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“Flood Management of Jhelum Basin”

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***Abstract* - Kashmir valley is highly prone to floods due to its geographical structure and location. Ever since the valley assumed its present form after draining out of the ancient karewa lake, the frequency of flood has been very high. Measures for flood mitigation were taken from 1950 onwards, a number of dams and barrages have been reportedly constructed. Floods continue to be a menace however mainly because of the huge quantity of silt being carried by the rivers emanating from Himalayas.**

Key Words –Flood, Rainfall, Dredging, Tributries, Historical Floods, Flood Managment

1.INTRODUCTION

1.1 GENERAL

The state of Jammu and Kashmir covers an area of about 222236 sq.km extending from 320 17 N to 36058’ N and from 730 26’ E to 80030’E.The state is mountainously rising in several tiers from plains in the south to higher altitude valleys and peaks in north, enclosing some of the highest mountain peaks of the world. On the basis of climatic conditions state of Jammu and Kashmir is divided viz. Temperate Kashmir valley, Tropical Jammu province, Alpine Ladakh and Kargil regions .The Kashmir valley is surrounded by Himalayas which vary in their heights between 1000 feet to 1800 feet above mean sea level extending from 330 22’ N to 340 43’ N and 730 52’ E to 750 42’ E covering an area of about 15948 Sq.Km The Kashmir valley is bestowed with enormous and rich aquatic resources in the shape of lakes, rivers, streams, high altitude lakes, springs and low lying containing a total water spread of about 32765.3 hectares which is nearly 2% total land of Kashmir valley. The water bodies of Kashmir include the giant river Jhelum, India’s largest fresh water lake Wular, world famous Dal lake, Mansbal lake, Nageen lake, springs like Achabal, Kokernag and Verinag, streams like Madhumati, Erin, Sindh,Bringi and high altitude lakes like Kishansar, Vishansar, Gangabal etc. The river Jhelum is called the life line entire of Kashmir valley from South to North and catering the requirements of 255 of population of the valley. It’s the major water body of Kashmir valley. The river starting its journey from Verinag spring and travels first 241 kms in Kashmir, next 162 km in POK (PAKISTAN OCCUPIED KASHMIR) and remaining in 321 Pakistan, travelling a total distance of about 724 Km before merging with Chenab at Bunji in Pakistan.

1.2 Tributaries

The Jhelum basin has 19 tributaries and some of them drain from the slope of the Pir Panjal range and join the river on the left bank and some others flowing from Himalayan range and join the river on the right bank.

RIGHT HAND TRIBUTARIES		LEFT HAND TRIBUTARIES	
S.NO.	NAME OF TRIBUTARY	S.NO.	NAME OF TRIBUTARY
1.	Bringi	1.	Vishow
2.	Aripal	2.	Sukhnag
3.	Sandram	3.	Rambiara
4.	Sind	4.	Ferozpora
5.	Arapath	5.	Wankron
6.	Madhumati	6.	Nirgi
7.	Lidder	7.	Romshi
8.	Pohru	8.	Khurshi
9.	Erin	9.	Doodganga
10.	Vij		

2 OBJECTIVE OF THE STUDY

To mitigate the flood

3. LITERATURE REVIEW

According to Nott (2006) the causes of flood can be divided into two physical (climate forces) and human influenced (urban development and vegetation clearing) categories. Most of the floods are due to natural forces world widely and in most of the cases it is due to prolonged rainfalls. Cutting trees has changed the patterns of floods which are due to the human impact. Flood cannot be considered as natural disaster until it damages the human lives or property.

Flooding is normally caused by natural weather events such as heavy rainfall and thunderstorms over a short period, prolonged rainfall or extensive rainfall. It can also be caused by high tide combined with stormy conditions. It is predicted that climate change will increase the risk of flooding in the UK and other parts of the world (Petak and Atkisson, 1982).

