashma* Right Bank Canal (CRBC) area by NESPAK

Year 2007. Management of Hill Torrents in CRBC Area D.G.Khan, revised design / feasibility report by TA Consultants of ADB.

Year 2010. Site Visit Report on Hill Torrents in DG Khan and Rajanpur Districts by P&I, WAPDA.

Year 2012. Technical Committee of Irrigation Department, Punjab for mitigation of Hill Torrent floods which give its recommendations focusing to continue management projects with improved drainage of flood water in canal command area. WAPDA Expert team also visited the area and report submitted to Federal Government.

6.1. Recommendations from Studies.

Following are salient recommendations made in these studies report:

a) Delay action dams / flood flow diversion structures be provided where feasible.

b) Distribute and disperse the flood flows onto wider areas – as per *Haqooqs* – in the Fan area (*Pachad* regions)

c) Training of flood water into designated channels of Fan areas.

d) Provision of guide embankments and leading channels at the inlet points of Cross Drainage Structures of Kachhi Canal / D.G.Khan Canal / Dajal Branch.

e) Right bank of Kachhi Canal be converted into flood embankment to ensure its stability against rapid rise and fall of flood water level.

f) At inlet points of super X-ings of Kachhi Canal, special protection works on approaches be provided to face high velocity head / flows of torrents.

g) Rehabilitation / remodeling for enhanced capacity of existing drains and development of outlet channels from Cross Drainage Structures of D.G.Khan Canal to the collector Drains.

h) Provision of well designed surface drainage system and protection works in the District Rajanpur.

7. HILL TORRENT MANAGEMENT PROSPECTIVES.

From the technical reports and studies, hill torrent management may be divided into three areas, as per geographical and physical conditions which are briefly described below:-

a. Catchment areas management.

- Sites exist for storage dams at hill torrents Kaha and Chachar, but technically not feasible being very high silt contents in flood water.
- Check dams / retarding dams are feasible, which require detail technical feasibility based on ground survey, geological investigations and silt managements etc.

b. Fan area (Pachad area) Management.

- Based on “Master Feasibility Study for hill torrent management”, 1998 conducted by NESPAK, Government of Punjab is constructing Dispersion structures in “Pachad area” to divert hill torrent flows to existing channels to spread water over large area for irrigation, land development, environment improvement and partially flood management, which should be continued.

c. Drainage of hill torrent floods into River Indus.

- After crossings of hill torrent water from D.G.Khan Canal and Dajal Branch effective and efficient flood water drainage system is paramount. Existing seepage drains in District D.G.Khan can not drain out the flood water.
- Flood carrying channels from each crossing of D.G.Khan Canal / Dajal Branch to River Indus is the real solution.
- Alternatively existing flood flows routes / drains be improved and strengthened and water to be drained off through enhanced capacity of existing drains / new drains with protection dykes.

8. HILL TORRENT MANAGEMENT PROJECTS.

In view of complex nature of flood problem, in depth hydrologic and economic evaluation is an essential pre-requisite for drawing up an effective management plan of hill torrents. All studies till 1980 lacked comprehensive approach to the flood problem and flood events had not been related to the theoretical return period. Flood damage potential of each hill torrent and risk analysis studies were never carried out nor any exercise was conducted for economic evaluation of various alternatives and their cost estimates.

During 1980’s the Government of Punjab requested Federal Flood Commission of Pakistan (FFC) to take a comprehensive view of the flood problems of D.G.Khan Hill Torrents. The FFC engaged NESPAK to carry out the studies and propose a multipurpose plan for the management of flood flows of hill torrent of *Pachad* area. Accordingly, NESPAK carried out a comprehensive study of 13 major torrents separately and put up a report in 1984 considering various strategies to manage the torrent flows in technical and economic considerations. Management of flood flows in “Pachad” area, through dispersion structures was selected which envisaged the utilization of maximum quantities of flood flows in hilly and “Pachad” area for

agriculture. The plan consists of flow structures to be built with public investment on a technically sound and economically feasible basis duly protecting existing water right of each channel (Wah) based on 40 years return period discharge.