According to the study conducted by the International Flood Initiative (2003), floods are causing the most of the water related natural disasters which are not only damaging human and material assets but also the cultural and ecological resources. Ariyabandu and Wickramasighe (2005)observed that women are more affected than men due to their family responsibilities. Moreover women have more knowledge and skills to deal with such natural disasters but most of the time they are ignored in policy making.

Odunuga et al. (2012, p. 367) also established "that Flood occurs when there is overflow of urban drainages over the streets to extent that it cannot be absorbed by earth surface and consequently results to property damage, traffic obstruction and nuisance as well as health hazards".

According to Sinclair and Pegram (2003) stated that floods cannot be prevented but their effects can be minimized by introducing advance warning systems. More over many poor people live near river banks because these are the only unoccupied areas available for poor populations. These people are at more risk not only due to their location but also due to lack of financial resources they own.

Flood may also result from overflowing of a great body of water over land and extreme hydrological events or an unusual presence of water on land to a depth which affects normal activities (Olajuyigbe, 2012; and PointBlankNews.com). It also occurs as a result of combination of meteorological and hydrological extremes as well as activities of man on drainage basin (Adeaga, 2008). Floods often cause damage to homes and businesses if they are located in natural flood plains of rivers (Tinh and Hang, 2003).

Flood causes many socio-economic and political dimensions which further give birth to many complex problems. Some of the problems are displacement of people, infrastructure damages such as destruction of roads, crops and loss of cattle and livestock. These destructions delay the on-going development and political processes (Theron 2007).

4. METHODOLOGY

For the flood management of Jhelum basin, the whole work was first of all divided into two steps.

1. Flood Frequency analysis.

2. Flood Management

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4.1 Flood Frequency Analysis

For the flood frequency analysis the 50years discharge data was collected from planning and designing sub division of irrigation and flood control department and data was analysed for 50, 100,1000 years return period by GUMBEL distribution method in Microsoft excel, as follows.

4.2 Gumbel's Distribution

Gumbel's probability distribution a widely used method has been used for analysis of 40 years data collected at three gauge stations of rive Jhelum situated at SANGAM, RAMMUNSHI BAGH & ASHAM.

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4.2.1 Sangam Gauge Station of River Jhelum

TABLE 1

Sangam gauge station of River Jhelum

CALCULATION OF STANDARD DEVIATION & COEFFICIENT OF VARIATION

S.No	Year	Peak Flood (cusec)	Peak Flood (cumec)	Descending order of Flood Peak (Q)	$\bar{Q}$ - Q	$(\bar{Q} - Q)^2$
1	1975	47900.00	1355.57	3260.67	-2477.93	6140152.66
2	1976	50958.00	1442.11	1848.13	-1065.40	1135067.02
3	1977	9075.00	256.82	1779.39	-996.65	993320.28
4	1978	16528.00	467.74	1689.51	-906.77	822238.62
5	1979	14400.00	407.52	1681.02	-898.28	806913.68
6	1980	7900.00	223.57	1442.11	-659.38	434775.58
7	1981	26778.00	757.82	1383.87	-601.13	361361.78
8	1982	13505.00	382.19	1355.57	-572.83	328138.50
9	1983	14125.00	399.74	1338.59	-555.85	308973.38
10	1984	12885.00	364.65	1304.91	-522.18	272668.55
11	1985	33600.00	950.88	950.88	-168.14	28272.32
12	1986	26435.00	748.11	900.82	-118.08	13943.13
13	1987	29390.00	831.74	831.74	-49.00	2401.07
14	1988	48900.00	1383.87	815.38	-32.64	1065.59
15	1989	15150.00	428.75	757.82	24.92	620.95
16	1990	9520.00	269.42	756.09	26.65	709.96
17	1991	17660.00	499.78	748.11	34.63	1198.94
18	1992	65305.00	1848.13	674.96	107.78	11616.80
19	1993	46110.00	1304.91	621.24	161.49	26080.52
20	1994	23850.00	674.96	596.14	186.60	34818.35
21	1995	59400.00	1681.02	499.78	282.96	80065.38
22	1996	59700.00	1689.51	469.58	313.15	98065.65
23	1997	62876.00	1779.39	467.74	314.99	99221.13
24	1998	12950.00	366.49	428.75	353.99	125309.81
25	1999	8742.00	247.40	410.35	372.39	138671.52
26	2000	9865.00	279.18	407.52	375.22	140787.24
27	2001	2031.00	57.48	399.74	383.00	146688.05
28	2002	8676.00	245.53	382.19	400.54	160436.10
29	2003	21065.00	596.14	366.49	416.25	173265.11
30	2004	14500.00	410.35	364.65	418.09	174799.88
31	2005	16593.00	469.58	310.99	471.75	222545.76
32	2006	47300.00	1338.59	279.18	503.56	253569.41
33	2007	21952.00	621.24	269.42	513.32	263497.69
34	2008	8540.00	241.68	256.82	525.91	276585.28
35	2009	8610.00	243.66	247.40	535.34	286586.41
36	2010	28812.00	815.38	245.53	537.21	288589.70
37	2011	26717.00	756.09	243.66	539.07	290599.98

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38	2012	10989.00	310.99	241.68	541.05	292739.71
39	2013	31831.00	900.82	223.57	559.17	312666.90
40	2014	115218.00	3260.67	57.48	725.26	526000.56
			ΣQ	31309.45	$\Sigma(\bar{Q} - Q)^2$	16075028.95
No of years				N		40
Average Peak Q				$\bar{Q} = \Sigma Q/n$		782.74
Standard Deviation				$\sigma = \sqrt{(\Sigma(\bar{Q} - Q)^2/(n-1))}$		642.01
Coefficient of variation				$C_V = \sigma/\bar{Q}$		0.8202
Expected Mean of Reduced Extremes					$\bar{y}_n$	0.5501
Expected Standard Deviation of Reduced Extremes					σ_n	1.1667

Expected Means & Standard Deviation of Reduced Extremes			
(After Emil Julius Gumbel)			
S. No.	N	$\bar{y}_n$	σ_n
1	8	0.4843	0.9043
2	9	0.4902	0.9288
3	10	0.4952	0.9497
4	11	0.4996	0.9676
5	12	0.5035	0.9833
6	13	0.5070	0.9972
7	14	0.5100	1.0095
8	15	0.5128	1.0206
9	16	0.5157	1.0316
10	17	0.5181	1.0411
11	18	0.5202	1.0493
12	19	0.5220	1.0566
13	20	0.5236	1.0628
14	21	0.5252	1.0696
15	22	0.5268	1.0754
16	23	0.5283	1.0811
17	24	0.5296	1.0864
18	25	0.5309	1.0915
19	26	0.5320	1.0961
20	27	0.5332	1.1004
21	28	0.5343	1.1047
22	29	0.5353	1.1086
23	30	0.5362	1.1124
24	31	0.5371	1.1159
25	32	0.5380	1.1193
26	33	0.5388	1.1226
27	34	0.5396	1.1255

28	35	0.5403	1.1285
29	36	0.5410	1.1313
30	37	0.5418	1.1339
31	38	0.5424	1.1363
32	39	0.5430	1.1388
33	40	0.5436	1.1413
34	41	0.5442	1.1436
35	42	0.5448	1.1458
36	43	0.5453	1.1480
37	44	0.5458	1.1499
38	45	0.5463	1.1519
39	46	0.5468	1.1538
40	47	0.5473	1.1557
41	48	0.5477	1.1574
42	49	0.5481	1.1590
43	50	0.5485	1.1607
44	51	0.5489	1.1623
45	52	0.5493	1.1638
46	53	0.5497	1.1653
47	54	0.5501	1.1667
48	55	0.5504	1.1681
49	56	0.5508	1.1696
50	57	0.5511	1.1708
51	58	0.5515	1.1721
52	59	0.5518	1.1734
53	60	0.5521	1.1747
54	100	0.5600	1.2065
55	200	0.5672	1.2360
56	500	0.5724	1.2588
57	1000	0.5745	1.2685