During 1990's, the report was updated as part of the "Master Feasibility Studies for Flood Management of Hill Torrents of Pakistan". Consequently a Pilot Project was formulated and executed on Kaha Hill Torrent (1992 – 96) and for Mithawan Hill Torrent (1993 – 96) as Phase – I and at Kaura, Vehova, Sanghar, Kaha & Vidore hill torrents (2009 – 14) as Phase – II. The details are given below:-

8.1. Phase – I Hill Torrent management Projects.

Sr. No.	Name of hill torrent.	Project period	Detail of works.	Objectives / Main purpose.
1	Mithawan (Phase – I)	1993-96	Above Darrah site Management structure at Choti Nallah. Watershed management in Mithawan & Siri Nallah i.e. checks dam, plantation, and diversion dikes.	To reduce the steep slope by constructing check dam to delay flood at Darrah point. Further plantation & vegetation is developed to stabilize the slope of mountains.
2	Mithawan (Phase – II)	2002-06	Main distributor & allied structure, guide banks, bed fixer and central bund on Shakh Shumali & Shakh Janubi having equal share of flood water. Escape structure on non haqooq branch	The distributor structure was constructed at the junction of three branches i.e. Northern Branch (15000 Cs), Southern Branch (15000 Cs) and Ganahar Branch (20000 Cs) for equal distribution of flood water.
3	Vidore	1995-96	Distributor – I on Phullar, Suchani + Chhabri Branch. U/s bed fixer, D/s bed fixer. Distributor – II D/s bed fixer, left & right & separating dikes. Dumb wah structure, Noor wah structure.	2 No. distributors were constructed for feeding the equal discharge to off taking branch channel i.e. Chhabri, Suchani & Phullar Branch.
4	Kaha	1992-96	13 No. flexible structure, Bed Fixers, Guide Bank and Regulators	The flood water is dispersed in different wahs for flood irrigation as per right of irrigators. Intensity of flood is reduced to avoid damages to infrastructure.

The evaluation of Kaha hill torrent Management made by NESPAK and report submitted in 2004. After completion of structures, flood peaks of various magnitudes recorded at the Darrah and at hill torrent crossings on Dajal Branch from the year 1997 to 2003 are given as:

Year	Date	Peak Discharge	
		At Dajal Branch Crossing (cfs)	At Darrah (cfs)
1997	4th May	---	35000
	3rd June	---	35000
1998	---	1464	50641
1999	---	1304	45080
	September	---	19359
2000	---	560	19359
2001	---	4596	62295
	27th July	---	60000
2002	17th July	3540	54000
	30th June	---	54000
2003	2nd July	9563	60000
	10th July	---	60000
	14th July	---	51900

From the perusal of flood peaks at the Darrah and at the hill torrent crossings, it is clear that there has been substantial reduction in flood peaks, after structural interventions which changed the flood routing pattern. It has been estimated that 50% flood flows have been diverted to channels.

8.2. Phase – II Hill Torrent management Projects.

Sr. No.	Name of hill torrent.	Project period	Detail of works.	Objectives / Main purpose.
1	Kaura	2009-14	Improvement of Sad Loharan Bund, construction of U/s bed fixer, Qallandar wah complex, D/s bed fixer, Kuppi wah distributor structure & Distributor structure on Bhuch & Chaharum Wah.	To utilize flows for agriculture development in Pachad area by construction of dispersion structures which will reduce the flood damage potential in canal command area of CRBC & to bring more area in to irrigation through controlled