4.2.2 Ram Munshi Bagh Gauge Station Of River Jhelum

TABLE 1

Ram Munshi Bagh

CALCULATION OF STANDARD DEVIATION & COEFFICIENT OF VARIATION

S.No	Year	Peak Flood (cusec)	Peak Flood (cumec)	Descending order of Flood Peak (Q)	$\bar{Q}$ - Q	$(\bar{Q} - Q)^2$
1	1975	30596.00	865.87	2054.16	-1410.47	1989413.30
2	1976	30290.00	857.21	1284.25	-640.56	410322.41
3	1977	7339.00	207.69	1158.21	-514.52	264726.64
4	1978	9884.00	279.72	1158.21	-514.52	264726.64
5	1979	9995.00	282.86	1097.47	-453.78	205920.04

6	1980	17093.00	483.73	1014.27	-370.58	137331.12
7	1981	25536.00	722.67	975.56	-331.87	110136.19
8	1982	19358.00	547.83	865.87	-222.18	49362.59
9	1983	14860.00	420.54	857.21	-213.52	45589.57
10	1984	12100.00	342.43	849.00	-205.31	42152.25
11	1985	29298.00	829.13	829.13	-185.44	34389.30
12	1986	27506.00	778.42	817.87	-174.18	30338.72
13	1987	28900.00	817.87	778.42	-134.73	18152.15
14	1988	35840.00	1014.27	741.04	-97.35	9476.17
15	1989	17260.00	488.46	722.67	-78.98	6237.67
16	1990	23470.00	664.20	714.32	-70.63	4988.66
17	1991	19870.00	562.32	664.20	-20.51	420.71
18	1992	40926.00	1158.21	632.79	10.90	118.85
19	1993	38780.00	1097.47	572.79	70.90	5026.51
20	1994	22360.00	632.79	562.32	81.37	6620.89
21	1995	45380.00	1284.25	554.68	89.01	7922.76
22	1996	40926.00	1158.21	547.83	95.86	9188.85
23	1997	34472.00	975.56	537.70	105.99	11233.85
24	1998	11875.00	336.06	532.38	111.31	12389.98
25	1999	8722.00	246.83	527.43	116.26	13517.03
26	2000	14282.00	404.18	488.46	155.23	24096.93
27	2001	3271.00	92.57	483.73	159.96	25586.55
28	2002	10400.00	294.32	420.54	223.15	49796.76
29	2003	12320.00	348.66	404.18	239.51	57364.69
30	2004	20240.00	572.79	348.66	295.03	87044.98
31	2005	19600.00	554.68	342.43	301.26	90757.51
32	2006	30000.00	849.00	336.06	307.63	94634.60
33	2007	19000.00	537.70	294.32	349.37	122059.30
34	2008	9250.00	261.78	282.86	360.83	130199.28
35	2009	7350.00	208.01	279.72	363.97	132476.10
36	2010	26185.00	741.04	261.78	381.91	145858.97
37	2011	18812.00	532.38	246.83	396.86	157495.69
38	2012	18637.00	527.43	208.01	435.68	189821.30
39	2013	25241.00	714.32	207.69	436.00	190092.66
40	2014	72585.00	2054.16	92.57	551.12	303733.88
			ΣQ	25747.59	$\Sigma(\bar{Q} - Q)^2$	5490722.05
No of years				N		40
Average Peak Q				$\bar{Q} = \Sigma Q/n$		643.69
Standard Deviation				$\sigma = \sqrt{(\Sigma(\bar{Q} - Q)^2/(n-1))}$		375.22
Coefficient of variation				$C_V = \sigma/\bar{Q}$		0.5829
Expected Mean of Reduced Extremes					$\bar{y}_n$	0.5501
Expected Standard Deviation of Reduced Extremes					σ_n	1.1667

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4.2.3 Asham Gauge Station of River Jhelum

TABLE 1						
ASHAM						
CALCULATION OF STANDARD DEVIATION & COEFFICIENT OF VARIATION						
S.No	Year	Peak Flood (cusec)	Peak Flood (cumec)	Descending order of Flood Peak (Q)	Q̄ - Q	(Q̄ - Q)^2
1	1975	25404.00	718.93	1056.16	-419.55	176024.26
2	1976	35800.00	1013.14	1036.49	-399.88	159907.18
3	1977	12260.00	346.96	1013.14	-376.54	141779.70
4	1978	20900.00	591.47	1005.22	-368.61	135875.14
5	1979	19270.00	545.34	974.65	-338.05	114276.76
6	1980	17880.00	506.00	920.06	-283.46	80348.30
7	1981	26500.00	749.95	903.22	-266.62	71085.83
8	1982	18668.00	528.30	843.06	-206.45	42623.03
9	1983	27460.00	777.12	838.87	-202.27	40911.15
10	1984	18270.00	517.04	815.41	-178.80	31971.00
11	1985	17800.00	503.74	810.09	-173.48	30096.68
12	1986	31916.00	903.22	796.65	-160.04	25613.27
13	1987	35520.00	1005.22	777.12	-140.51	19744.31
14	1988	26045.00	737.07	749.95	-113.35	12847.42
15	1989	26380.00	746.55	746.55	-109.95	12089.10
16	1990	28625.00	810.09	741.63	-105.03	11030.51
17	1991	29790.00	843.06	737.07	-100.47	10094.21
18	1992	34440.00	974.65	718.93	-82.33	6778.17
19	1993	29642.00	838.87	710.84	-74.24	5510.96
20	1994	20580.00	582.41	626.42	10.18	103.69
21	1995	36625.00	1036.49	591.47	45.13	2037.04
22	1996	37320.00	1056.16	582.41	54.19	2936.51
23	1997	25118.00	710.84	567.50	69.10	4775.31
24	1998	28813.00	815.41	545.34	91.26	8328.85
25	1999	11907.00	336.97	528.30	108.30	11728.71
26	2000	10860.00	307.34	517.04	119.56	14295.20
27	2001	11527.00	326.21	506.00	130.60	17056.24
28	2002	13305.00	376.53	503.74	132.86	17652.72
29	2003	26206.00	741.63	486.76	149.84	22453.09
30	2004	17200.00	486.76	475.38	161.22	25991.94
31	2005	20053.00	567.50	441.40	195.21	38106.34
32	2006	22135.00	626.42	376.53	260.07	67637.47
33	2007	15597.00	441.40	346.96	289.65	83894.54
34	2008	10402.00	294.38	336.97	299.64	89781.40
35	2009	10680.00	302.24	334.51	302.10	91262.93

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36	2010	16798.00	475.38	326.21	310.39	96341.61
37	2011	11820.00	334.51	307.34	329.27	108415.80
38	2012	28150.00	796.65	302.24	334.36	111796.31
39	2013	9616.00	272.13	294.38	342.23	117119.28
40	2014	32511.00	920.06	272.13	364.47	132838.93
			ΣQ	25464.14	$\Sigma(\bar{Q} - Q)^2$	2193160.88
No of years				N		40
Average Peak Q				$\bar{Q} = \Sigma Q/n$		636.60
Standard Deviation				$\sigma = \sqrt{(\Sigma(\bar{Q} - Q)^2/(n-1))}$		237.14
Coefficient of variation				$C_V = \sigma/\bar{Q}$		0.3725
Expected Mean of Reduced Extremes					$\bar{y}_n$	0.5501
Expected Standard Deviation of Reduced Extremes					σ_n	1.1667