2	Vehova	2009-14	Construction of distributor structure main Kobhi wah, Jallu & Allah Nawaz wah, Construction of flood protection bund Jallu wali, Gat village & Churkin village.	structures. The project is 90% completed and benefits have been observed during 2012 & 2013 torrent floods. Project is 90% completed.
3	Sanghar	2009-14	Construction of main distributor structure with allied structures (Jat wah, Jam wah, D/s bed fixer, Bughlani wah, Bhegwari wah, Budhu wah)	
4	Kaha	2011-14	Improvement of 13 No. structures with semi solid structure.	To improve the condition of 13 No. structures already constructed, to irrigate non-inclusive areas left in the past and the haqooq area lying still abandoned. Project is 70% completed.
5	Vidore – Chhabri Branch.	2012-14	Management of 7 No. distributors / dispersion structures.	Make maximum use of flood water for irrigation in Chhabri Branch of Vidore hill torrent in Pachad area & reduce the flood damage potential in canal command area of D.G.Khan Canal. Project is at initial stage.

The main structures consist of followings:-

a) Construction of a weir along whole width of hill torrent flow path which is a dispersion structure (such no of weirs are constructed, as per channels sites along the torrent flow).

b) Upstream, downstream and central cut off walls on the basis of worst scour.

c) Off taking channels on right and left side with regulators upstream of weir.

d) Abutments, wing walls and retaining walls.

e) Bed fixer on downstream of main weir.

f) Protection bunds / embankments.

The typical design of structures at Kaura hill torrent and line diagram of Kaura, Vehova and Sanghar hill torrents are shown in Fig. XIII to XVII reflecting the weirs and off taking channels details.