Expected Means & Standard Deviation of Reduced Extremes			
(After Emil Julius Gumbel)			
S. No.	N	$\bar{y}_n$	σ_n
1	8	0.4843	0.9043
2	9	0.4902	0.9288
3	10	0.4952	0.9497
4	11	0.4996	0.9676
5	12	0.5035	0.9833
6	13	0.5070	0.9972
7	14	0.5100	1.0095
8	15	0.5128	1.0206
9	16	0.5157	1.0316
10	17	0.5181	1.0411
11	18	0.5202	1.0493
12	19	0.5220	1.0566
13	20	0.5236	1.0628
14	21	0.5252	1.0696
15	22	0.5268	1.0754
16	23	0.5283	1.0811
17	24	0.5296	1.0864
18	25	0.5309	1.0915
19	26	0.5320	1.0961
20	27	0.5332	1.1004
21	28	0.5343	1.1047
22	29	0.5353	1.1086
23	30	0.5362	1.1124
24	31	0.5371	1.1159
25	32	0.5380	1.1193
26	33	0.5388	1.1226

27	34	0.5396	1.1255
28	35	0.5403	1.1285
29	36	0.5410	1.1313
30	37	0.5418	1.1339
31	38	0.5424	1.1363
32	39	0.5430	1.1388
33	40	0.5436	1.1413
34	41	0.5442	1.1436
35	42	0.5448	1.1458
36	43	0.5453	1.1480
37	44	0.5458	1.1499
38	45	0.5463	1.1519
39	46	0.5468	1.1538
40	47	0.5473	1.1557
41	48	0.5477	1.1574
42	49	0.5481	1.1590
43	50	0.5485	1.1607
44	51	0.5489	1.1623
45	52	0.5493	1.1638
46	53	0.5497	1.1653
47	54	0.5501	1.1667
48	55	0.5504	1.1681
49	56	0.5508	1.1696
50	57	0.5511	1.1708
51	58	0.5515	1.1721
52	59	0.5518	1.1734
53	60	0.5521	1.1747
54	100	0.5600	1.2065
55	200	0.5672	1.2360
56	500	0.5724	1.2588
57	1000	0.5745	1.2685

5. FLOOD MANAGMENT

5.1 Measures For Flood Management

5.1.1 Increasing the carrying capacity of existing flood mitigation infrastructure

1. River Jhelum treatment (dredging, re-sectioning etc).
2. Optimum functioning of the Flood Channels
    1. Flood Spill Channel (FSC) to 25000 Cusec/39000 cusec)
    2. Kutte Kull
    3. Sonar Kull
3. Wetland conservation

5.1.2 Dredging

It has been seen that velocity of the water in the Jhelum River is quite less due to very low bed grade and lot of sediment load gets deposited on the bed with the result there is a lot of reduction in the carrying capacity of the basin at different parts. So, the carrying capacity of these areas can be improved with dredgers.

a. The outflow channels in the line of wullar intake need to be dredged to create laminar flow to the lake.
b. The dredging of the river Jhelum must start from the tail end on the down-stream side of the river to avoid back flow and the dredging on the upstream side be taken up next, to avoid heavy flood

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discharge from the upstream side resulting in the overflow of embankments due to chocking through the city.

c. Fix time frame for each segment dredging controlled and monitored by the expert team based on primavera software. The total volumes for dredging should be monitored based on latest available equipment in the market.

5.2.2 Rise of Embankments

A levee or dyke may be defined as an earthen embankment extending generally parallel to the river channel and designed to protect the area behind it from overflow of flood waters.

Embankments are the oldest known forms of flood protection works and have been used extensively for this purpose. These serve to prevent inundation, when the stream spills over its natural section, and safeguard lands, villages and other properties against damages.

5.2.2.1 Embankment Classification

Manual, CW&PC, **Embankments**1960 stipulates that An embankment is designated as low, medium or major (according to its height above natural surface level (NSL).