Fig. XIII
KAURA HILL TORRENT
Design of Structure

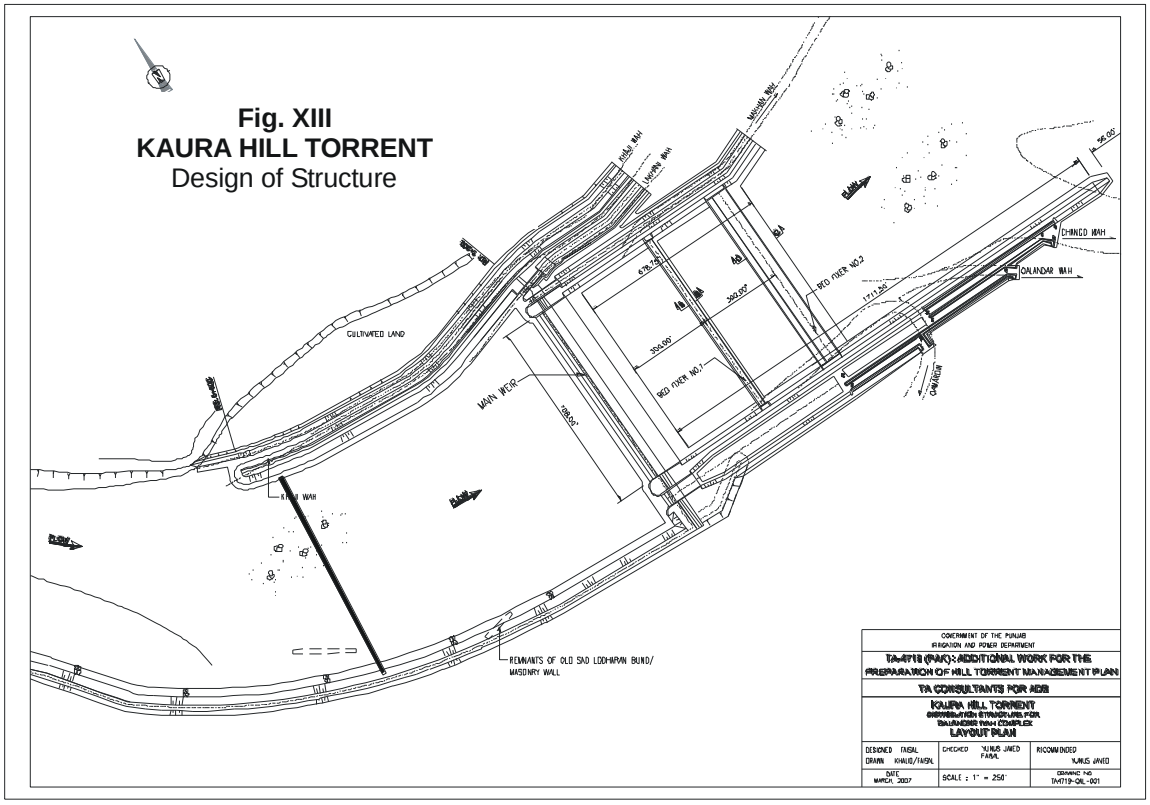
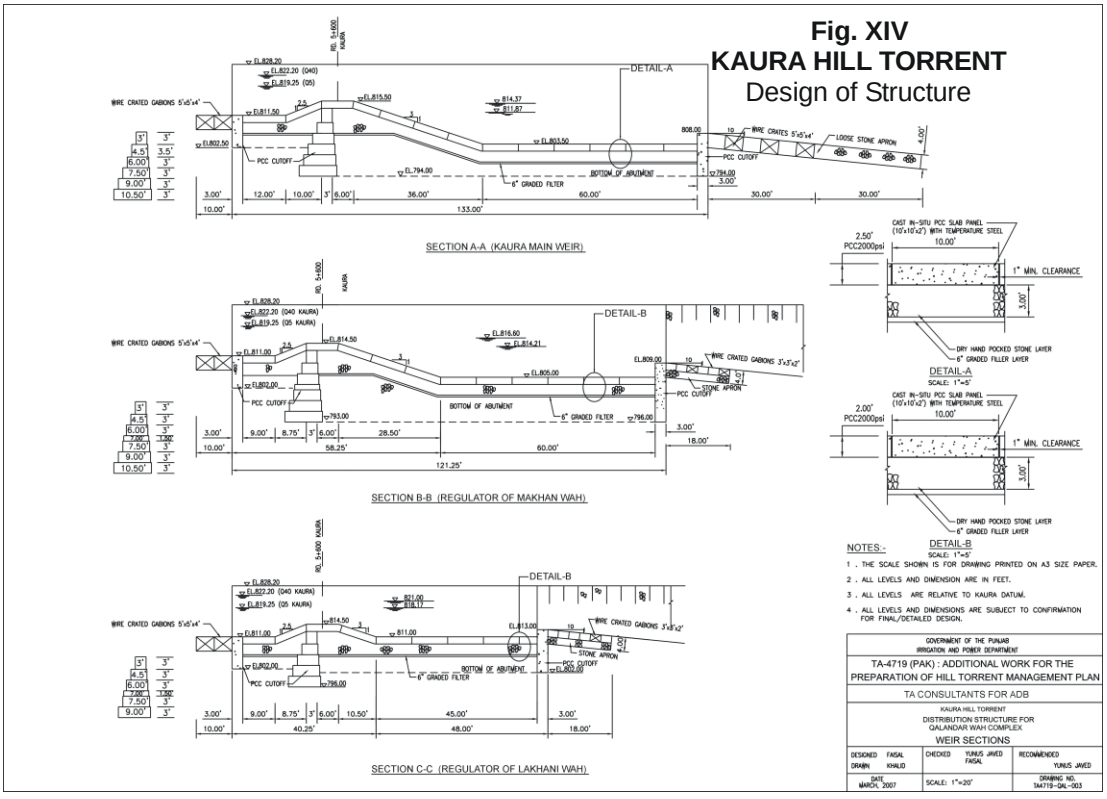


Fig. XIV
KAURA HILL TORRENT
Design of Structure



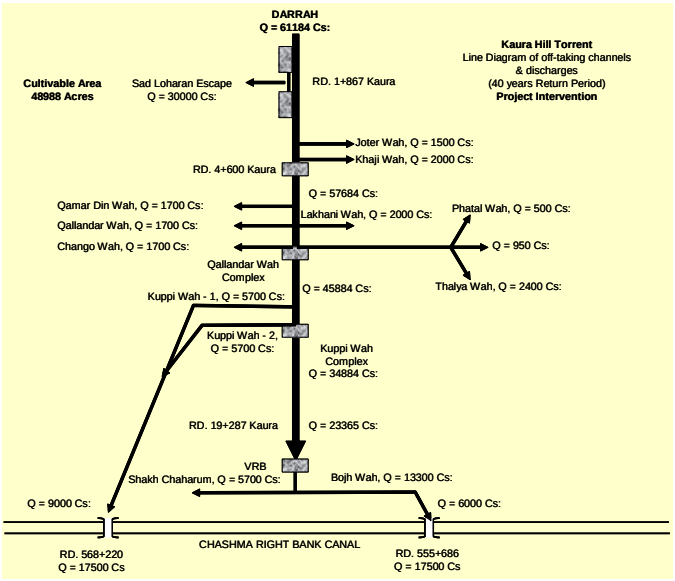
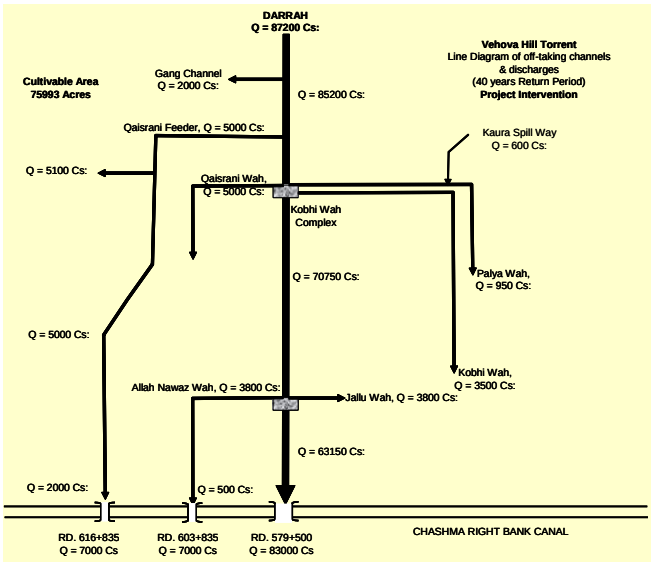


Fig – XV – Line Diagram indicating Constructed Structures at Kaura H.T.

Fig – XVI – Line Diagram indicating Constructed Structures at Vehova H.T.



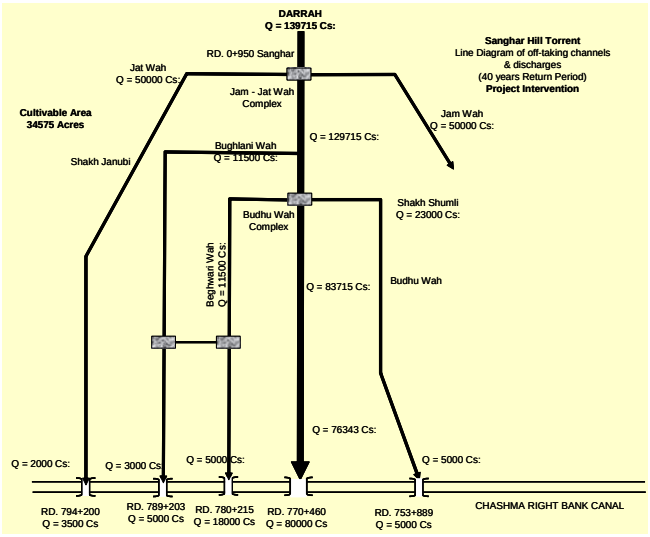


Fig – XVII – Line Diagram indicating Constructed Structures at Sanghar H.T.

9. IMPACT ANALYSIS OF INITIATIVES.

The hill torrent management projects in Chashma Right Bank Canal area i.e. Kaura, Vehova and Sanghar hill torrents (Fig. XVIII) are almost completed and their tangible benefits as envisaged have been experienced during hill torrent flood 2012.