1	Low Embankment	Height. < 10 ft. (3m.)
2	Medium 10ft. (3m) <Height.> 30 ft. (9 m)	Embankment
3	Major Height> 30 ft. (9 m Embankment)	

5.2.3 Gabion Treatment

Visiting the site at Asham and the surrounding areas, a real bad situation of the site Hajan was found in which the side banks were completely washed out due to erosion of the material from the side walls and the extents of the erosion was so much that the whole side slope was washed out and the bank then converted into a vertical one.

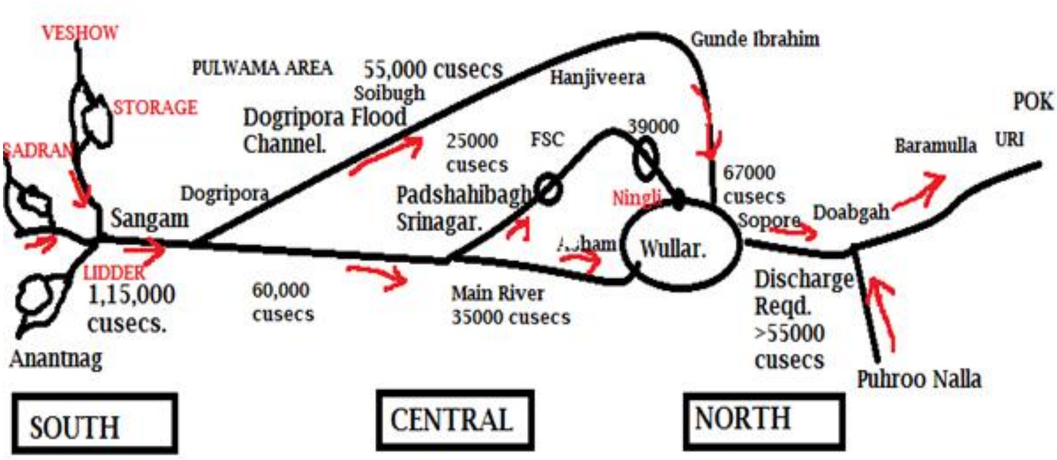
On discussing about this issue with J.E‟s at IFC, the reason behind this was found that the life of cohesiveness of the soil is over and now, the material of the banks has become loose and non-cohesive.

Discussing with J.E‟s, we got to know that none of the erosion control measure work here, everything has been tried here from wooden piles to riveting but nothing as such worked. This place needs to be provided with the gabion treatment. And IFC‟s team of engg. is even working on it.

5.2.4 Construction of flood water storage reservoirs in various tributary catchments of the River Jhelum (within the ambit of IWT 1960)

By the construction of storage reservoirs on the catchment of tributaries, a huge quantity of water can be arrested and besides a sediment load / silt, Carried by the tributaries shall be reduced to a great extent.

5.2.5 Additional Flood spill channel from Dorgipora (Pulwama) to Wullar Lake.



- Dogripora- wullar alternate channel to increase the capacity of the flood spill channel to 25000 cuses from the current 8000 cusecs would act as a major relief to the flood measures, this would be the least resistant path for flood mitigation and prevention

5.2.6 Flood Zoning (Hazard mapping of Kashmir)

- Areas under the risk of submergence.
- Proper city planning.

5.2.7 Life safety jackets and inflated rubber boats should be stocked by all the house-holds falling in the flood prone area. Young boys/girls need to be taught swimming to face any eventuality.

5.2.8Early Flood warning system

A flood forecasting system to be developed and installed that could provide 12-48hrs flood prediction in order to reduce the risk to people in future.

- Automatic Weather Stations (IMD)
- Doppler Radar (IMD)
- Automatic Water Level Recorders

  Proper announcement system
- Radio
- TV
- Social Media *(Face book)*
- Android App *(Flood Alert)*

5.2.9 Government must ensure availability of sufficient funds for executing the work in time-bound manner.

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