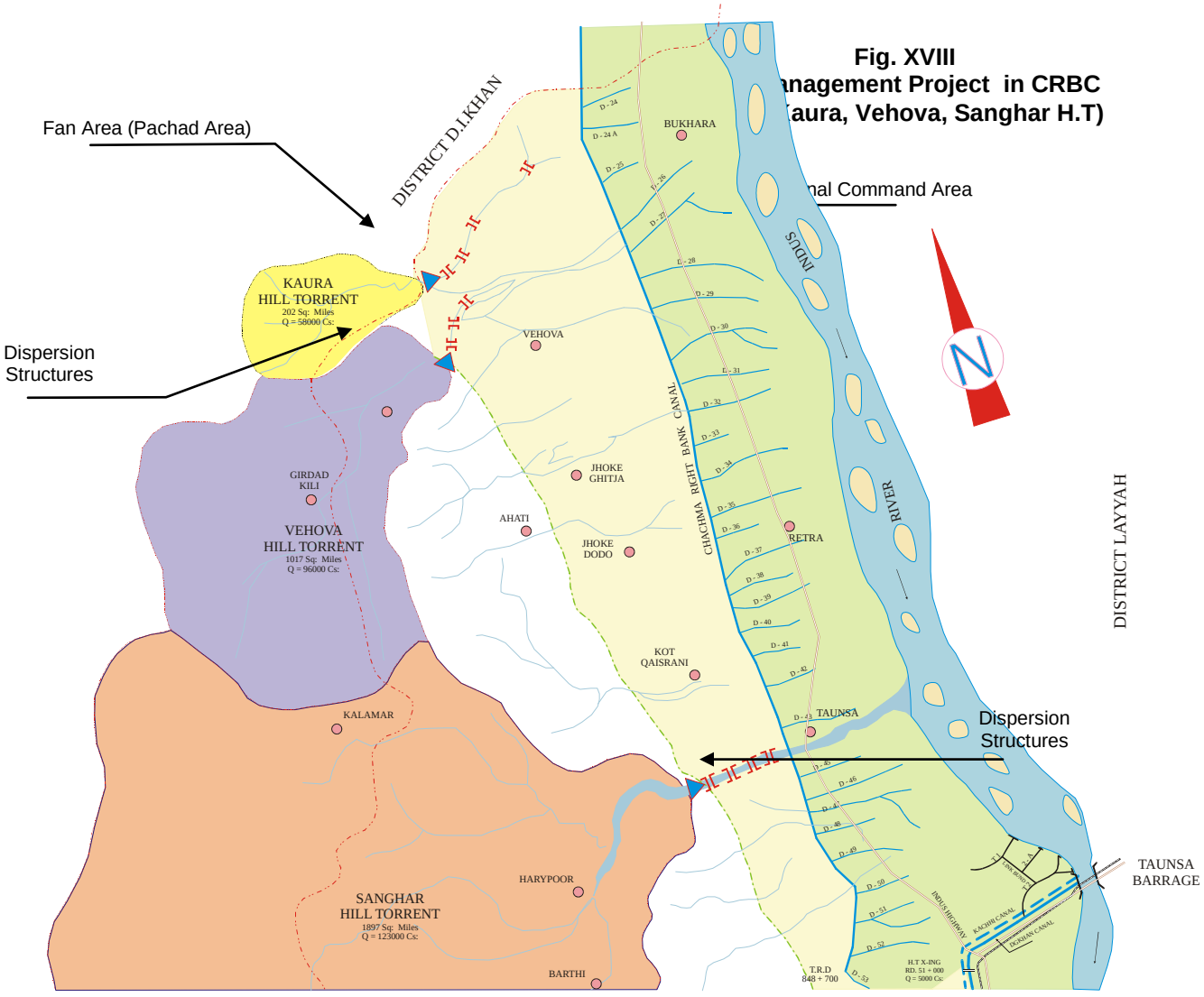


Fig. XVIII
…nagement Project in CRBC
…aura, Vehova, Sanghar H.T)

The analysis of different aspects of impact of the project has been made which is briefly described below:-

1. Flood intensity reduced due to improved dispersing the stream flows to off taking channels. Table – I shows the dispersion of flood water of August 2012.

Table – I - Improved Flood Water Dispersion.

Description.	Kaura hill torrent (cfs)	Vehova hill torrent (cfs)	Sanghar hill torrent (cfs)
Design capacity of main structure (40 years return period)	61184	87000	139000
Flood (August 2012)	43626	66882	99225
Flood water dispersed to off taking channels.	26178	40729	63535
Dispersion %age.	60%	61%	64%

2. Enhancement in agriculture activities and cultivated area in fan regions with improved plantation and vegetation, thus better environment conditions. Table–II shows the improved diversion of flows into off taking channels, resulted enhanced agriculture. Table – III shows the detail of cultivated area.

Table – II - Improved dispersion inflow to allied channels.

Sr. No	Hill Torrent.	Mauza	Off take channels constructed for irrigation	**Discharges (Cusecs)**		
				Maximum designed	Prior to project.	During floods 2012 after construction of project
1	**Kaura** Maximum Discharge during 2012 = 43626 Cs 26-08-2012	Kotani	Khaji Wah	2000	200	1250
			Qaladar wah	1700	190	1458
			Qamar Din Wah	1700	150	1458
			Chango Wah	1700	165	1458
			Kuppi 1	5700	600	Under Construction
			Kuppi 2	5700	625	
		Lakhani	Thalya Wah	2400	250	2025
			Phatel Wah	500	40	410
			Makhan Wah	950	100	648
			Lakhani Wah	2850	285	2430
		Bojh	Chaharum Wah	5700	600	4073
			Bojh Wah	13300	780	9503
	Net Discharge Crossing CRBC :-			**16500 Cusecs**		

Sr. No	Hill Torrent.	Mauza	Off take channels constructed for irrigation	Discharges (Cusecs)		
				Maximum designed	Prior to project.	During floods 2012 after construction of project
2	**Vehvoa** Maximum Discharge during 2012 = 67882 Cs 26-08-2012	Kotani	Palya Wah	950	100	878
			Kobhi Wah	3500	350	2629
			Qaisrani Wah	5000	400	3651
		Kohar, Jallu Wali & Mithey Wali	Jallu Wah	3800	380	Under Construction
			Allah Nawaz Wah	3800	350	
	Net Discharge Crossing CRBC :-			**48125 Cusecs**		
3	**Sanghar** Maximum Discharge during 2012 = 99225 Cs 26-08-2012	Jat Gadi & Bughlani	Jat Wah	5000	250	3500
		Pukhan & Koko	Jam Wah	5000	250	3400
		Bughlani	Bughlani Wah	11500	750	9750
		Mundrani, Sokar & Binda	Bhegwari Wah	11500	750	9850
		Mangrotha	Budhu Wah	23000	950	19440
	Net Discharge Crossing CRBC :-			**49650 Cusecs**		

Table – III - Improvement in cultivated area.

Sr. No.	Hill Torrent	Mauza	Off take channels constructed for irrigation	Area (Acres)		
				Total	Cultivated area prior to project.	Cultivated during the year 2012-13
1	Kaura	Kotani	Qaladar wah, Qamar Din, Chango & Khaji Wahs, (4 channels)	3100	260	2850
		Lakhani	Thalia wah, Phatil wah, Makhan wah and Lakhani Wahs.	8254	475	4500
		Bojh	Shakh Chaharum	716	82	700
		Daulat Wala	Thalia Wah, Main Kaura Hill Torrent.	3837	257	2600
		Jhangra Shumali & Janubi	Shakh Chaharum	26179	750	11500
		Shadi Wala	Shakh Chaharum	3581	205	1850
Sub Total :-				**45667**	**2029**	**24000**
2	Vehova	Kotani	Palia wah + Kobhi Wah Qaisrani wah	3322	300	2900
		Vehova Shumali & Janubi	Dagar wali	45377	650	7250
		Kohar	Qaisrani Wah	5852	425	4800

Sr. No.	Hill Torrent	Mauza	Off take channels constructed for irrigation	Area (Acres)		
				Total	Cultivated area prior to project.	Cultivated during the year 2012-13
		Qassrani Wala	Qaisrani Wah	1195	82	800
		Jallo Wali	Qaisrani Wah	7349	455	4800
		Mithey Wali	Kobhi wah + Qaisrani Wah	9798	530	5900
Sub Total :-				**72893**	**2442**	**26450**
3	Sanghar	Jat Gadi	Jat Wah	4410	295	3100
		Bughlani	Jat Wah, Bughlani Wah	5022	315	3500
		Mundrani	Bhegwari Wah	2108	110	1035
		Sokar	Bhegwari Wah	3163	90	970
		Binda	Bhegwari Wah	570	28	315
		Pukhan	Jam Wah	7658	525	*5400*
		Koko Wah	Jam Wah	2489	170	*1800*
		Mangrotha	Buddhu Wah	8198	390	3800
Sub Total :-				**33618**	**1923**	**19920**
TOTAL :-				**152178**	**6394**	**70370***

***** The area will further increase with increased flow and leveling of lands for cultivation by community.

3. Protection against flood hazards to cultivable land & soil erosion. The figures XIX – XXII shows the works executed.
4. Improved yield of the crops, thus increase in production resulting reduction in poverty with increased economic activities in the region. Table IV reflects the improved economy in the area.

Table – IV - Improved Economy of area.

Sr. No.	Description.	Statistics prior to project.	Statistics after construction of dispersion structures.
1	Intensity of irrigation.	8% - 10%	50%
2	Yield per acre (Wheat, Oil Seeds)	400 – 500 Kgs	10000 – 12000 Kgs
3	Value of land / acres.	Rs. 10000/- to 20000/-	Upto Rs. 200000/-

5. Positive impacts on livestock, dairy development and social uplift. Figures XXIII – XXIV shows the crops sown with dispersed flood water.
6. Reduced flood damages to valuable agricultural lands, public properties, abadis in fan areas, irrigation system in D.G.Khan Canal Command area and other infrastructures.
7. Raising in sub soil water, due to increased recharge of the aquifer resulting from enhanced quantity of water (in depth and number of applications). This water is being used for drinking purpose and for irrigation.



Fig. XIX - Completed main Weir Qallandar Wah Complex, Kaura Hill Torrent



Fig. XX - Jam – Jat Wah Complex (Dispersion structure) Sanghar Hill Torrent



Fig. XXI - Budhu Head Regulator on Sanghar Hill Torrent



Fig. XXII - Kobhi Wah Complex on Vehova Hill Torrent



Fig. XXIII - Barren area of Mouza Daulat Wala converted to green fields by irrigation of Makhan & Palya Wah of Kaura Hill Torrent.



Fig. XXIV - Effects of flood water in command of Jatwah off taking channel Sanghar Hill Torrent.

10. CONCLUSIONS AND WAY FORWARD

1. Pakistan water resources are diminishing and development of irrigated area has been almost ceased. With initiation of management of hill torrent water in D.G.Khan and Rajanpur Districts will result in better irrigation facilities to 5,00,000 acres agricultural lands. This move of Government of Punjab is very positive in improvement of flood mitigation efforts with uplift of economy of the Pachad area and required to be extended in the each torrent area at fast track.
2. The Development projects under execution at different hill torrents are limited to dispersement of stream flows to off taking channels according to Haqooq Areas. Although the diversion capacity of each canal has been considerably enhanced but increased water could not be used by farmers as the capacity of channels is limited. The Government should also invest on channelization of canals to carry diverted water at dispersion structure to fields with X – regulators, fall structures, land leveling etc so as to achieve the objectives of flood mitigation and extended agriculture in the area more effectively.
3. The escapage of flood water, where possible be provided to mitigate flood hazard in canal command areas and to help recharge of aquifer.
4. The community should be involved in maintenance of development structures, as during each flood, damages to wahs took places. Water user organizations at each channel (wah) required to be developed, which may require legislation, which will be responsible for operation and maintenance of concerned channel.

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